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Dear colleagues and friends,

On behalf of the Faculty of Textiles, Leather and Industrial Management, we are greatly honored and pleased to welcome you all to the 15-th Romanian Textiles and Leather International Conference, CORTEP 2014.

Generally speaking, the textile field offers a generous and valuable research approach. We discuss about a huge number of applications, numerous problem solving is strongly interdisciplinary. This is why the organizers have deemed very suggestive the conference logo: “textiles 4all, textiles 4ever”.

The conference topics were carefully selected to highlight the diversity of research problems in the field of textiles and leather. We are sure that the selected topics will provide you with a wealth of information and many opportunities for discussions. Thus, the main areas of interest proposed for papers submission, cover the following topics:

- New fibres and advanced materials
- Textile science and technology
- Textile structures and properties
- Functional textiles and clothing
- IT applications
- Machinery developments
- Fashion design and product development
- Innovations in textile finishing
- Advances in leather processing
- Footwear design and technology
- Ecology in textiles and leather processing
- Marketing and management
- Engineering education

The interest of the international scientific community is clear. The CORTEP Conference have attracted 112 participants from 14 countries. We will hear 44 oral presentations, and have the opportunity to see about 80 poster presentations.

For a number of important reasons, the CORTEP 2014 is organized in Poiana Braşov, one of the oldest and most famous mountain resorts. Located in a beautiful mountainous region, at about 1,020 meters above sea level near the city of Brașov it is surrounded by four mountains: Postăvaru, Piatra Craiului, Bucegi and Piatra Mare. The main touristic objectives are: city of Braşov, Bran Castle, Râşnov Fortress, Peles Castle and many others.

Finally, we would like to express our sincerest thanks to all the participants for their valuable contribution and readiness to spend a part of their time in Poiana Brasov. The conference would not be possible without the joint effort of the organizing committee and evaluating committee, to whom we are deeply grateful.

The organizers express their gratitude to all conference sponsors for their support, which made this conference possible.

Prof. dr. Eng. Carmen Maria LOGHIN

Dean of the Faculty of Textiles, Leather and Industrial Management

President of CORTEP’2014

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Section 1: New Fibres and Advanced Materials

BIO-INNOVATED COTTON CELLULOSE – SURFACE FREE ENERGY

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Abstract: *Raw cotton fibres contain around 95% of pure cellulose balanced by the non-cellulosic impurities of proteins, oils, waxes, pectins, carbohydrates and inorganic materials which should be removed in desizing, scouring, and bleaching processes. The enzymatic pre-treatments of cellulose fabrics have received much attention in the last decade due to its environmental benefits and special performance in comparison with the conventional processing of textiles. The use of protease, lipase, pectinase, cutinase and cellulase, individually or in a mixture can replace alkaline scouring. Amylase, glucose oxidase and peroxidase enzymes can be used for desizing and bleaching of cotton-like fabrics. Since textile wettability and adsorption depend to a large extend on the kind and magnitude of the solid surface free energy, the influence of bio-innovation (amylase, alkali and neutral pectinase, and cellulase treatment) of the plain woven cotton fabric to its surface free energy, as well as its hydrophilicity and whiteness, was researched in this paper.*

Keywords: *surface free energy, bio-innovation of cotton, amylase, pectinase, cellulase*

INTRODUCTION

Raw cotton fiber is highly hydrophobic due to all genetic and added impurities. It contains around 95% of pure cellulose balanced by the non-cellulosic impurities of proteins, oils, waxes, pectins, carbohydrates and inorganic materials [1-4]. Since the most of textile finishing procedures are performed in an aqueous medium, it is necessary to remove them and enable absorbency of cotton materials for further textile processing. Impurites are usually removed in desizing, scouring, and bleaching processes. In the conventional scouring with sodium hydroxide (NaOH) the non-cellulosic genetic and added impurities from the cuticle of cotton fiber are removed, but the presence of oxygen results in partial damages to the cellulose causing a high weight loss, decreasing the strength and degree of polymerization as well. The large quantities of alkali require an extensive rinsing process that loads wastewater with environmentally harmful chemicals. Therefore, the enzymatic pre-treatments of cellulose fabrics have received much attention in the last decade due to its environmental benefits and special performance in comparison with the conventional processing of textiles.

The use of enzymes in textile finishing has been carried out from the 20th century (1910) using amylase during starch degradation [5,6]. According to the key-lock model / enzyme - substrate theory, introduced by Michaelis-Menten in 1913, a substrate diffuses towards the direction of an enzymes', links to it and an enzyme substrate complex is then formed. The final reactive products diffuse from the split products' active centre thus enabling a new linking of the substrate and catalyse all over again [6]. According to Ro ner, about 75% of organic contaminants from the textile industry come from cotton pre-treatment, which is reason enough for replacing NaOH with biodegradable enzymes 2-4].

The use of protease, lipase, pectinase and cellulase, individually or in a mixture can replace alkaline scouring [2-13]. To obtain bioscoured cotton with a good hydrophilic effect, it is important to degrade a complex mix of different substances out of pectin, cellulose, protein etc. including Ca, Mg and Fe which forms an interlaced net structure difficult to solve in water [7,8]. A complete degradation is not necessary, because after pectin net structure degradation, fragments of the complex structure are soluble in water and can be washed off. For that purpose the enzyme pectate lyase (pectinase) which very rapidly catalyzes hydrolysis of salts of polygalacturonic acids (pectins) in the primary wall matrix was used in alkali medium for last 15 years. The process was named bioscouring with alkali pectinases [3-5,9,10]. Lately, the progress was achieved through application of neutral and acid pectinases [11-13]. The result of biopreparation with pectinase is not degraded cellulose, having less weight or strength loss than alkaline scoured one. Additionally, the amount of wax removed is less than that removed by the other processes, which results in an improved hand. Applying neutral one, there is no need to perform neutralization [11-13].

Amylase, glucose oxidase and peroxidase enzymes can be used for desizing and bleaching of cotton-like fabrics [9,10-16]. An amyloglucosidase/pullanase enzyme mixture can be used to degrade starch into glucose during desizing. The generated glucose can be converted to hydrogen peroxide and gluconic acid by glucose oxidase enzyme during bleaching. The gluconic acid was a good peroxide stabilizer during bleaching and a good sequestering agent [10,15].

Since protease, lipase, pectinase, cutinase and cellulase, individually or in a mixture can replace alkaline scouring, the research in this paper was focused on the application of amylase, alkali and neutral pectinase, and cellulase for the bio-inovation of cotton cellulose. Such change in the number of accessible functional fiber surface groups affects the distribution of surface charge, resulting in change of its surface free energy and wettability [16-19]. Therefore, the influence of bio-innovation of the plain woven cotton fabric to its surface free energy, as well as its hydrophilicity and whiteness, was researched in this paper.

EXPERIMENTAL

2.1 Material

A plain weave fabric of 100 % cotton and surface mass 120 g/m^2 was used. For comparison fabric was *alkali scoured according to the standard procedure* for 2 h at 100°C in autoclave (Scholl) by pad roll using 3 % NaOH and 2 g/l Kemonetzer NI. It was neutralised and rinsed until pH 7 was reached.

2.2 Bio-inovation

Amilase. Fabric was enzimatically desized for 3 h at 60°C in autoclave (Scholl) by pad roll using 3 g/l of amilase Beisol LZV (Bezema) and 2 g/l of nonionic wetting agent Lavotan TBU (Bezema). *Pectinases*. Enzymatic scouring was performed by exhaustion method in the Linitest (Hanau) using two different pectinases - alkali and neutral one. Fabric was treated with 2 g/l of neutral pectinase Beisol PRO (Bezema) and 1 g/l of wetting agent Felosan NOG (Bezema) at pH 7, for 50 min at 80°C, BR 1:25. Treatment with 0.2 % (owf) of alkali pectinase BioPrep 3000L (Novozymes), was performed in the bath containing 0.5 g/l Kemonetzer NI and buffer (Na_2HPO_4), pH 9.2 and 65°C, BR 1:25. *Cellulase*. Fabric was treated with 0.5 % (owf) of cellulase Cellusoft L (Novo Nordisk) and 1 g/l of wetting agent Kemonetzer NI at pH 4.9 (CH_3COONa), for 30 min at 50°C, BR 1:25. Combination of p*ectinase and cellulase*. Fabric was treated in 2 steps: 1° cellulase treatment; 2° alkali pectinase treatment according to the procedures above. Labels and treatments are given in Table 1.

Table 1: Labels, treatments and procedures

Label	Treatment of cotton fabric
R	Raw
ED	Enzymatic desizing with amilase
AS	Alkali scouring
ESAP	Enzymatic scouring with alkali pectinase BioPrep 3000L
ESNP	Enzymatic scouring with neutral pectinase Beisol PRO
ESC	Enzymatic scouring with cellulase Cellusoft L
ESCAP	Enzymatic scouring with cellulase Cellusoft L and alkali pectinase BioPrep 3000L

All the fabrics were neutralised and rinsed until pH 7 was reached. For determination of surface free energy all the fabrics were rinsed to the conductivity of deionised water (2-4 μS/cm).

2.3. Test methods

Since the scouring and bleaching processes have major impact on fabric damage, mechanical wear, as well as fabric whiteness were determined. For that purpose **breaking force and elongation** were measured according to EN ISO 13934-1:1999 *Textiles - Tensile properties of fabrics – Part 1: Determination of maximum force and elongation at maximum force using the strip method* on MesdanLab Strength Tester. **The mechanical wear** was calculated according to ISO 4312:1989 *Surface active agents -- Evaluation of certain effects of laundering -- Methods of analysis and test for unsoiled cotton control cloth*:

$$U_m = \frac{F_0}{F} \cdot 100 \text{ [\%]} \quad (1)$$

where U_m is mechanical wear (damage) [%], F_0 is breaking force of untreated, raw fabric [N], F is breaking force of treated fabric [N].

The mass loss was calculated according to:

$$\Delta m = \frac{m_0}{m} \cdot 100\ [\%] \qquad (2)$$

where m is mass loss [%], m_0 is mass of untreated, raw fabric [g], m is mass of treated fabric [g].

Degree of whiteness (W_{CIE}) was calculated from spectral characteristics measured on remission spectrophotometer SF 600 PLUS CT (Datacolor) according to ISO 105-J02:1997 *Textiles - Tests for colour fastness - Part J02: Instrumental assessment of relative whiteness,* whilst **Yellowing Index** (YI) according to DIN 6167:1980-1 - *Beschreibung der Vergilbung von nahezu weißen oder nahezu farblosen Materialien (Description of yellowness of near-white or near-colourless materials).*

Different theories and practices can be used for determining textile **surface free energy (SFE) components**. If the solid surface is sufficiently hydrophobic that liquid droplets will stay on the surface forming an angle, then the contact angle can be measured and the SFE components calculated according to different models, e.g. Acid-base, Wu's, etc. Textiles are heterogeneous, porous and mostly hydrophilic, therefore surface free energy is complicate and sometimes impossible to measure by the contact angle method [18,19].

For the determination of the textile surface free energy components in this paper the theory and practice of *thin-layer wicking* was used [20]. In accordance to this technique the rate of the liquid penetration (wicking) into the porous solid can be described with the general form of Washburn equation for the horizontal capillary [16,18,20]:

$$\frac{x^2}{t} = \frac{R}{2\eta}\Delta G \qquad (3)$$

where x is the penetrated distance, R is the effective radius of porous solid, t is the penetration time of the distance x, is the liquid viscosity and G is the free energy change, accompanying the liquid penetration process. If the wicking experiments are carried out in four wicking systems, four different values of G appear in equation (1), and the work of adhesion, W_A can be determined from the results of the liquid penetration rates by the following equation [20]:

$$W_A = 2\sqrt{\gamma_S^{LW}\gamma_L^{LW}} + 2\sqrt{\gamma_S^{+}\gamma_L^{-}} + 2\sqrt{\gamma_S^{-}\gamma_L^{+}} \qquad (4)$$

from which nonpolar Lifshitz-van der Waals, $_S^{LW}$, and polar electron donor, $_S^{-}$, and electron acceptor, $_S^{+}$, components of the solid surface free energy can be calculated, if the components $_L^{LW}$, $_L^{-}$ and $_L^{+}$ of the liquids are known. In order to determine the solid surface free energy components at least three liquids, one apolar completely spreading liquid and two polar liquids, must be used for wicking. Experiments were carried out in the same way as recommended by Grancarić et al. [16]. For every fabric sample ten measurements were made at 20±1 °C. From wicking distance of n-heptane as an apolar completely spreading liquid and water and formamide as polar non-completely wetting ones, components of surface free energy were calculated. Afterwards, the work of spreading, Ws was calculated according to:

$$Ws = 2\sqrt{\gamma_S^{LW}\gamma_L^{LW}} + 2\sqrt{\gamma_S^{+}\gamma_L^{-}} - 2\sqrt{\gamma_S^{-}\gamma_L^{+}} - 2\gamma_L \qquad (5)$$

Hydrophilicity of cotton fabrics was determined according to drop test, vertical and horizontal wicking methods. In Drop test (AATCC 79-2010 - *Absorbency of Bleached Textiles*) is allowing a drop of water to fall from 1 cm height on the taut surface of cotton sample. Time necessary to spread into fabric is measured. Fabric is hydrophilic if the time is < 3 s. According to standard vertical wicking test DIN 53924 (1997-03) *Bestimmung der Sauggeschwindigkeit von textilen Flächengebilden gegenüber Wasser (Steighöhenverfahren) (Testing of Textiles; Velocity of Soaking Water of Textile Fabrics (method by Determining the Rising Height))* the lower edge of a sample with dimensions of 25.0 by 2.0 cm was placed 1 cm vertically in the vessel with water. The wicking length in 120 s was measured. In horizontal wicking test according Chibowski

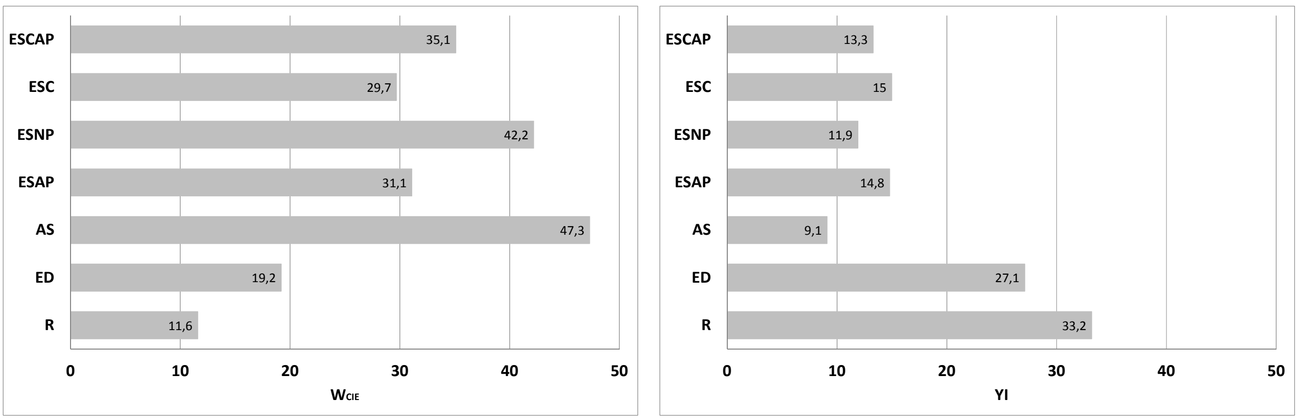
[18] a procedure is similar to a vertical test but a cotton strip was placed under the small angle (8°) in the closed chamber ousted for planar chromatography.

RESULTS AND DISSCUSSION

Raw cotton possesses a hydrophobic nature due to its impurities that should be removed in order to achieve an absorbency of cotton materials necessary for further textile processing. The influence of pre-treatment procedures often damages the cotton cellulose. Therefore the fabric quality was determined through the breaking force, and elongation, the whiteness and yellowness, as well as weigth loss. The mechanical damage of cotton cellulose, which corresponds to the reduction of the breaking load, was calculated. The results are shown in Figure 1 and Tables 2. The hydrophilicity was measured according to vertical, horizontal and Drop test of raw, scoured and bio-innovated cotton fabrics. The results are collected in Tables 3.

Table 2: Weight loss, breaking force (F), breaking elongation ( ), and mechanical damage (Um) of raw, scoured and bio-innovated cotton fabrics

Fabric	Weigth loss [%]	F [N]	[%]	U_m [%]
R	0	565	12.3	0
ED	1.2	551	13.8	2.48
AS	10.3	470	14.0	16.81
ESAP	1.8	500	18.0	11.50
ESNP	2.0	515	17.2	8.85
ESC	1.7	425	17.0	24.78
ESCAP	1.9	445	16.0	21.24



a. b.

Figure 1: Whiteness according to CIE (a), and Yellowing Index (b) of raw, scoured and bio-innovated cotton fabrics

After mechanical removal of sculls, seeds, and dust, raw woven fabric contains starch applied to obtain a high productivity during weaving. The warp threads are covered with a protective film the so-called size which makes the warp threads more resistant to mechanical treatment during the weaving processes and decreases the number of warp thread breaks. Starch is carbohydrate consisting of three different polymers, the amylose, the amylopectin and a so-called intermediate fraction considered also as abnormal amylopectin and water (approx. 20 %), which has to be removed before further processing. Amylose is the linear composition is called a 1.4 glucosidic compound. Amylopectin consists of amylose, and apart from 1.4-glucosidic linkages, the presence of 1.3- and 1.6- glucosidic linkages are possible as well. An average the part of amylopectin is 70 – 80 %, but depending on the kind of starch, the part of amylopectin might be up to 99 %. After the removing added impurities, raw fiber is mostly cellulose; while natural impurities such pectine, waxes, fats, organic acids, ash, vitamin B, sugars, proteins, mineral substances etc. still remain. All these impurities are mostly in the cotton primary wall, which is responsible for the lack of water absorbency of the fiber in the various aqueous processing baths. As it can be seen from Tables 2 and 3 and Figure 1, raw cotton (R) is highly hydrophobic and yellow, therefore, desizing and scouring are needed [1-13].

Table 3: The hydrophilicity according to vertical, horizontal and Drop test of raw, scoured and bio-innovated cotton fabrics

Fabric	Vertical test [cm in 120 s]	Horizontal test [cm in 120 s]	Drop test [s]
R	0	0	> 60 min
ED	1.20	2.05	5
AS	3.45	5.55	1
ESAP	1.95	3.40	2
ESNP	4.15	4.20	1
ESC	1.40	3.75	1
ESCAP	2.80	4.00	1

In this paper starch splitting enzyme (-amylase) was applied to desize starch sized woven fabric. -amylase only split 1.4-glucosidic linkages, and cannot split 1.3- or the 1.6-gluosidic linkage of amylopectin. However, -amylases irregularly split the 1.4-glucosidic linkage inside the starch molecule. Among others fragments which are soluble in water like dextrin and oligosaccharide are formed. The complete degradation of starch to maltose is not necessary, because already bigger decomposition products are soluble in water. From the results in Table 2 for enzymatic desized cotton fabric (ED) it can be seen the amylases are highly efficient to degrade starch without damaging the fibers. Weight loss is 1.2 %, and mechanical damage less than 2.5 %. Removing the starch, whiteness increases, whilst yellowness decreases accordingly (Figure 1). From Table 3 can be seen that by removing starch in enzymatic desizing results in hydrophilic fabric.

Considering fiber damage usually analyzed by weight loss and breaking force. It is evident from Table 2 that pectinase scoured fabrics (ESAP, ESNP) have significantly lower weight loss and mechanic damage, and higher breaking force than alkaline scoured fabric (AP), regardless of alkali or neutral pectinase usage. Pectin is composed of the homologous pectin, the polygalacturon acid on the one hand and on the other hand of the heterologous part, the rhamnogalacturonan, which is bound at the rest of the rhamnosyl residue irregularity with arabinan, galactan, and many other compounds, mostly polysaccharides. As the pectin on cellulose fibres is a complex mix of different substances which forms an interlaced net structure difficult to solve in water, and holding fats and waxes, it was important to degrade the pectin net structure in order to obtain bioscoured cotton with a good hydrophilic effect. A complete degradation was not necessary because the fragments of the complex structure were soluble in water and were washed off. Therefore, the weight loss of all bio-innovated fabrics was around 2 % whilst for alkaline scoured one cotton was higher than 10 %. That is because only the pectin was degraded with pectinase application. It is to point out that bioscouring with neutral pectinase is better than with alkali one because those scoured fabrics are less damaged. The reason for that is in that scouring with alkali pectinase was performed in alkali medium. Although expected higher negative mechanical changes, pectinase treated fabrics showed good properties. Cellulase treatment led to lower breaking force, and little bit higher mechanical damage (around 20 %) what was expected because cellulase degrades cellulose.

Whiteness is a very important criterion for assessing the effects achieved in bleaching, and it has been related to the process of scouring. The aim of scouring is to achieve hydrophilic and minimal damage to the cotton fabric having satisfactory whiteness. It is evident from the results for whiteness (W_{CIE}) presented in Figure 1a that the removal of genetic and added impurities such are waxes, protein substances, pectin, and others during alkali scouring, to enhanced whiteness. Bioscouring degraded only the pectine, therefore the whiteness of the bioscoured cotton was less enhanced than the whiteness of the alkali scoured one. Bioscoured cotton with neutral pectinase (ESNP) has a little bit higher whiteness than bioscoured with alkali pectinase (ESAP), and almost good as alkaline scoured fabric (AS). On the other hand, cellulase application (ESC) results in lower whiteness than other enzymes, but in combination with alkali pectinase (ESCAP) gives off good results. Analogue to whiteness increment, yellowing index decreases (Figure 1b).

The results of wicking according to the horizontal test shown in Table 2 indicate that the raw cotton fabric (R) is completely hydrophobic. The rate of water penetration to differently scoured cotton fabrics is noticeable. Water penetration is faster on bioscoured cotton fabrics with neutral pectinase (ESNP) than on the alkali one (AS). These results indicated that a high absorbency is not only property for achieving of sufficient uptake of dyestuff and finishing agents. In this case, high cotton absorbency can be an indication of fiber damage. Wicking distance for alkali pectinase and cellulose is little bit lower, but still indicating hydrophilic surface. The wicking behaviour of the cotton fabrics evaluated by vertical and horizontal tests was similar but less prominent.

Since the hydrophilicity was improved, the surface free energy and work of spreading were calculated. The values of surface free energy components of the studied fabrics were calculated from the results of the liquid penetration rates (Figure 2) according to Chibowski thin-layer wicking method.

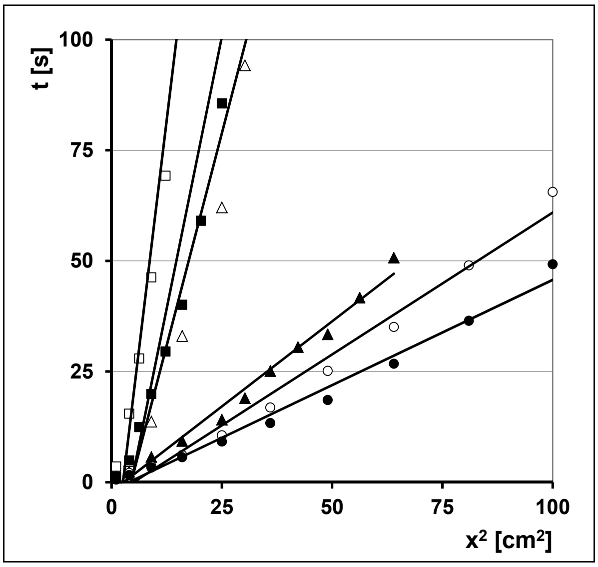


Figure 2: Liquid penetration rates into enzymatic desized fabric: -○- n-heptane, -△- water, -□- formamid; precontacted fabrics with liquid saturated vapour: -●- n-heptane, -▲- water, -■- formamid

Figure 2 show plots of the liquid penetration rate into enzymatically desized cotton fabric, ED. Since Washburn equation (3) is only valid if the squared penetrated distance, x^2, is a linear function of the time, t, it is presented just those parts of plots where linear relationship was obtained. According to the Washburn equation, the higher the penetration rate, the lower the slope of plot. It can be seen from figure that the liquid penetration rate depends on the liquid properties as well as on the fabric preparation. The highest penetration rate is obtained for n-heptane and the lowest one for formamid irrespective of the fabric preparation. It is also evident that the liquid wicking velocity into the bare fabric differs from that obtained for the pre-contacted one. Since the bioinnovated cotton fabrics are highly wettable by all studied liquids, n-heptane is the only wicking liquid in the case of the hydrophobic fabric R.

The values of surface free energy components of all studied fabrics, which are calculated from the results of the liquid penetration rates, as well as work of spreading, are collected in Table 4.

Table 4: Surface free energy components and Work of spreading of the raw, scoured and bio-innovated cotton fabrics determined from the thin-layer wicking experiments

Fabric	$_S^{LW}$ [mJ/m^2]	$_S^{-}$ [mJ/m^2]	$_S^{+}$ [mJ/m^2]	$_S^{AB}$ [mJ/m^2]	$_S^{TOT}$ [mJ/m^2]	W_S [mJ/m^2]
R	48.00	0	0	0	48.00	-80.90
ED	47.02	51.91	0.37	8.80	55.90	-2.58
AS	37.31	84.60	0.54	13.52	50.83	11.75
ESAP	39.02	54.23	1.53	18.22	57.23	-0.40
ESNP	71.98	45.70	0.11	4.41	76.39	5.19
ESC	35.12	74.95	0.15	6.66	41.78	1.06
ESCAP	42.35	65.78	0.50	11.47	53.82	4.22

The cotton fibres immersed in a neutral aqueous medium, as most of the textile fibres, have negative surface charge due to the presence of the existing hydroxyl or carboxyl groups. In the case of raw (untreated) cotton, hydroxyl and carboxyl groups existed but they were covered by non-cellulose compounds (proteins, oils, waxes, pectin, carbohydrates and inorganic materials, etc.). Therefore, the raw cotton fabric is highly hydrophobic, with $_S^{LW}$ equals to its total surface free energy, $_S^{tot}$. The scouring degrades and removes practically all non-cellulose compounds except waxes, which remain to about 50% on the fiber, making available and cause the formation of new surface groups (-CO, -CHO and –COOH) [19]. It causes inter-fibrillar swelling and the active surface is increased, but the amount of dissociable groups stays the same.

Therefore, fabric desizing and scouring results in the high increase of the $_S^-$ value, but does not have a significant effect on the increase of $_S^+$. This suggests that bioinnovated cotton fabrics can be described as monopolar surfaces with a strong electron donor capacity which arises from existing hydroxyl or carboxyl groups. From the Table 4 it is clear that the $_S^-$ value of the alkali scoured fabric is much higher than the bioinnovated ones, indicating a higher degree of purity and hydrophilicity. However, treatment with neutral pectinase showed the best results, having highest $_S^{TOT}$ value of all bioinnovated fabrics, as well as instantaneous water penetration. These results are in good correlation with wicking hydrophilicity test shown in Table 2.

Surface free energy components makes possible to calculate fabric wettability by work of spreading (Ws). It is evident that raw fabric has high negative value (-80.9 mJ/m^2) because it is highly hydrophobic. Therefore, high amount of energy is necessary for the wetting this fabric. Pretreated fabrics are hydrophilic and for their wetting lower energy is required. Degradation of impurities in desizing and scouring enhance fabric wetting. It can be seen that work of spreading of alkali scoured fabric is positive. Bioscouring with alkali pectinase leads to Ws almoust equal to zero indicating energy needing for its wetting. However, bioinnovated cotton fabrics with neutral pectinases and cellulase have very similar work of spreading as the alkali scoured one, indicating that no energy is required for wetting. If applied alkali pectinase with cellulase, the positive Ws is reached as well, so it can be said that bioinnovation of cotton results in great wettability and hydrophility.

CONCLUSIONS

In this paper the research was focused on the application of amylase, alkali and neutral pectinase, and cellulase for the bio-inovation of cotton cellulose. The influence of bio-innovation of the plain woven cotton fabric to its surface free energy, as well as its hydrophilicity, wetting and whiteness, was discussed.

Bio-innovative pretreatment processes of cotton fabrics cause the change in the textile surface properties resulting in a great change of its surface free energy. Raw as untreated cotton is apolar with $_S^{LW}$ equals to its total surface free energy, $_S^{TOT}$; and therefore highly hydrophobic. The bio-innovation of cotton results in the high increase of the $_S^-$ value, but does not have a significant effect on the increase of $_S^+$, suggesting that the bio-innovated cotton fabrics can be described as monopolar surfaces of strong electron donor capacity. The hydrophilicity of the bioscoured cotton fabric was improved but loos still less than the alkali scoured fabric that showed instantaneous penetration In this case, high cotton absorbency can be an indication of fiber damage.. However, bio-scouring with pectinases do not damage cotton fibers resulting in great wettability and hydrophility. This confirms the importance of the enzymatic treatment in cotton pre-treatment and finishing.

When considering the hydrophilicity and whiteness, as well as from the ecological point of view, it is to conclude that the use of neutral pectinase was of benefit as there was no need for neutralisation of the wastewaters.

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STRUCTURAL ANALYSIS AND MECHANICAL PROPERTIES OF POLYPROPYLENE FILAMENT YARNS CONTAINING FLAME RETARDANT ADDITIVE

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Abstract: *Especially in recent years, filament yarns have gained various functional properties such as UV-resistance, flame retardant (FR), anti-bacterial properties, etc. One of the most preferred methods for production these types of products is adding micro- and nano scale additives to polymer raw material in the chip form during production. As a result, end products with unique properties are produced by using this method for different areas of use. However, in addition to these unique properties, structural and mechanical properties (tenacity, breaking elongation, unevenness etc.) are important. Also, these important features should be at specific values for the production of high quality filament yarn. Purpose of this study is to analyse basic structural and mechanical properties of polypropylene (PP), flame retardant yarns that are produced using additives.*

Keywords: *Polypropylene filament yarn, mechanical properties, flame retardant (FR), SEM and EDX analysis.*

INTRODUCTION

Synthetic filament yarn production plays an essential role within the textile industry. Thanks to the Research & Development and Production & Development studies that have been conducted on these products especially in recent years, filament yarns have gained many functional properties. On the other hand, in addition to these unique properties, structural and mechanical properties such as tenacity, breaking elongation, unevenness etc. are also important. Especially when SEM analysis results of filament yarns are examined, particles on the yarn surface are determined indicating that the additive cannot be evenly distributed to the yarn structure. These particles of various sizes are distributed along the yarn surface and cause agglomeration by clustering to each other. As a result of the research literature, we can see that increase of studies in this area in recent years.

In this field, a study carried out in 2010 by Erdem, et al. have shown that surfaces of PP fibres are even and smooth while others that include nano-particle additives have uneven surfaces, based on SEM images of filament yarns. Moreover, it has been observed that unevenness that are situated along the fibre surface increase with the increasing rate of nano-particle additives [1]. Also, a study carried out in 2011 by Salaün, et al., flame retardant microcapsules have been prepared by in-situ polymerization and mixed into a PP matrix and, using these produced multi-filaments, they have been processed flame retardant knitted fabrics. Tests performed later on have shown that knitted fabrics had obtained desired unique properties. On the other hand, other test studies have demonstrated an important increase in the interfacial tension caused by the presence of particles between microparticles and the isotactic PP matrix and these results have been supported by SEM analysis images [2]. These studies display that even though using additives successfully produce the products with desired properties, they cause other undesired negative effects on the structural and mechanical properties (such as tenacity, breaking elongation, unevenness, etc.) of the products. For example, a study carried out in 2010 by Selver, nano-particle added PP monofilament yarns have been produced and tenacity test results of these yarns have been examined. Results have shown that nanoparticle agglomerations have a negative effect on filament yarn tenacity [3].

When these studies are examined, it is seen that use of additive materials affect the product structural and mechanical features. In this study, we present the preparation of polypropylene filaments incorporating micro particles and investigate the effects of these particles on mechanical properties (tenacity and breaking elongation) of the filament yarns.

EXPERIMENTAL

Material

Polypropylene (PP) filament yarns which have an important place and many application areas of use among synthetic yarns, has been used as material of this study. These yarns have been produced by using PP polymer chips and FR additive material as an experiment.
The base polymer used was a commercially available isotactic polypropylene homopolymer grade (PP 518P) supplied in pellet form, with a Melt Flow Index (MFI) of 24 g/10 min (230°C, 2.16 kg load) and a density of 905 kg/m3. Also, organo-phosphonate based micro particles have been used for the production of the flame retardancy filament yarns.

Method

PP filament yarns have been produced according to melt spinning principle by using a laboratory type filament yarn machine (Figure 1). The PP polymer chips and FR additives were fed into the hopper consisting of a single-screw extrusion system. The heating along the screw was adjusted to obtain a temperature gradient from 220°C to 245°C and a volumetric pump regulated the injection of molten polymer towards the dies at a flow rate of 350 cm^3 per minute. Then, the filaments were air cooled and spin finish was applied on the filaments before their passage in the drawing godets. Then filaments were drawn by means of heated godets before being wound. The speeds of the two godets serve to adjust the drawing ratio: the first godet speed was set at 400 rpm, whereas the second one was set at 800 rpm, giving a drawing ratio of 2. Finally, the filament yarns were wound on a cheese package. In addition to, during the production process, all other parameters except for the factors whose effects were aimed to be investigated (ratio of additive material) were kept constant. The filament yarns obtained consisted of 144 individual filaments and linear density of these yarns 918 denier. Also, these yarns have round cross-sectional shape.

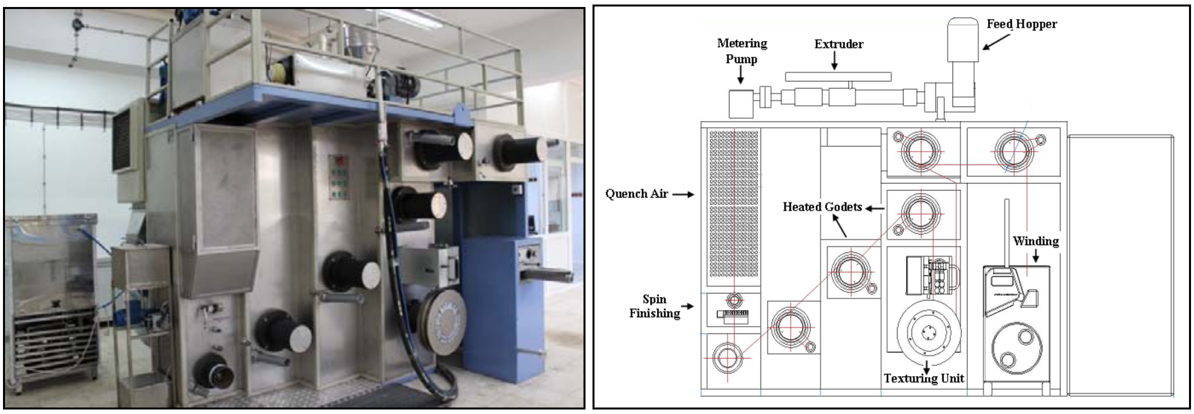


Figure 1: Laboratory type filament yarn machine views used for production [4]

Filament yarn samples were conditioned for 24 hours at 20°C±2 temperature and 65±2% relative humidity, which are the standard atmospheric conditions. After, tenacity-elongation and unevenness tests were applied on PP filament yarns which were taken as basis of the study. Tenacity-Elongation tests were carried out with Uster Tensorapid-3 test device according to BS EN ISO 2062, 1995 test standard and unevenness tests were carried out with Uster Unevenness Measurement device according to DIN 53817-1 test standard [5, 6]. Additionally, the surface morphology of filament yarns were investigated with the help of a Scanning Electron Microscope-SEM (Jeol JSM-6390 LV) at voltage of 20 kV. Furthermore, results have been supported by Energy Dispersive X-ray Analysis (EDX) analysis. As a result, structural and mechanical properties of yarns were examined and the results were interpreted.

RESULT AND DISCUSSION

Based on the results of the study, filament yarn products have been concluded to have desired flame retardant properties. As a result of flammability tests, the LOI values of all phosphorus-containing PP knitted fabrics were determined between 25% and 30%. On the other hand, some differences in the properties of the produced yarns such as tenacity, breaking elongation, unevenness have been observed and surface images of these yarns have been examined using SEM analysis. SEM images of the surface morphology of pure PP and FR added PP filament yarns and effect of FR additive ratio on yarn tenacity (cN/tex) and breaking elongation (%) values are given in Table-1. As seen, all the important properties of yarn samples have been evaluated during the experiment. Here only yarn tenacity and breaking elongation features are considered as an indication parameters of evaluation in this study.

Table 1: SEM (longitudinal) observations and mechanical properties of PP filament yarns

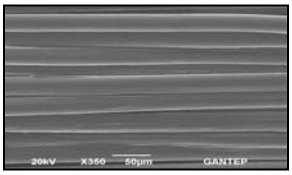
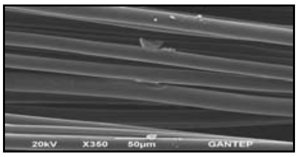
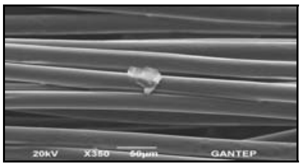
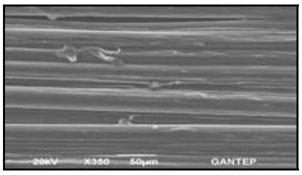
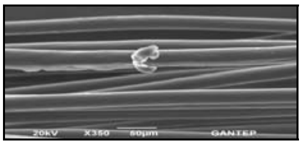
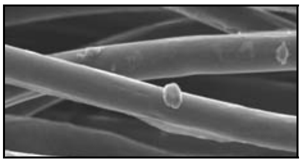
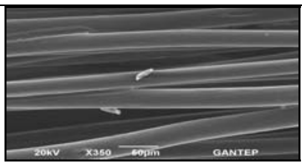
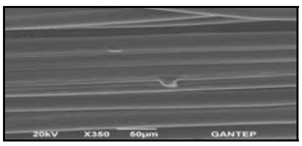
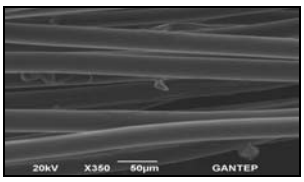
Sample	SEM Pictures	Tenacity (cN/tex)	Breaking Elongation (%)	Uster (%)	CVm (%)	Intermingling (Number of nips per meter)
PP Filament Yarn		22,8	28,4	5,94	7,49	10.1
1% FR		23,6	28,4	5,29	6,63	10.2
2% FR		23	27,4	5,45	6,88	11.0
3% FR		22,5	26,7	5,60	6,95	8.9
4% FR		22,7	27,3	5,98	7,53	10.1
5% FR		22,8	26,2	5,95	7,41	9.7
6% F.R.		23,4	26,6	5,37	6,64	10.0
7% FR		23,7	28,7	5,97	7,50	12.0
8 % FR		22,5	26,6	6,17	7,63	9.2

Table-1 indicates that PP filament yarn without additives has an even and smooth surface structure while filament yarns with additives show particle agglomerations along their surfaces. Also, chemical analysis of particles was performed with EDX. As a result, these particles have been identified as FR additive's elements by using EDX.

The results obtained from the tenacity and breaking elongation tests applied onto PP filament yarns have been graphically shown in Figures 2 and 3.

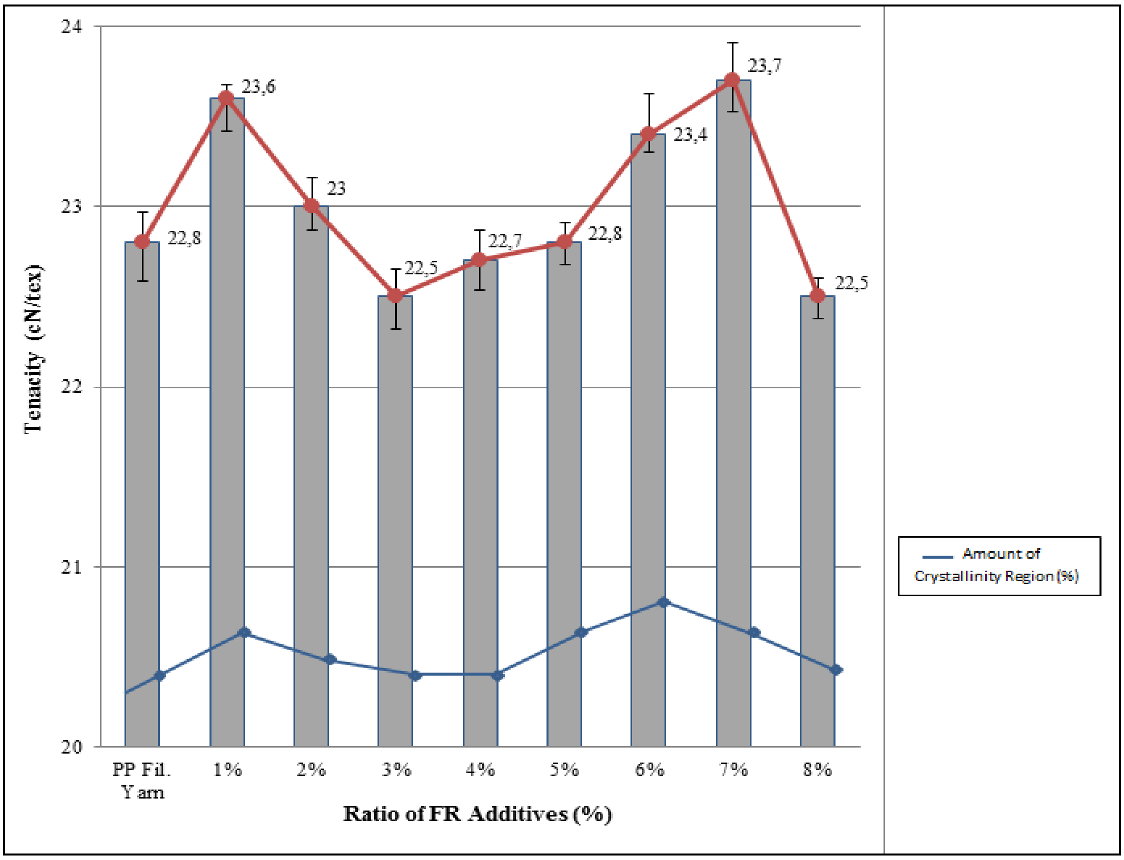


Figure 2: Effect of ratio of flame retardant additives on PP filament yarn's tenacity (cN/tex)

As seen that PP filament yarns produced with 3% and 8% FR additive have the lowest tenacity values while yarns with 1% and 7% FR have high tenacity values. Also, yarn produced with 5% FR has the lowest breaking elongation value while 7% FR added yarn has highest breaking elongation value. In addition to, it is seen that the increase in amount of crystalline region enabled yarns to have a higher tenacity, as expected. For example, the amount of crystalline regions of PP filament yarn (38,7%) is less than other filament yarns. Also, tenacity value of this yarn (22,8 cN/tex) is lower than other yarns.

Furthermore, when filament yarn SEM images in the Table-1 and tenacity test results given in the graph are examined together, it can be concluded that FR added filament yarns that show more agglomeration along the surface have lower tenacity values (3% and 8%) while more even yarns have higher tenacity values (1%, 6% and 7%). Reduction of tenacity values is mainly due to agglomeration of flame retardants. Since particles on surface of yarns can cause the formation of voids, these voids act as a crack initiator under the load. Besides, breaking elongation results of yarn have also changed depending on surface features.

The effect of ratio of FR additive variables on the unevenness of yarns was also investigated. According to the % Uster test results, %Um values of the yarn were determined between 5% and 6%.

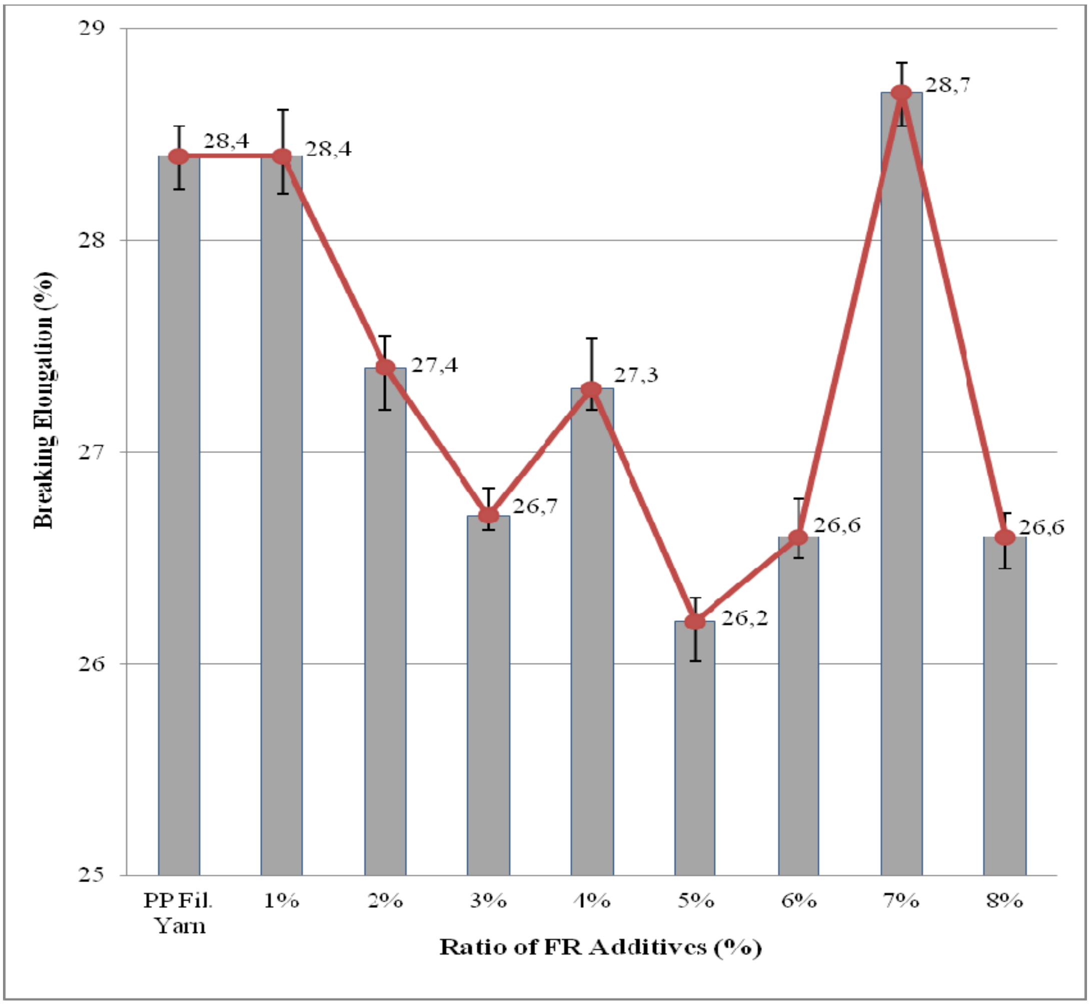


Figure 3: Effect of ratio of flame retardant additives on PP filament yarn's breaking elongation (%)

CONCLUSIONS

This study shows that in addition to functional properties, structural and mechanical properties such as tenacity, breaking elongation, unevenness etc. are also important for functionalized filament yarns. Hence, these important properties should be at specific values for the production of high quality filament yarn. In this study as a result of flammability tests, the LOI values of all phosphorus-containing PP knitted fabrics were determined between 25% and 30%. However, some differences in the properties of the produced yarns such as tenacity, breaking elongation, unevenness have been observed and surface images of these yarns have been examined by using SEM analysis. When filament yarn SEM images and tenacity test results given are examined together, it can be concluded that FR added filament yarns that show more agglomeration along the surface have lower tenacity values (3% and 8%) while more even yarns have higher tenacity values (1%, 6% and 7%). Reduction of tenacity values is mainly due to agglomeration of flame retardants. Since particles on surface of yarns can cause the formation of voids, these voids act as a crack initiator under the load. Also, chemical analysis of particles was performed with EDX. According to this test results, these particles have been identified as FR additive's elements. Besides, breaking elongation results of yarn have also changed depending on surface features. According to the % Uster test results, %Um values of the yarn were determined between 5% and 6%.

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AN INVESTIGATION ON STRUCTURAL PROPERTIES OF JUTE PARTICLE DOPED POLYPROPYLENE FILAMENTS

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Abstract: *The production process and structural characterization of jute particle doped polypropylene filaments were considered in this paper. Prior to compounding, surface modification of jute was also carried out with alkali, silane coupling agent, fluorocarbon based agent and also argon plasma. Modified jute particles and maleic anhydride grafted polypropylene as a compatibilizer were incorporated into polypropylene in a twin-screw extruder and then master-batches were converted to polypropylene multi-filaments in lab-scale melt spinning machine. 100% polypropylene and composite multi-filaments were characterized by fourier transform infrared spectrometer, thermo-gravimetric analyzer, differential scanning calorimeter, and X-Ray diffractometer. Fiber tensile tests and moisture contents were also studied. Distributions of fillers along the composite filaments were detected by fluorescence microscopy. The analyses showed the addition of both modified jute particles and MAPP had no significant effects on crytallographic structure of the polypropylene due to the low content fillers. On the other hand, the presence of fillers caused an increment in the moisture absorption of the composite filaments. TGA analysis also pointed out that the polypropylene filaments achieved the maximum moisture absorption with the addition of alkali treated jute particles.*

Keywords: *polypropylene, composite filament, jute, characterization*

INTRODUCTION

Textile fibers are commonly used as apparel, upholstery, and carpets [1]. Among the textile fibers, polypropylene (PP) is a well-known and one of the most widely used man-made fibers. Recent trend towards textile products of polypropylene have been focused on to its easy processing property, low density, excellent chemical stability and also low cost. However, PP fibers have very poor water and moisture absorption properties. Thus, it is necessary to apply modifications to the PP fibers for some applications. Fibers can be modified physically or chemically. Physical modifications include changing the cross section shape of the filaments in spinning process by means of increasing surface area of the filaments. Several researches were reported on the effect of fiber cross section shape on various properties of fibers such as water absorption, compressibility, surface characteristics [2-5]. On the other hand, PP fibers can be also modified chemically by graft polymerization, finishing treatments and incorporation of a various additives or fillers (organic or inorganic) in molten PP during extrusion process [2, 6-8]. Among these techniques, composite filament production method by doping fillers to polymers becomes even more important recently.

In this study, polypropylene composite filaments doped with modified jute particles were manufactured and structural characterization of these filaments were studied. Prior to compounding, jute particles were modified with several surface treatments to enhance compatibility with PP and to provide homogeneous distribution of jute particles along the filament. It is well known that PP has no side groups that cellulose based particles could be attached to. Previous related scientific literature confirmed that surface treatments of cellulose based fibers enhanced the interaction with non-polar polymer [9-11]. Therefore, jute fibers as in particle form were treated with alkali (as a pretreatment process) (AJ), silane coupling agent (ASJ), fluorocarbon based agent (AFJ) and also exposed to argon plasma modification (APJ). PP master-batches containing 0.5% wt modified jute particles and 5% wt maleic anhydride grafted polypropylene (MAPP) as a compatibilizer agent were manufactured and then spinning process of multi-filaments were carried out. 100% PP and composite multi-filaments were characterized by fourier transform infrared spectrometer (FTIR), thermo-gravimetric analyzer (TGA), differential scanning calorimeter (DSC), and X-Ray diffractometer (XRD). In addition to these analyses, tensile tests, color measurements, and determination of moisture absorption of the multi-filaments were also studied. Moreover, distributions of fillers along the composite filaments were detected by fluorescence microscopy.

EXPERIMENTAL

2.1. Materials

Waste jute yarns supplied from Atlantik Halı A.Ş were used as filler materials. The contents of cellulose, hemicellulose, lignin and the others constituents of the jute yarns were determined as 69.6%, 10.2%, 12.5% and 7.7%, respectively [12]. Sodium hydroxide and ethanol were purchased from Merck Corp. 3-aminopropyl triethoxysilane was supplied from ChemCruz Biochemicals. Fluorocarbon chemical agent (Rucostar EEE) was provided from Rudolf Group. Polypropylene was supplied from Hellenic Petroleum with the trade number of HZ40S for fiber spinning. Maleic anhydride grafted polypropylene (MAPP) used as a compatibilizer was purchased from Sigma Aldrich.

2.2. Methods

2.2.1. *Preparation of jute particles*

Waste jute yarns were grinded in Retsch Cutting Mill SM 100 grinder by using a sieve having holes in 250µm. In order to reduce the size of the jute particles, they were exposed to grinding process again in Fritsch Pulverisette 7 grinder at the speed of 850rpm for 20min.

2.2.2. *Surface treatments of jute particles*

Jutes were treated with 5% NaOH aqueous solution for 2h at ambient temperature. The jutes were rinsed out with distilled water several times to remove the chemical residues and then neutralized with distilled water with few drops of acetic acid. After treatment, jutes were oven-dried at 60^{o}C until it dried and then kept in a desiccator [13, 14]. It should be mentioned that alkali treatment was performed as a pretreatment process for surface cleaning before plasma modification, silane and fluorocarbon treatments.

Subsequent to alkali pretreatment, silane treatment was carried out to modify the jutes to achieve less hydrophilic surface character. Before treatment, silane coupling agent was hydrolyzed in water/ethanol solution (60/40 v/v) with the addition of concentrated acetic acid to adjust pH4 and continuously stirred for 1h. Then, jutes were immersed in 5% w/w silane hydrolyzed solution for 3h at ambient temperature. The jutes were washed with distilled water several times to remove the chemical residues. The treated jutes were dried in ambient temperature for 3 days and then oven dried at 80^{o}C [15].

After alkali pretreatment, 50g/L fluorocarbon based compound was added in the padding liquor for fluorocarbon treatment of jutes. The jutes were immersed in the padding liquor for 3min. After washing several times, the jutes were oven-dried at 170^{o}C for 2h.

After alkali pretreatment, the jutes were plasma modified in PICO RF (radio frequency) plasma polymerization system (Diener electronic GmbH+Co.KG, Germany). The jutes were modified with argon plasma (discharge power, 90W) for 15min.

2.2.3. *Preparation of polypropylene composite masterbatches*

PP, MAPP and jute masterbatches were compounded at various ratios (Table 1) by using a laboratory scale twin screw melt extruder. Prior to extrusion process, all compounds in powder form were mechanically mixed, dried and then melt blended in the extruder at a 170rpm screw speed. The temperatures from feeder to spinneret hole including six extrusion zones were set at approximately 190^{o}C. After extrusion, the compounded material was cooled down and pelletized as granules with the aforementioned concentrations.

2.2.4. *Spinning of polypropylene composite multi-filaments*

The polypropylene composite masterbatches were fed into a lab scale melt spinning machine having single screw extruder with two spinning nozzles in circular cross sections in order to spin multi-filaments. The temperatures from feeder to spinneret hole were including six extrusion zones in the range of 205-215°C. The extrusion speed and the extrusion pressure were set as 14dpf and 80bar, respectively. A draw ratio of 3.25 was applied to all samples by setting the speeds of the first and the second godet rolls at 200rpm and 650rpm, respectively. The temperatures of the first and the second godet rolls were set as 105°C and 115°C, respectively. Components of the composite filaments are detailed in Table 1.

Table 1. Components of the composite PP granules and multi-filaments

	Jute particle, wt %	Type of jute particle	MAPP, wt %	Pure PP, wt %
PP0	0	None	0	100
PP1	0	None	5	95
PP2	0.5	Alkali treated (AJ)	5	94.5
PP3	0.5	Alkali+silane treated (ASJ)	5	94.5
PP4	0.5	Alkali+fluorocarbon treated (AFJ)	5	94.5
PP5	0.5	Alkali+plasma modified /APJ)	5	94.5

2.2.5. Characterization of the polypropylene composite filaments

The percentage crystallization of the polypropylene filaments was analyzed by using Perkin Elmer/Pyris 1 Differential Scanning Calorimeter (DSC) under nitrogen atmosphere. The temperature raised from 0^{o}C to 200^{o}C at heating and cooling rates of 20^{o}C/min. The percentage of crystallinity was calculated using the melting enthalpy by following formula:

$$\% \text{ Crystallinity} = (\ H_m / \ H_m^o) \times 100 \qquad (1)$$

where H_m is the melting enthalpy of the PP analyzed in this experimental study, H_m^o is assigned to the melting enthalpy of 100% crystalline PP, 207J/g [16].

The fine structure of polypropylene filaments were investigated by X-Ray diffractometer (XRD) using XRD Rigaku D/Max 2200 PC using Cu-Kα radiation and operating at 40 kV and 36 mA. The diffraction angles (2θ) of each sample were measured from 3^o to 90^o at a scan speed of 4^o/min. The thermal decomposition of polypropylene filaments was studied by Thermogravimetric analysis (TGA) using Perkin Elmer Diamond TG/DTA instrument under nitrogen atmosphere (10 mLmin^{-1}) from 25^{o}C to 600°C at a rate of 10°C min^{-1}. The polypropylene filaments were also characterized by Fourier transform infrared spectrometer (FTIR) analysis using Perkin Elmer Spectrum BX. Each spectrum was recorded in the range of 400–4000 cm^{-1} with a resolution of 2 cm^{-1}.

Longitudinal views of composite filaments were taken by using Olympus BX 43 Fluorescence microscope for tracking the jute particles. The breaking strength, elongation at break and tenacity of the polypropylene filaments were determined by single fiber tensile test using Instron Tensile Testing Machine according to ASTM D 3822-07. The cross head speed and the gauge length was kept as 60 mm/min and 25mm, respectively. Moisture absorption performances were tested in order to investigate the effect of jute particles and MAPP on moisture absorption behavior of the polypropylene filaments. Before testing, each sample for all types of the PP filaments having a mass of 0.5g was dried at 60◦C for 1h in an oven. Then, each sample which was put in a closed weighing bottle, was taken to the constant temperature and humidity room (the temperature is 20±2◦C, and the humidity is 65±2%). The weighing bottles were opened and the samples were weighed for every 5 minutes until the filaments were reached to moisture absorption balance [17]. The colour measurements of the polypropylene filaments were performed by Minolta 3600D CM spectrophotometer (D65 illuminant, specular included, 10^o observer angle). The spectrophotometer having a software that could calculate CIEL**a*b*C*h*^{0}. The software also gives data about colour strength (K/S) values from the reflectance values at the appropriate λ_{max} for each filament sample.

RESULTS AND DISCUSSION

3.1. DSC analysis

Table 2 lists the results of thermal analyses obtained by DSC and the crystallinity percentage values of the polypropylene filaments. DSC analysis resulted that melting temperature of PP0 is higher than that of PP1 which may be due to deterioration in polymer chain orientation as a result of the compatibilizer [16]. However, the melting temperatures of the PP filaments incorporated with the modified jute particles are higher than that of PP1. This may be due to the nucleating agent effect of the jute particles. The changes in the melting ($\Delta H_{(melting)}$) and crystallization ($\Delta H_{(crystallization)}$) enthalpies of the PP filaments confirm the thermal demonstration of the components during crystallization, as well as the interaction between PP, the compatibilizer and the jute particles in creating the supermolecular structure of the polypropylene filaments [18].

Table 2 Calorimeric data of the PP filaments

	Melting temperature (°C)	Crystallization temperature (°C)	Crystallinity (%)	$\Delta H_{(melting)}$ (J/g)	$\Delta H_{(crystallization)}$ (J/g)
PP0	163.77	112.94	38.46	79.61	-85.10
PP1	161.40	111.60	38.83	90.38	-86.87
PP2	163.08	111.93	38.32	79.33	-86.00
PP3	164.07	114.33	39.50	81.77	-88.48
PP4	163.07	112.62	37.31	77.24	-81.78
PP5	162.07	112.29	38.08	78.83	-82.71

3.2. XRD analysis

Figure 1 illustrates XRD patterns of the polypropylene filaments. It is determined that the diffraction peaks of the crystals which ranged from 10° to 30°, indicated a typical form of PP crystals [7]. The diffraction peaks of the PP filaments observed at around 14°, 17° and 25° correspond to (110), (040) and (060) crystallographic planes, respectively [19]. It is noticed that the PP filaments exhibited similar diffraction patterns. This may be due to the low content of jute particles and the compatibilizer agent.

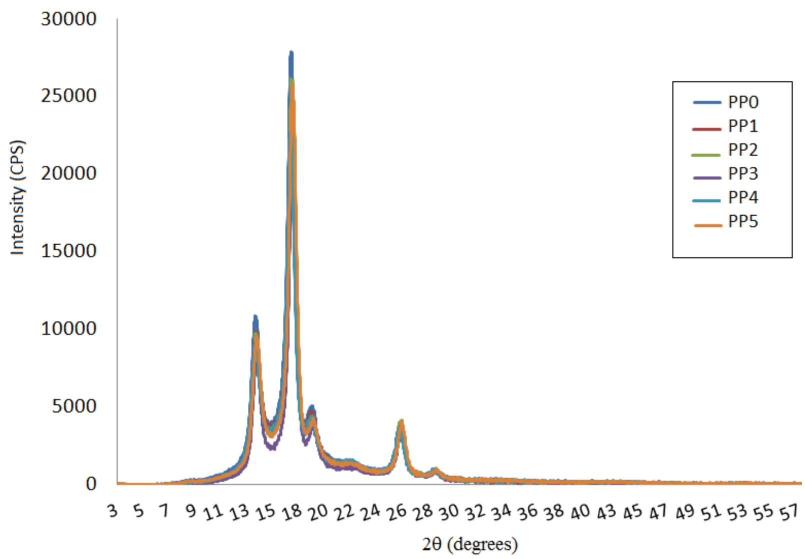


Figure 1. XRD pattern of the PP filaments

3.3. TGA analysis

TGA was carried out to evaluate thermal stability of the polypropylene filaments as well as the effects of the jute particles and the compatibilizer on the PP. Figure 2 shows TGA thermograms and Table 2 lists mass losses of the PP filaments until several temperatures. The single degradation step for both of the PP filaments confirms that the polymers are composed of the carbon-carbon bonds in the main chain, thereby allowing a temperature increase to promote random scission, with associated thermal degradation and thermal depolymerization taking a place at a weak part of the polymer main chain [20].

As easily figured out from Table 2 that no mass loss was recoded until 120°C for PP0 due to their highly apolar character. But PP1 (having 5% MAPP) was observed to lose 0.22% of its mass until 120°C which can indicate its moisture content. Futher, the addition of AJ particle increased the weight loss of PP2 until this temperature due to the presence of highly polar alkali treated jute particles. But PP4 and PP5 are noticed to have no moisture content. These may be due to the application of fluorine groups by fluorocarbon treatment and reduction in hydrophilic groups of jute particles by argon plasma modification.

Close examination of the thermogravimetric results that the temperatures which PP0, PP1, PP2, PP3, PP4 and PP5 filaments lose 50% of their masses are 455°C, 448°C, 441°C, 432°C, 458°C and 427°C, respectively. It is figured out that the addition of MAPP and AJ, ASJ and APJ particles negatively influenced the thermal stability of the PP filaments. The jute particles may agglomerate and act as impurities in the PP. But the improved thermal stability of PP4 might be due to enhanced interaction occurred between the jute particles and the PP.

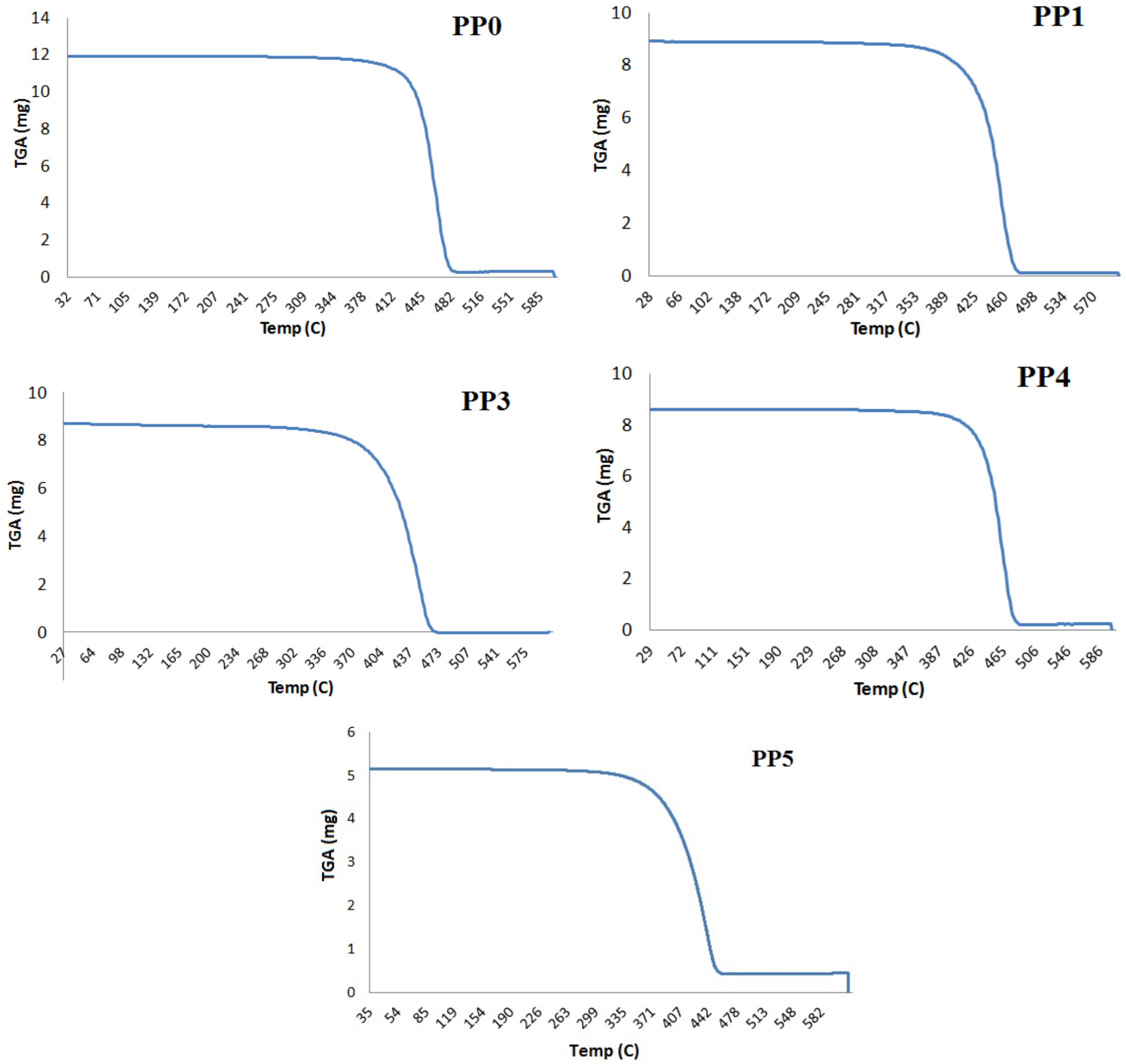


Figure 2. TGA curves of the PP filaments

Table 2. Percentage mass losses until several temperatures according to TGA analysis of the PP filaments

	Temperature (^{o}C)					
	120	**250**	**375**	**450**	**500**	**600**
PP0	0	0	1.8	36.5	97.81	100
PP1	0.22	0.56	4.26	57.01	98.88	100
PP2	0.7	0.98	7.59	66.53	99.3	100
PP3	0.57	1.37	9.43	82.07	100	100
PP4	0	0.23	1.4	33.84	97.56	100
PP5	0	0.64	10.90	87.99	91.86	91.49

3.4. FTIR analysis

Fourier transform infrared spectroscopy was utilized to identify various functional groups that emerged in the samples, as well as the disappearance of determinate groups [16]. Figure 3 shows FTIR spectra of the PP filaments. It is determined that the spectrums of the PP filaments are very similar to each other. A peak was obtained at the 2,951 cm^{-1}absorption band assigned to asymmetric CH_3 and the other peaks at 2,918 cm^{-1} and 2,838-2,839 cm^{-1} concern with asymmetric and symmetric CH_2 stretching vibrations, respectively [21]. The C=C bending vibrations which are in the region of about 1,300–1,400 cm^{-1} are overlapped with the symmetrical and asymmetrical bending vibrations of CH_3 in the PP at 1,374 cm^{-1} and 1,456 cm^{-1}, respectively [22]. The band at 1,102 cm^{-1} may be attributed to C-C and C-H deformations. The absorption band at 998 cm^{-1} is assigned to the characteristic crystalline band of PP [23].

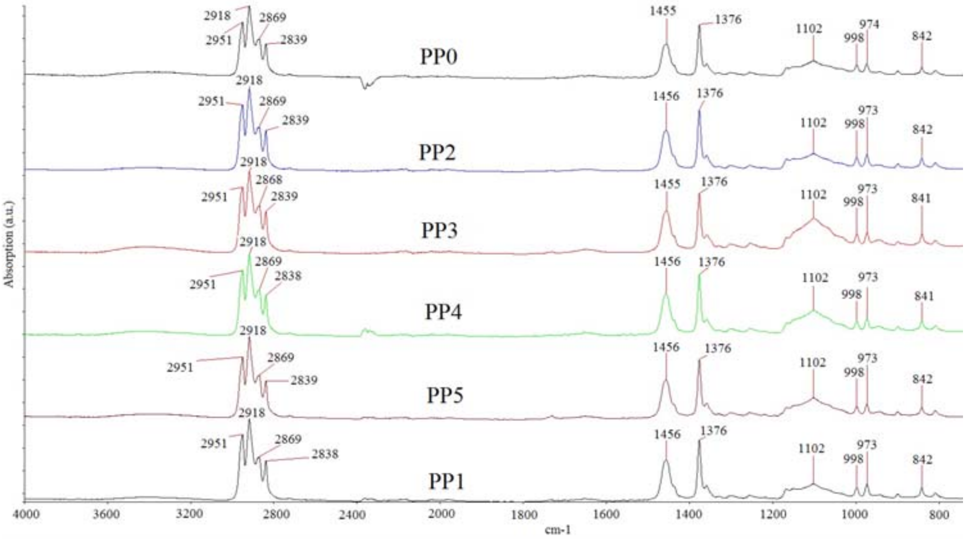
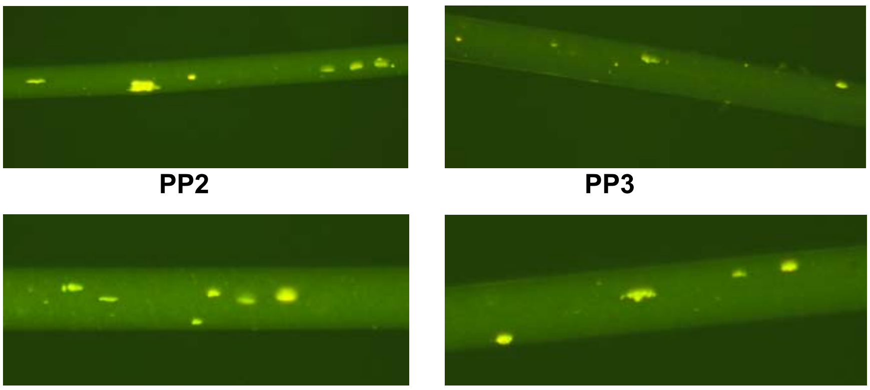


Figure 3. FTIR spectra of the PP filaments

3.5. Longitudinal views of PP composite filaments

To track the distribution and homogeneity of jute particles throughout the PP composite filaments, an optical control method was performed by using fluorescence microscopy technique. As shown in Figure 4, the jute particles are seen in different colors due to their auto-fluorescence characteristics. Optical observations also indicate the agglomeration of the jute particles in the composite filaments.



PP2 **PP3**

PP4 **PP5**

Figure 4. Longitudinal views of PP composite filaments

3.6. Tenacity of the PP filaments

In order to investigate the effect of jute particles and the compatibilizer on the tenacity of the PP filaments, single fiber tensile tests were performed. Tenacity of the PP filaments are presented in Figure 5. Tenacity results of PP0, PP1, PP2, PP3, PP4 and PP5 are 2.72 g/denier, 2.26 g/denier, 2.19 g/denier, 2.71 g/denier, 2.27 g/denier and 2.83 g/denier, respectively. It is clearly understood from Figure 5 that standard deviation values are observed to be high for all tested PP filaments. This may be owing to non-homogeneous distribution of jute particles in the filament. As also noticed in Figure 5, there are slight differences between the tenacity values of the PP filaments. This can be due to the addition of low jute particle content.

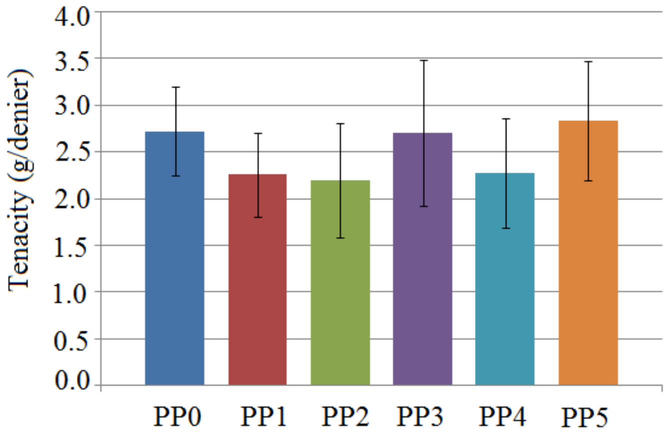


Figure 5. Tenacity of the PP filaments

3.7. Moisture absorption of the PP filaments

Representative results of moisture absorption values of the PP filaments are shown in Figure 6. It is observed that moisture absorption of PP filaments increased in the presence of MAPP compatibilizing agent. And moisture absorption values are extremely higher in PP composite filamnets as compared to PP0 filament. It is found that PP2 have noticably higher moisture absorption results in comparison with PP3, PP4 and PP5 filaments incorporating ASJ, AFJ and APJ particles, respectively. In case of silane treatment, reactive silanol groups of silane coupling agent can from chemical bonds with hydroxyl groups of jute particles and can form polysiloxane layer on the surface of the jute particles. With fluorocarbon treatment, a great amount of fluorine containing groups may cause hydrophicity on the surface of the jute particles. Adtitionally, a reduction in hydrophilic groups of jute particles may exist after argon plasma modification.

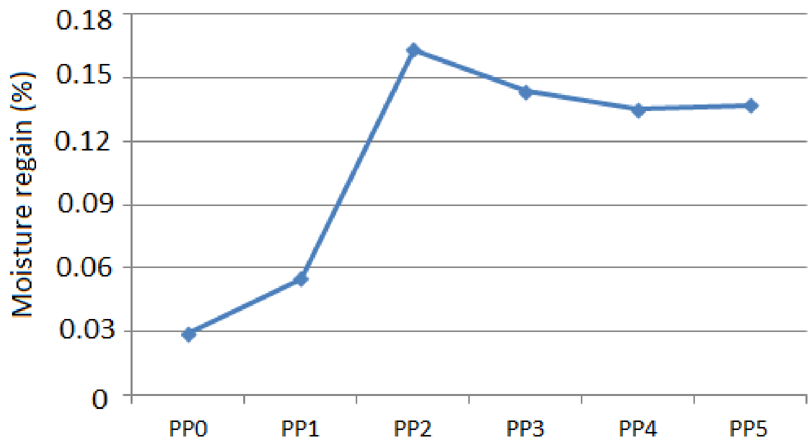


Figure 6. Moisture absorption of the PP filaments

3.8. Colorimetric values of the PP filaments

The colorimetric values of the PP filaments are tabulated in Table 3. As clearly seen in Table 3, color difference (ΔE) value between PP0 and PP1 is calculated to be 2.212. But the addition of AJ, ASJ, AFJ and APJ particles increase this color difference by 190%, 180%, 150% and 176%, respectively. Yellowness (*b**) value of PP0 increase by 130.8% with the addition of 5% MAPP. The highest *b** value obtained for PP2 which have 0.5% AJ particle and 5% MAPP compatibilizer. But silane, fluorocarbon and plasma treatments of jute particles which were applied after alkali pretreatment may decrease the yellowness value of AJ particles. K/S and R% which indicate the color strength and reflectance values of PP filaments are also given in Table 3. It is detemined that the addition of MAPP compatibilizer (PP1) increase reflectance value but decrease the color strengh of PP0 filament. But the incorporation of treated jute particles decrease reflectance values whereas increase colour strength of PP1.

Table 3. The colour data of the PP filaments

	ΔE (Colour difference)	***b****	**%R (min) (400 nm)**	**K/S (max) (400 nm)**
PP0	*Control sample*	*1.58*	*55.806*	*0.175*
PP1	2.212	3.646	68.45	0.0727
PP2	6.413	7.525	56.606	0.1663
PP3	6.193	6.146	56.79	0.1644
PP4	5.534	6.366	59.123	0.1413
PP5	6.113	6.724	52.27	0.1594

CONCLUSION

In this paper, polypropylene multi-filaments doped with modified jute particles and MAPP were manufactured and the effects of these fillers on structural characterization, tenacity and moisture absorption of the polypropylene filaments were investigated. The influence of surface treatments on compatibility of constituents and on distribution of jute particles along the filaments were also studied. It was found that the moisture absorption of filaments increase with the incorporation of MAPP agent. The addition of alkali treated jute particles extremely increase moisture absorption of the PP due to high polarity of the jute particles. However, surface coating of silane and fluorocarbon agents and surface modification with of argon plasma of the jute particles decrase the moisture absorption capacity of the PP by changing the surface character of the jute from hydrophilic into more hydrophobic. TGA analysis also pointed out that the polypropylene filaments achieved the maximum moisture absorption with the addition of alkali treated jute particles. DSC and XRD analyses showed the addition of both modified jute particles and MAPP had no significant effects on crytallographic structure of the PP due to the low content of fillers. Similar tenacity values were obtained for all of the filaments. On the other hand, the presence of fillers chance the color of PP filaments.

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Section 2: Textile Science and Technology

CONTRIBUTIONS ON THE SYRINGE PUMP CONTROL FOR NANOFIBER ELECTROSPINNING USING BRESENHAM ALGORITHM

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Abstract: *Electrospinning is the most efficient technique to produce polymeric nanofibers. The electrospinning setup usually consists of a syringe with a hypodermic needle connected to a high voltage direct current power supply, a syringe pump, and a grounded collector. Here, a new design for the syringe pump is presented. The main goal of this was to replace stepper motors in precise clock movement type applications, such as a syringe pump for electrospinning, without increasing the costs of the device.To maintain a perfect average speed the microcontroller system generates a reference frequency using a Bresenham math algorithm which is a very versatile zero cummulative error timing system. For testing the syringe pump distilled water (1 g/ml density, 1 cP viscosity) and PVA (1.1 g/ml density, 10000 cP viscosity) were used to fill in the syringes. A stroboscopic tachometer was developed for measuring the exact speed of the motor at any time.*

Keywords: *electrospinning, nanofibers, syringe pump, Bresenham algorithm*

1. INTRODUCTION

Electrospinning is the most efficient technique to produce polymeric nanofibers [1]. The electrospinning setup usually consists of a syringe with a hypodermic needle connected to a high voltage direct current power supply, a syringe pump, and a grounded collector. One of the important parameters for the electrospinning process is the syringe pump feed rate. There is a relation between the resulted nanofibers diameter and the syringe pump feed rate [2].

Here, a new design for the syringe pump is presented. It is a system for driving a cheap DC motor very slowly, and for that speed to have very high accuracy. The benefits of using this setup are that it uses much less power, and is quieter/ smoother than a stepper motor, motor speed is locked to a crystal, keeps clock time accuracy, motor speed is adjustable in incredible fine steps (parts per billion), motor speed can be very slow (less gearing needed), auto-recovers speed and position after being bumped, relative simple driving electronics.

The main goal of this was to replace stepper motors in precise clock-movement type applications, such as a syringe pump for electrospinning, without increasing the costs of the device. Unlike a stepper motor, a DC motor might speed up or slow down in response to short term load events, (i.e. a few degrees or fraction of a second) so the main focus was on making the average speed perfect.

To maintain a perfect average speed the microcontroller system generates a reference frequency using a Bresenham math algorithm which is a very versatile zero cumulative error timing system [3]. Bresenham algorithm is a system where two imperfect periods can be alternated to produce an average that matches any perfect period [4]. Bresenham algorithm was originally designed for high speed calculating imperfect periods in grid movement on a two dimensional matrix like an X-Y Plotter [5]. A similar system can be used for generating one average timed period from any other timed period (like the microcontroller internal timers).

For testing the syringe pump distilled water (1 g/ml density, 1 cP viscosity) and PVA (1.1 g/ml density, 10000 cP viscosity) were used to fill in the syringes. A stroboscopic tachometer was developed for measuring the exact speed of the motor at any time, and the eventual speed variations that could appear due to the liquid viscosity.

2. EXPERIMENTAL

The syringe pump (Figure 1) was developed at the Faculty of Textiles & Leather Engineering and Industrial Management Iasi in collaboration with the Faculty of Automatic Control and Computer Engineering Iasi. An Infineon Hexagon Application Kit [6][7][8] controls the syringe pump functioning and features an OLED display and capacitive buttons for the user interface [9]. A power driver/inverter was developed to interface the DC motor to the control unit. For the motor speed feedback an optical quadrature encoder salvaged from a mouse was used. The optical encoder is connected to the motor with a 1:1 ratio timing belt (toothed belt). The motor is a 24V DC motor salvaged from a printer. The motor is connected to the screw via a 1:3025 gear reduction through a flexible coupling. The drive screw is a 3 mm pitch,12 mm diameter trapezoidal screw. The drive nut is made of polyamide with teflon. The pusher block is made of polyethylene and aluminium. The two guide rods are 8 mm in diameter and are salvaged from a printer. The two support plates are made of 8 mm thick textolite and incorporate the 8 mm flange bearings. The syringe holder block connects to one support plate.

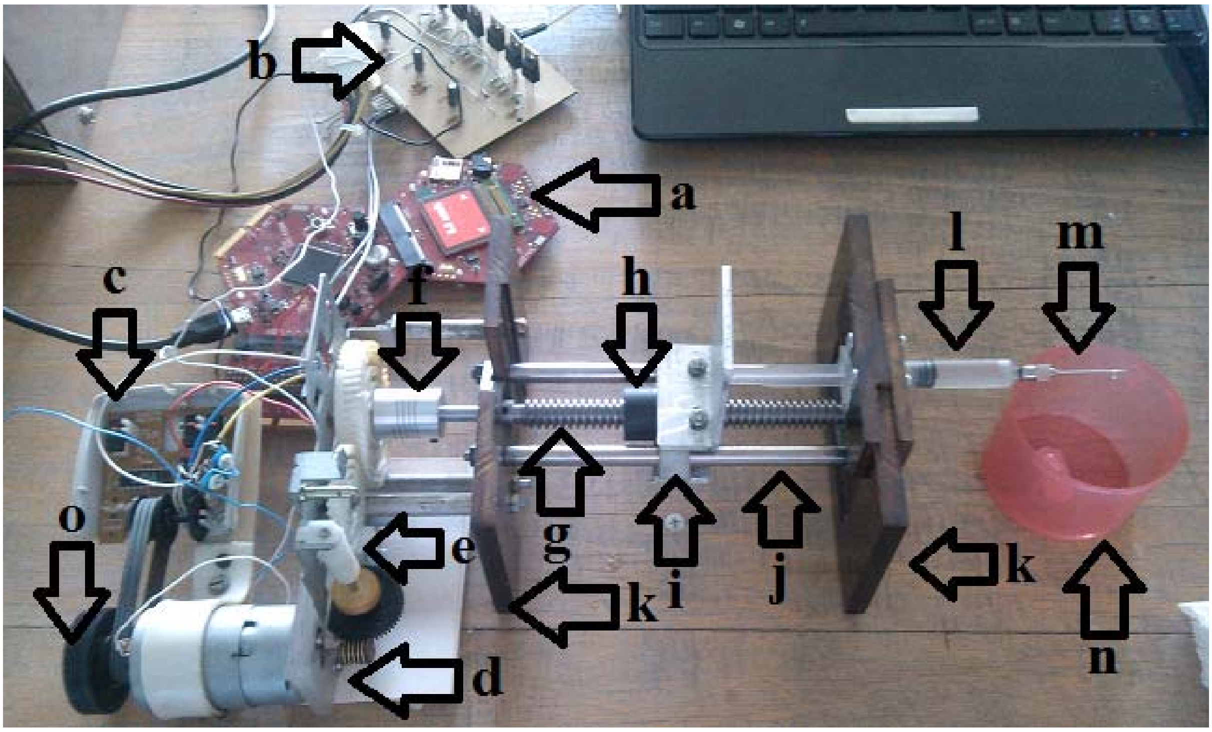

Figure 1: Picture of the syringe pump; ***a*** *– Infineon Hexagon Application Kit,* ***b*** *– DC motor driver/inverter,* ***c*** *– Optical quadrature encoder,* ***d*** *– DC motor,* ***e*** *– Gear reduction,* ***f*** *– Flexible coupling,* ***g*** *– Drive screw,* ***h*** *– Drive nut,* ***i*** *– Pusher block,* ***j*** *– Guide rod,* ***k*** *– Support plates,* ***l*** *– Syringe,* ***m*** *– Needle, n – Collecting container, o – Measuring point for the stroboscopic tachometer*

2.5 ml polypropylene Luer Slip syringes with an internal diameter of 8.66 mm were used. The needles used were 0.311 mm internal diameter with 25.4 mm in length and 0.311 mm internal diameter with 6.35 mm in length all metal (stainless steel) hypodermic type. Distilled water (1 g/ml density, 1 cP viscosity) and PVA (1.1 g/ml density, 10000 cP viscosity) were used to fill in the syringes.

A stroboscopic tachometer was developed for measuring the exact speed of the motor at any time, and the eventual speed variations that could appear due to the liquid viscosity [10]. The speed was measured on the marked wheel at the back of the motor (Figure 1 - o).

The syringe pump was programmed for different feed rates, part of a central composite design experimental plan. For each programmed feed rate the syringe was filled with 3 ml of solution. Each experiment lasted for an hour. There were three identical consecutive experiments for each programmed feed rate value. A 100 g ± 0.01 g precision scale was used to measure the fluid mass that streamed from the syringe in the set time interval. Knowing the mass and the density of the solution, the real flow rate of the syringe pump was calculated.
In each experiment there were two operating regimes, the transient regime and the permanent regime. The transient regime represents the period in which the syringe pump is priming. In this regime the pump is

working at maximum speed until the pusher block (Figure 1 - i) is touching the syringe piston. After this moment the pump is working at the corresponding programmed feed rate.

3. RESULTS AND DISCUSSIONS

Table 1 shows the programmed flow rate and the measured initial mass (without the solution), total mass (with the solution) and fluid mass for the case in which the syringes were filled with distilled water.

Table 2 shows the programmed flow rate, the measured initial mass (without the solution), total mass (with the solution), fluid mass, and the calculated fluid volume for the case in which the syringes were filled with PVA.

The initial mass represents the mass of the collecting container (Figure 1 - n). The total mass represents the mass of the collecting container plus the mass of the fluid accumulated in one hour time. The measured parameters values in the table represent an average value between the three identical experiments.

Table 1: Programmed and measured parameters for the distilled water

No	Programmed flow rate [ml/h]	Average initial mass [g]	Average total mass [g]	Average fluid mass [g]
1	0.6	9.3	9.9	0.6
2	0.94	9.35	10.26	0.91
3	1.8	9.31	11.11	1.8
4	2.66	9.31	12.03	2.72

Table 2: Programmed, measured and calculated parameters for the PVA

No	Programmed flow rate [ml/h]	Average initial mass [g]	Average total mass [g]	Average fluid mass [g]	Average fluid volume [ml]
1	0.6	9.31	9.97	0.66	0.6
2	1.8	9.31	11.28	1.97	1.79
3	2.66	9.35	12.25	2.9	2.64

In order to see if the syringe pump is working as it should (programmed flow rate corresponds to measured flow rate), the regression curves for the distilled water (Figure 2) and PVA (Figure 3) were drawn.

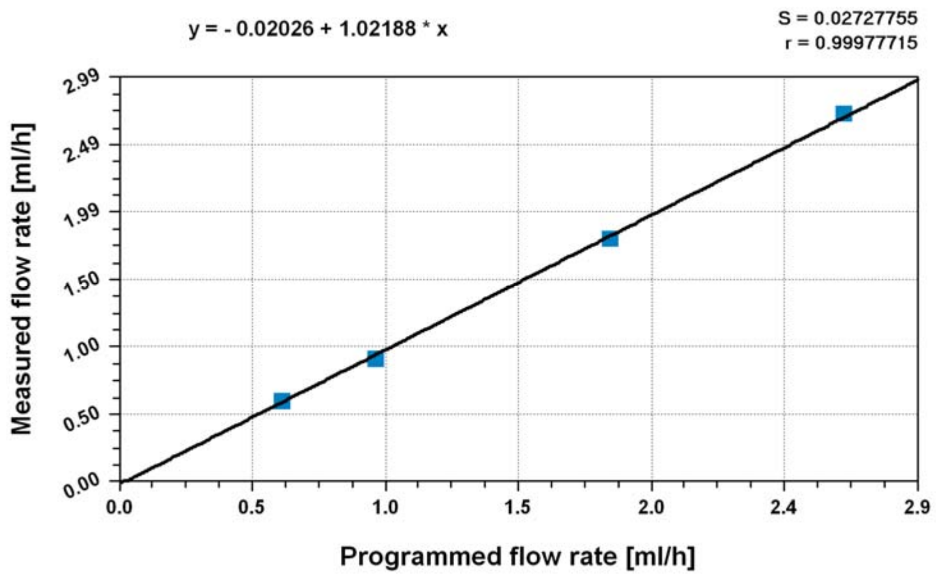

Figure 2: Regression curve for the distilled water generated with CurveExpert 1.4

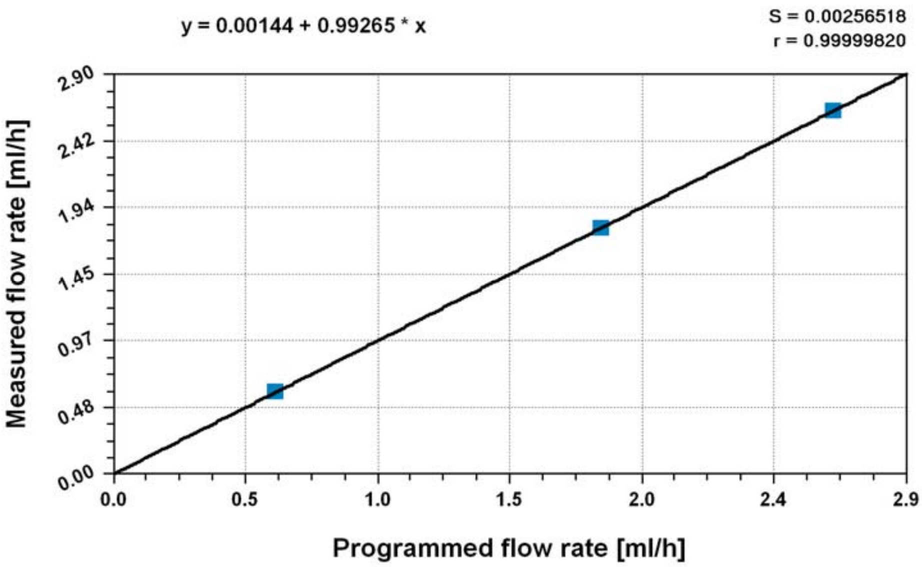

Figure 3: Regression curve for the PVA generated with CurveExpert 1.4

4. CONCLUSIONS

By looking at the coefficient of determination and standard error in figure 2 and figure 3, it can be concluded that there is a good correlation between the programmed feed rate values and the measured feed rate values resulting from the experiments. Using Bresenham algorithm as control loop for a DC motor, a reliable and precise syringe pump for nanofiber electrospinning was developed.

Acknowledgments: The authors would like to thank Infineon Technologies Romania for the provided application kits used for the syringe pump and the stroboscopic tachometer.

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ANALYSIS OF TEXTILE FABRICS SURFACE AFTER LASER MARKING

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Abstract: *The paper presents study on textile fabric after laser marking. For the explanation of the changes, occurring as a result of the treatment with the laser beam of the textiles, the naked eye and microscope is used. Observation of the fabric is carried out to more detailed analysis on fiber surface deformations. The laser causes visual and mechanical modifications on the fibres from upper layer and they look like burnt or cut if the parameters of the laser are not adjusted correctly.* ***Woven samples with different composition:*** *cotton, polyester and cotton-polyester blend were investigated. Diverse lasers were used:* CO_2 *laser with a wavelength of 10.6   m and CuBr laser – 0.511   m.*

The results indicate that, under the one and the same parameters of the laser, the structural changes are different and depend on the composition of the fabric. The color of the fabric is a very significant for the quality of marking. The quality of the marked effects can be controlled in order to obtaining the desired results by adjusting the parameters of the laser.

Keywords: *image analysis, lasers, marking, surface changes, cotton, polyester, fabric*

INTRODUCTION

The computer image analysis technique was applied very often for researching textile products and especially for study of their surface properties [1]. Many scientists were explored and analyzed the surface of textile fibers and fabrics as they were applied different methods depending on the objectives pursued: naked eye, optical and electronic microscopes, image analysis and so on. The image analysis by microscopic pictures was used also for evaluated the surface morphology of cotton fibres, treating with CO_2 laser [2,3]. The scanning electron microscope analysis was applied for denim fabric investigation in [4]. The laser is widespread in the clothing and textile industry for marking of fabrics in recent years. Laser marking is used in practice for information through labeling, but also for decoration. The effect of laser technological parameters on the color and structure of denim fabric were investigated [5]. A very popular application of lasers is bleaching of denim fabric, instead of traditional methods for whitening. The denim surface, which was bleached by chemical finishing methods, is not environmentally friendly and cause pollution problems [6]. The laser technology is applied as a substitute of the traditional finishing processes increasingly [7]. It is becoming more popular because eliminate several problems, associated with the high costs and pollution of the environment.

The purpose of the study, which was presented in the paper, is to explore the modification the surface of the woven fabric after treatment with the laser beam. The results are exhibited in the form of microscopic pictures that show the changes in the surface of the fabric. For an explanation of the process of marking by laser beam on textiles, the naked eye and the microscope is used.

EXPERIMENTAL

Three category of samples with different composition were analyzed: 100% cotton, 100% polyester and cotton-polyester blend. Each category of samples were represented by four different colours: black, blue, white and mixed colours. The microscopic pictures permitted the visualization of the surface of the samples and compared the quality of the marking for different raw and colors. The plan of sample preparation and the sample labeling scheme is defined in Table 1. The marking was performed according to the test field shown on the figures 1 and 2.

Table 1: The sample labeling scheme

№	Meaning	Symbol	Number	Designation
1	Laser	L	1	CO_2
			2	CuBr
2	Raw material	R	1	$Cotton_d$
			2	Cotton
			3	PES
			4	C/PES
3	Color	C	1	Black
			2	Blue
			3	White
			4	Mixed colours
4	Velocity	V	1-9	mm/s
5	Power (Pp)	P	1-9	W (kW)

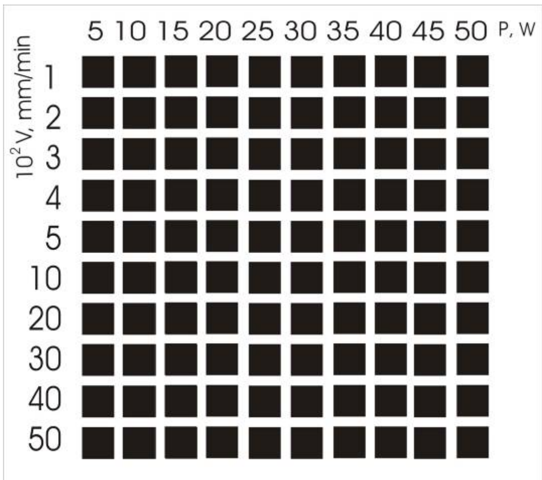


Figure 1 The test field for CO_2 Laser

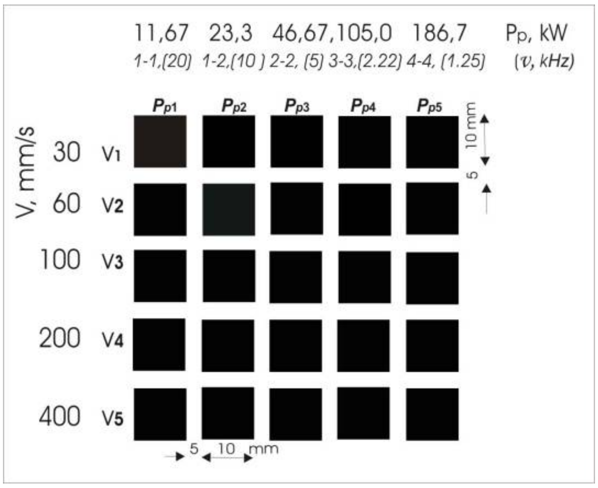


Figure 2: The test field for CuBr Laser

The marking of the samples with CO_2 laser was carried out in series of experiments:
- the power of the laser radiation (P) is amended in the interval P Є [5-50] W;
- the velocity of the laser radiation (v) is amended in the intervals v Є [1-50] x10^2mm/min.

The marking of the samples with CuBr laser was carried out in series of experiments:
- the pulse power of the laser radiation (P_p) is amended in the interval P_p Є [10-200] kW;
- the velocity of the laser radiation (v) is amended in the intervals v Є [30-400] mm/s.

The parameters of the laser system: P, n, τ are related and to determine the impulse power (Pp) using the following relation:

$$P_p = \frac{P_m}{\tau.\nu}, kW \qquad (1)$$

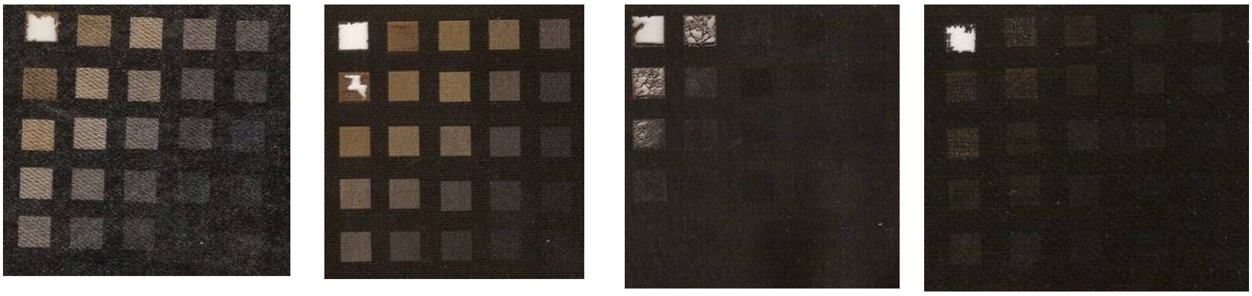
Each laser type emits a characteristic wavelength. In order to study the influence of the wavelength of the laser, were used diverse lasers: CO_2 laser with a wavelength of 10.6   m and CuBr laser – 0,578   m (Table 2).

Table 2: Technical characteristics of the lasers.

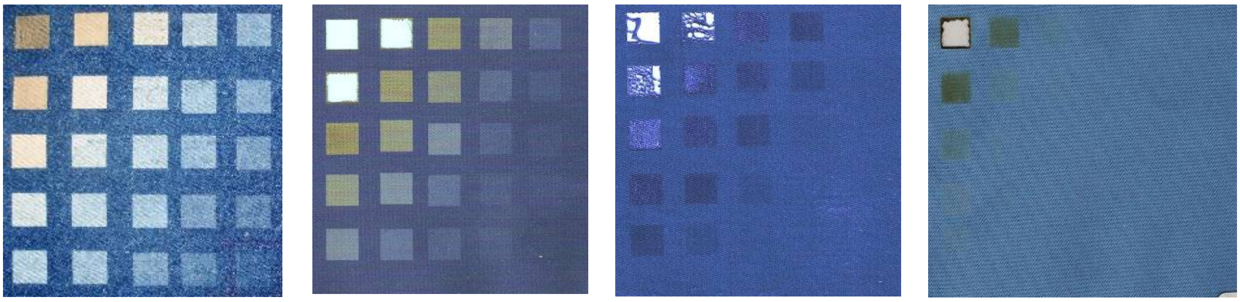
Parameters			Type of laser	
			CO_2	CuBr
Wavelength		m	10,6	0,511
Power	P	W	50	10
Frequency	n	kHz	0,250 50	20
Duration of pulses	τ	ns	20	30

RESULTS

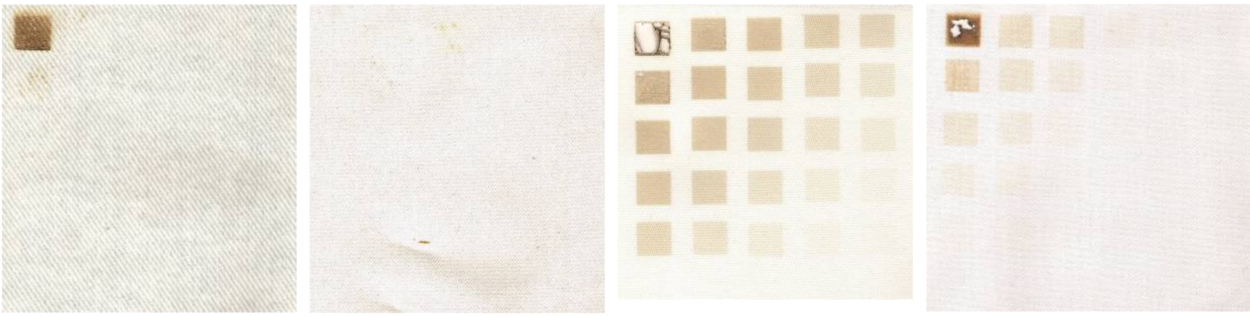
The samples are treated with laser beam on their front-side. The pictures are made on the same side. The images showed the surface changes. They are presented on the following figures:



L2.R1.C1. L2.R2.C1. L2.R3.C1. L2.R4.C1.



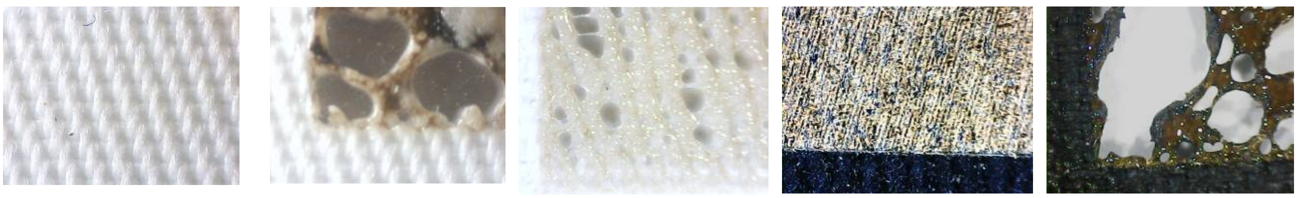
L2.R1.C2. L2.R2.C2. L2.R3.C2. L2.R4.C2.



L2.R1.C3. L2.R2.C3. L2.R3.C3. L2.R4.C3.

Figure 3: The marked samples with CuBr Laser - the test field.

Photos of treated samples are placed next to each other to be able to correlate and analyze the results. This is done for all tested materials and for each of the two laser. Part of the samples are shown on the Figure 3. Some marked samples with CuBr laser were shown on Fig.4. With the help of a microscope is observed the structure of the sample L2.R1.C2. (Fig.5) to track the changes under the action of the laser at the level of the yarn. Each square is marked with various power (impulse power) and at different speeds according to the test field (Fig.2).



L2.R3.C3.-front side L2.R3.C3.V1.Pp1 L2.R3.C3.V1.Pp2 L2.R2.C1.V2.Pp1 L2.R3.C1.V1.Pp21

Figure 4: Some marked samples with CuBr Laser


Front side of the denim fabric (weave twill 3/1)


Back side of the denim fabric (weave twill 3/1)

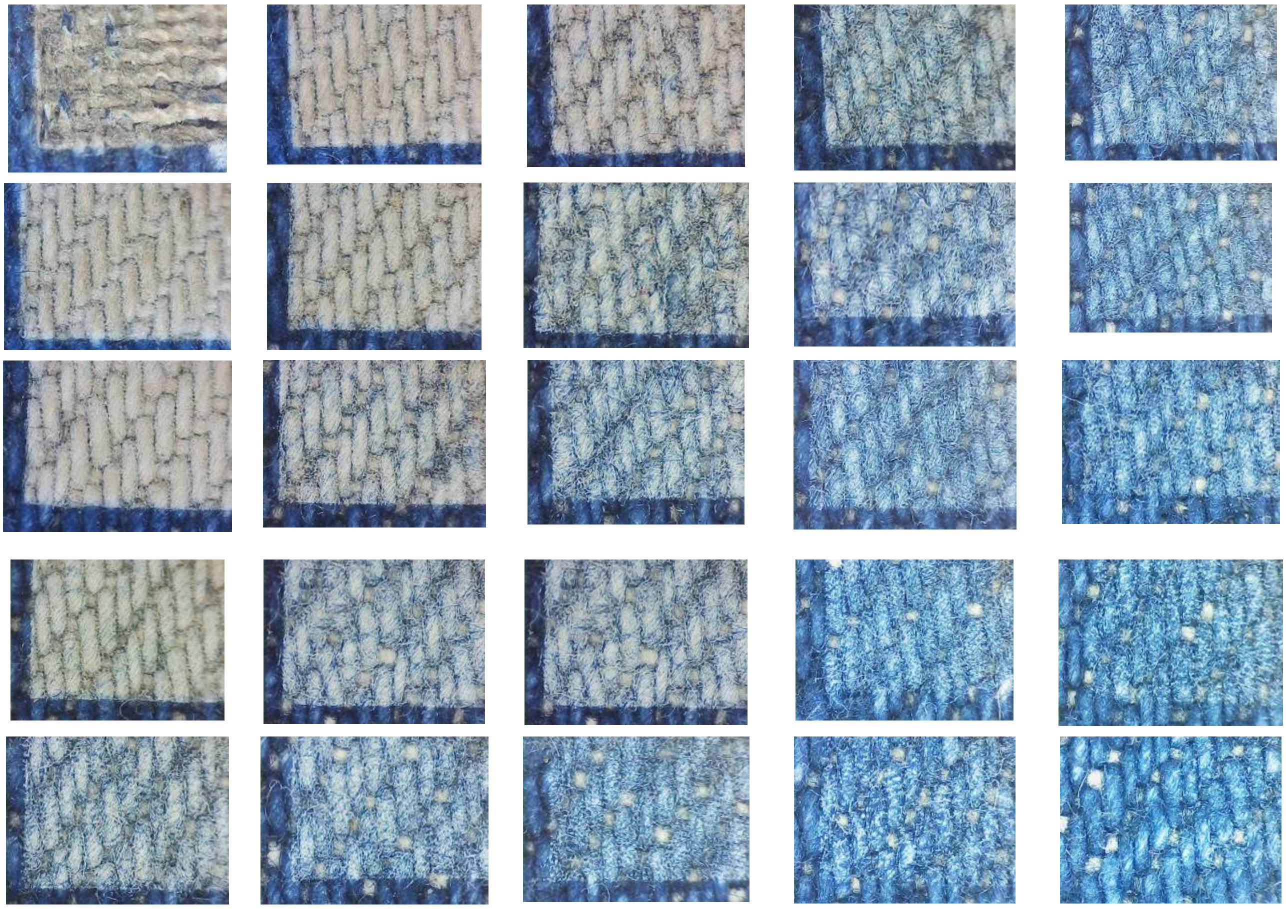


Figure 5: The marked sample L2.R1.C2. with CuBr Laser - the test field.

DISCUSSION

The quality of laser marking depends on numerous factors, which generally can be addressed in three groups relating to: laser system for marking, the material which will be marked (in this case with the characteristics of the textile fabrics) and with the technological process of marking.

The results showed that the laser beam power had the highest effect on the structure of the marking part. It should be noted that the denim fabric color was changed most significantly when the laser beam power was changed. It was found that the laser speed (v) had the high effect on the structure also. However, the laser beam also can cause the negative effect on the upper layers of fibres and reducing the strength of the yarns and fabric. The laser can leads to the break of a great amount of fibres at the fabric surface or even to cut of the fabric if the parameters aren't conformable to textiles properties. That results in appearance and strength loss. That's why is very important to be investigate the parameters of laser marking process for textile fabrics. The marked effects can be controlled in order to obtaining the desired results by adjusting the parameters of the laser.

On the other hand, the results indicate that, under the one and the same parameters of the laser, the structural changes are different and depend on the composition, thickness, density and structure of the fabric. Depending on the material (the raw), part of the fabric becomes carbonized (cotton) or melt (L2.R3.C3.V1.Pp1 - polyester). The color of the fabric is a very significant for the quality of marking. In order to improve the physical and mechanical parameters of the marked fabrics, it is necessary to explore the changes that occur in the micro and macro-structure of the products.

The laser marking can be applied to the fabric before or after the garments are produced. Even more the laser marking process allows to be "Marking-on-the-Fly" during the manufacture. For a successful laser marking, it is essential that the processes to be conducted and monitored exactly.

The results obtained in experimental studies can be laid in some technological tables and the operator can quickly reach the optimal technological parameters, necessary to get qualitative marking of respective manufactured fabrics. Quality of the marked effects can be controlled in order to obtaining the desired results by adjusting the parameters of the laser.

CONCLUSIONS

The use of laser beam for marking of textile fabrics was explored in this paper. The computer image analysis on woven fabrics before and after laser marking was done. The ability of the microscopic analysis to show the structural and colour modifications, after laser treatment, is confirmed by the results obtained. For more detailed analysis, to see what happen with the fibers, it is necessary to extend the study with a scanning electron microscope. That is of great importance for optimization of this method and his development.

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3D WOOL PANELS DEVELOPMENT TECHNOLOGIES FOR CONSTRUCTION INSULATION

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Abstract: *This paper present technology for developing nonwoven wool panels for usage in construction insulation field.*
The wool fibers have many overlapping scales which create a very flexible and create a memory-effect after compression and the wool will return to its original shape. The wool fibers are hygroscopic and will have a moisture weight content of up to 35%, dependent on the relative humidity of the surroundings. While absorbing this moisture, wool releases energy in the form of heat, thus raising the temperature of inside areas. Naturally releasing this moisture in the warmer seasons, wool creates a cooling effect on the same habitat.
Regarding the panels forming technology, the wool fibers are carded or aerodynamically formed and then bonded by using the methods – needle-punching, thermo-bonding, chemical bonding and hydro-entanglement.
The technologies used in this work were carding and needle-punching.
The goal of carding is to separate entangled tufts of fibers from bales by using mechanical actions and to deliver the individual fibers in the form of a web.

Keywords: *technology, wool, panel, insulation, construction*

INTRODUCTION

According to ISO 9092, the nonwoven structure is a manufactured sheet, web or batt of directionally or randomly oriented fibers, bonded by friction, and/or cohesion and/or adhesion, excluding paper and products which are woven, knitted, tufted, stitch- bonded incorporating binding yarns or filaments or felted by wet-milling, whether or not additionally needled (figure 1). Definition of nonwoven by ISO 9092 has been adapted by CEN (EN 29092) and consequently by DIN, AFNOR, and all standardization offices in the EU [1].

Now are two associations of nonwovens producers in the world, namely EDANA (the European Disposables and Nonwovens Association) and INDA (the North American Association of the Nonwoven Fabrics Industry). The association EDANA defines 3D nonwoven structure according to ISO 9092 [1].

The association INDA defines nonwoven fabrics as sheet or web structures bonded together by entangling fiber or filaments (and by perforating films) mechanically, thermally or chemically. Generally are flat and porous sheets that are made directly from separate fibers or from molten plastic or plastic film [1].
The interest for using wool fibers in construction is due to the wool fibers properties: good thermal insulation properties, ecological material and chemical substance indoor absorbent [2].

Mechanical bonding processes include needle-punching, stitch-bonding and hydro-entanglement. In the needle-punching process (needle felting), the batt of wool fibers is drawn through a needle loom.
Insulation based on wool panels is natural, environmentally friendly, quick, easy and nonntoxic on the instalation process [2].

Many architects and engineering are now specifying natural materials in their building projects for architecture. Even if they are many others forms of insulation–mineral wool, glass wool or polystyrene, the nonwoven wool panels used for insulation is the green way to insulate [3]. In Ireland, UK, Germany, New Zeeland and US there are companies that already are producing the 3D nonwoven structures for different areas in buildings thermal and phonic insulation [4, 5]. It is known that wool fibres can improve the air condition and absorb indoor contaminants (formaldehyde, sulphur dioxide and nitrogen dioxide) [6]

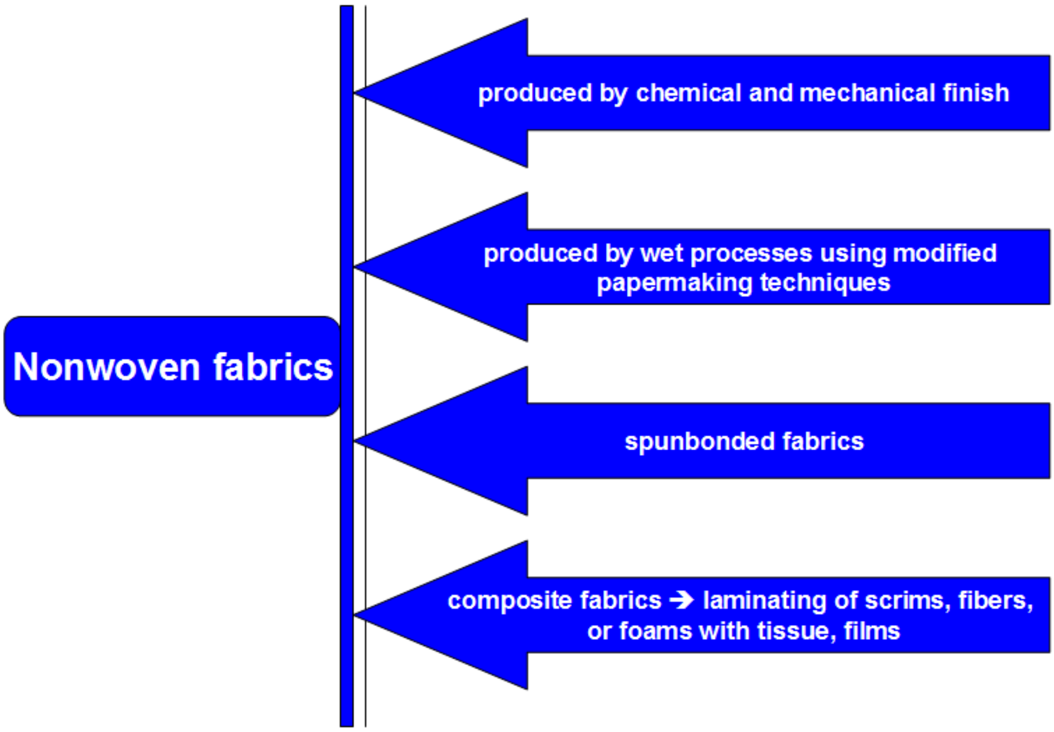

Figure 1: Nonwoven fabrics classification - Bikales (1976) [1]

EXPERIMENTAL PART

The 3D wool panels (figure 2) analyzed in this paper were produced in a national research project "Researches regarding developing of new technical textile products with regenerate, wool and new fibers content" that is developed in the National Research & Development Institute for Textiles and Leather [7].

Figure 2: Wool panels obtained in research project

The raw material – wool fibers are made into a batt with directionally or randomly oriented fibres by a variety of means and the fibres are entangled or bonded by mechanical (friction or cohesion) or thermal (adhesion) or chemical (adhesion) for produsing the 3D nonwoven structure [8, 9].

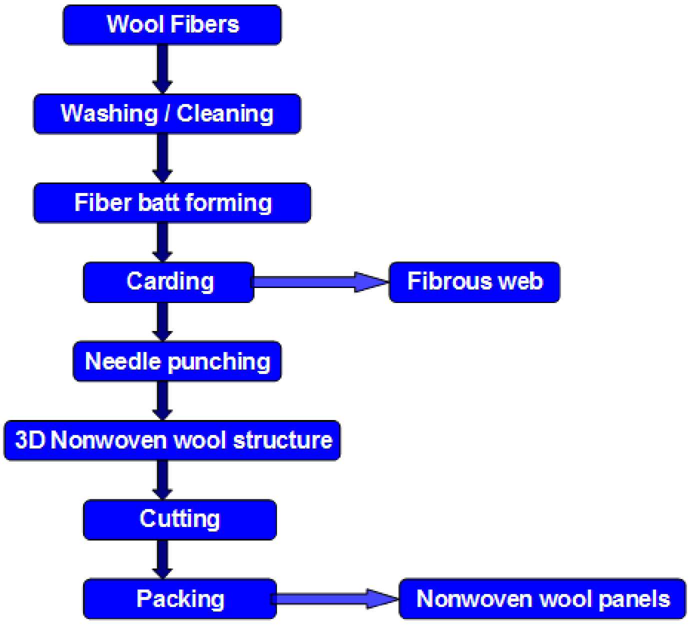

Figure 3: Nonwoven wool panels logical chart

The 3D nonwoven wool panel structure was developed [10] by using steps presented in logical chart –figure 3.

The wool panels produced were tested for analyzing the parameters: thermal conductivity and thermal resistance in function of thickness values. The parameters values for wool panels and control samples-mineral wool panels-AF are presented in Table 1.

Table 1. Wool panels and mineral wool panels control samples – thermal conductivity and thernal resistance values

No.	Parameters analyzed	Sample no. 1 Wool Panel	Sample no.2 Wool Panel	Sample no.3 Wool Panel	Sample no. 4 Wool Panel	Control Sample no.1 Mineral Wool Panel-AF	Control Sample no.2 Mineral Wool Panel-AF
1	Width *d [mm]*	9	27.15	26,8	45,2	10	30
2	Thermal conductivity λ *[W/mK]*	0.03705	0.04955	0.03728	0.0388	0.038	0.04
3	Thermal resistance R_{ct} *[m^2 K/W]*	0.24291	0.54793	0.7189	1.1650	0.25	0.75

RESULTS AND DISCUSSIONS

By comparative analyze of wool panels parameters (thickness, thermal resitance and thermal conductivity) values with mineral wool panels, were used data about mineral wool panels that already exist on the market, with width values between 10 ÷ 30 milimeters. The thermal conductivity for wool panel no. 1 0.03705 W/mK indicates a thermal conductivity lower with 2.5% than control sample no. 1 - mineral wool panel – AF with thermal conductivity 0.038 W/mK and this means that the thermal resistance for wool panel 1 is higher with aproximative 2.8%. For wool panel no. 2, thermal conductivity value 0.04955 W/mK indicates a thermal resistance 0.54793, lower than thermal resistance for mineral wool panel - AF with 27% .
Mineral wool panel – AF (with width 10 mm) have a thermal resistance value 0.25m^2 K/W, in comparation with wool panel no.1 (with width 9mm) which have a thermal resistance 0.24291 m^2 K/W, lower with 2.8%.
Mineral wool panel – AF(with width 30 mm) have a thermal resistance about de 0.75 m^2 K/W, in comparation with wool panel (with width 27.15 mm) which have a lower value for thermal resistance 0.54793 m^2 K/W.
For thermal resistance was used formula 1:

$$R_{ct} = \frac{d}{\lambda}\left[m^2 K / W\right] \quad (1)$$

By analyzing the correlation coefficients for thermal conductivity and thickness from math formula 2 (R_1), for thermal resistance and thickness from math formula 3 (R_2), respectively for thermal resistance and thermal conductivity from math formula 4 (R_3), we can conclude that $r_1(1, 2) = r_1(2, 1) = -0.8206$, $r_2(1, 2) = r_2(2, 1) = 0.9764$ and $r_3(1, 2) = r_3(2, 1) = -0.7510$, which means that between thermal conductivity, thermal resistance and thickness it is not a linear correlation.

$$R_1 = \begin{vmatrix} 1.0000 & -0.8206 \\ -0.8206 & 1.0000 \end{vmatrix} \quad (2)$$

$$R_2 = \begin{vmatrix} 1.0000 & 0.9764 \\ 0.9764 & 1.0000 \end{vmatrix} \quad (3)$$

$$R_3 = \begin{vmatrix} 1.0000 & -0.7510 \\ -0.7510 & 1.0000 \end{vmatrix} \quad (4)$$

CONCLUSIONS

Even if mineral wool panels presents higher values for thermal resistance and insulation capacity, the advantages of using 3D nonwoven wool panels in construction are:
-The nonwoven wool panels are ecological materials.
-Is not toxic for the worker that manipulate these panels on the building during thermal insulation 3D panel montage work.
-There is a correlation between stationary air and fibres density in 3D wool panel and thermal isolation capacity.
-Thermal insulation capacity of 3D wool panel structure depends on fibres disposition for creating a voluminous structure with stationary air embedded.
-Production technology for 3D wool panel is not huge energy consumer like mineral wool production.
-The challenge is to keep 3D wool panels like ecological product by using less toxic substances in fabrication process.

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TWIST LIVELINESS OF COTTON/ RECYCLED COTTON BLENDED ROTOR SPUN YARNS

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Abstract: *The purpose of this study is to evaluate the effect of twist and waste ratio on twist liveliness of rotor yarns of 25 tex linear density spun from blends of virgin and recycled cotton fibres. The measurements of twist liveliness of yarns were performed using the Keisokki Kringel Factor Meter. Results indicate that as twist increases, twist liveliness value increases as well. An increase in waste ratio leads to a decrease of twist liveliness value.*

Keywords: *twist liveliness, recycled cotton, Kringel factor, rotor yarn.*

1. INTRODUCTION

Staple fibre yarns are produced of bundles of parallel fibres, drafted to the desired degree of fineness and twisted in order to better exploit the strength of the individual fibres and to obtain strength in the yarn. Below the critical twist value, the higher the twist applied to the yarn, the higher the strength of the yarn. During twisting, fibres extend and exert pressure towards the yarn interior. This pressure causes a strong compression of the yarn body that leads to an increase of the inter-fibre frictional forces and thus an increase in yarn strength [1].

Due to fibre elasticity, when the yarn is free of tension, there is a constant tendency of fibres to draw back (to return to the initial length). Thus, the stresses built up in fibres during twisting will generate a torque when the strain energy is released. In an attempt to reach equilibrium, this torque causes the freshly spun yarn a tendency to untwist or snarl [2]. This property of a spun yarn is referred as "twist liveliness".

Twist liveliness is considered a negative property of a spun yarn. Yarn snarling tendency leads to spirality problems of fabrics and causes several difficulties during downstream processes, such as winding, warping, weaving and knitting [3]. There are two methods to counteract the curling tendency of the spun yarns: fibres' length stabilization by using steaming or chemical treatments and plying the single yarns with a ply twist in the opposite direction which untwists the single yarns and balances the yarn torque. Both methods present some disadvantages mainly related to increased costs, fibre damage or incomplete elimination of the snarling tendency [4]. The main factors that influence the yarn twist liveliness are twist factor, yarn fineness and fibres behaviour in torsional, bending and tensile stresses [5].

Over the last two decades textile waste recycling has gained growing interest from textile products' manufacturers because of the increasing costs and the negative environmental impact of waste disposal [6]. Furthermore, the reuse of waste can decrease the costs of raw material and thus the product cost.

The research previously conducted on spinning blends of virgin cotton and recycled cotton fibres pointed out that higher twists were necessary for a better spinning stability [7]. But higher twist leads to a higher yarn tendency to snarl. The purpose of this study is to evaluate the effect of twist and waste ratio on twist liveliness of rotor yarns of 25 tex linear density spun from blends of virgin and recycled cotton fibres.

2. EXPERIMENTAL

The recycled cotton fibres were obtained by cutting and shredding of clippings generated from the garment manufacturing and are characterised by a mean fiber length close to half an inch. Because of the high percent of short fibres, blends with virgin cotton as carrier fibres were necessary. The properties of virgin cotton fibres were as follows: 0.198 tex liner density, 30.62 mm mean length, 3.64 cN/tex tenacity, 14.27 % breaking strength coefficient of variation.

In order to study the influence of twist and waste ratio on twist liveliness of yarns, the waste ratio has been set at three levels: 20 %, 30 %, and 40 %, and the metric twist multiplier (α_m) has also taken three levels: 120, 135, and 150. The yarn samples of 25 tex linear density were obtained using standard mill procedures and practices on a BD-200 RN rotor spinning machine.

The measurements of twist liveliness of yarns were performed under a standard atmosphere (20 ± 2°C and 65± 2% RH) using the Keisokki Kringel Factor Meter (Figure 1). The measuring principle is based on the tendency of twisting spontaneously in the opposite direction of a spun yarn in the form of a loop that hangs under standard weight between two fixed points. The height of the twisted portion measured on a 0-10 scale after the yarn reached the steady state is defined as Kringel factor (Kr) and gives a quantitative measure of the twist liveliness of yarn.

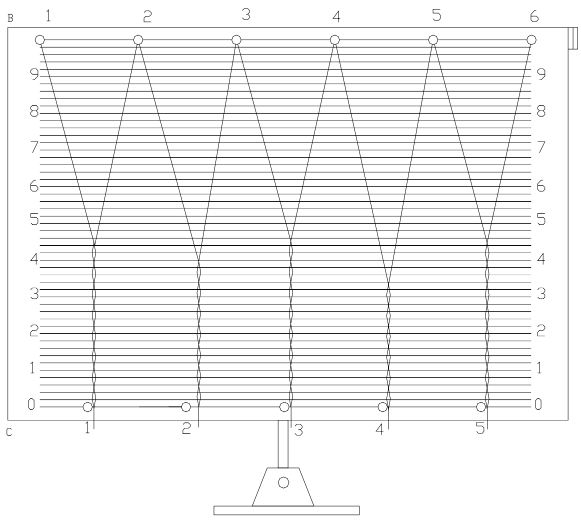

Figure 1: Kringel Factor Meter

In order to establish whether the waste ratio and twist multiplier are significantly related to the response data (Kringel factor) the two-way analysis of variance was used. The null hypotheses to be tested are:
H_0: There is no difference among the means for the main effect due to twist multiplier.
$H_{0'}$: There is no difference among the means for the main effect due to waste ratio.
$H_{0''}$: There is no interaction between the two factors, twist multiplier and waste ratio.
In the analysis of variance table, the p-value is used to determine whether a factor is significant, usually for a significance level of 0.05. If the p-value is lower than 0.05, then the factor is significant.

3. RESULTS AND DISSCUSSIONS

The two-way analysis of variance enables to perform hypothesis tests for equality of means for the different levels of the twist multiplier and waste ratio as well as the interaction between twist multiplier and waste ratio. Minitab 16 Statistical Software (trial version) has been used to perform the statistical analysis. Table 1 presents the two-way analysis of variance for the Kringel factor (Kr).

Table 1: The analysis of variance for the Kringel factor

Source	DF	SS	MS	F	p
Twist multiplier	2	18.4597	9.22983	78.94	0.000
Waste ratio	2	6.1345	3.06726	26.23	0.000
Interaction	4	0.9993	0.24983	2.14	0.075
Error	441	51.5613	0.11692		

DF – degrees of freedom; SS – sum of squares; MS – mean squares; F – F-statistic.

The p-values for the twist multiplier and for the waste ratio are 0. Since 0 < 0.05, the H_0 and $H_{0'}$ null hypotheses are rejected. This means that, at the 5% level of significance, the average values of the Kringel factor for the three twist multipliers and waste ratio are significantly different from each other. Both twist multiplier and waste ratio are significant factors.

The p-value for the interraction between twist multiplier and waste ratio is 0,075. Since 0.075 > 0.05, the $H_{0''}$ hypothesis cannot be rejected. In this case, at the 5% level of significance, one can conclude that the interaction between twist multiplier and waste ratio does not affect the Kringel factor value.

Figure 2 shows the effect of twist multiplier and waste ratio on Kringel factor. As twist multiplier increases, the Kringel factor value increases. At higher twist the fibres extend more. When the yarn is free of tension the strain energy is released and the yarn tends to snarl. With the increase of waste ratio, the Kringel factor value decreases. During yarn formation short fibres migrate from the core to the yarn surface [8]. They are less integrated into the yarn body and do not take up as much tension as long fibres during twist insertion.

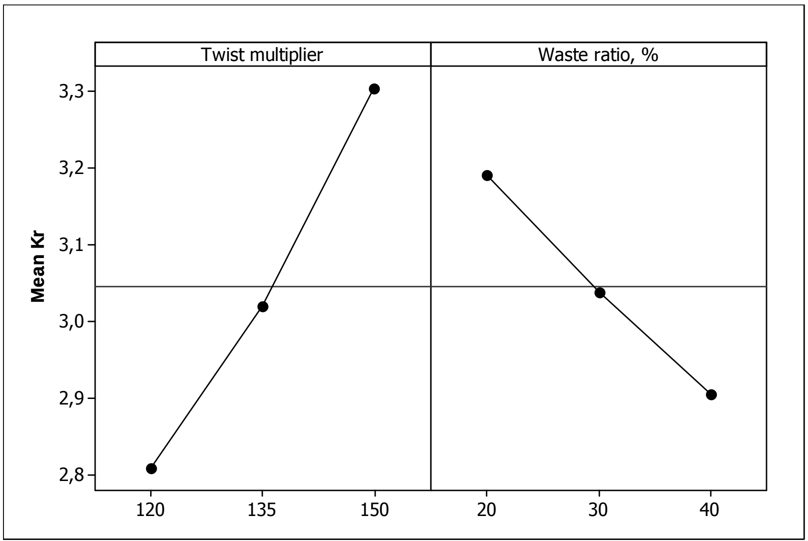

Figure 2: The effect of twist multiplier and waste ratio on Kringel factor

Figure 3 shows the interaction plot for Kringel factor. For a given waste ratio, as twist multiplier increases from 120 to 135, the Kringel factor value increases by 13 % to 21 %. For a given twist multiplier, as waste ratio increases from 20 % to 40 %, the Kringel factor value decreases by 7 % to 12 %. The twist multiplier has a greater influence on Kringel factor value than the waste ratio.

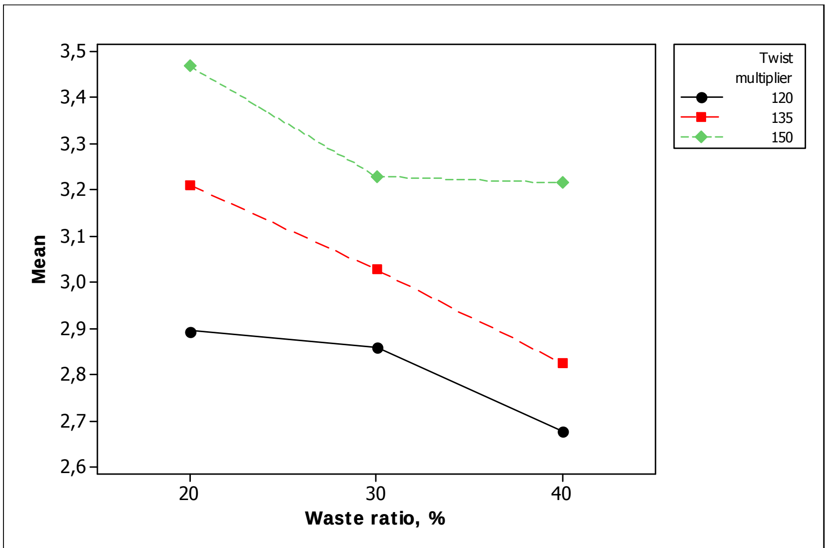

Figure 3: Interaction plot for Kringel factor

One can observe that even at high twists the Kringel factor does not exceed the maximum value (4.5) admitted for a trouble-free subsequent processing [9]. This can be due to the twist loss in rotor spinning [10].

4. CONCLUSIONS

During twisting fibres extend and exert pressure towards the yarn interior. When the yarn is free of tension, the fibres tend to return to the initial length causing the yarn a tendency to untwist or snarl. This twist liveliness causes several problems during various post-spinning processes, such as winding, warping, weaving and knitting.

In this study, the measurements of twist liveliness of 25 tex cotton/recycled cotton rotor blended yarns were performed using the Keisokki Kringel Factor Meter. The two-way analysis of variance has been used to evaluate the effects of twist multiplier and waste ratio on the Kringel factor value. Both twist multiplier and waste ratio are significant factors, but the interaction between twist multiplier and waste ratio does not affect the Kringel factor value.

The results of this study indicate that as waste ratio increases, the Kringel factor value decreases. With the increase of twist multiplier, the Kringel factor value increases as well. The twist multiplier has a greater influence on Kringel factor value than the waste ratio.

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HEMP – AN ENVIRONMENTALLY FRIENDLY ALTERNATIVE TO COTTON

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Abstract: *In this paper the results of a research regarding the properties of cottonised hemp/cotton blended yarns spun on the cotton system are presented. Rotor yarns of Nm 10, Nm 17 and Nm 27 fineness were obtained from 30/70, 50/50 cottonised hemp/cotton blends and also from 100 % cotton blend. In comparison to all-cotton yarns, the cottonised hemp/cotton blended yarns have lower tenacity, higher strength irregularity, lower breaking elongation, and higher mass irregularity.*

Keywords: *cottonised hemp, hemp/cotton blend, rotor yarns.*

1. INTRODUCTION

Hemp is one of the oldest textile fibres whose domestication has been initiated in China 5000 years ago. From there hemp cultivation migrated to Eastern and Southern Asia and then to Europe about 2000–2200 years ago. Since that time until the middle of 20th century hemp become widely cultivated because of its many uses: cloth, ropes, sails, paper, food and oils. After the World War II, the competition from synthetic fibres and cotton (mechanically harvested) and the misinformation about differences between marijuana and industrial hemp led to a continuously decrease of the land areas devoted to hemp cultivation [1, 2].

In recent years, the interest in hemp industry has heightened due to environmental concerns associated with cotton and synthetic production and the necessity to find new sources of renewable resources and alternatives to food crops. The production of synthetic fibres depletes non-renewable petroleum resources, while conventional cotton farming requires substantial amounts of pesticides, fungicides, and chemical fertilizers which pollute soil and groundwater. Even though cotton takes only 3% of the world's cultivated land, its production uses about 25% of the world's pesticides and insecticides. Furthermore, the cotton growing requires massive amounts of water with negative impacts on environment and water resources. The most famous environmental impact of increased water usage for cotton irrigation is the Aral Sea desiccation. In the 1960s the two rivers that fed the Aral Sea were diverted in order to irrigate the desert for cotton farming. As a result, the Aral Sea lost approximately 60% of its area with dramatic consequences on sea water salinity, salinization of soil, desertification, climate change, and population health [1, 3, 4, 5].

Hemp is a bast fibre obtained from the stalk of the Cannabis sativa L. plant and represents an outstanding ecological alternative to polluting conventional cotton cultivation. Hemp is more resistant to pests and diseases and thus can be grown without the use of pesticides or fungicides. Due to its rapid growth, dense foliage, and high planting density, hemp suppresses weeds so herbicide applications are not necessary. Hemp needs little or no fertilizers. When left in the field for retting, the dried leaves add nutrients to the soil and thus the next hemp crop can grow without fertilizers. Hemp is irrigated only in drought conditions, otherwise the rain water is enough during plant growing. Besides, hemp can extract heavy metals purifying the contaminated soils. Because of the deep root system, hemp aerates the soil leaving it in optimum conditions for the following crop. Hemp is a favourable crop in the traditional crop rotation, but also can be cultivated several years in a row in the same field being self-compatible. After the cultivation of hemp, an increase of wheat yield by 10–20% has been reported [1, 6]. On the same land area, hemp produces 250 percent more fibre than cotton [7].

Unlike cotton fibres that are single cells, the technical hemp fibres consist of many individual fibre cells. The technical hemp fibres are much longer and coarser than cotton fibres, but the dimensions of individual fibre cells are similar to those of cotton fibres. In order to process hemp fibres on the more economical and more efficient cotton equipment, the technical fibres must be split to the level of fibre cells by cottonisation.

In this research cottonised hemp fibres were blended with cotton in ratios of 30/70 and 50/50 and the blends were processed on the cotton system. All-cotton yarns of similar finenesses (Nm 10, Nm 17, and Nm 27) were spun for comparison purposes.

2. EXPERIMENTAL

The characteristics of the cottonised hemp and cotton fibres are presented in Table 1.

Table 1: Characteristics of the Raw Materials

Characteristics	Unit	Cotton	Cottonised hemp
Fineness	Nm	5400	1675
Fibre strength	cN/fibre	3.52	5.37
Fibre tenacity	cN/tex	19	9
Fibre length	mm	28	43.7
Fibre impurities	%	1.2	6.6

As can be seen in Table 1 the cottonised hemp fibres are coarser, weaker (lower tenacity) and dirtier than cotton fibres. In turn, they are longer than cotton fibres.

Before blending with cotton, the cottonised hemp has been emulsified in order to diminish the rigidity of fibres, to protect the fibres and to reduce the emissions of dust during subsequent processing. The blends of 30/70 and 50/50 cottonised hemp/cotton were prepared manually by horizontal layering of fibres. The layers were cut vertically for feeding to the first machine of blowroom line. Unlike the traditional system of sliver preparation that consists of two draw frame passages after carding, a double carding technology has been developed. Thus, after the first passage of fibres through the carding machine, the card slivers were wound into sliver laps on a sliver lap machine. Feeding simultaneously three sliver laps, a second passage of fibres through the carding machine has been done for a better individualization of multi-cells hemp fibres. Two passages of drawframe were used for blending, drafting and leveling the card slivers. The drafted slivers were converted into Nm 10, Nm 17, and Nm 27 yarns on a BD-200 RN rotor spinning machine. All-cotton yarns of similar finenesses were spun for comparison purposes.

The properties of yarns were measured under a standard atmosphere of 20 ± 2°C and 65± 2% RH. TINIUS OLSEN H5 K-T tensile yarn tester was used to assess the tensile properties of yarns. Twist measurements were performed on a Mesdan twist tester using a clamping distance of 250 mm. Yarn mass irregularity and imperfections were tested on an Uster Tester-II apparatus at a speed of 25 m/min.

3. RESULTS AND DISSCUSSIONS

Yarns of Nm 10, Nm 17 and Nm 27 fineness were obtained from blends of cottonised hemp and cotton of 0/100, 30/70, and 50/50 ratios. The minimum twist of cottonised hemp/cotton blended yarns that ensured good spinning stability corresponded to a metric twist multiplier of 150, which means an increase in twist by 25 % to 35 % when compared to twist of all-cotton yarns.

Figure 1 presents the tenacity of yarns. As cottonised hemp content increases the tenacity of yarns decreases. In the case of yarns with cottonised hemp content of 30 % the decrease in tenacity ranges between 8 and 18 %. The tenacity of 50/50 cottonised hemp/cotton yarns is much lower when compared to tenacity of all-cotton yarns of similar fineness. The magnitude of decrease lies between 30 % and 35 %. Because the cottonised hemp fibres are coarser than cotton, as the content of cottonised hemp in the yarns increases, the number of fibres in the cross-section of blended yarns decreases. Besides, the cottonised hemp fibres are weaker than cotton and an increase of their content in the yarn affects yarn tenacity.

The CV of breaking strength of cottonised hemp/cotton blended yarns is higher than the CV of breaking strength of all-cotton yarns (Figure 2). An increase in the cottonised hemp content led to an increase of breaking strength irregularity of yarns.

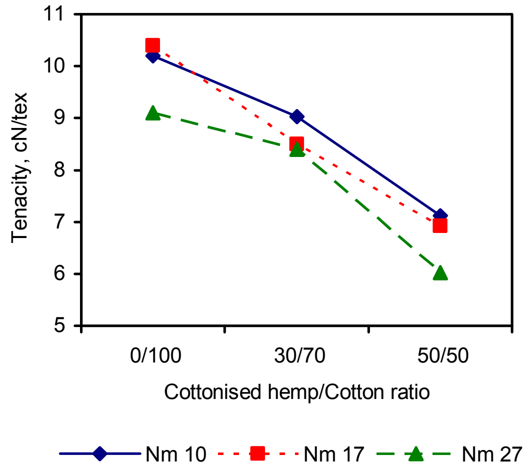

Figure 1: Tenacity of yarns

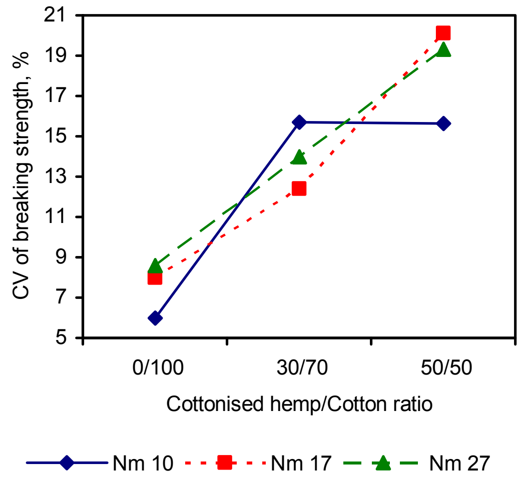

Figure 2: CV of breaking strength of yarns

Figure 3 shows the influence of cottonised hemp content on the yarn breaking elongation for the experimental yarn assortment. When the content of cottonised hemp in the yarn increases, the breaking elongation of the blended yarns decreases. This expected variation is due to the extremely low elongation of hemp fibres. As yarns become finer, their elongation at break decreases as a result of the reduction of the number of fibres in the yarn cross-section.

All-cotton yarns showed a lower mass irregularity on short terms than the cottonised hemp/cotton blended yarns (Figure 4). This behaviour can be explained by the fact that the cotton fibres are finer and less variable in fineness than the cottonised hemp fibres. Finer fibres lead to a higher number of fibres in the yarn cross-section and thus to a lower mass irregularity. With the increase of cottonised hemp content in the yarn, the yarn unevenness increases. With the exception of Nm 10 yarn from 30 % cottonised hemp//70 % cotton, as yarns become coarser and the number of fibres in the yarn cross-section increases, the mass irregularity of yarns decreases.

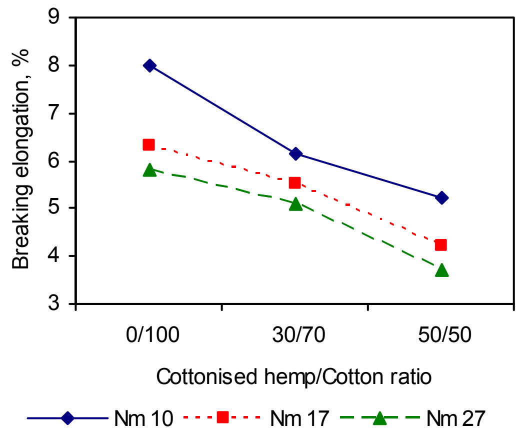

Figure 3: Breaking elongation of yarns

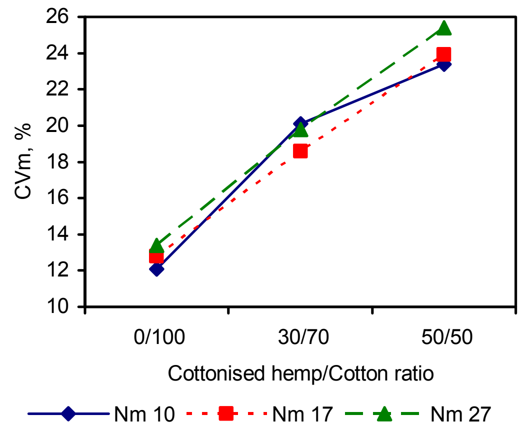

Figure 4: CV of mass of yarns

4. CONCLUSIONS

The current trends towards sustainability have highlighted the necessity to consider alternative ecological resources to environmentally destructive fibres. Hemp is one of the natural fibres that is renewable, biodegradable and less polluting that can constitute an alternative to cotton. Blends of cottonised hemp and cotton were processed on the more economical and more efficient cotton equipment using a double carding technology. Rotor spun yarns of Nm 10, Nm 17 and Nm 27 fineness have been obtained from 30/70, 50/ 50 cottonised hemp/ cotton blends and 100 % cotton.

Based on the results of this research, the following conclusions can be drawn:

1. Compared to all-cotton yarns, the cottonised hemp/cotton blended yarns have lower tenacity, higher strength irregularity, lower elongation at break, and higher mass irregularity. These differences between the characteristics of the two types of yarns can be explained by the fact that the cottonised hemp fibres are coarser than cotton, and the number of fibres in the cross-section of blended yarns is lower.
2. An increase in cottonised hemp content from 30 % to 50 % causes the worsening of all yarn characteristics so that the optimum cottonised hemp content is 30 %.
3. In order to achieve good spinning stability, the twist imparted to cottonised hemp/cotton blended yarns is higher by 25 % to 35 % than the twist of all-cotton yarns.

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Scholarly communication paper

ELECTROSPINNING CONSTRUCTIVE VARIANTS OVERVIEW

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Abstract: *Researchers have developed different setups trying multiple electrospinning constructive variants, modifying the spinneret and/or type of solution, which can allow the creation of fibers with unique structures and properties. The obtained fibers can adopt different morphologies (e.g., porous or core–shell) depending on the type of materials being used as well as the evaporation rates and miscibility of the solvents involved. Besides the basic setup, which implies a polymer solution and the use of one spinneret (usually a hypodermic syringe needle), scientists came up with different techniques by changing the solution type, as follows: emulsion electrospinning, melt electrospinning and splashing electrospinning. Over time, researchers have improved electrospinning using spinnerets with different shapes and functions obtaining: co-axial spinneret (core-shell electrospinning), multi-channel spinneret, tri-axial spinneret, side by side spinneret, needleless spinneret (removing the needle) and multi-needle spinneret (adding multiple needles to speed up the process). Also, to speed up the process and to obtain specific properties, multiple fluids can be electrospunned in the same time. Thus, each electrospinning technique has something different to offer, being developed for obtaining certain results. Researchers first set clear what properties need to be obtained and after they worked on the electrospinning setup to make it better for their needs. Through our study we attempt to cover the electrospinning variants found by us until now, discussing in detail the principle and purpose of each setup, showing the strengths and weaknesses.*

Keywords: *coaxial electrospinning, emulsion electrospinning, melt electrospinning, spash electrospinning, needleless electrospinning, multi-needle electrospinning.*

INTRODUCTION

Although nowadays there are many methods of obtaining nanofibres, electrospinning is perhaps the most versatile and flexible process. Other fabrication techniques, such as template synthesis, drawing, and phase separation, can also be used to obtain nanofibers, but comparing to them, electrospinning is a simple method that can produce fibers with specific diameters. The electrospinning process does not require the use of high temperatures or coagulation chemistry to yield fibers from solution. Thus, nanofibers can be obtained from solutions with large and complex molecules. It has been observed that most of the parameters implied in electrospinning can be calculated and predicted through mathematical functions, having the opportunity to control the process. Knowing and controlling each process parameter is very important, because any small change can affect the resulted nanofibers morphology, having smaller or bigger fiber dimensions or different properties. Besides the fiber morphology, the architecture is also a significant variable which has an impact on the flexibility of the nanofibers. Also, it has been demonstrated that electrospinning can be scaled up for industrialization.[1] One of the best things is that a wide range of solutions can be used in electrospinning from which different materials can be obtained such as polymer, composites, ceramic and metal nanofibres.[2] Through electrospinning we can yield various fibre structures with specific morphologies. Thus, from the need of diversification, scientists have developed different setups for electrospinning, modifying the basic approach of the process. Starting from the traditional approach, the single needle spinneret, different setups have been created threw the modification of the spinneret, using spinnerets with different shapes and functions to obtain fibers with certain properties or to speed up the process in order to push it toward industrialization. In this article, are presented some of the setups that have been developed and used until now by different researchers, their scope and also the main applications and importance in research.

SINGLE NEEDLE ELECTROSPINNING

The single needle electrospinning represents the standard setup used in electrospinning, which consists of a spinneret (tipically a hypodermic syringe needle) threw which flows a polymer solution or melt, while a high voltage is applied to it. A schematic of the single needle electrospinning setup is shown in Figure. 1. This is the simpliest and most common setup that has been used in the recent decades. Threw this method many polymer solutions can be electrospun, including blended polymers from which composite nanofibers can be obtained. The composite nanofibers benefit of all the properties of the implied polymer solutions. The electrospinning of polymer blends is only possible if the implied polymer solutions are compatible with each other. As example, for biomedical applications, electrospinning blends of sodium alginate and polyethylene oxide (PEO), or chitosan and PEO, the biomedical capabilities of alginate and chitosan are combined with the chain entanglement capability of PEO, leading to an electrospinnable nanofiber for tissue regeneration applications.[1] Also, different material nanoparticles can be included in the polymeric solution. For example, silver nanoparticles, known by its antimicrobial properties, can be dispersed in the polymer solution for making antimicrobial nanofibers. [1] The incorporation of silver nanoparticles in nanofibers can be used also in novel specific applications in catalysis, sensors, photonics and electronics. There are many studies that mention including silver salts or compounds in polymeric solution for obtaining materials for wound treatment.[3]

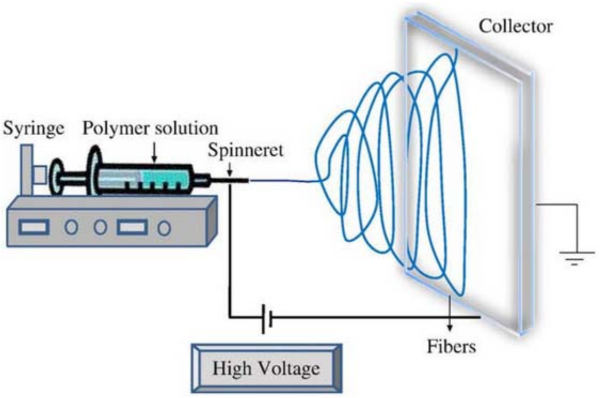

Figure 1: Single needle electrospinning setup[4]

MULTI-NEEDLE ELECTROSPINNING

The most logic development of the basic electrospinning setup has been the increase of the number of the spinnerets. While in a classical electrospinning configuration with a single needle, composite nanofibers can be fabricated from blending polymer solutions that are compatible, in multi-needle electrospinning we can have polymer solutions that are not miscible with one another, ejecting the solutions from separate orifices, resulting in a composite nanofiber assembly.[1] To prepare composite nanofibers we can use a dual spinneret electrospinning system with needles that can be placed side by side, or on opposite sides (dual-opposite-spinneret) of a rotating collector (Figure 2). It has been observed that for the dual spinneret, two power sources can be used when the needles are placed on opposite sides of a rotating collector, one power source for each needle. When the configuration has side by side needles, the needles can’t have separate power sources due to the variations in charge for each needle causing interference between them. Needing a uniform charge distribution, a single power supply can be used and the needles can be interconnected using a metallic support.[1]
Researchers have developed dual spinnerets, with side by side needles, with different configurations: bifarious dual spinneret (the outlets of the two spinnerets are bifarious), inconsistent dual spinneret (one outlet is planus and the other is acuate), consistent dual spinneret (the outlets are both planus), relative dual spinneret (the outlets are relative and acuate) and relative curved dual spinneret (the outlets are relative and curved). There is one article mentioning an experiment which includes all the above mentioned dual spinnerets configurations.[5] The schematic of the configuration is shown in Figure 3.
In a multi-needle electrospinning system can be used more than two needles, disposing the needles in a circle, a linear array or multiple arrays. As example, we took some spinneret models from the TONG LI TECH website (http://www.electro-spinning.com), a chinese company that supplies a wide variety of laboratory equipments and devices neccesary for conducting the electrospinning process (Figure 4).

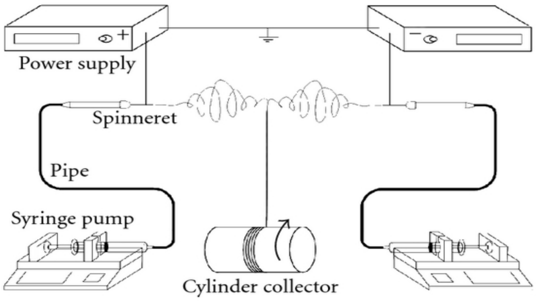

Figure 2: Schematic diagram of dual-opposite-spinneret electrospinning system (http://www.hindawi.com/journals/jnm/2012/575926/sch1/)

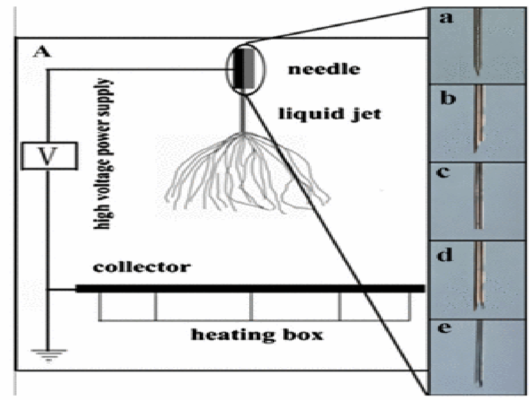

Figure 3: The schematic of experimental facilities for preparing composite nanofibres with side by side heterojunctions and digital photographs of five dual spinnerets: a) bifarious dual spinneret, b) inconsistent dual spinneret, c) consistent dual spinneret, d) relative dual spinneret, e) relative curved dual spinneret.[5]

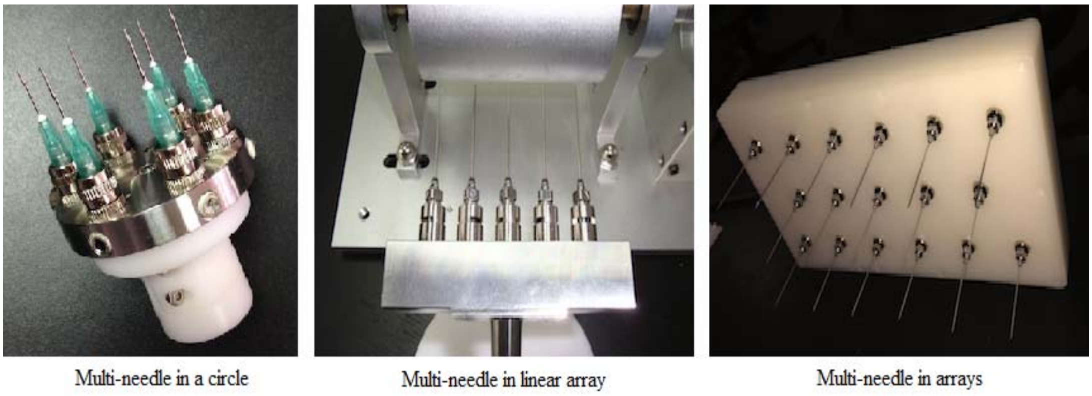

Figure 4: Multi-needle spinnerets (http://www.electro-spinning.com/multi_spinnerets.html)

Beside the fact that multi-needle electrospinning offers the possibility to electrospun polymeric solutions that are not compatible with each other, another important thing is that due to its multiple needles configuration it can speed up the electrospinning process, making possible to obtain nanofibers at a industrial scale.

It has been reported that multi-needle electrospinning has some disadvantages, such as complex design and potential clogging.[6]

COAXIAL ELECTROSPINNING

The most popular bi-component electrospinning is coaxial electrospinning. The coaxial electrospinning setup involves a coaxial spinneret with one nozzle inside a larger nozzle, which produce hollow nanofibers or core-shell nanofiber structures. A coaxial electrospinning setup schematic is shown in Figure 5.

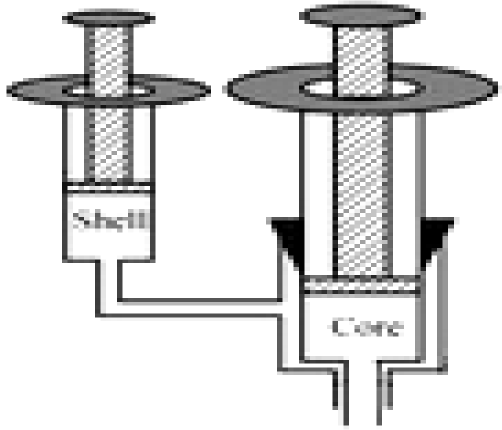

Figure 5: Coaxial spinneret schematic (http://www.electro-spinning.com/multi_spinnerets.html)

Using the coaxial spinneret, different characteristics from each polymer can be combined into one nanofiber. Some polymer solutions with low spinnability can also be electrospunned using this spinneret. The polymer with better spinnability should be used as core fiber, and the one with low spinnability should be the shell. An advantage of this method is that non-spinnable materials such as oligomers, metal salts, enzymes, and liquids can also be used as core solution in fibers to make functional nanofibers. The core solution does not need to be electrospinnable. The most important factor is that a shell fiber can be electrospun to contain a uniform channel within to carry the core solution. Coaxial eletrospinning is not limited to produce only core-shell nanofibers, by controlling the viscosity of inner and outer solutions we can obtain systems with buckling, drop-shape inclusions inside a continuous shell.
Using a coaxial spinneret we can also have gas assisted electrospinning. Hot blowing air, inert gas, or other kinds of gases can be inserted through the outer needle to create a flowing gas jacket. This method helps the electrospinning process by reducing the clogging of the spinneret, decreasing the viscosity of the solution, enhancing the evaporation of the solvent and stretching the jet.
The core-shell nanofibers are suitable for biomedical applications, in drug delivery systems where drugs or proteins can be incorporated into the core fiber protected by the shell that can be composed of a more mechanically stable or less degradable polymer. This way the core-shell nanofiber structure adds an extra layer of control over the release rate of drugs or proteins, allowing for a more sustained release profile.[1]

NEEDLELESS ELECTROSPINNING

In needleless electrospinning, multiple polymer solution jets can be ejected from a free surface, instead of needles. According to the researchers, spinnerets for needleless electrospinning can be classified in two categories: rotating or stationary spinnerets. The rotating spinnerets can introduce mechanical vibration to the polymer solution to assist in initiating the solution jets. Usually, rotating spinnerets have to work continuously. In the case of the stationary spinneret, an additional force (eg: magnetic field, gravity, gas bubble) is needed to initiate the electrospinning process. Researchers have established that the geometry of the spinneret plays a crucial role in needleless electrospinning, showing that it affects the process and the fiber quality. They found that compared to a cylinder spinneret, a disc spinneret has better electrospinning performance, forming higher intensity electric field. Following these results, the researchers invented a spiral coil setup and proved that the spiral coil had higher fiber production rate and better control toward the fiber morphology compared to the disc and cylinder electrospinning. More recently, to continue the needleless electrospinning, they created spinnerets using a moving bead chain or a spiral coil.[7]
This system can produce high-quality nanofibers with a significantly increased production rate compared with needle electrospinning. Comparing to the other electrospinning setups, this method eliminates the high possibility of clogging. Thus, needleless electrospinning cannot be controlled precisely, having fibers with lower or greater diameters than the desired values and unstable morphology.[6]

DIFFERENT ELECTROSPINNING SOLUTIONS

Different polymer solutions have been used in electrospinning to obtain certain properties or to improve the process without being necessary to modify the hardware configuration.

EMULSION ELECTROSPINNING

Emulsion electrospinning allows for immiscible solutions to be electrospun into a single fibrous structure. In this technique, the immiscible solutions are mixed into an emulsion which is then electrospinned.[8] It has the advantage that core shell or composite fibers can be obtained without needing to modify the spinneret. However, these fibers are more difficult to produce, as compared to coaxial spinning, due to the numerous variables which must be taken in consideration for creating the emulsion. In some cases, the major disadvantage of this method has been the need for the emulsified solution to remain stable throughout the electrospinning process. To avoid phase separation, vigorous mixing of the polymer and other solutions and the incorporation of an emulsifying agent has been necessary.[8] So, a water phase and an immiscible solvent phase are mixed in the presence of an emulsifying agent to form the emulsion. During the electrospinning process the emulsion droplets within the fluid are stretched and gradually confined leading to their fusion, forming a continuous inner core.
Nanofibers obtained through emulsion electrospinning have shown potential in drug delivery and protein release applications.[1]

MELT ELECTROSPINNING

The setup is very similar to the conventional electrospinning, including the use of a spinneret (syringe), a high voltage power supply and the collector. The polymer melt is usually produced by heating from either resistance heating, circulating fluids, air heating or lasers. Melt electrospinning can be considered an alternative to solution electrospinning, eliminating the need for volatile solvents. This way we can obtain semi crystalline polymer fibers such as PE, PET and PP, which would otherwise be impossible or very difficult to create using solution electrospinning.
The fiber uniformity is very good upon achieving stable flow rates and thermal equilibrium. Due to the low conductivity and high viscosity of the melt, the whipping instability, present in solution electrospinning, can be absent from the process. The feed rate, the molecular weight of the polymer and the diameter of the spinneret are the most significant factors which affect the fiber size. Due to the high viscosity of the polymer melts, the fiber diameters are usually slightly larger than those obtained from solution electrospinning.

SPLASHING ELECTROSPINNING

This setup implies that instead of a regular capillary, a splashing needleless electrospinning method is used to create nanofibers. The system setup consists in a metal roller spinneret, a stationary collector and a syringe pump. The configuration of the system is shown in Figure 6. During electrospinning, the polymer solution droplets are splashed onto the surface of the metal roller spinneret through the holes of the solution distributor which is located above the spinneret. The advantage of this setup is its potential scale-up for increased output of nanofibers by increasing the solution distributor length. It is a simplified electrospinning setup due to the fact that gravity is used to assist in conveying the solution to the electrospinning sites.[9]

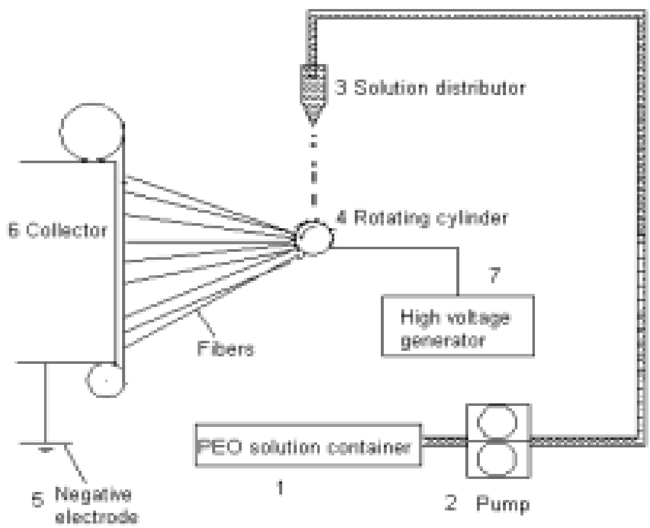

Figure 6: Splash electrospinning schematic[9]

CONCLUSIONS

The use of nanofibres offers the potential to significantly improve current technology and find application in new areas. Applications for nanofibres include, among others, nanocatalysis, chemical and biological protective clothing and masks, air and water filtration and nano-electronics [2], biomedical (eg. tissue scaffolds, dental restructuring, cardiac and nerve regeneration [5], orthopaedic surgery [10], cell activities and administration of drugs [1]). The methods to fabricate different kinds of nanofibers discussed above expand the variety of applications in which nanofibers can be used. Among the applications, the area of biomedical nanofibers has found extensive use of single needle, coaxial and emulsion electrospinning. Mainly, all the electrospinning setups can be used for the same applications, the difference being the kind of solution that is used in the process. A big difference is between the coaxial and emulsion electrospinning, and the other setups, because the first two offer the possibility to create hollow nanofibers or core-shell nanofiber structures. As expected, the multi-needle electrospinning is the setup that brings electrospinning to industrialization, due to the fact that it can be a high speed process if we have enough spinnerets and power source to feed the system. The needleless electrospinning is also a fast process which can be taken in consideration. We should not forget about the control of the process parameters, a point where we think that the standard setup with the single needle configuration beats all the rest of the configurations due to simplicity and the fact that it’s the senior configuration that has been analysed the most. But, even if the electrospinning process is old and new setups have been developed, there are still gaps in the systems configuration which have to be solved and filled.

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Section 3: Textile Structures and Properties

ELECTRICAL AND MECHANICAL BEHAVIOR OF MIXTURE OF FLAX AND POLYESTER FIBRES

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Abstract: *Chemical structure and different physical structure of flax and polyester can assigned different electrical charges inside the fibers. During the processing and use due to the effect of friction, on the surface of fibers or fabrics can appear electrical charges (positive or negative) depending on the chemical structure of their components. The load with static electricity specific to dielectrics, favor the transfer of electrons or ions from an area to another at the contact of two different surfaces until equilibrium is reached (Ionescu Muscel I., 1990, Vlad I.,1964). The aim of this paper is to study the homogeneous mixtures of flax and polyester fibers in terms of the electrical and mechanical behavior and to analyze the process of transfer and compensation of the two kinds of properties.*

Keywords: *homogeneous mixture, flax, polyester, electrical properties, breaking elongation.*

INTRODUCTION

Mixing of the natural cellulosic fibres with synthetic fibres in different proportions may vary their electrical resistance. By friction, textile fibres absorb a large amount of electrons [1-2]. Thus, a method to reduce the static electricity charge of the textile fibres can be the mixing process of different types of fibres. Electrostatic behavior of the fibres and yarns depends on their thickness, and their surface condition, the material nature from which they are made, temperature and relative air humidity etc. The moisture content influence in a large extent, electrical permittivity value because the textile moistened constitutes a mixture of fibres on $\xi_r = 2 - 6$, air with $\xi_r = 1$, and water by $\xi_r = 80$. It is noted the large share of the water on the values of permittivity [3].

Chemical structure of polymer fibers, respectively the presence or absence of polar groups and the macromolecules orientation influences the electrical permittivity [4]. Elementary flax fiber is constituted by almost pure cellulose [5]. In figure 1 is shown the structural unit of cellulose.

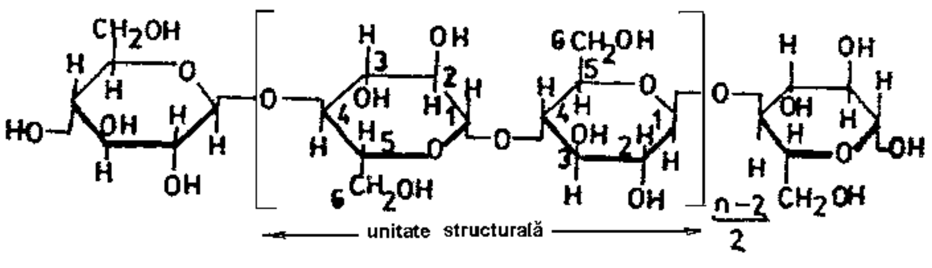

Figure 1. Structural unit of cellulose, [4].

The elementary unit of cellulose contains three free hydroxyl groups, one primary to C6 and two secondary to C2 and C3. These groups differ each other in reactivity atoms, so the primary hydroxyl is 5-6 times more reactive than the secondary hydroxyls.

Polyester fibres type flax is cut to 100 mm length. The polyester used in blended with flax is polyethylene terephthalate obtained by polycondensation reaction of dimethyl terephthalate (DMT) and ethylene glycol (EG). In Figure 2 is presented structural unit of polyethyleneterephthalate (PET).

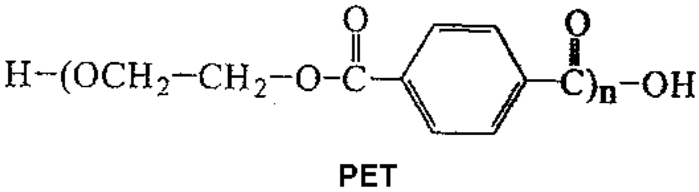

Figure 2. Structural unit of polyethyleneterephthalate (PET), [6].

Supramolecular structure of polyester fibres and of cellulose is biphasic type, the share of the two zones (amorphous and crystalline) depending on the phases of processing. Filamentary yarns cooled are noncrystalline. Crystallization takes place at the stretching. In normal climatic circumstances, the polyester fibres have a low hygroscopicity of around 0.4% which causes good electrical insulating properties, even at high temperatures. Reduced moisture content causes high capacity of electrostatic charge of the polyester that affect the processing behavior causing accumulation of dust and dirt on products from 100% polyester [7].
This paper presents a study of some homogeneous mixtures of flax and polyester fibers in terms of the electrical and mechanical behavior.

EXPERIMENTAL

Materials

Fibres used in this study were like roving. There were analysed the following types of roving: flax 100%; PES 100%; 67% flax and 33% PES; 50% flax and 50% PES.

Metods used

The variation of the electric permittivity related with the specific material was measured with capacitor method. The installation wiring diagram is shown in Figure 3. Measuring of the capacity of the fibers is made like roving. Textile materials analyzed were used as dielectric for a capacitor Cx (Figure 3). Measuring of the capacity of the fibers like roving was performed with Ultra-precision Capacitance Bridge AH 2700 A (ANDEEN-HAGERLING – 50 Hz-20 kHz) apparatus.

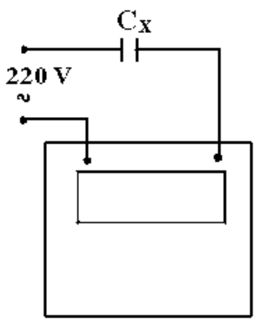

Figure 3. The installation wiring diagram where the fibres like roving layer represent the equivalent of a capacitor (Cx).

Evaluation of the electrical behavior of the fibres studied in this paper was made using relative electrical permittivity. The fibers were pressed between two polished aluminum electrodes having the area (A) of 0.05 m^2 (250 mm x 200 mm) with a force of 30 kg/m^2. The values of the relative electrical permittivity (ξ_r) were calculated using the equation (1), [7]:

$$\xi_r = \frac{C \cdot d}{\xi_0 \cdot A} \quad (1)$$

where: C is the capacitance of the material, (F); d is the thickness of the sample, (m); ξ_0 - electrical permittivity of vacuum or air, ($\xi_0 = 8.85 \cdot 10^{-12} F/m$) and A is the area of sample under electrode, (m^2). The electrostatic behavior of the fibers depends by their surface state, by their thickness, by chemical and supramolecular structure and by the temperature and relative air humidity. The thickness of the stratum of roving was measured on a MICROMASTER capa μ system IP54 TESA micrometer. The measuring of the capacity and of the thickness was made in ten points on the surface of the stratum of roving. Measurements were conducted in the following work conditions: temperature: 25°C, air relative humidity: 35%.

The tensile strength of the flax fibres from raw roving was measured according to ISO 2062 on TINIUS OLSEN H5 K-T (UK) by automatic registering of the force–extension curve. Average length of the flax fibers from roving was 210 mm. The initial length of the tested sample was 50 mm. The distance 50 mm between the clamps of the dynamometer allows the registration of the strength and the elongation at break of the fibers. Average title was 3 tex for flax fibres and 0.6 tex for polyester fibers. The average number of fibers from the cross section has allowed the establishing of fiber strength. For the serial testing in wet stage, the fibres were stressed after 10 minutes of moistening.

Fourier transform infrared (FTIR) spectra of polyester and flax were measured using a Vertex 70 spectrophotometer (Bruker-Germany). The frequencies were expressed in wavenumbers [cm^{-1}]. FTIR spectra are recorded in the 400-4000 cm^{-1} domain with a resolution of 4 cm^{-1}.

RESULTS AND DISCUSSION

In Table 1 are presented the values of the electrical permittivity of fibres homogeneous blended like roving from flax and PES, in dry stage, as the average of 10 measurements.

Table 1. Electrical permittivity of fibres homogeneous blended like roving from flax and PES, in dry stage

Nr. crt.	Name of product	Length density of the roving, [tex]	Capacity, [nF]	Thickness of the roving layer, [mm]	Relative electrical permittivity, ξ_r
1.	Roving from 100% PES	330	0.8	0.9	1.63
2.	Roving from flax 100%	888	0.7	1.4	1.89
3.	Roving from 67% flax + 33% PES	380	1.2	1.0	2.26
4.	Roving from 50% flax + 50% PES	380	1.0	1.0	2.44

Analysis of relative electrical permittivity of the flax fibers, polyester and mixture of flax and polyester (Table 1) allows to the following comments:

Under the same test conditions, the relative electrical permittivity of the flax fibers of 1.89 is close to that of polyester fibers (1.63), by the difference of around 14% (13.7%). This difference may be due to the different internal structure of the two types of fibers. The flax fibers used in this experiment are raw fibers composed from fascicles of cells and natural pigments, potential carriers of electrical charges, as assessed by FT-IR analysis (Figure 4). The major polar groups of the chemical structure in the two types of fibers with active role of the electrical behavior are: in polyester: ester groups (-OC = O), (Figure 5), and in cellulose: hydroxil groups (-OH), (Figure 4). In the spectrum of polyester, the signal located at 1713 cm^{-1} can be attributable to C = O from the carboxyl group and the signals present in the range of 1300-1045 cm^{-1} can be assigned to the ester group. The hydroxil groups from cellulose are present as a broad signal at 3300 cm^{-1}.

The values of relative electrical permittivity of the mixture from flax and polyester fibres are higher compared to those measured for the two pure fibers (Table 1). The cause may be the compensation of the negative electrical charges of polyester fibers with positive electrical charges of the cellulose from flax, that polarize temporarily fibres from the mixture [8].

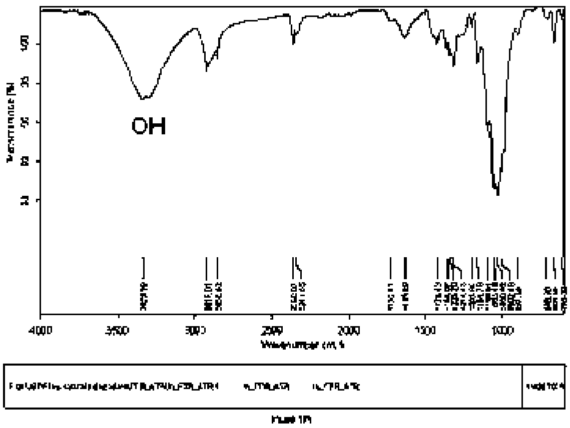

Figure 4. Spectrum FTIR for Flax 100%.

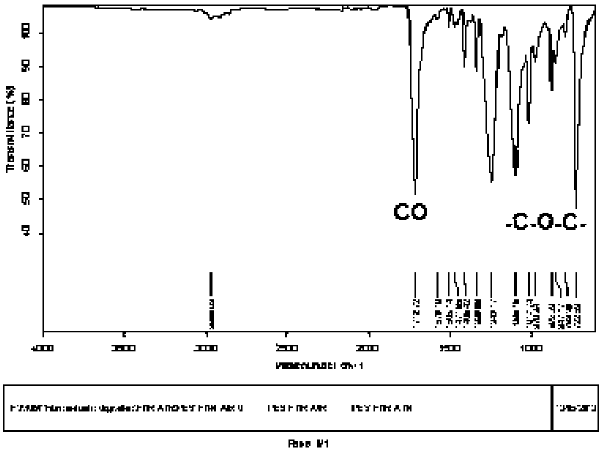

Figure 5. Spectrum FTIR for PES 100%.

The presence of polyester fibres in structure of fabrics type flax improves the behavior of the mixture to electrical and mechanical requests. Major disadvantage of flax, which creates problems in processing and use of products from 100% flax, is reduced elongation at break. Polyester fibres show a high degree of uncreasable that keeps to wearing products [6]. The mixture of flax with polyester contributes first of all on increase the elongation at break of the fibres mixture (Figures: 6 - 9).

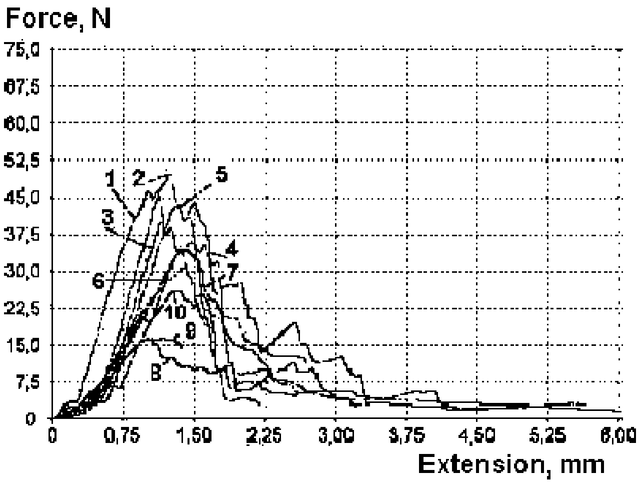

Figure 6. Force-extension curves of fibres from roving flax 100%, tested in dry state: 1-5 curves and in wet state after 10 minutes wetting: curves 6-10.

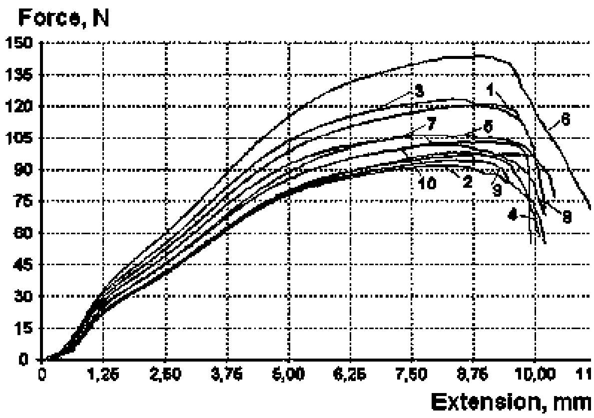

Figure 7. Force-extension curves of fibres from roving PES%, tested in dry state: 1-5 curves and in wet state after 10 minutes wetting: curves 6-10.

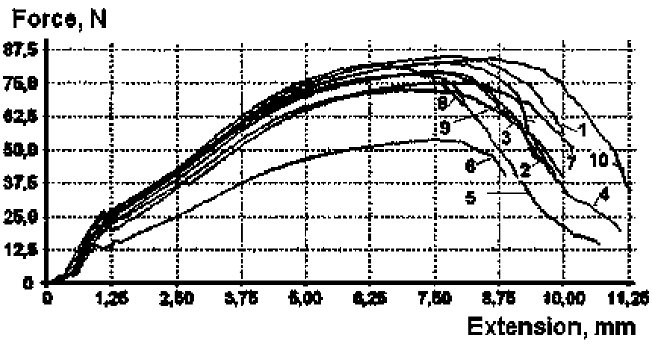

Figure 8. Force-extension curves of fibres from roving: 67% pes – 33% flax, tested in dry state: 1-5 curves and in wet state after 10 minutes wetting: curves 6-10.

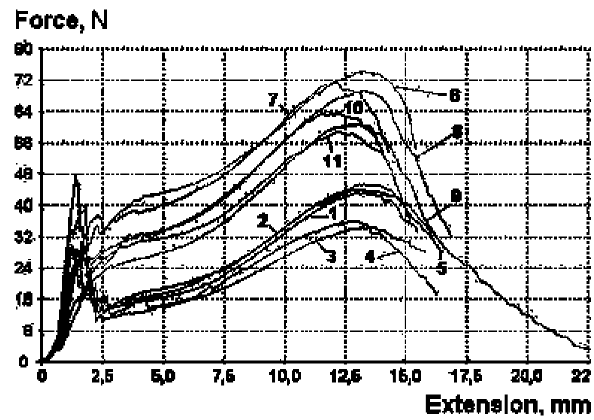

Figure 9. Force-extension curves of fibres from roving: 50% pes – 50% flax, tested in dry state: 1-5 curves and in wet state after 10 minutes wetting: curves 6-10.

The specific resistance of the flax fibers in dry state was 5.2 cN / tex and in wet condition 6.2 cN / tex. Increases of the strength fibers in the wet state by almost 20% after 10 minutes of wetting may be related to increased hydrogen bonds created between macromolecular chains by water absorption. Low relative elongation of fibers in wet state is maintained in the level of 2.5%.

Polyester fibers have similar tensile behavior in dry and humid stages (Figure 7) due to the low hygroscopicity of fibers. This is reflected by values close in two different situations, the specific resistance of the fibers of 30.9 cN / tex, respectively 31.3 cN / tex and relative elongation of 16.9%. Fibers from mixed 67% polyester and 33% flax have specific resistance in the range 20.5-21 cN / tex, in dry state and after 10 minutes of wetting. Average relative elongation of the fibers in the mixture is 15% in dry and 14.8% in wet state.

In the case of mixture of 50% and 50% polyester, the average tenacity is of 10.2 cN / tex in dry state and 16.6 cN / tex in wet condition. The behavior to moisture of the fibers of this mixture is dominated by the flax fibers to which increase the wetting resistance. Average relative elongation is at the level of 26-27% in both cases.

CONCLUSIONS

The presence of polyester fibers in a mixture with flax, increases first of all the elongation at break, which will cause a better behavior at processing and use.

The homogeneous mixture of flax and polyester present an improvement of electrostatic characteristics after friction, by compensation of the negative electrical charges of polyester fibers with positive electrical charges of the cellulose from flax, that polarize temporarily fibres in the mixture.

These mixtures contribute to offsetting the physical and mechanical inconveniences of each type of fibers through the properties of the second type.

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THE EFFECTS OF HEAT-SETTING ON THE TENSILE PROPERTIES OF FLAX/POLYESTER YARNS

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Abstract: *The heat-setting treatment improves efficiency and quality in weaving and knitting plants by slackening yarns, by snarling preventing, by reducing yarn tension, and by fixing yarn twisting. In order to determine how heat-setting influences the tensile properties of flax/polyester blended yarns, on a wet spinning frame there were obtained yarns with average linear density of 140 tex and a composition of 23% flax, 46.7% polyester fibers and 30.3% polyester filaments. After spinning, they were dried and then heat treated at different durations. The analysis of the stress-strain diagrams has demonstrated structural transformations during the deformation of the flax/polyester yarns with filament core. Heat-setting has led to a decrease of yarns mechanical work at break and to a decrease of the factor of mechanical work, but for the treatment with a duration of 5 minutes the values were close by those of the untreated yarn.*

Keywords: *flax/polyester yarns, tensile properties, heat-setting.*

INTRODUCTION

The aims of heat-setting are to slacken yarns, to prevent them from snarling, and to fix yarn twisting, thus making them able to be processed productively in the subsequent operations. The heat-setting treatment improves efficiency and quality in weaving and knitting plants by reducing yarn tension, eliminating electrostatic effects and reducing fly and dust [1]. Previous studies have indicated that the effects of steaming methods on the tenacity, and unevenness of 100% cotton and 100% viscose yarns were statistically significant [2]. The changes of yarns characteristics depend on the treatment parameters, and in some cases heat setting may lead to a loss of mechanical properties [3]. Therefore, the experiments which results are presented in this paper have aimed to determine how heat-setting influences the tensile properties of flax/polyester blended yarns with filament core.

EXPERIMENTAL

The roving made of 67% polyester and 33% flax fibers was processed on a wet spinning frame together with a polyester filament yarn as core yarn. The resulted yarns have had an average linear density of 140 tex and a composition of 23% flax, 46.7% polyester fibers and 30.3% polyester filaments. After spinning they were dried and then heat treated. In order to determine the influence of the duration of the treatment on the tensile behavior, yarns have been heat treated at different treatment duration, for 5 minutes, 10 minutes, 15 minutes, 20 minutes and 25 minutes. Detailed information about the method use for the heat treatment and about the characteristics of the polyester fibers and filaments were presented in a previous paper [4]. From the same flax/polyester roving it was obtained an yarn which was compared with the one spun with the filament core.

The mechanical characterization of the blended flax/polyester yarns was realized according to the standardized methodology (ISO 2062), using a Tinius Olsen H5KT electronic dynamometer and an electronic analytical balance. Before testing, the flax/polyester yarns were conditioned in a standard atmosphere for 24 hours. The initial length of the tested sample was 500 mm. The Tinius Olsen yarn tester registers automatically the values of the breaking force, the breaking elongation and the force-elongation curves. With the help of these curves there was determined for each type of yarn the mechanical work of breaking, which is defined as the necessary energy consumed for yarn elongation up to the breaking moment. This energy is given by the area enclosed under the force-elongation curve [5,6]. For the proportionality area it was determined the slope of the curve.

The factor of the mechanical work was calculated as a ratio of the real mechanical work and the theoretic mechanical work.

$$f_{MW} = \frac{MW_{real}}{MW_{theoretic}} \quad (1)$$

where:
f_{MW} is the factor of mechanical work;
MW_{real} – the real mechanical work, the area enclosed under the force-elongation curve;
$MW_{theoretic}$ – the theoretic mechanical work, which is given by the entire area or by the product of the breaking force and the elongation at break [5,6].

RESULTS AND DISCUSSION

Analyzing the graphs presented in figures 1 to 7, it can be observed that the configurations of the stress-strain curves are characterized by three zones. Thus, for the first zone the stress-strain curve starts at the lower left point as straight line, because the load increases in direct proportion to the extension of the specimen, according to Hooke's Law, until the highest point attained before the line begins to curve, which is called the proportional limit [5,6,7]. Beyond this point the curve proceeds with a zone characterized by elastic deformations, until the point corresponding to the elastic limit, which is the maximum stress that can be applied without any permanent strain remaining when the stress is released. The second zone is characterized by a great deformation for relatively small loads, in presence of the flow phenomenon, and the third zone is characterized by a modification of the curve slope, corresponding to accelerated breaks, finalized by the yarn break.

The behavior of the yarns in the proportionality area of the stress-strain curve is different for the heat treated yarns in comparison with that for the untreated yarns. Thus, for the untreated flax/polyester yarn with filament core it was recorded the highest value of the load corresponding to the limit of proportionality, as can be seen in figure 2. For the flax/polyester yarn with filament core, heat treated for 5 minutes, the load corresponding to the limit of proportionality slightly decreases and the elongation increases, as can be observed in figure 3. For the flax/polyester yarns with filament core, heat treated for 10 to 25 minutes, the loads corresponding to proportional limits decrease intensely and the elongations slightly decrease, as can be found in figures 4 to 7. The yarn fibers are fixed in the yarn sections, because of the twist applied to the yarns and because of the binding substances between flax fibers which remains on the fibers after their exit from the immersion vat of the wet spinning frame. The drying process that follows the wet spinning contributes to the fixing of the fibers into the yarn through these binding substances, leading to yarn strengthen. After heat-setting the structure of yarns modifies, the number of fibers fixed into the yarn decreases, the adhesion coefficient varies and the density of the fibers in the yarn modifies as a consequence of the yarn shrinkage. Thus, for the yarns heat treated for 10 to 25 minutes, the loads corresponding to proportional limits decrease intensely and the afferent elongations slightly decrease.

The flow zone on the stress-strain diagram is characterized by a large extension due to slightly small loads. For all tested yarns the slope of the curve in the flow area decreases strongly compared with the slope of initial straight portion of curve. The slope of flow area varies between 10.7 and 16.7 degrees for flax/polyester yarns with filament core. Analyzing the graphs presented in figures 1 and 2 it can be found that the difference between the values of the maximum and minimum extensions corresponding to the flow zone is greater with approximately 3% for the untreated flax/polyester yarn with filament core, than the flax/polyester yarn, untreated. In the same time, for the untreated flax/polyester yarn with filament core, this value is the greatest among the recorded values for the differences between the maximum and minimum extensions appropriated to flow zone for all type of yarns. For the heat treated yarns this difference slightly decreases with 1-2%. The differences between maximum and minimum specific stresses corresponding to the flow zone, for all type of yarns, vary between 2 and 3.5 cN/tex, but the minimum value decreases with almost 3 cN/tex for the heat treated yarns, with a duration of the treatment of 10 to 25 minutes, compared with the untreated flax/polyester yarn with filament core.

The breaking zone of the stress-strain curve is characterized by accelerated breaking phenomena which occurs in the weakest part of the stressed section of yarn. During the breaking process, irreversible slippages take place between the macromolecular chains of the fibers internal structure. Massive displacements take place between fibers also, and when the forces applied to the yarns overcome the friction forces between fibers and the binding forces between the macromolecular chains, the yarn breaking occurs.

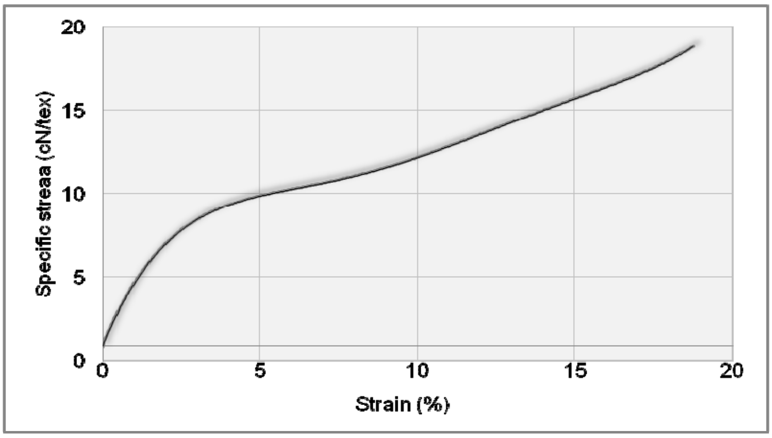

Figure 1: Stress-strain diagram for flax/polyester yarn, untreated (trend curve)

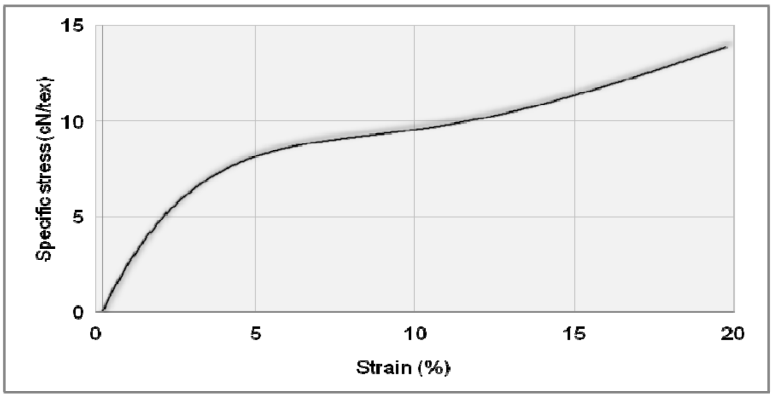

Figure 2: Stress-strain diagram for flax/polyester yarn with filament core, untreated (trend curve)

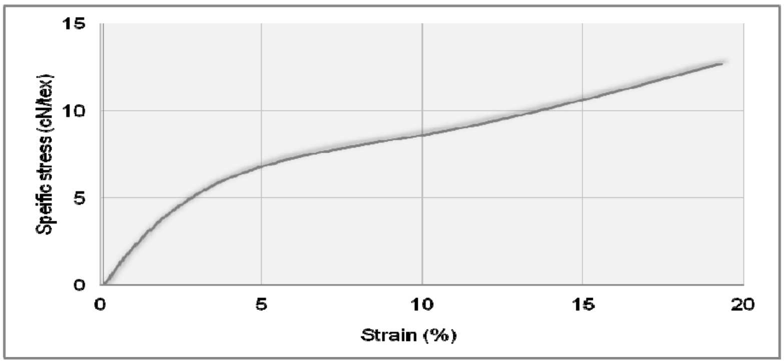

Figure 3: Stress-strain diagram for flax/polyester yarn with filament core, heat treated for 5 minutes (trend curve)

The flow area is separated by the breaking moment by an area in which it is recorded an increasing of the slope of the curve, as a consequence of a temporary phenomenon of strength increasing caused by the interchain binding formed by chain parallelization. The slope of the curve in the breaking area compared with the slope of the flow zone is a little greater, but it is smaller in comparison with the slope of the initial straight portion of curve, the values varying between 18.1 and 23 degrees, for flax/polyester yarns with filament core. The differences between the values of the maximum and minimum extensions corresponding to the breaking zone, for the flax/polyester yarns with filament core, vary between 4 and 7%. The differences between maximum and minimum specific stresses corresponding to the breaking area, for the same yarns, vary between 2 and 4.5 cN/tex.

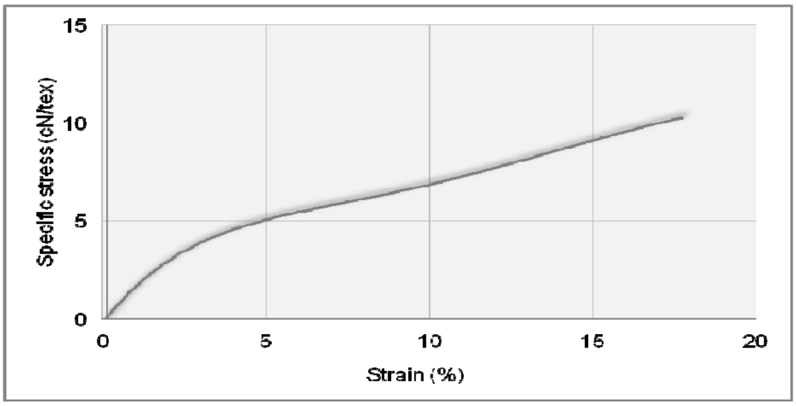

Figure 4: Stress-strain diagram for flax/polyester yarn with filament core, heat treated for 10 minutes (trend curve)

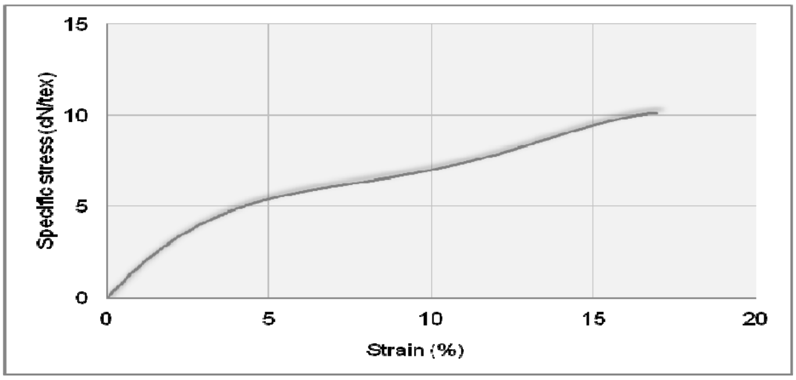

Figure 5: Stress-strain diagram for flax/polyester yarn with filament core, heat treated for 15 minutes (trend curve)

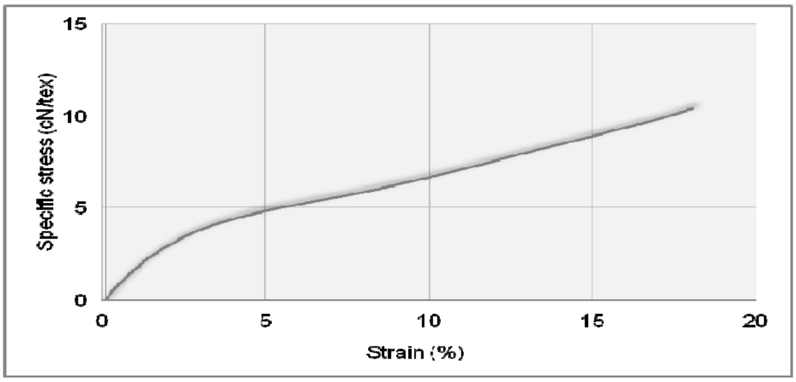

Figure 6: Stress-strain diagram for flax/polyester yarn with filament core, heat treated for 20 minutes (trend curve)

The mechanical work at break represents the energy necessary for yarn extension up to the time of breaking and it can be deduced by calculating the area enclosed under the force-elongation diagram. Values of the breaking mechanical work for the flax/polyester yarns with filament core are presented in table 1. For flax/polyester yarns with filament core, heat treated, there were recorded smaller values of the breaking mechanical work in comparison with the untreated flax/polyester yarn with filament core. This result is a consequence of water vapors absorption of fibers during the heat-setting which modifies the yarns structures and the internal configuration of fibers. The water vapors soak the binding substances of flax thus slacken the bindings between fibers, which do not oppose with a great resistance during tensile testing. The loss of fiber strength is increasing with the duration of treatment at higher temperatures, especially in the presence of air, as a result of oxidative degradation [6].

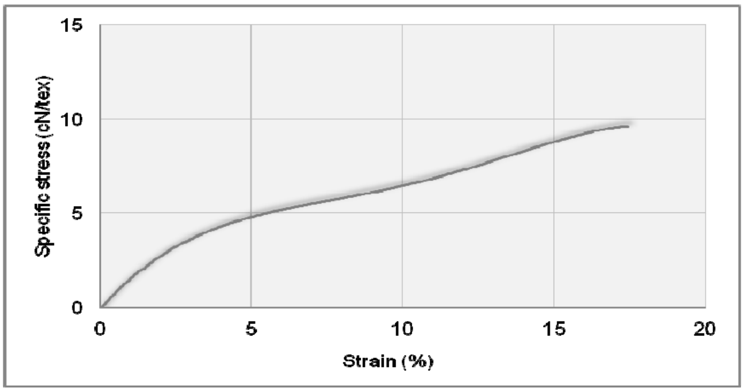

Figure 7: Stress-strain diagram for flax/polyester yarn with filament core, heat treated for 25 minutes (trend curve)

Table 1: Factors for the estimation of the tensional behavior

Type of yarns	Mechanical work at break, J	Factor of mechanical work	Slope of initial straight portion of curve, degrees	Breaking specific stress, cN/tex	Breaking strain, %
Flax/polyester yarn, untreated	0.8391	0.6143	79	18.49	18.70
Flax/polyester yarn with filament core, untreated	1.2787	0.6648	67	13.84	19.74
Flax/polyester yarn with filament core, heat treated for 5 minutes	1.1822	0.6480	61.5	12.61	19.28
Flax/polyester yarn with filament core, heat treated for 10 minutes	0.8125	0.6138	56.7	10.40	17.73
Flax/polyester yarn with filament core, heat treated for 15 minutes	0.7737	0,6271	56.8	10.02	16.95
Flax/polyester yarn with filament core, heat treated for 20 minutes	0.8144	0.5958	55.8	10.43	18,06
Flax/polyester yarn with filament core, heat treated for 25 minutes	0.7600	0.6150	54	9.63	17.43

The yarn ability to support strains and deformations can be evaluated by the factor of mechanical work, which for the ideal curve has the value of 0.5, according to Hooke's law. Analyzing the data presented in table 1, it can be found that all the values of the ratio of mechanical work are greater than 0.5, which means that the fibers develop a strong resistance to deformation. This resistance decreases with the increasing of the duration of heat treatment applied on yarn, as a result of the decreasing of the cohesion forces. Under the influence of heat occurs chemical modification in flax and polyester fibers, such as degradation, decomposition, cross-linking, etc. In general, the breaking strength decreases with the increasing of temperature as a result of the increase in kinetic energy and in molecular mobility [6].

The slopes of initial straight portions of curves decrease with the increasing of the duration of the treatment. Thus, for a heat treatment of 25 minutes the corresponding slope decreases with 13 degrees compared with the slope of the initial straight portions of the curve recorded for the untreated flax/polyester yarn with filament core, as can be observed in table 1.
The maximum value of the breaking specific stress was recorded for the untreated flax/polyester yarn, as can be seen in table 1. As concern the flax/polyester yarns with filament core, for the untreated yarn it was recorded the maximum value of the breaking specific stress, followed by the yarn heat treated for 5 minutes. Durations of treatment longer than 5 minutes have lead to a decrease of the breaking specific stress by maximum 30%. As concern the yarn extension at break, the maximum values have been recorded for the

flax/polyester yarn with filament core, untreated, and for the flax/polyester yarn with filament core, heat treated for 5 minutes. For flax/polyester yarn treated more than 5 minutes, the extension have decreased with maximum 2.3%, compared with the untreated yarn.

CONCLUSIONS

The analysis of the stress-strain diagrams has demonstrated structural transformations during the deformation of the flax/polyester yarns with filament core.

- Heat-setting has led to a decrease of yarns mechanical work at break and to a decrease of the factor of mechanical work, but for the 5 minutes treatment the values were close by those of the untreated yarn.
- The breaking specific stress decreases as a result of the application of heat treatment on yarns; for a heat-setting duration of 5 minutes it was recorded a value of the specific stress proximate to that obtained for the untreated flax/polyester yarn with filament core.
- The breaking strain decreases as a consequence of heat-setting, but for a treatment duration of 5 minutes it was registered a value of the breaking strain close by that resulted for the untreated flax/polyester yarn with filament core.
- The optimal duration of heat-setting is of 5 minutes; after the heat treatment the structure of yarns modifies, the number of fibers fixed into the yarn decreases, the adhesion coefficient varies and the density of the fibers in the yarn modifies as a consequence of the yarn shrinkage. Thus, for the yarns heat treated for 10 to 25 minutes, the loads corresponding to proportional limits decrease intensely and the afferent elongations slightly decrease.

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TENSILE PROPRETIES ANALYSIS OF PLASMA TREATED PP FIBERS

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Abstract:
The paper deals with the influence of plasma treatment process parameters on tensile properties of PP fibers by using ANCOVA (Analysis of covariance) model. This model is a general linear model which blends ANOVA and regression. ANCOVA evaluates whether population means of a depedent variables (DV) are equal across levels of a categorical independent variable (IV). Statistically, the model control the effects of other continuos variables that are not of primary interest, known as covariates (CV).The study has been conducted on three groups of PP fibers depending on fibers position (random, parallel or vertical position) to the electrodes in the treatment field and the coefficient of friction fiber / metal. The position of PP fibers and the coefficient of friction fiber/metal been used as independent variables and tensile strength as dependent variables for ANCOVA model. Based on experimental data, the model find a significant between groups.

Keywords: *plasma, ANCOVA model, tensile properties,SPSS*

1. INTRODUCTION

Low-temperature plasma technology - both glow discharge under reduced pressure as well as barrier discharge under normal pressure - are well established in different industrial applications [1, 2]. However, the plasma technology is being introduced in textile industry as well. Fields of application are desizing, functionalizing, and design of surface properties of textile fibers [3, 4]. Plasma technology is suitable to modify the chemical structure as well as the topography of the surface of the fiber. Hence, an additional surface modification is required to achieve the desired properties, while maintaining the characteristics of the volume [5, 6, 7].
Polypropilene (PP) is a very interesting material for plasma treatment: it is a very hydrophobic material with extreme low surface tension. The plasma treatment will improve fibers properties in special wettability or adhesion properties [7]. Plasma technology, when developed at a commercially viable level, has strong potential to offer in an attractive way achievement of new functionalities in textiles. In recent years, considerable efforts have been made by many plasma technology suppliers to develop both low-pressure and atmospheric-pressure based plasma machinery and processes designed for industrial treatment of textiles and nonwovens to impart a broad range of functionalities [8].
The paper uses the mathematical model ANCOVA to determine correlations between tensile strength and fiber position in the field of treatment, the coefficient of static friction fiber-metal.
ANCOVA model is a useful statistical procedure that is commonly utilized in experimental designs. ANCOVA is essentially a hybrid form of multiple regression and ANOVA and is used to make comparisons between two or more group means after statistically removing the effect of one or more extraneous variables (covariates) on the dependent variable (DV) [9].The purpose of the ANCOVA in experimental designs is to increase the sensitivity of the test of main effects and interactions by reducing the error term [10]. In ANCOVA, the error term is adjusted for the relationship between the DV and the covariate (CV). ANCOVA, CVs are used to assess the "noise" or undesirable variance in the DV that is estimated by scores on the CV [9-12] .

2. EXPERIMENTAL

2.1. Materials

For experiments were used wool-type polypropylene fibres of 6 dtex/ 60 mm, of which yarns destined to double plush carpets manufacturing were obtained. The polypropylene fibres were treated in plasma medium in order to establish if and how their surface and physical-mechanical properties are affected and if improvements can be brought to the polypropylene fibres processing and finishing processes. Being a fibre from the non-polar materials category, the adhesion of inks, dyestuffs and adhesives is much reduced, which makes difficult operations like: printing, dyeing, stratification, flocking, etc.

2.2. Methods

Plasma treatment of polypropylene fibres was performed on a HF-CORONA CGH-20, ARCOTEC GmbH Rotweg installation [13], consisting of three components: Generator, High Frequency Transformer (HVT); Discharge Unit. The alternative current is transformed in direct current, which is then activated at a high frequency of 25÷50 kHz with a voltage of up to 25 kV.

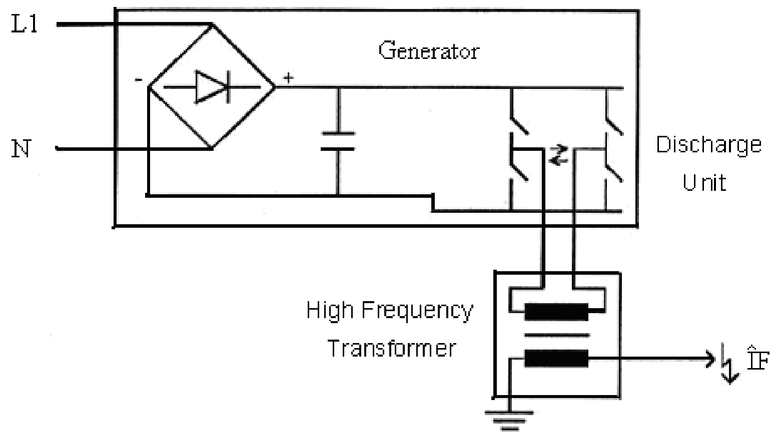

Figure 1. HF-CORONA CG-20 treatment installation

The plasma treated polypropylene fibres have been tested from a physical-mechanical standpoint on the apparatus Textechno H-Stein GmbH 4106 Mönchengladbach, Fafegraph ME, Germany, which records both the individual stress-strain diagrams, and the average diagram; it processes the obtained data and displays the statistical parameters.

3. RESULTS AND DISCUSSION

3.1. Collection, systematization and processing of experimental data

The database in SPSS (Statistical Package for the Social Sciences) includes 25 records concerning the tensile strength variation and the coefficient of fibre/metal friction, differentiated through the fibres position in the treatment field (fibres placed randomly, parallel and perpendicular to the electrodes).
An ANCOVE regression model is built with a nominal independent variable and a quantitative variable, in which:

- dependent variable (Y) = variation of tensile strength Pr (cN);
- nominal independent variable = yarn position (random fibres, fibres parallel to the electrodes and fibres perpendicular to the electrodes);
- quantitative independent variable: coefficient of fibre/metal friction, μ_s.

3.2. (Enunciation of) Hypotheses

Ho: there are no significant differences between the tensile strengths of polypropylene fibres depending on the fibres position in the treatment field, and the static coefficient of fibre/metal friction;
H1: there are significant differences between the tensile strengths of polypropylene fibres depending on the fibre position in the treatment field, and the static coefficient of fibre/metal friction.

3.3. Building the regression model

The nominal independent variable "yarns position" has three categories; therefore two dummy variables will be built. The position of the reference fibres (D1, D2= 0) will be that of random yarns; therefore all the interpretations will be made in comparison with this category of fibres. Table 1 presents the transformation in dummy variables.

Table 1. Transformation in dummy variables

Group	D_1	D_2	Fibres position
1	1	0	Fibres parallel with the electrodes
2	0	1	Fibres perpendicular to the electrodes
3	0	0	Random fibres

The ANCOVA model is defined by the relation:
$Y = \alpha_o + \alpha_1 D_1 + \alpha_2 D_2 + \beta_1 X_1 + \varepsilon$
Conditioned mean:
$M (Y/D) = (\alpha_o + \alpha_2) + \beta_1 X_1$ $D_1 = 0$, $D_2 = 1$- variation of tensile strength for random fibres;
$M (Y/D) = (\alpha_o + \alpha_2) + \beta_1 X_1$ $D_1 = 1$, $D_2 = 1$ - variation of tensile strength for fibres perpendicular to the electrodes;
$M (Y/D) = (\alpha_o + \alpha_1) + \beta_1 X_1$ $D_1 = 1$, $D_2 = 0$ - variation of tensile strength for fibres perpendicular to the electrodes.
The coefficients of ANCOVA model are calculated in Table 2. The model's estimators and estimates are defined similarly to the previous models.

Tabel 2 – Model ANCOVA - Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	21.136	3.423		6.175	0.000
	D_1	-3.923	0.404	-1.002	-9.705	0.000
	D_2	-1.962	0.497	-0.404	-3.951	0.001
	Coefficient friction	-5.122	9.706	-0.049	-0.528	0.603

a. Dependent variable: breaking strength Pr (cN)

The regression model will have the form:
$Y = 21.136 – 3.923 D_1 – 1.962 D_2 – 5.122 X_1$

3.4. Interpretation
a) a_o = **21.136** - variation of tensile strength of random fibres under the condition that the friction coefficient is zero;
b) $a_o + a_1 = 21.136 - 3.923 =$ **17.213 -** variation of tensile strength of the fibres parallel to the electrodes under the condition that the friction coefficient is zero;
c) $a_o + a_2 = 21.136 - 1.962 =$ **19.174** - variation of tensile strength of the fibres perpendicular to electrodes under the condition that the friction coefficient is zero;
d) b_1= - 5.122 shows the variation of tensile strength of random fibres when the contact surface between fibres and electrodes is smaller, therefore the friction coefficient decreases. In Table 2 one can notice that Sig. < 0.05 (except for sig. for the friction coefficient, its value being 0.603).
Note: Though Sig. for the friction coefficient exceeds the value 0.05 (which proves that the friction coefficient does not significantly influence the dependent variable), it was not excluded at processing through *Backward* method (Table 3).

Tabelul 3. Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Coefficient friction, D_2, D_1	0.000	Enter

a. All requested variables entered.
b. Dependent Variable: Breaking strength Pr (cN)

By interpreting the value of Sig., one can conclude that there are significant differences between the variation of tensile strength of polypropylene fibres depending on the fibres position in the treatment field (the null hypothesis H_o is rejected). The fibre/metal friction coefficient significantly influences the variation of tensile strength for random fibres.

3.5. Hypothesis on errors
3.5.1. M(ε) = 0 (null error mean).
Hypotheses:
H_o: $M (\varepsilon) = 0$
H_1: $M (\varepsilon) \neq 0$
One applies the t Student test for errors (unstandardized Residual) - Table 4.

Tabel 4 – One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper
Unstandardized Residual	0.000	24	1.000	0.00000000	-0.3433753	0.3433753

Sig. = 1 (>0.05), therefore H_o is accepted, the error mean being 0.

3.5.2. V (εi) = σ^2 (homoscedasticity hypothesis)

A test of non-parametric correlation between estimated errors and dependent variables is applied; then and the Sperman correlation coefficient and the Student tests are calculated for this coefficient (Table 5).

Hypotheses:

H_o: the correlation coefficient differs insignificantly from 0 (null hypothesis of the test t Student)

H_1: the correlation coefficient significantly differs from 0 (the null hypothesis of the test t Student is rejected).

The values of Sig. t for the correlations are: breaking load Pr (cN)- estimated errors (0,181), D_1- estimated errors (0.710), D_2- estimated errors (0.895), friction coefficient - estimated errors (0.667) are >0.05; the null hypothesis of the Student test is rejected, therefore the model is homoscedastic.

Table 5. Spearman test for the verification of homoscedasticity hypothesis

			breaking load Pr (cN)	D1	D2	Coefficient friction	Unstandardized Residual
Spearman's rho	breaking load Pr (cN)	Correlation Coefficient	1.000	-0.860**	0.069	-0.079	0.276
		Sig. (2-tailed)	.	0.000	0.742	0.707	0.181
	D_1	Correlation Coefficient	-0.860**	1.000	-0.443*	0.112	0.078
		Sig. (2-tailed)	0.000	.	0.026	0.594	0.710
	D_2	Correlation Coefficient	0.069	-0.443*	1.000	-0.202	-0.028
		Sig. (2-tailed)	0.742	0.026	.	0.334	0.895
	Coefficient friction	Correlation Coefficient	-0.079	0.112	-0.202	1.000	0.091
		Sig. (2-tailed)	0.707	0.594	0.334	.	0.667
	Unstandardized Residual	Correlation Coefficient	0.276	0.078	-0.028	0.091	1.000
		Sig. (2-tailed)	0.181	0.710	0.895	0.667	.

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

3.5.3. $\varepsilon_i \sim N(0, \sigma^2)$ – Hypothesis of normality

The normality of errors distribution is tested by means of the Kolmogorov- Smirnov non-parametric test (Table 6).

Table 6 – Test of normality hypothesis

One-Sample Kolmogorov-Smirnov Test		Unstandardized Residual
N		25
Normal Parameters[a,b]	Mean	0.0000000
	Std. Deviation	0.83186083
Most Extreme Differences	Absolute	0.120
	Positive	0.092
	Negative	-0.120
Kolmogorov-Smirnov Z		0.598
Asymp. Sig. (2-tailed)		0.867

a. Test distribution is Normal.

b. Calculated from data.

Sig. = 0.876 (bigger than 0.05), therefore the hypothesis of normality is accepted (H_o).
As one can see in Figure 2, the parameter estimations indicate a deviation of errors distribution from the normal distribution.

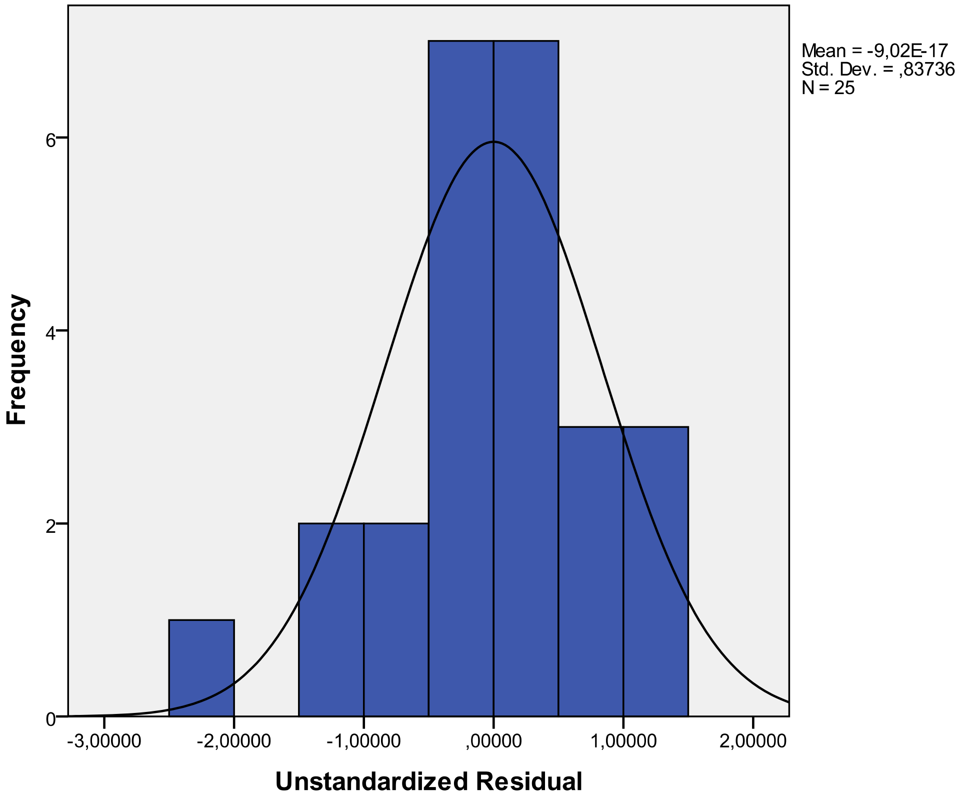

Figure 2. Estimated errors distribution

3.5.4. cov (εi , εj) – error autocorrelation test
Hypotheses:

H_o: ρ= 0 (errors are not correlated)
H_1: ρ ≠ 0 (errors are correlated.

Verification is made with Durbin-Watson test (Table 7).

Table 7. Durbin-Watson test for error auto correlation verification

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.908[a]	0.824	0.799	0.88930	2.036

The value 2.036 is compared with the calculated value of the test (dl, du). One can notice that the obtain value ranges within the interval (du, 4 – du), which leads to the acceptance of null hypothesis (errors are not auto-correlated).
The test statistic is the following: $DW = d = 2(1-\hat{\rho})$ where $\hat{\rho}$ is the correlation coefficient error estimator and fulfilling the following condition: $-1 \le \hat{\rho} \le 1$. If $d = 2(1-\hat{\rho})$; the statistic values are within the range: $0 \le d \le 4$.
The calculated value of Durbin-Watson statistic d_{calc} = 2.036 is shown in Table 6. This value is compared with the critical values, noted d_L = 1.288 (lower limit) and d_U=1.454 (upper limit) which are read from the Durbin-Watson table for a threshold of significance 0.05, for a regression model with two parameters [14].

3.6. Test of independent variables co-linearity

Test of independent variables co-linearity in Table 8

Table 8. Test of independent variables co-linearity- Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B		Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1 (Constant)	21.14	3.423		60.18	0.000	14,018	28.254		
D_1	-3.923	0.404	-1.002	-9.705	0.000	-4.764	-3.082	0.786	1.273
D_2	-1.962	0.497	-0.404	-3.951	0.001	-2.995	-0.929	0.802	1.247
coeffriction	-5.122	9.706	-0.049	-0.028	0.603	-25.306	15.062	0.977	1.023

The value of the VIF indicator ranges between (1.023 ÷ 1.273), which indicates that there is a co-linearity between the independent variables used in the model.

CONCLUSIONS

1. The ANCOVA model permits us to evaluate the homogeneous character of a population by separating and testing of the effects caused by the considered factors.

2. If the test data obtained after trials on the elements of a sample taken from one homogeneous population are divided in distinct groups, then the mean values of the groups do not differ significantly between themselves.

3. In the case of a non-homogeneous population, the deviations of the individual values as compare to the mean value are no longer accidental and when dividing the test data in distinct groups, the mean values differ between themselves significantly because of some causes having a systematic action.

4. The plasma-treated polypropylene fibres loose part of their tensile strength, namely they have smaller values than for the untreated fibres; this indicator is influenced by the treatment conditions and the fibres position in the treatment field.

5. For all the tested variants the coefficients of fibre-metal friction recorded values above the witness-sample; the bigger increase of the static friction coefficient of about 33% being obtained at the variants at which the fibres were disposed parallel to the electrode.

6. By using the ANCOVA model and interpreting the Sig value, one can draw the conclusion that there are significant differences between the tensile strength variations of polypropylene fibres depending on the fibres positions in the treatment field (the null hypothesis H_o is rejected). The coefficient of fibre-metal friction significantly influences the tensile strength variations of the random fibres.

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COMPUTER METHOD FOR EVALUATING OF CROSS-SECTION FILAMENTS IN PP YARNS USED FOR CARPETS

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Abstract: *In this paper, image processing technique applied to the cross-sectional areas of the filaments in PP yarns. There are many parameters of cross section which affects the physical and mechanical properties of yarns. The surface area and perimeter are the main cross section parameters. Therefore, they were evaluated by an original image processing technique. This fast method provides an accurate method that can measure the area and perimeter of filaments without errors.*
The research work wad done on four variants of dyed yarns from isotactic PP filaments and isotactic and maleic PP filaments. Based on experimental data were plotted histograms for average values of areas and perimeters of the studied PP yarns. Comparing the experimental data are observed differences between the areas of the filaments in yarns containing in composition maleic PP and filaments in 100%PP isotactic yarns. The areas of filaments in PP yarns with maleic PP are smaller than areas of 100% isotactic PP yarns. The values of perimeter are almost the same for those four yarn variants. Maintain perimeter around the same value and a decreasing of area means changing the shape of the section, namely a better trilobal shape of filaments. The effects of these changes will affect the yarns characteristics and the processing textile of those yarns.

Keywords: *image processing, cross-section area, cross-section perimeter*

1. INTRODUCTION

The dynamic developing in computer technologies has founded a broad opportunities in different aspects of engineering. Image processing techniques become a widespread mean for identifying, monitoring and measuring. Therefore, in textile engineering, this technique has been used in many aspects of textile field [1-3]. Polypropylene is the most utilized thermoplastic polymer used as thermoplastic matrix. The polymeric materials selected to be used as polymer matrix in the realization of composites must satisfy a series of conditions. The polymeric matrix has the role to take over and to transmit the shocks perceived by the composite material. In this connection, the polymeric matrix must be made of flexible, elastic materials and to possess high mechanical strength. The polymeric material also need to be compatible with the reinforcement; it must adhere to and to incorporate the reinforcement, in order to produce a strong bond with this [4,6] Based on the polypropylene polymeric compound, BCF–type yarns were obtained, which were dyed through the liquor bath and dope dyeing technologies. At dyeing, the fibre enters in contact with an aqueous dyestuff solution, which, besides the dyes, includes auxiliary agents, such as alkali, acids, neutral salts or dyeing agents. The type of these chemicals mainly depends on fibre type and presentation form, as well as on the dyeing process [7,8]. The work presents the evaluation of filaments perimeter and cross-area surface using the method described by the CAV 2 program. A procedure for measuring the cross-section areas of cotton fibres with an image analyzer was developed [9, 10].

2. EXPERIMENTAL

2.1. Materials

This study was performed on BCF yarns of the blend 95 iPP/5 PP-g-AM, with the nominal yarn number of 2600/150 dtex, in two variants: dyed in liquor bath (V_B) and dope dyed (V_D). Witness samples (V_A, V_C) have been realized for each variant. The basic materials used for the realization and dyeing of BCF yarns are presented in Table 1.

Table 1. Basic materials used for the realization and dyeing of BCF yarns

	Basic materials	
BCF YARNS	realization	- isotactic polypropylene MIDILENA III- J700 - polypropylene grafted with maleic anhydride EXXELOR PO1015
	dyeing	- dispersion dyes: REMAFIN BRUNO TPP 82076039, BEMACRON MARINE BLAU SE-RDL, TERASIN GELB 4G SANYLENE NOIR PP BLCN; - preparation- CONOLAN; - dispersion agent – DISPERGER MITTEL; - acetic acid; - carrier- EGAZOL; - defoaming agent- COLASOL; - antistatic- paraffin coating- RAYOLAN FRS

The five variants of utilized yarns differ from each other through the components of polymer material and the dyeing technology, namely:
- variants of float dyed yarns:
V_A of 100% iPP;
V_B of 95% iPP/ 5% PP-g-AM;
- variants of dope dyed yarns:
V_C of 100% iPP;
V_D of 95% iPP/ 5% PP-g-AM.
V_E of 100% iPP.

The variants V_C and V_E differ through the utilized dyes. The V_E variant is necessary for providing the number of five plush yarn systems, required by the structure of the carpet to be woven.

2.2. Methods

The area of fiber cross-section can be determined through:
- gravimetric method;
-area measurement/planimetric method.

Both methods imply fiber sectioning and drawing the contour on calking paper. In the gravimetric method, the relation for fiber cross-section area calculation is:

$$A = \frac{A_h}{m_h} \cdot m = k \cdot m \tag{1}$$

where: A_h is the known reference area;
m_h – mass of the calking paper corresponding to the reference area drawing;
m - mass of the calking paper on which the fiber section contour was drawn;
k – gravimetric constant, namely the area of paper unit mass.

The second method also consists in drawing the contour of the measured area, as well as the contour of reference surface, which is then integrated. The ratio between the area of a surface and the number of divisions recorded by the planimeter is then calculated.

3. RESULTS AND SISCUSSIONS

The work proposes an original method to determine the perimeter and the area of filament cross section, described by the CAV 2 software [11]. The main stages realized by this software are:

Operation I: Load/enter the images of filament cross sections in the program (Fig. 1).

Operation II: Load/enter in the program the images of the filaments selected from each cross section apart, after having been previously chosen, making use of a specific selection version (Fig. 2).

Operation III: make the selection in terms of colors: “red” image; “green” image and “blue” image (Fig. 3). Image analysis shows that in all the cases the “blue” image gives maximum of information and has an optimum quality for subsequent processing. Thenceforth use only the “blue” image for specific images processing.

Operation IV: convert the “blue” images into representations in grey hues ranging within the interval [0 1], where level “0” corresponds to perfect black, while the level “1” corresponds to perfect white. There are 256 grey hues.

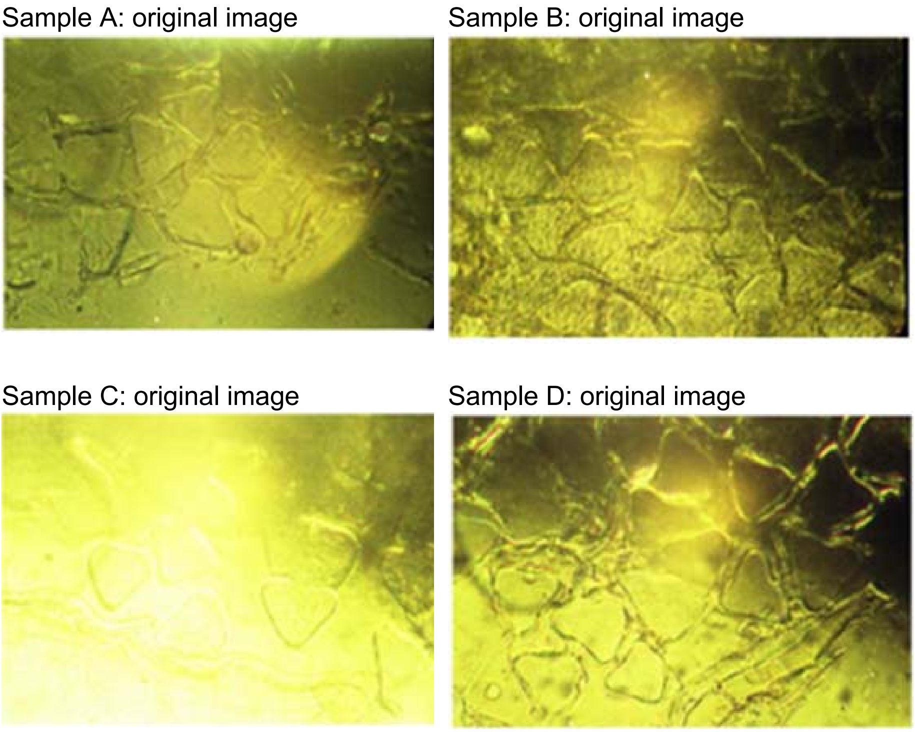

Figure 1. Images of filaments cross sections

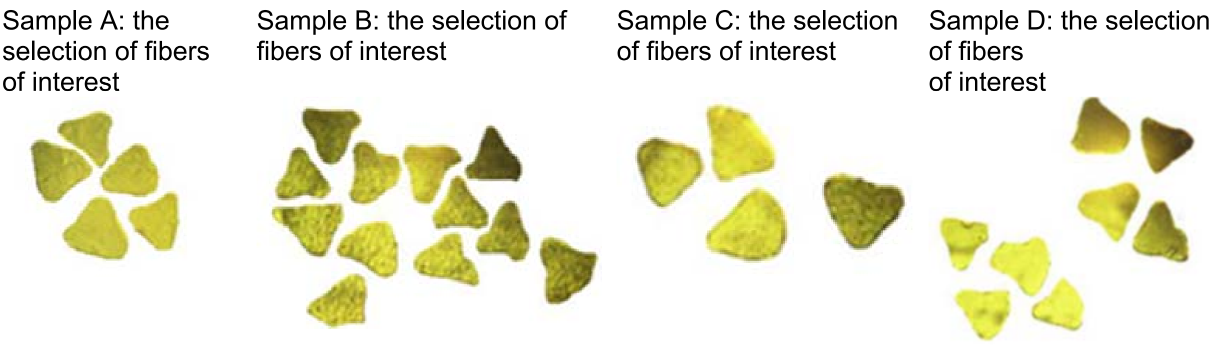

Figure 2. Images of selected filaments

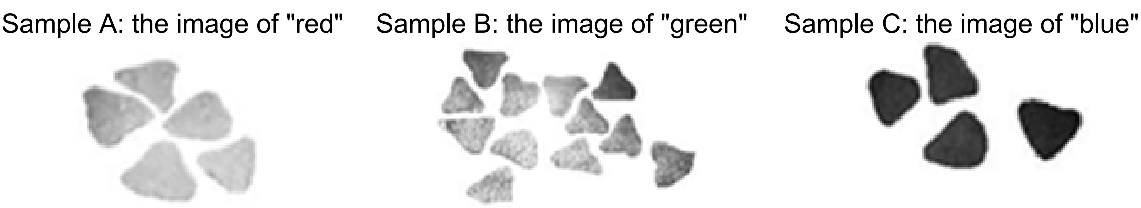

Figure 3. Images selected in terms of colors

Operation V: Filter the images by means of a “median” type digital filter on 15 pixels.

Operation VI: Convert the images in binary system (there are only two possible values for pixels, namely “0” for black and “1” for white. This operation is performed by means of a threshold established based on the previous image histograms (operation V) (Fig. 4).

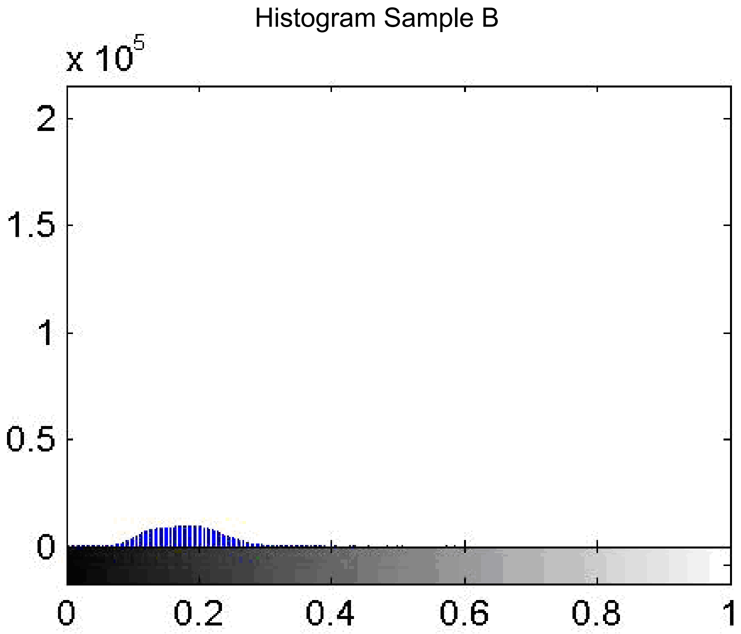

Figure 4. Binary images for the four sample B

Operation VII: Automatically count the selected filaments; determine the mean filaments area on each cross section apart.
Operation VIII. Determine the filaments mean diameter; binary images are segmented by means of Canny algorithm (Fig. 5).

Figure 5. Binary image segmentation with Canny algorithm

The mean determined areas have the pixel as a measuring unit. In order to find the correspondent in surface measuring units, load the image which contains the scale calibrated in mm. The distance between two consecutive small divisions is 0.01 mm. Estimate then the number of pixels between two divisions and the dimension of a pixel in mm^2 respectively. Proceed similarly to the perimeter evaluation in unit length.
The mean values of the two measured parameters are presented in Table 6.5

Table 6. Mean values of aria and perimeter of filaments cross section.

Varianta **Parametrul**	**U.M.**	V_A	V_B	V_C	V_D
Aria	mm^2	0,0026	0,0021	0,0027	0,0023
Perimeter	mm	0,1767	0,1687	0,1772	0,1690

The method proposed for the determination of the cross section areas and perimeters of fibers or filaments is fast and precise. It removes apparatus or measurement errors that can appear at the methods used for this analysis.
By comparing the values from the above table, one can notice the differences between filaments areas, namely: the filaments of maleate polypropylene have areas by 20% (V_B) and 15% (V_D) respectively smaller than those of the corresponding 100% polypropylene filaments (V_A and V_C). In exchange, the perimeter recorded for the both variants of modified polypropylene presents only a 4.5% decrease. Maintaining the perimeter around the same value and decreasing the area, signify the cross section modification, namely a better outlining of the trilobate filament shape. The effects of these modifications will affect the yarn characteristics, as well as their textile processing.

CONCLUSIONS

Development of a new method for the determination of filaments perimeter and cross section, solved through an original program, CAV 2. The method comes into prominence by fastness, precision measurements and complex results interpretation; it can be applied to all types of fibers. The filaments from the blend with maleate polypropylene have the area by 20% (V_B) and 15% (V_D) respectively smaller than that of the 100% polypropylene filaments (V_A and V_C), while the perimeter has recorded a decrease by about 4.5% for the both variants of modified polypropylene.
Maintaining the perimeter at about the same value and the more pronounced area diminution determine a better outlining of the trilobate filament shape.

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BURNING BEHAVIOR OF COTTON FABRIC COATED WITH PERLITE

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Abstract: *In this study, perlite mineral was applied to the textile surface for the first time. Perlite is an industrial mineral, which contains over than 70 percent SiO_2 in its composition. Perlite is used in many different industrial fields, due to its porous structure, flame resistance, heat and sound insulating properties. To take advantage of the properties owned by perlite, both expanded and unexpanded perlite were separately applied to cotton fabric surface. Cotton fabrics were coated with perlite one sided and both sided. LOI, vertical, horizontal and 45^o slope flammability tests were performed for determining the effect of perlite on the burning behavior of the cotton fabric. According to the results obtained from the burning tests, it can be said that perlite has affected the burning behavior of cotton fabric by increasing the burning time and reducing the flame spread rate. Unexpanded perlite coated fabrics have demonstrated better results than that the expanded perlite coated fabrics.*

Keywords: *perlite, expanded perlite, cotton fabric, burning behavior.*

INTRODUCTION

Cotton fabric has been widely used in textiles and clothing products due to its excellent properties such as softness, breathability, and ability to absorb moisture. Also cotton is comfortable, a natural product, a renewable resource, and environmentally friendly [1]. The main obstacle of using cotton fabric for special textiles is its high flammability [2]. Cotton fabric burns rapidly once ignited, and the flame spreads quickly, potentially causing fatal burns within 15 seconds (s) of ignition [3]. It is very important for human safety to find ways to render the fabric less flammable. There is a better chance for people to escape uncontrolled fires by slowing down the burning process. Hence there have been a large number of studies on the treatment of cotton fabric with flame retardants [4-11]. The most important commercial flame retardants are based on phosphorus compounds [3]. Mostly used method is, applying the fire retardant formulations on textile structures during the finishing processes. In recent years, inorganic materials such as SiO_2, TiO_2 and clays, etc., are investigated for improving flame retardancy of cotton fabric [3,12-16].

Perlite is an industrial mineral which contains SiO_2 more than 70% and used in the industry due to its resistance to flame, both heat and sound insulation properties. Perlite is a siliceous volcanic glassy rock with an amorphous structure. When it is heated rapidly to elevated temperatures (600-1280 ^oC), it expands to 4-40 times of its initial volume and it is afterwards named “expanded perlite” [17-18]. Result of its expansion, tiny bubbles occur in perlite structure which are giving the material an excellent insulation property, lower density and high porosity (90%) [19-20]. The expanded perlite is white in color, and has a density of about 32 kg/m^3 [21]. Perlite is mainly composed of silicon dioxide (71-75%), aluminium oxide (12-16%), potassium oxide (4-5%) and sodium oxide (2.9-4.0%) [22-23]. Expanded perlite acts as an excellent insulator for both thermally and acoustically, resists fire and is classified as ultra-light weight material [23-27].

Perlite has a considerable production and consumption amount in worldwide. The leading countries producing perlite include United States, China, Greece, Japan, Hungary, Armenia, Italy, Mexico, Philippines and Turkey [18]. Turkey has the most of perlite reserves in the world (about 70%) [22]. It is estimated that the total amount of perlite reserve in the country is approximately 4.5 billion tons [27-28]. Perlite is very cheap and easily available in Turkish markets. Expanded perlite is extensively used in many industrial applications due to its favorable physical and chemical characteristics. It is used as a lightweight aggregate for insulation board, plaster and concrete in the construction industry, an insulation material in cryogenic applications, a rooting medium and soil conditioner in horticulture, an aid in filtering water and other liquids in food and pharmaceutical industry, an adsorbent material in chemical industry and a filler material in various processes such as paints, enamels, glazes, plastics and cosmetics [23, 28-32]. Perlite is used in textile industry only for washing of denim clothes. It is used as a bleaching agent which gives stoning effect to the denim fabric. However, it has not been found any study in the literature on the use of perlite in textile surfaces.

In the present study, we have aimed to apply perlite to the textile surface for taking advantage of the some properties that perlite has such as the flame resistance and heat insulation properties. For this purpose, both expanded and unexpanded perlite were applied to cotton fabric surface via industrial knife coating machine. Cotton fabrics were coated with perlite one sided and both sided. The effect of perlite on the burning behavior of the fabric was evaluated by LOI (Limiting oxygen index), vertical, horizontal and 45^o flammability tests.

EXPERIMENTAL

In this study 2/1 twill weave 100% cotton fabric that has 194 g/m^2 mass per unit area was used. Perlite was obtained from Cumaovası Perlite Processing Plants of Etibank (İzmir, Turkey). The chemical composition of the perlite is given in Table 1.

Table 1: Chemical composition of perlite

Constituent	Percentage
SiO_2	74.24
Al_2O_3	13.57
K_2O	5.14
Na_2O	3.04
CaO	0.96
Fe_2O_3	0.89
MgO	0.20

Perlite was used both in unexpanded and expanded forms but not together. Two different recipies were prepared as shown in Table 2. Bleached cotton fabrics were coated seperately with expanded and unexpanded perlite by a commercial knife coating machine (Stork CT4). The coated fabrics were dried and cured at 170 ^{o}C for 2 min. Fabrics were coated with perlite by one side and both two sides.

Table 2: Formulation of the recipies

Contents	Paste with unexpanded perlite	Paste with expanded perlite
Perlite (g/L)	500	417
Anti foam agent (g/L) (Mensan Tego PS-10)	3	2
Ammonia (g/L) (Gürtaş)	5	3.3
Acrylic binder (g/L) (BASF Helizarin ET-95)	200	200
Thickening agent (g/L) (CİBA Alcoprint PT-RV)	4	2.5
Water (g/L)	287.4	372

The surface morphology of coated and uncoated fabrics was observed by JEOL JSM-6060 scanning electron microscope (SEM) operating at 8 kV.

The vertical flammability of fabrics was performed on a SDL Flammability Tester M233/B according to the standard of TS EN ISO 6941 [33]. Flame length was 40 mm and flame was applied for 12 s. In this method, a vertical fabric with the sizes of 560 mm x 170 mm was exposed to the flame of a horizontal burner at a distance of 2 cm from the short bottom side. The flame spread times to the marking threads (merserized bleached 50 tex cotton threads) were strung at 24, 39 and 54 cm distances from the bottom were recorded for the evaluation. The moment of any of the threads burned, the breakage was automatically recorded from sensors to the time recorders. For each fabric type, three specimens for both warp and weft directions were tested.

The horizontal flammability of fabrics was determined according to the standard of TS 6346 [34]. The length of the flame was 38 mm and the flame was applied to the fabric specimen for 15 s. In this test method, the specimen sizes of 335 mm x 95 mm was mounted horizontally and exposed to the flame from the short side of the fabric. Burning time was recorded from the breakage of two marking threads that have 254 mm distance between each other. Flame spread rate (mm/min) and burning time (s) were determined by the average of five measurements for both warp and weft directions.

The 45^o flammability of the fabrics was measured according to ASTM Test Method D1230 [35] using a flammability tester (Model 7633 E manufactured by United States Testing Co. Inc). Each fabric specimen (50 mm x 150 mm) was mounted in a specimen holder positioning at 45^o angle. A standardized butane flame was applied to the fabric surface near the lower end for 1 s, and the time required for the flame to proceed up the fabric a distance of 127 mm is recorded. For each fabric type, flame spread time was determined according to average of five specimens for weft direction.

Limiting oxygen index (LOI) was measured for coated and uncoated fabrics according to ASTM D 2863-77 [36] by using LOI instrument which was designed according to related standard. Five specimens of each sample were prepared in 52 mm x 140 mm. The minimum fraction of oxygen in a mixture of oxygen and nitrogen in which one specimen will just sustain burning was determined and reported as the LOI value.

Prior to all the measurements, the fabric samples were conditioned under standard atmospheric pressure at 65±2% relative humidity and 20±2 ^{o}C temperature for at least 24 h.

RESULTS AND DISCUSSION

3.1 SEM observation of the surface

The micrographs of uncoated and coated fabrics determined from SEM records are given in Figure 1. The cotton fibers are seen from the image of uncoated fabric Fig. 1(a). It can be seen that for both of the fabrics that were coated with expanded and unexpanded perlite (Fig. 1(b) and (c)), the whole surface was covered with perlite. Perlite has filled the gaps between the fibers so the surface has become smoother.

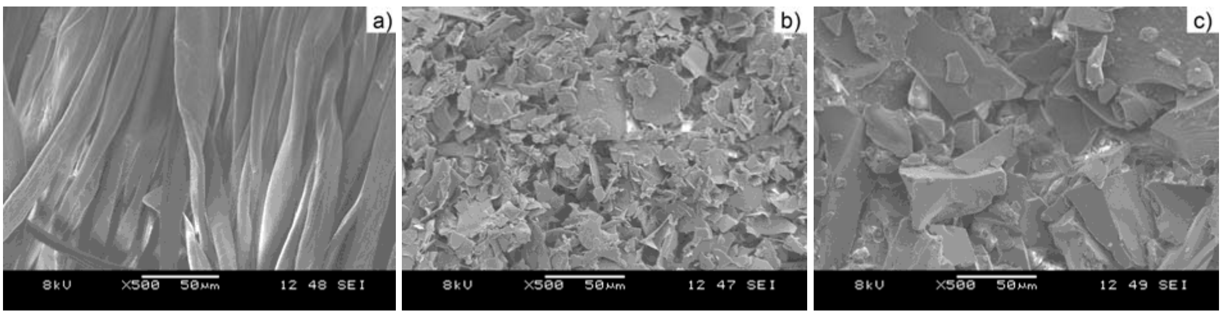

Figure 1: SEM images of fabrics a) uncoated fabric b) fabric coated with expanded perlite c) fabric coated with unexpanded fabric.

3.2 Vertical flammability of fabrics

Vertical flammability test results according to TS EN ISO 6941 are given in Figure 2 as the flame spread time (s) that was obtained from the breakage time of the first, second and third threads which strung at 24, 39 and 54 cm distances from the bottom, respectively. It can be seen that flame spread times of coated fabrics are higher than that the uncoated fabric. The flame spread times of the fabrics coated by two sides are more than that the fabrics coated by one side as expected. The flame spread time of the fabric coated with expanded perlite by two sides is almost 2 times of that uncoated fabric results. The fabric coated both sided with unexpanded perlite shows the highest flame spread time among all fabrics and that is approximately 3 times more than that uncoated cotton fabric. It can be said that the spread speed of the flame on the perlite coated fabrics is retarded.

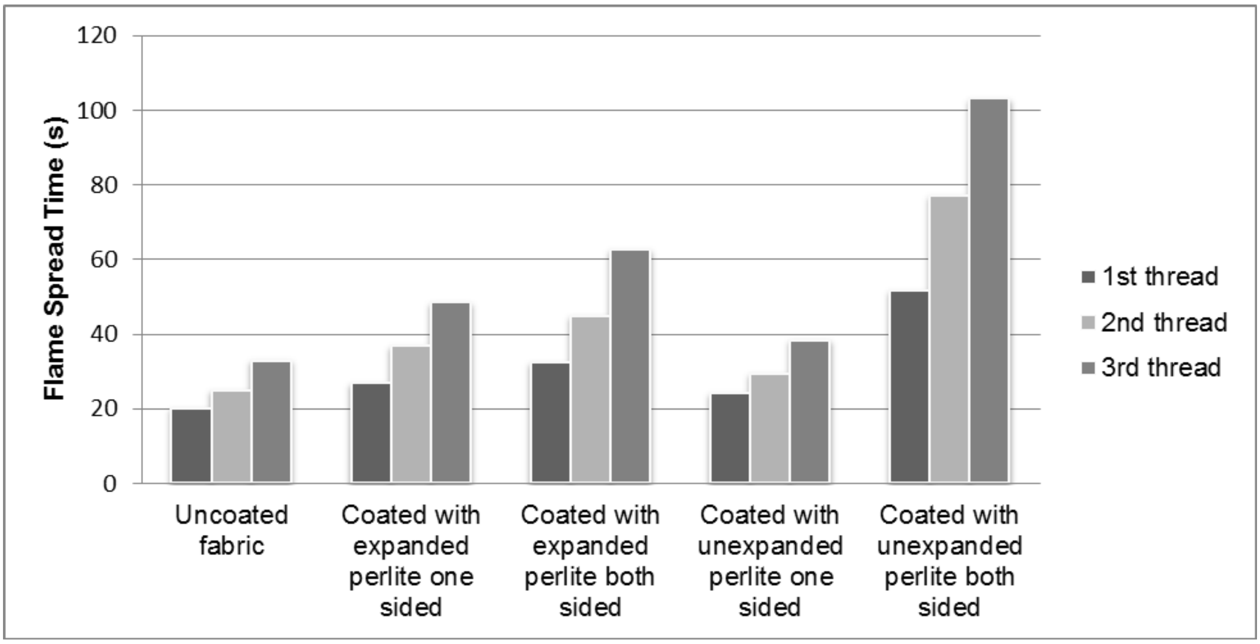

Figure 2: Flame spread time of fabrics according to vertical flammability test

3.3 Horizontal flammability of fabrics

Horizontal flammability of fabrics are shown in Figure 3 as flame spread rate (mm/min) and burning time (s) which were determined according to TS 6346. As seen in Figure 3, from left to right there is an increase in the burning time values and a decrease in flame spread rates gradually. Compared to the uncoated fabric, the coated fabrics have shorter flame spread rate and longer burning time in the horizontal burning test. The fabrics coated with unexpanded perlite show better performance than the fabrics coated with expanded perlite. The flame spread rate of the fabric coated both sides with unexpanded perlite is 22% less than the uncoated fabric and the burning time is 25% higher than the values of uncoated fabric.

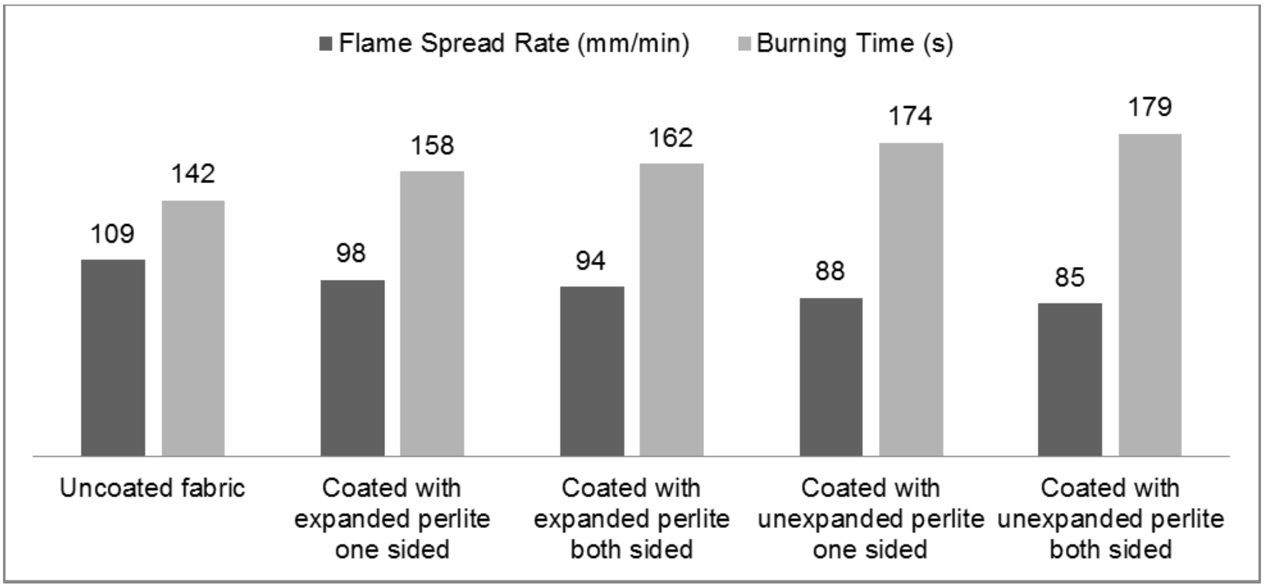

Figure 3: Flame spread rate and burning time of fabrics according to horizontal flammability test

3.4 The 45° flammability of the fabrics

The 45° flammability test results of the fabrics are presented in Table 3 as flame spread time. As seen from the Table 3, the flame spread times of coated fabrics are higher than that the uncoated fabric except the fabric coated one sided with expanded perlite. The increase is about 27% with expanded perlite coated by both sides and 63% with unexpanded perlite coated by one side. The flame spread time of the fabric which is coated two sided with unexpanded perlite is 151 s which is 2.3 times more than the value of the uncoated fabric.

Table 3: The 45° flammability results of the fabrics

Fabrics	Flame spread time (s)
Uncoated fabric	67
Coated with expanded perlite by one side	66
Coated with expanded perlite by two sides	85
Coated with unexpanded perlite by one side	109
Coated with unexpanded perlite by two sides	151

3.5 LOI of fabrics

LOI values indicate the minimum amount of oxygen needed to sustain a candle-like flame when a sample is burned in an atmosphere of oxygen and nitrogen. The higher the LOI value, the more effective is the flame retardant treatment. LOI values are classified as LOI < 21%, easily burn in the air; 21% < LOI < 26-28%, slow burning and LOI > 26-28%, flame retardant [37]. Table 4 shows the LOI values of the fabrics. The LOI of uncoated cotton fabric is 19%. The LOI values of the perlite coated fabrics increase from 19 to 20.6%. The results show that LOI values of the perlite coated cotton fabrics are increased but still flammable. It was observed during the test, the coated fabrics burned very slowly than the uncoated fabric. After burning, no uncoated fabric was left on the sample holder, but all four perlite-coated fabrics left significant residues. The residues from the coated fabrics have preserved the fabric structure.

Table 4: LOI values of fabrics

Fabrics	LOI (%)
Uncoated fabric	19.0
Coated with expanded perlite by one side	19.8
Coated with expanded perlite by two sides	19.8
Coated with unexpanded perlite by one side	19.8
Coated with unexpanded perlite by two sides	20.6

CONCLUSION

Benefit from the flame resistance property that perlite has, both expanded and unexpanded perlite were applied seperately to cotton fabric surface by one side and both two sides. LOI, vertical, horizontal and 45° flammability tests were performed. It was seen that, in the coated fabrics, flame spread rate reduced and burning time increased. But the same performance was not obtained from LOI values. From the point of these results, it can be said that perlite changes the burning behavior but not the flammability of the cotton fabric. The high proportion of Si within perlite caused to change the burning behavior of the fabric. According to the results obtained from the burning tests, unexpanded perlite coated fabric was performed better than the expanded perlite coated fabrics. This may be the result of the high porosity of expanded perlite. Because, the air within the lots of open and closed pores of expanded perlite, helps to burn and not allow to slow down the burning that unexpanded perlite does. In future studies, other applications such as, producing composite fibers containing perlite, coating the fabric by multi-layer instead of one layer, using other materials instead of cotton could be investigated.

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RESEARCH REGARDING THE BEHAVIOUR OF AIRBAG FABRICS AT LOW TEMPERATURES

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Abstract: *Airbags are important safety devices for the vehicles, which mean that the materials used in manufacturing process of airbags, must conserve their original properties in different conditions of temperatures and humidity and have to ensure passengers safety.*
This paper reports the results obtained in axial tensile testing of fabrics for airbags, after subjecting to low temperatures. The samples were maintained for 10 hours at temperature of -20 °C with the help of a mechanical vapour compression refrigerator, capable to produce temperatures in the range of +4…-35 °C. The variation of temperature and humidity in the refrigerator was recorded by a logger for temperature and humidity.

Keywords: *nylon fabrics, refrigerator, airbags, low temperatures*

1: INTRODUCTION

1.1 Historical review

The first concept of the airbag system appears in the sixties and describes a self-opening air bag inflated after a sudden deceleration of the vehicle, but the implementation of the airbag system is first introduced in the USA in the year 1989. European automobile manufacturers also initiated developments of airbag systems, primarily by Mercedes Benz in the year 1967. At first, the air bags were inflated using compressed-gas canisters. However, the pressure canisters could only be positioned in the front panel so the connection to the steering wheel was very difficult. New experiments were carried out with liquefied gas and solid fuels. The necessary inflation time of 1/30 second was reached, but the system was still too heavy. The first used material for airbag cushion was neoprene-coated polyamide fabrics. Since the beginning of the nineties, all automobile manufacturers have been provided airbags as a standard feature or optional extra, even for compact class cars. [1]

1.2 The working principle of air bags systems

The airbags are designed to minimize the forces and the excessive motion of a passenger who has his safety belt fastened, by the help of elastic deformation and the control of hot gas flow through the fabric controlled by special vents, in case of a collision. [2]

Airbag systems have four general components:
1. A sensor system,
2. A deployment mechanism,
3. The air bag or the cushion,
4. Wiring harness.

In case of a crash, enters in action the sensor system and triggers the deployment mechanism. This system has various sensors on the chassis of the car and can detect the direction of the impact, so that if a side impact is made the front air bag will not deploy. The sensor system sends a voltage to the deployment mechanism and heats the pyrotechnic material or the inflator that generates an inert gas which replenish the air bag in milliseconds. In figure 1 it can be seen the principle of airbag sensors. [3]

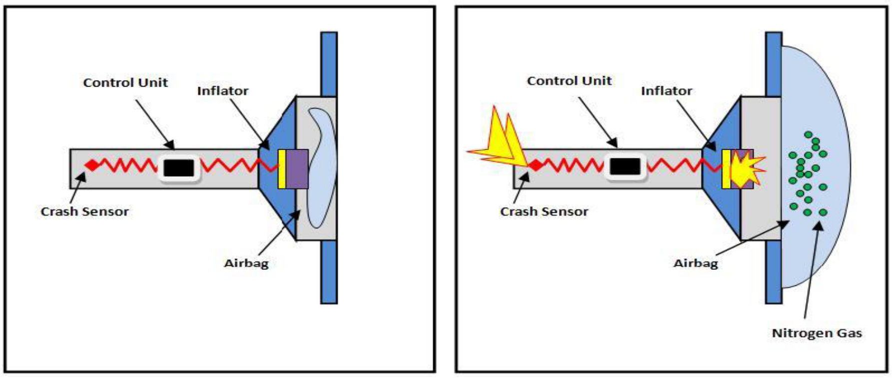


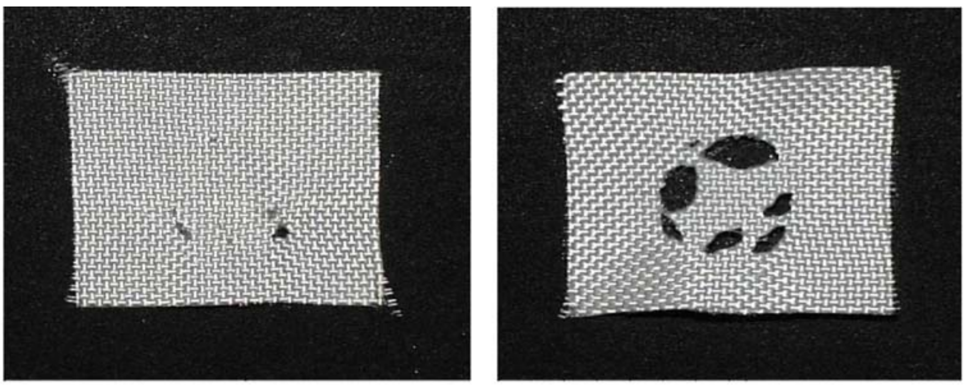
Figure 1: Airbag sensors principle (Source: The Clemsons University Vehicular Electronics Laboratory)

1.3 Air bag fabrics

Nowadays all the fabrics that are used to manufacture the airbag cushion are made of nylon 6.6 yarns, all other materials that were used in the past being left aside because of the benefits and the costs of this material. [4]

The constituent material of cushion must have a reliable and predictable behaviour and some key properties as: good abrasion resistance, energy absorption capacity, high specific strength and good ageing characteristics. The ageing characteristic is very important because the lasting period of an airbag is considered to be 15 years, and the performances of the airbag cushion have to remain unchanged over this period. [3]

If comparing nylon to other materials, with polyester for instance, one can make interesting observations. The melting point of both materials is about the same, approximate 260 °C. This characteristic is very important because the airbag is inflated after a pyrotechnic blast that can generate, for a short amount of time, a temperature of 250-400 °C.
A large difference comes from the specific heat capacity which is approximate 30 % lower for polyester comparing to nylon 6.6, meaning that the energy needed to melt the polyester is lower than for the nylon 6.6. The figure 2 shows fabrics made from nylon 6.6 and polyester that have been in contact with a body at 400°C, for about 2 second.



A B

Figure 2: Nylon 6.6 (A) and polyester (B) (Source: http://www2.dupont.com)

Another advantage of nylon 6.6 comparing to polyester is the density, which is 1140 kg/m3 for nylon and 1380 kg/m3 for polyester, the last one being with about 20% heavier than the first. Due to its lower density, the nylon 6.6 allows to produce lightweight airbags, helping to reduce the impact energy for the vehicle's occupant thus enhancing safety and lowering the overall weight of the vehicle. [4].

The hygroscopic nature of nylon 6.6 helps quenching the hot gases produced by the pyrotechnic inflator. [5]

2: EXPERIMENTS

During the airbags lifetime, the fabrics used for the cushion are subjected to large variation of temperatures, which may vary between +70 °C and -35 °C, depending on the season and weather condition.
This paper aims to study the influence of negative temperatures on the dynamometric characteristics of airbag fabrics.

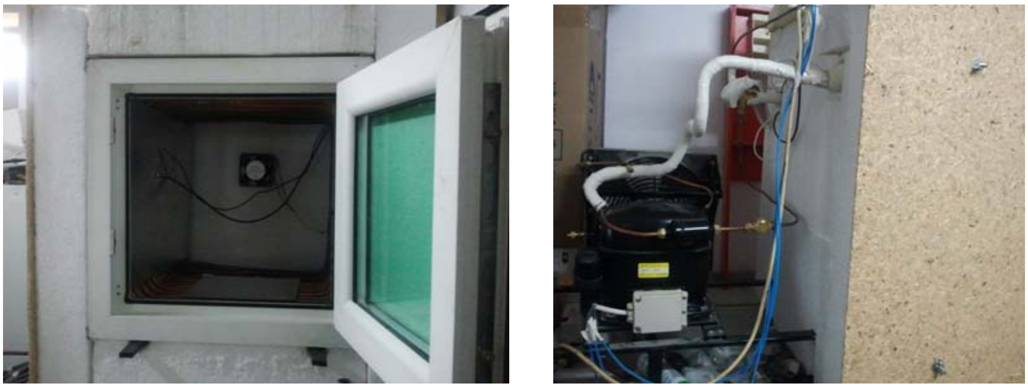
As testing material has been used an airbag cushion originated from an exploded airbag. From the nylon fabric taken from this airbag were cut eight specimens with length of 350 mm and width of 50 mm each. Four of them were maintained for 10 hours at temperature of -20 °C and the other four have not been subjected to any treatment.

The characteristics of the airbag fabric used for tests are shown in table 1.

Table 1: Fabric characteristics

Raw material	Yarn structure	Yarn finesse [dtex]	Fabric structure	Fabric weight [g/m^2]	Warp density [yarns/10 cm]	Weft density [yarns/10 cm]
Nylon 6.6	Filament yarn	Warp: 980 Weft: 980	Ripstop fabric	256	128	126

To maintain the samples at temperature of -20 °C, a mechanical vapor compressor refrigerator, capable to produce temperatures in the range of +4 °C and 35 °C was used. The installation includes a cool box and the condensing unit, as is shown in figure 3 [6]. We chose the temperature of -20 °C because the Logger of temperature and humidity cannot record data below this value.



A. **B.**

Figure 3: Refrigerator used to maintain the samples at temperature of -20 °C
(A - Cool box, B - Condensing unit)

The samples were treated in above specified conditions for ten hours, were monitored by a logger for temperature and humidity and the results were recorded by the specialised software ThermaData. The results can be seen in figure 4. The right axis of the graphic is for temperature and the left axis is for humidity recorded in the cool box.

At the end of the treatment, the samples were introduced in a freezer. The moment that were placed in the freezer it can be seen in the humidity graphic that rised to the maximum of 94.8 %. After that, were transported to the testing place in about 2 hours. In figure 4 it can be seen that the temperature of the samples at the time of test was about 5 °C and the relative humidity was 70 %.

Both groups of samples, treated and untreated, were subdued to axial tensile tests, on the H5KT tensile testing machine produced by SDL ATLAS, equipped with suitable clamps for woven fabric. In figure 5 it can be seen the machine while working.

The fabric samples have been tested until breaking and the force-elongation diagrams were recorded. The tests were performed according to [7], using following testing conditions:

specimen size: 350 mm x 50 mm,
gauge length: 200 mm,
testing speed: 100 mm/min;

In figure 6 it can be seen the image of the broken samples.

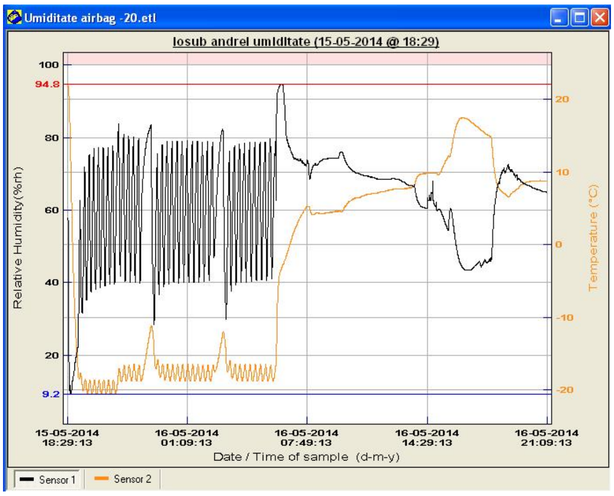


Figure 4: Temperature and humidity graphic (Source: ThermaData Logger software)

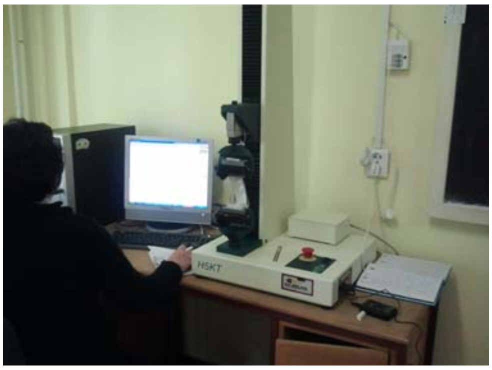


Figure 5: Textile testing machine H5KT

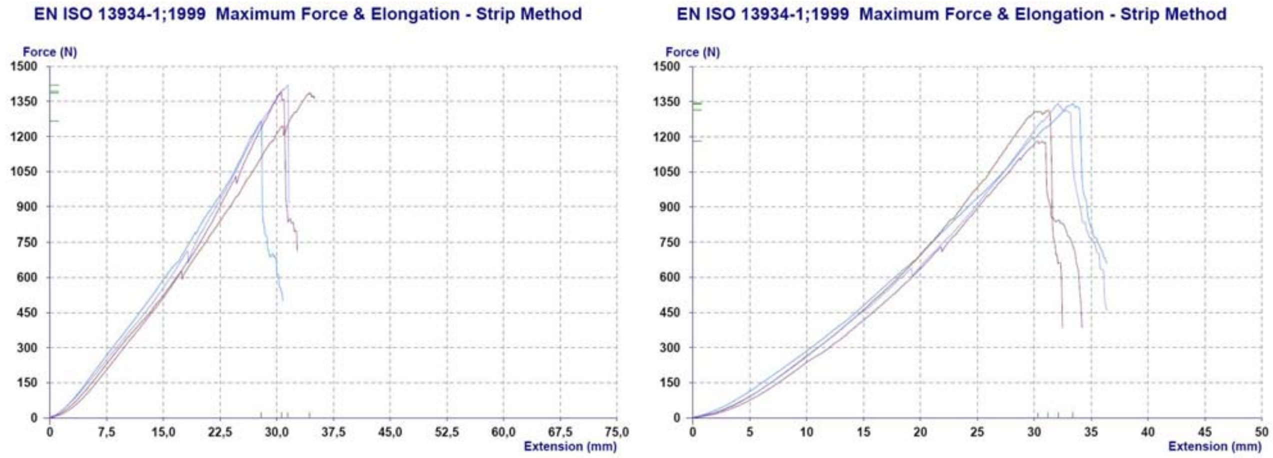
Figure 6: Airbag fabric samples after test

3: RESULTS AND DISCUTIONS

Results obtained after performing tensile test are presented in table 2, while figure 7 shows the force-elongation curves for untreated fabric samples (A) and treated fabric samples (B).

Table 2: Experimental data and calculation performed by QMAT TEXTILE software

Sample number		Maximum force [N]	Breaking force [N]	Relative elongation [%]	Limit of proportionality [mm]	Absolute elongation [mm]	Mech. work at breaking [N*mm]	Mech. work at high force [N*mm]
Untreated samples	1	1266,00	501,00	27,92	28,04	30,80	17,82	15,78
	2	1386,00	1361,00	34,30	17,45	35,00	22,79	21,82
	3	1419,00	915,00	31,45	18,30	31,60	20,14	19,96
	4	1392,00	713,00	30,60	31,13	32,70	19,81	17,82
Treated samples	5	1341,00	969,00	33,40	10,80	36,40	22,57	19,81
	6	1313,00	384,00	31,20	31,56	32,48	18,26	17,20
	7	1343,00	459,00	32,10	9,75	36,40	21,52	17,53
	8	1181,00	386,30	30,30	10,95	32,20	17,77	14,45



A B

Figure 7: Force-elongation curves (A– untreated fabric samples, B – treated fabric samples)

From the analyze of the mean values of tensile characteristics, can be noted that the treated samples shows lower values for maximum force and breaking force comparing to those obtained for the untreated samples. The same situation is found in the case of other parameters as limit of proportionality and mechanical work at maximum force. For elongation at break, treated samples show slightly higher values.

In order to test the statistical significance of the observed differences between average values was used Student's T-test. The calculated statistic t_{calc} was compared with t ,n for a confidence level of 95% and a degree of freedom n = 6. The results of statistical analysis displayed in table 3 indicate that between the mean values of tensile parameters are not statistically significant differences.

Table 3: Results of statistical analysis

Mechanical characteristics / Statistical parameters	Maximum force [N]		Breaking force [N]		Absolute elongation [mm]		Limit of proportionality [mm]	
	Untreated sample	Treated sample	Untreated sample	Treated sample	Untreated sample	Treated sample	Untreated sample	Treated sample
Average value	1365,75	1294,50	872,50	549,58	32,53	34,87	23,73	15.77
Standard deviation	68,03	76,90	366,92	281,78	1,82	1,90	6,54	10,54
t_{calc}	1,387934		1,396033		1,779859		1,283926	
$t_{0,05,\,6}$	2,45		2,45		2,45		2,45	
Statistic decision	The difference is not statistically significant		The difference is not statistically significant		The difference is not statistically significant		The difference is not statistically significant	

However, the values obtained for limit of proportionality, lead to the idea that the samples treated at temperatures of -20 °C have an increased elasticity compared to untreated samples. The value of modulus of elasticity for treated samples is 5707 N while for untreated samples, this is *7585 N, which means that through treatment of nylon fabric at low temperatures, was obtained an* increase in fabric elasticity.

4: CONCLUSIONS

This paper, aimed at analyzing the behaviour of fabrics for airbags at low temperatures (-20 °C), presents the results obtained in axial tensile testing. The fabric samples taken from the cushion of an exploded airbag were maintained at low temperature for 10 hours and their tensile characteristics were compared with those of the untreated samples.

Statistic analysis of the obtained results showed that the treatment at temperature of -20 °C does not negatively influence the mechanical characteristics of the fabric at axial tensile test.

However, the differences between average values of some mechanical characteristics, as maximum force, breaking force, limit of proportionality, require carrying out further research, at lower temperature, using an higher number of tested samples and unused airbag fabrics.

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THE OPTIMIZATION OF THE DISPLACEMENT VALUE AT CRB PUNCHING TEST

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The geotextiles are used in earthworks, earth containing various components (sand, gravel , rocks with variable geometry, etc.). Because the geotextiles come in contact with objects with different geometries, is possible that these to be pierced and do not play the role for that are used. Therefore, is very important that the size of the average displacement of the geotextile from the horizontal position to extreme position, to be correlated with resistance of geotextile.The optimization of parameters values of interweaving process, will decrease the size of the punching movement, from the horizontal position. The behavior of the geotextile at solicitation of punching is apreciatte by determined values of puncture resistance and the displacement at the puncture CRB test.This paper presents a mathematical model of the displacement. The displacement noun refers at average distance walking during solicitation of punching. In case consider the depth and the density of penetration of the interweaving needles as main parameters of the interweaving process, when using the factorial experiment, it obtain a number of variants of geotextile. These the variants are tested for puncture CRB test. It can determine the value of puncture resistance and the displacement, parameters which characterizing the behavior of a geotextile. The values of CRB test parameters obtained using a factorial experiment, by a program centered, compound, rotatable, are processed with a software application that generates a mathematical model with two variables by second degree. From the mathematical analysis and 3D and 2D graphical representations of the regression equation, can be determined the optimal value for displacement. The veracity of this analysis was done by adjustment of the equipment, using the optimal values of the technological parameters established above. The CRB test value of the geotextile new variant, is compared with the value considered optimal. It is consider that mathematical model can be used, if the difference between these is more less 10%.

Keywords: *geotextile, mathematical model, technological parameters, optimization, displacement*

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THE DYNAMOMETRIC ANALYSIS OF TECHNICAL FABRICS FOR UPHOLSTERY

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The technical fabrics used in upholstery, must present a number of requirements such as dimensional stability, the high mechanical strength, uniformity behavior on any direction, the elastic ability. Also, is required: the fire protection, higher long life and friction resistance. Used as resistance elements and protection, for a number of components of a furniture item, the fabric must be made from yarns with the corresponding properties. This paper presents the analysis of the dynamometric properties of technical fabrics variants for upholstery. Analyzed technical fabrics are made from technical yarns polypropylene fibrillated Romanian production. The variants of the technical fabrics tested, are obtained using factorial experiments, based on centered composite rotate program, with the two variables.The two variables are the densities of warp and weft system, which use the same fibrillated polypropylene yarn, with the length density Ttex = 115dtex. The analysis it refers to the value of the breaking force of each variant fabric. From point of view of the elongation at break the registrations show the constant values. Each option is analyzed from point of view of value of breaking force. After, is established which fabric variant, which is density of the two systems, which provide appropriate value. The analysis of dynamometric results shows the fabric-backed version, which has the physic - mechanical optimal properties, according with the requirements of using area. The fabric is then subjected to a finishing treatment to achieve dimensional stability; stability which improves its dynamometric behavior. It is possible therefore to determine which version of the fabric has adequate results.

Keywords: *upholstery, technical fabrics, length density, breaking force.*

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THE DENSITY OPTIMISATION OF THE TECHNICAL FABRIC FOR UPHOLSTERY

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Abstract: *The technical fabrics used in upholstery, must present a number of requirements such as dimensional stability, the high mechanical strength, uniformity behavior on any direction, the elastic ability. Also, is required: higher long life and friction resistance. Used as resistance elements and protection, for a number of components of a furniture item, the fabric must be made from yarns with the corresponding properties. This paper presents the analysis of the dynamometric properties of technical fabrics variants for upholstery. Analyzed technical fabrics are made from technical yarns polypropylene fibrillated. The variants of the technical fabrics tested, are obtained using factorial experiments, based on centered composite rotate program, with the two variables.Those two variables are the densities of warp and weft system, which use the same fibrillated polypropylene yarns, with the length density Ttex = 115dtex. The analysis it refers to the value of the breaking force of each variant fabric. From point of view of the elongation at break the registrations show the constant values. After, is established which fabric variant, who is density of the two systems, which provide appropriate value. The analysis of dynasmometric results shows the fabric-backed version, which has the physic - mechanical optimal properties, according with the requirements of using area. The fabric is then subjected to a finishing treatment to achieve dimensional stability; stability which improves its dynamometric behavior. It is possible therefore to determine which version of the fabric has adequate results.*

Keywords: *upholstery, technical fabric, polypropylene yarns, mathematica model*

INTRODUCTION

In the production of furniture like armchairs, chairs, sofas, it use chipboard (PAL). These plates obtained by the processing of wood chips mixed with a chemical (formaldehyde) are dangerous for the environment and so for users. Additionally boards have mass and dimension large so are difficult to handle and the cutted, to obtain the necessary parts, and produce waste, too. Therefore it was proposed replacing these plates with a technical fabric. It examines the dynamometric properties of technical fabric with density of 120 yarns/10cm, in both systems, plain weave, made of polypropylene fibrillated technical yarnsTd =1150den. The advantages to use such fabric as a substitute for a piece of chipboard are evident, namely: is more cheap, occupy the low storage volume ,handling and cutting easy, non-polluting and environmentally friendly, the conditions in which successfully meets with the same. The load at break and elongation at break are analyzed in corelation by warp and weft density. The considerations based on the values recorded in dynamometric tests allowed to determine the fabric material version that is able to successfully replace the corresponding piece of chipboard. The thermal treatment, under certain conditions of pressure and temperature, allows getting a technical fabric who replaces with success PAL piece.

THEORETICAL ASPECTS

Making research using mathematical methods of experiment planning and analysis overcomes the traditional passive methods, research and scientific activities increase efficiency. The utilisation of mathematical methods for planning the experiment ensure increased opportunities for researcher, facilitates problem formulation, experimental results have a clear and convincing nature and permit rapid interpretation of results [1,2,3,4]. For developing statistical and mathematical models involves obtaining experimental data following certain experiments conducted.

Within the active learning, the experimental data are obtained by measuring the output of the process quantities for certain combinations of input quantities.

Mathematical model of a process is a functional relationship between a response or dependent variable y and independent variables or parameters tehnologici.x_1, x_2, ... x_k, which can be accurately measured and controlled:

$$Y = f(x_1, x_2, \ldots x_k) \quad (1)$$

To determine the functional relationship is carried out a number of experiments, ordered in a certain way, and a program of these experiments is presented in the form of a matrix experimental (Table 2).
To obtain a nonlinear mathematical model used a program wich ensure an equal and uniform distribution of points, equally spaced from the center of the experiment [2,3,4].

Experimental plan is prepared based on a well-defined schedule, so that the number of experiments exceed the number of coefficients wich will be determined. Factorial experimental plan is a central, composite, rotatable plane whose order is equal to the regression equation order that will be generated by processing data in the experiments.Technological parameter values considered as independent variables is recommended to take the values in central area assumed to be optimal, and otherwise can be appreciated from previous practical knowledge [1, 2, 4].

For experimental data obtained under experimental program, it was used the software "OPTEX" from the laboratory of Applied Science Faculty of Textile - Leather and Industrial Management [4].

The particular form of the equation depends on the number of input variables or parameters of technology. For this paper for two independent variables equation has the form of the relationship.

$$Y = b_0 + b_1x_1 + b_2x_2 + b_{12}\, b_{11}\, x_1x_2 + x_{12} + b_{22}x_{22} \quad 2)$$

Further details of mathematical modeling in [2,4].

EXPERIMENTS

The yarns polypropylene shows the physical and mechanical characteristics which allow assessment of the possibility of obtaining technical fabrics for upholstery, namely to obtain a support layer for sitting surface of chairs, armchairs and sofas. The question, given the intended use and that the thread is first time used as such, is to seek the optimal density of yarns for this type of fabric. For this purpose used the mathematical modeling wich consider as independent variables, inputs or technological parameters the warp and weft densities in a range of their variation, which afford to made a fabric balanced in terms of densities of the two systems of threads, and default physical-mechanical properties of those. This model will be used to optimize the densities of the two systems of threads, in order to obtain a fabric that meets the requirements imposed by the above use.

RESULTS

Article researched has varied densities as seen in table 1.

Table 1: The variation of densities

Input variable	UM	Basic level=1000; Variation level=20									
		Real	Code	Real	Code	Real	Code	Real	Code	Real	Code
Warp density	Yarns/10cm	72	-1,414	80	-1	100	0	120	+1	128	+1,414
Weft density	Yarns/10cm	72	-1,414	80	-1	100	0	120	+1	128	+1,414

It is used in both warp and weft the same polypropylene technical yarns, length density Td = 1150 den. The input parameters are densities in warp and weft directions (table 2.)

Table 2: Experimental matrix

No. Exp.	$X_{1cod.}$	X_{1real}	$X_{2cod.}$	X_{2real}	$Y_{mes.}$	y_{calc}	D[%]
1	+1	120	+1	120	1358	1261	7,1
2	-1	80	+1	120	958	896	6,5
3	+1	120	-1	80	972	880	9,4

4	-1	80	-1	80	892	835	6,4
5	-1,414	72	0	100	759	807	6,4
6	+1,414	128	0	100	1000	1097	9,8
7	0	100	-1,414	72	758	827	9,2
8	0	100	+1,414	128	1063	1139	7,2
9	0	100	0	100	1187	1126	5,1
10	0	100	0	100	1187	1126	0,1
11	0	100	0	100	1056	1126	6,7
12	0	100	0	100	1100	1126	2,4
13	0	100	0	100	1103	1126	2,2

Measured values of the breaking force of fabric variants results [2] was processed with OPTEX aplication software is generated regression equation 3.

$$y = 1126.816\ 102\ 597\ 110\ 409\ x1\ x2 + 80.000x1x2 - 86.999x12 - 71.504x22 \qquad (3)$$

DISCUSSION

The coefficient b0 = 1126.816 is free term representing the arithmetic mean of the measured values for the breaking load for the 13 fabric variants analyzed. This value will be modified by variation in experimental limits region, of the values of technological parameters, x_1 and x_2, respectively density in warp and weft densities, by the numerical coefficients that accompany these parameters.

The coefficient b_1 = 102 597 is the numerical coefficient of the variable x_1 component linear part of the model. The variation of the variable x_1 with unit, will influence the value of b_0 with cca.9% .Such when x_1 will Vary to the upper limits of the region will amplify coefficient b_0 with cca.9% and will decrease the value of b_0 the same percentage when $x_1$va range to the lower limit of the experimental region.

The coefficient b_2 = 110 409 is the numerical coefficient of the variable x_2, weft density. Variation to the upper limit of x_2 with unit will amplify the value of the constant term b_0 with cca.9 8% and will decrease by the same percentage to the variance of x_2 for the lower limit.

The coefficient b_{12} = 80,000 is the interaction coefficient of the variables x_1 and x_2 and measure the influence that the simultaneous variation of the variables x_1 and x_2 , irrespective of the direction of variation and will influence the coefficient b_0 b_{12} with approx. 7%.

The coefficient b_{11} = -86.999 accompanying square value of x_1, reduce the value of the constant term b_0 with 7.72% irrespective of the direction of variation of the variable x_1.

The coefficient b_{22} = -71.504, which accompanies square value of x_2 will reduce the value of the constant term b_0 with 6.34% irrespective of the direction of variation of x_2.

This way allows technological analyzing and interpreting of regression equation. 3D graph of the equation of regression is a well-shaped surface, as seen in figure 2.

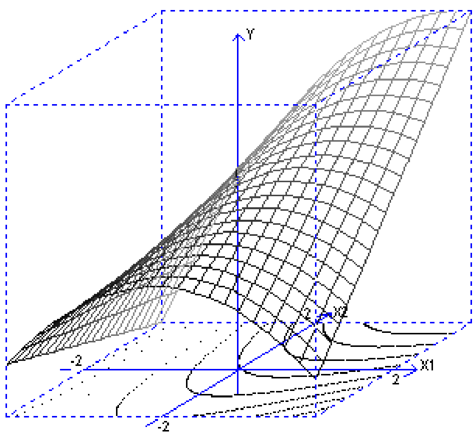

Figure 1: The 3D graph, $y = f(x_1, x_2)$

From figure 1 it is observed that the surface is oriented towards the upper limits of the experimental region, placing it in the quadrant 1, positive values x_1 and x_2, suggest that the optimal value of the result will be obtained when the two input variables, densities of the two systems, will have the values will varies in concert, to the code values and $x_2 = x_1 =+ 1.414$.

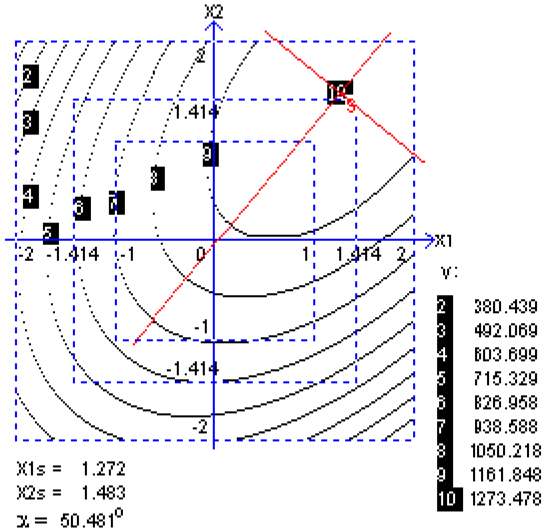

Figure 2: The 2D Graph $y=f(x_1,x_2)$

2D representation of figure 2 contains the constant level curves resulting from intersection 3D surface with plans y = constant. The result is a new parables family with particular values which are displayed on screen image in figure 2. It is found that the maximum values of the variable y, ie the maximum breaking force of the tissue analyzed are placed in quadrant 1. Such the maximum value of y = 1273.478 N, which corresponds to the pair of values x_1 and x_2 which form the coordinates of the center. The value of this maximum corresponds approximately identical technological densities for the two-wire systems. It can be concluded that to obtain a high breaking load for fabric analyzed, those two independent variables x1 respective density in warp and weft density x_2 will have to vary simultaneous , to the upper limits of the experimental region. It is obvious that one can use the graphical representation from figure to find that pair of values x_1 x_2, which ensures a certain value of the breaking force. The correctness of this assumption is checked by entering coded values of the two variables in the regression equation and identify this new value on one of the curves of y constant. Also if known breaking force value, one can find with a reasonable approximation, the pair of values of x_1 and x_2.

CONCLUSIONS

Was made Mathematical model for a technical fabric for upholstery, with the input variables values densities in the warp and weft and the output variable breaking force of them.
Was performed technological interpretation of regression equation by explanation the influence variation of the two input variables concerning output variable, breaking force.
It made the breaking force optimization of fabric by graphical interpretation of the regression equation.
There has shown that 3D and 2D graphics regression equation can be used to select either selectively breaking load value or values of the pairs of input variables.

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THERMAL COMFORT PROPERTIES OF WEFT KNITS MADE OF NILIT® INNERGY YARNS

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Abstract: *The task of developing new functional yarns continues to be a high priority of the companies, in order to bring fare more than good looks to today's most advanced garments. This study has been conducted to verify the suitability of Nilit® Innergy nylon 6.6 yarns for providing thermal comfort properties in double face weft knitted fabrics. The aim of this research work was to study the influence of the fabric structure and its parameters on the thermal comfort properties of the knitted fabrics made of this type of yarns. The relationship between fabric tightness, thickness, weight and thermal comfort properties was discussed.*

Keywords: *Weft knitted spacer fabrics, thermal comfort properties, Nilit Innergy® yarns.*

1. INTRODUCTION

The task of developing new functional yarns continues to be a high priority of the companies, in order to bring fare more than good looks to today's most advanced garments.

Nilit Innergy® is a nylon 6.6 fiber with a built-in, naturally occurring, mineral additive that produces far infrared ray (FIR) emissions. This special fiber converts the thermo energy of the human body into far infrared rays. Nilit Innergy® reflects the FIR back to the skin, generating gentle heat. This comfort heat increases feelings of well-being and is useful in reducing the appearance of cellulite [1]. Being a microfiber, NILIT Innergy has a soft feel and is easy care. It is perfect for creating shapers, hosiery and lingerie because of its cellulite appearance reduction properties. It is also suitable for use in apparel applications where improved stimulation through heat would be beneficial to the wearer, including medical socks, gloves and sportswear. Nilit Innergy® invigorates the body, enhances performance in sports activities and may help to reduce the appearance of cellulite. Nilit Innergy® used in sports garments enhances muscle elasticity for better performance and improves muscle recovery after exercising. When applied in apparel applications, like medical socks and gloves, improves stimulation via body heating [2].

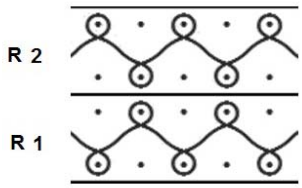
The knitted spacer fabrics or two-faced fabrics represents a special class of knits, comprising of two outer layers connected by yarns transformed in tucks or loops, by various connecting points. This class of fabrics can be produced on electronic flat knitting machines, by exploiting their technical features of manufacturing them in a single stage on the knitting machine, with advantages concerning the: simplified manufacturing process, high quality of the product, lower costs with the machinery. The first great advantage of the modern technology is the possibility of engineering the spacer fabrics according to their end uses, by using different types of structures, raw materials, and finishing processes [3]. Special attention has been given to weft knitted spacer fabrics, due to their good transversal compressibility and excellent air permeability. Their good comfort properties make them suitable for apparels and medical care [4]. On flat knitting machines, the distance between layers is limited by the stitch length of the spacer yarn, making thus the physical properties of three-dimensional fabrics produced on electronic flat knitting machines to be mainly affected by the yarn combination, tightness and washing process [5]. Need of comfortable garments has been constantly a strong reason of the developments, and double layer knits made of natural and synthetic yarns, have been always recommended for producing clothes with a large range of thermal adjustment.

In this context, of the great flexibility of producing spacer knits on electronic flat knitting machines, and the limited existing studies on the thermal properties of this category of fabrics, the present research focuses on searching the thermal comfort properties of weft knitted spacer fabrics, made of new Nilit Innergy® yarns, considering the above mentioned destination of these yarns. Thus, in this study, the effect of fabric structure and its structural parameters on thermal comfort properties of weft knitted spacer fabrics were in deep investigated.

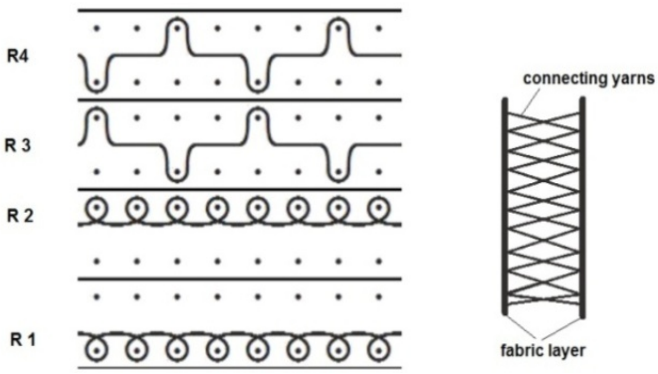
2. EXPERIMENTAL PART

2.1. Material

The investigations were carried out on two variants of structures, interlock and spacer fabrics, as part of the double face type (Fig.1). Both faces of spacer fabric have a closed structure. The knitting process was performed on E 6.2 gauge, 3 systems, CMS 530 computer controlled flat knitting machine, with three stitch cam positions, adjusted in correlation with yarns and structure, in order to obtain a comparable tightness factor for both structures. The samples design and the settings were performed on M1plus pattern station from Stoll, Germany.



Interlock structure



Spacer fabric structure

Figure 1: Types of produced knitted fabrics

Nilit® Innergy yarn, dtex 78/68/2, with 4.76 N breaking strength and 23.76% breaking elongation, was used for the production of samples. In case of sandwich structure, monofilament of polyamide yarn is connecting the outer layers.

2.2. Method

After the knitting, the fabrics were relaxed according to the TS EN ISO 6330 standard. The values of the fabric structural parameters that refer to the vertical density cpc, horizontal density wpc, thickness (mm) and mass per unit area (g/m^2) were measured on raw fabrics. Thickness of the fabrics was measured using Alambeta instrument, under constant pressure of 200 Pa. All measurements were repeated five times and Table 1 shows the mean values of the characteristics of the fabrics.

Table 1: Fabrics characteristics

Structure	NP	Stitch density		Loop length (mm)	Thickness (mm)	Mass per unit area (g/m^2)	Material density (kg/m^3)	Porosity (%)
		(Courses/ 5cm)	(Wales/ 5cm)					
Spacer fabric	10.5	61	33	5.00	2.97	658.33	221.83	75.32
	11.0	54	30	5.20	3.13	628.33	200.67	77.68
	11.5	48	28	5.70	3.15	514.17	163.46	81.64
Interlock fabric	8.5	58	34	5.00	1.77	481.67	271.70	70.24
	9.0	48	34	5.20	1.87	455.00	243.03	72.48
	9.5	44	34	5.40	1.94	332.50	171.48	80.57

Statistical software was used to evaluate the experimental data and the analysis of variance (ANOVA) was performed to evaluate the significance of fabric structural parameters on the thermal comfort properties of the fabrics. To conclude whether the parameters are significant or not, *p* values were examined. The mean values of the thermal comfort properties are given in Table 2.

Table 2: Thermal comfort properties of the fabrics

Structure	NP	Thermal Conductivity (W/mK)	Thermal Absorptivity ($WK/m^2s^{1/2}$)	Thermal Resistance (m^2K/W)	Air permeability [lt/m^2s]	Relative Water Vapour Permeability [%]
Spacer fabric	10.5	0.069	177.28	0.043	180.30	27.23
	11.0	0.066	161.12	0.048	194.70	29.27
	11.5	0.057	139.04	0.055	234.90	29.93
Interlock fabric	8.5	0.071	211.60	0.025	113.10	39.50
	9.0	0.066	191.20	0.028	121.60	39.63
	9.5	0.063	175.12	0.031	141.70	40.37

3. RESULTS and DISCUSSIONS

3.1. Fabric parameters

The results show that the thickness of the samples varies from 1.87 mm to 3.15 mm, the smallest values have been obtained from the interlock samples. For sandwich ones, spacer yarn forces the layers to be distanced, making thus their thickness values higher than for interlock structures (Fig.2). Almost the same situation was found in case of mass per unit area [g/m^2], the highest values were registered for the spacer fabric sample series. The stitch density values are determined by the stich cam position, thus with the NP increased position, the higher loop length is, the looser fabric becomes, with a lower number of stitches per unit. Material density [kg/m^3] plays an important role in the other fabric properties (Fig.3). Interlock fabrics expose a higher density, fact which leads to a lower structure porosity (Table 1), which will consequently influence the thermal comfort properties.

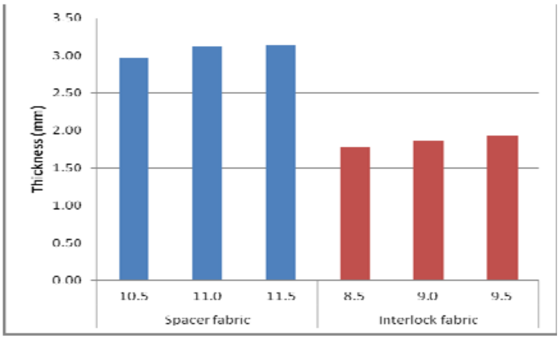


Figure 2: Fabrics thickness

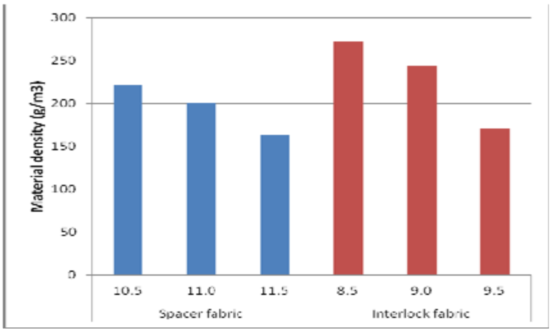


Figure 3: Material density

Air permeability is an important property of textiles, which influences the flow of fresh air into the body. The study reveals that for the air permeability, the fabric density is the most effective factor of influence (Fig. 4). The looser fabrics possess high insulation and higher air permeability, providing warmer feelings. The direct influence of the loop length on the air permeability is noticeable and confirmed in case of these fabrics too.

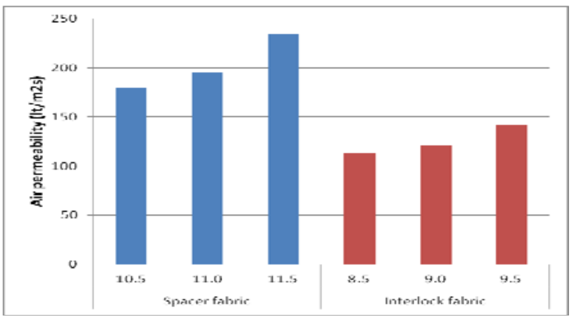


Figure 4: Fabrics air permeability

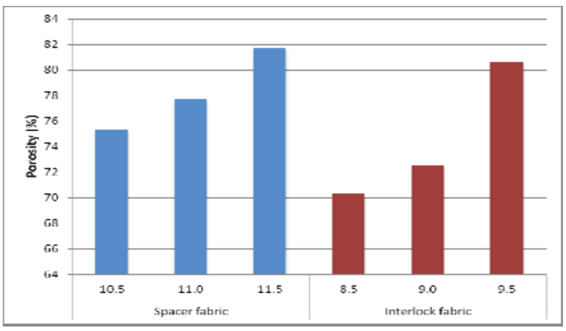


Figure 5: Fabrics porosity

As the fabric gets denser, the surface will be more compact, resulting poor air permeability. The spaces created between yarns by the loop geometry, specific to the knitted fabrics, will be reduced, and the fabric is acting like a barrier that hampers the passage of the air through it, behaviour confirmed by the graph displayed in Fig. 4.

The results of the air permeability plotted in Fig. 4 demonstrate that fabric structure and porosity significantly influence this property. The different air permeability behaviour between spacer and interlock structures is attributed to their different geometry section and thickness. The higher thickness of the spacer fabrics, created by the connecting polyamide monofilament, facilitates a better air permeability compared to interlock, where the two faces are closer to each other.

Air permeability is closely related with porosity (Fig.5). With the increasing of the porosity, the structure will be more open, facilitating in this way the transport of vapours through fabric from skin to the surface [7, 8]. Interlock fabrics exhibit the lowest porosity, due to their specific cross section and geometry, having small value of thickness and high value of fabric density (Table 1) confirming their compact structure. Their dense character leads to less space of fabric interstices, which prevents the air to be incorporated inside the structure, making them less porous. Porosity and thickness are two important factors for the air permeability, conclusion sustained by the results of the performed statistical analysis (p =0.002, p = 0.008).

3.2. Thermal comfort properties

Thermal conductivity coefficient λ represents the amount of heat, which passes from 1m^2 area of material through the distance 1m within 1s and creates the temperature difference of 1K. As stated in the literature, for textile materials, still air in the fabric structure is the most important factor for conductivity value, due its known low thermal conductivity (0.026) [9]. In this study, interlock and spacer fabrics present similar values of the thermal conductivity (Fig.6), but confirm the rule, that, heavier fabrics (Table 1) contain less still air, having thus higher thermal conductivity values [10].

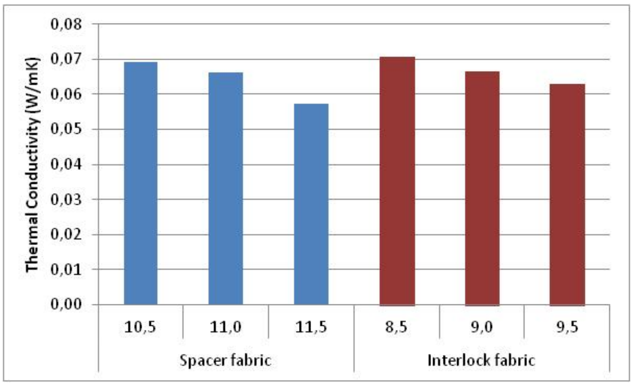


Figure 6: Fabrics thermal conductivity

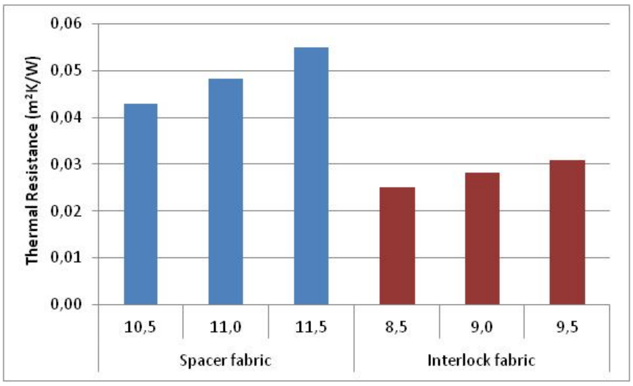


Figure 7: Fabrics thermal resistance

The fabric thermal conductivity can be discussed in relation to its porosity, as a determining factor, mentioned by previous researches [3, 11]. Figure 6 and Table 1 demonstrate the higher the porosity, the lower thermal conductivity, confirming thus, this finding.

Thermal resistance is a measure of the body's ability to prevent heat from flowing through it. Under a certain condition of climate, if the thermal resistance of clothing is small, the heat energy will gradually reduce with a sense of coolness. Thermal resistance Rct depends on fabric thickness (h) and thermal conductivity (λ) as illustrated in Equation 1:

$$Rct = \frac{h}{\lambda}(m^2K/W) \quad (1)$$

As it is observed in Fig.7, the spacer fabrics with higher thickness have higher thermal resistance values than interlock samples. The spacer yarn keeps the two constituent layers at a certain distance from each other, facilitating a quantity of air to be trapped inside. This acts as an insulating layer that slow down the conduction of heat to outside. This situation can be explained by the inverse relationship between thermal resistance and thermal conductivity as indicated in Equation 1. If the fabric is thin and has higher thermal conductivity values, thermal resistance will be low, fact demonstrated for both group of fabrics in the graphs displayed in Fig.6 and 7.

The water vapour permeability is the fabric property to transport the moisture away from the skin. To reduce the uncomfortable sensation, the textiles have to transport the moisture in the vapour state, before they become liquid, avoiding the fabric to get wet [3]. As a rule, it has been demonstrated that the water vapour permeability is increasing with the fabric porosity, fact confirmed also in this study, for both structural type (Fig.8) and Table 1. Having comparable porosity level, it was expected to reveal similar water vapour permeability values, but interlock proves a higher level of values. This behaviour can be explained by the stitch density values, which are lower for interlock fabrics (Table 1).

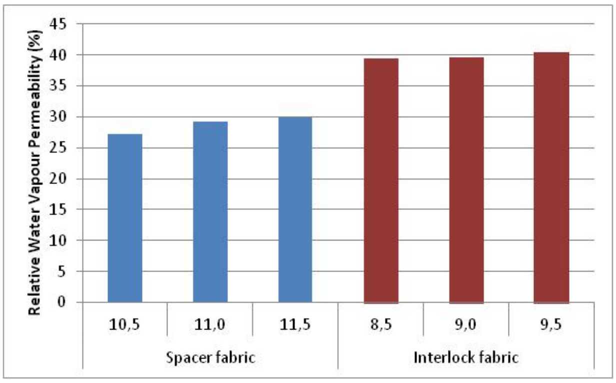


Figure 8: Fabrics water vapour permeability

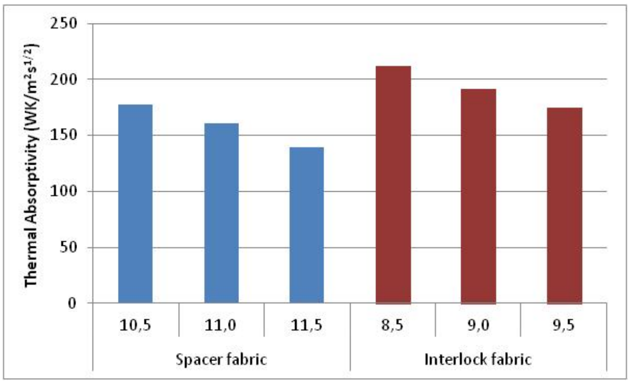


Figure 9: Fabrics thermal absorptivity

Thermal absorptivity reveals the warm-cool sensation of the fabric at initial touch. If the thermal absorptivity of clothing is high, it gives a cooler feeling at first contact. The fabric sensation is given by the surface roughness. A smoother surface will provide a cooler feeling [12]. It has been demonstrated that the compact fabrics, which means surfaces with an increased knit density, present a smoother fabric surface [13]. In the present study, the coolest feeling at initial touch, due to the increased knit density, proved interlock fabric with the highest stitch density (NP 8.5), as it is shown in Fig.9.

4. CONCLUSIONS

This paper deals with the study of the thermal comfort properties of weft knitted spacer fabrics, manufactured on electronic flat knitting machines. This technology allows the engineering of the double faced fabrics by combining different raw materials on both layers, by varying the spacer yarns as nature,and connecting ways, creating thus surfaces with different properties.

In this study, the goal was to measure the thermal comfort properties of the fabrics produced from Nilit Innergy® yarns. These yarns, as described by the producers, are based on a special nylon 6.6 fiber, with a built-in, naturally occurring, mineral additive, that produces far infrared ray (FIR) emissions, converting the thermo energy of the human body into far infrared rays, generating gentle heat. This comfort heat increases feelings of well-being and is useful in reducing the appearance of cellulite. Being a microfiber, Nilit Innergy has a soft feel and is easy care, recommendable for shapers, hosiery and lingerie, sportswear, medical socks and gloves.

Considering the possible end uses of the fabrics made of these yarns, as products worn next to the skin, either for sports or for medicine, they must provide comfort to the wearer. Besides the properties gathered from their specific internal constructions, for acting against cellulite, the fabrics must have the right air permeability and the proper comfort related properties, in order to make these products completely desirable to the users.

The results of the air permeability have clearly demonstrated a direct relationship with fabric structure and porosity. The spacer fabrics having a higher porosity are recommendable for products with high air permeability. Fabric tightness, as one design parameter, is the leading factor on the fabric thermal comfort properties and the samples behaviour is different, accordingly. Fabric thickness proved again, a significant role, influencing especially the thermal resistance of the samples, as it was demonstrated by other researchers [14].

The spacer fabrics exhibit the highest thickness and thermal resistance values, at the opposite, being located interlock structures. Fabric weight is attributed to their different behaviour, being also related to their thickness. Heavier fabrics contain less still air, having thus higher thermal conductivity values [10]. It is the case of spacer fabrics and interlock ones. Statistical analysis was also performed and confirmed the contribution of each factor, including their interactions.

According to the laboratory tests carried on the fabrics from Innergy® yarns [15], it is stated that, during wearing, an increased human body temperature of 1.14^{o}C and a blood flux (heat transfer) improved by 8.5% were measured. One can conclude that the knitted products should give a fast heat transfer, a quicker evaporation of the sweat from the skin, and a cooler feeling at initial touch. In our case, interlock fabrics are responding better to these conditions.

When producing fabrics of these yarns, all these conditions must derive from the particular end use, and all requirements should be considered together.

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DEVELOPMENT OF 3D KNITTED GARMENTS

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Abstract:
The paper explores the possibilities of producing 3D knitted garments and the techniques used for shaping different parts of the products. Several examples are given to illustrate the use of each shaping technique.
The paper also presents the potential of fashioning lines, defining the connection between the 3D shape and the 2D fabric. When designing the fabric for a garment, one must consider different factors – the 3D shape and its evolute, the knitting direction, the correspondence between the evolute and the 2D fabric, the fashioning lines to be created and the fabric structure, as fabric rigidity plays an important part in the aspect of the 3D effect.
The use of fashioning lines implies the type of the line – straight line or curved line (with direct influence on the 3D effect that is generated) and the position of these lines in the fabric. The fashioning lines are defined using the vertical and horizontal increment (the number of needles and rows with which the knitting varies).

Keywords: *3D knitting, fashioning lines, knitting direction, structural modules.*

INTRODUCTION

Knitted garments have an excellent market potential due to their versatility, patterning possibilities and shape control [4]. The developments in weft knitting machinery led to producing complex fabrics, as well as to integral knitting (wholegarment knitting). The advantages of producing whole garments on a flat knitting machine refer to the elimination of cutting and of fabric waste, the reduction of the production time and the control of the shape during knitting.

Such a process requires understanding the shape of the garment and use 2D and 3D fashioning techniques that will ensure the correct 3D form of the final product. The possibilities using these techniques are extremely wide and include all types of garments, from sport or casual clothing to high quality, expensive garments.

It is therefore important to understand how to control the knitting process so that the intended 3D shape and pattern are obtained. The design and the calculus for the garment pieces must be carried out according to the specifics of the knitted fabrics [2, 3] and the specifics of the knitting process. The paper presents some possibilities of knitting fabrics/products with spatial geometry, emphasising the possibilities offered by the 3D fashioning lines.

THEORETICAL PRESENTATION

In order to obtain a knitted garment with spatial geometry, several fashioning techniques can be used. These techniques ensure the 3D fashioning of the garments, the knitting of elements such as collars, pockets, flaps or decorative elements that increase the complexity of the final product and subsequently its value. Figure 1 presents the fashioning techniques that can be used to shape the products and the effects/items that can be obtained.

Tubular knitting is mostly used to create fabrics with cylindrical or conical aspect. It is used to produce hosiery, gloves, and tops. This type of knitting is also well used in flat knitting and one of its main advantages is that it eliminates the lateral sewing, improving the comfort of the garment. Tubular knitting can also produce complex shapes, as illustrated in Figure 2 [5].

The use of **modules of different structures and/or different stitch density** also ensures a spatial geometry for the products, but the complexity of this geometry is limited. For example, the use of tuck stitches can create areas with larger surfaces than the one created by normal stitches, and so the fabric has a certain degree of spatiality.

Another possibility of generating a spatial effect is the use of dynamic stitch length or cast-off techniques. In this case, exemplified in Figure 3, the stitches present different dimensions, producing zones in the fabric with different areas.

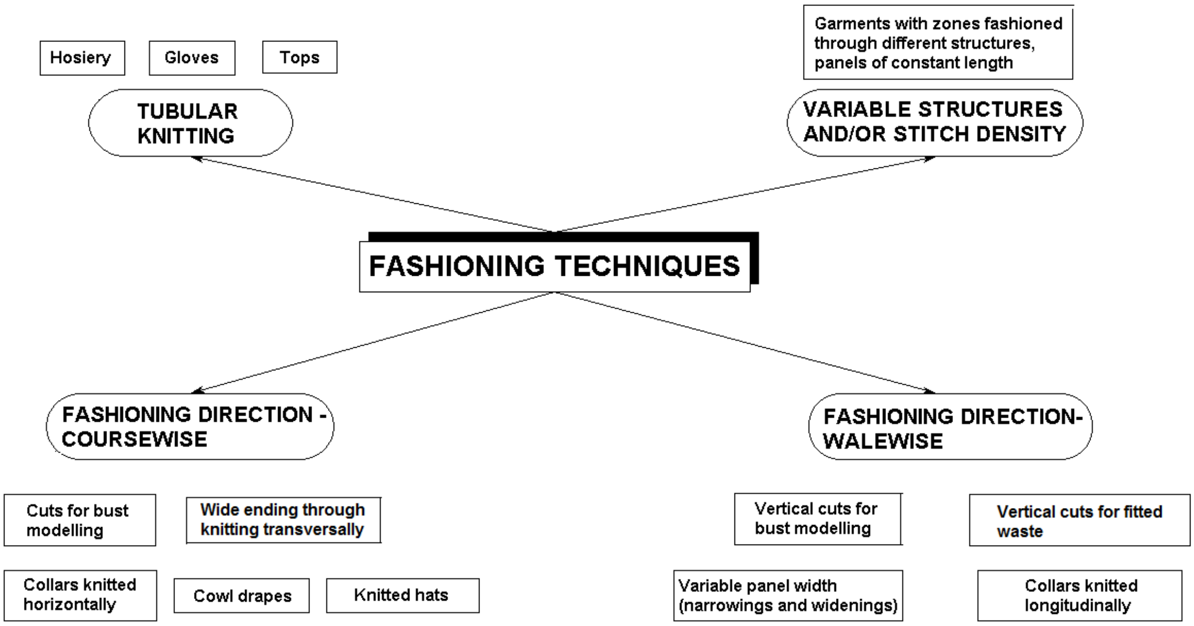


Figure 1: Different fashioning techniques for creating garments with spatial geometry through knitting

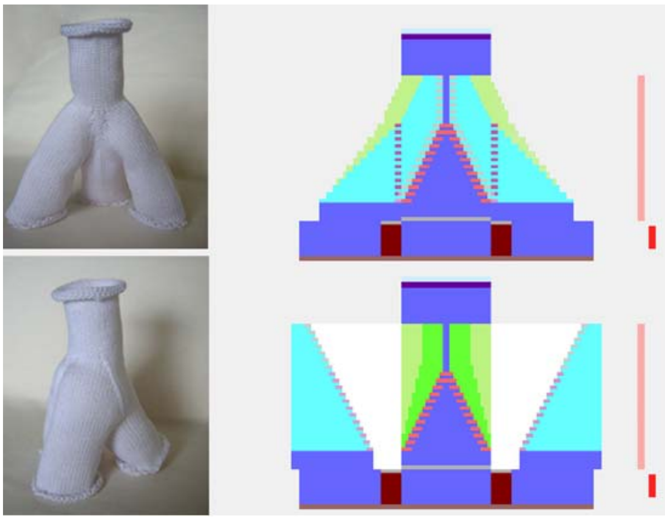


Figure 2: Examples of complex tubular shaping

Figure 3: Effect of dynamic stitch length/cast-off

Fashioning wale wise requires the decrease of the number of wales within the fabric. This variation is carried out using stitch transfer. It is used mostly to create vertical cuts.

Fashioning course wise involves the use of fashioning lines. These lines are obtained by knitting on a variable number of needles, first by decreasing the number of needles and then by increasing them. When the needles are reintroduced into the knitting process, the fashioning line is formed. Fashioning lines are widely used to shape the garments.

The fashioning lines [1] can be classified considering the following criteria:

Line form
- o Straight – with constant increment of the fashioning line (see Figure 4)
- o Curves, actually defined based on a polygonal contour – with variable increment of the fashioning line, creating a different 3D geometry depending on the line increment (see Figure 5).

Line symmetry
- o Symmetrical – the two component lines are symmetrical. This is the most common case because it generates the strongest 3D effect. The symmetry of the fashioning line is reflected in the spatial geometry of the fabric.
- o Non-symmetrical – the line corresponding to needles that stop working is not symmetrical with the line corresponding to the same needles restarting to work.

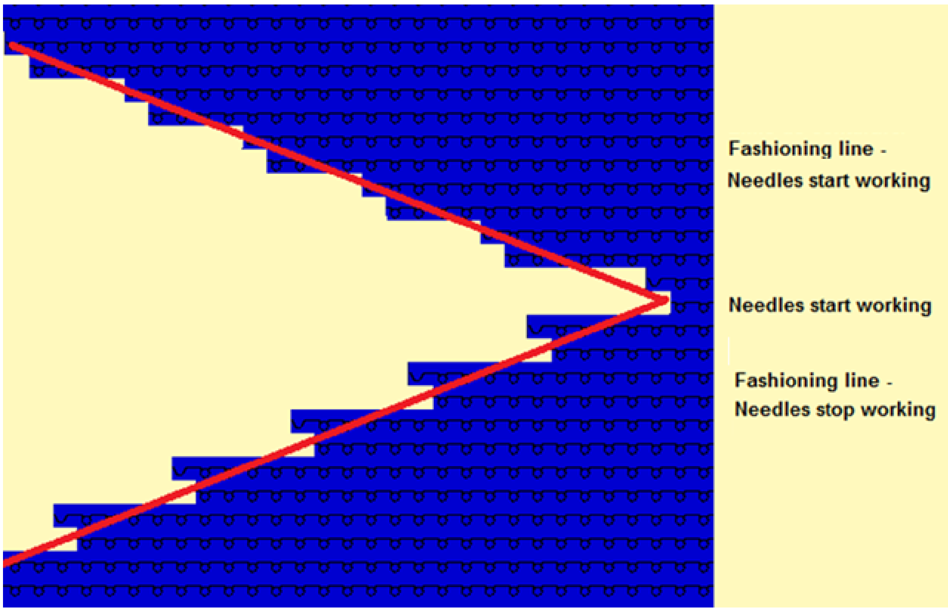


Figure 4: Fashioning line in the knitting programme

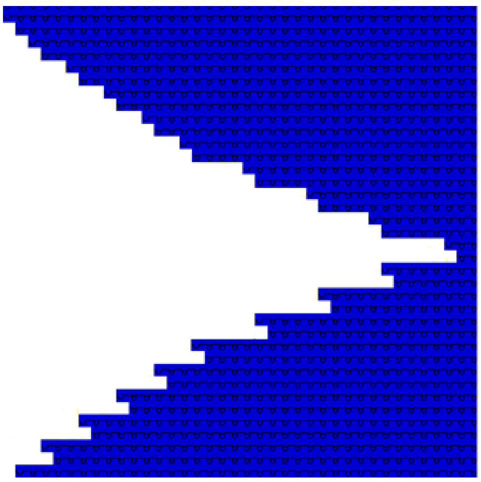


Figure 5: Polygonal fashioning line (curve)

From the knitting programming point of view, a fashioning line can be defined using the **line increment** – the number of needles that stop/start working in the fashioning zone Δa and the number of rows with the same number of needles working Δr. By repetition, the line increment gives the line dimensions (the number of needles and rows for the fashioning line).

By positioning the lines within the fabric panel and using different types of fashioning lines, different effects and shapes can be obtained. For example, curved fashioning lines are used to give the fabric a circular shape. In the case of non-symmetrical lines, when reintroducing the needles, the line can have a different slope or the slope can be eliminated, if all needles start working in the same row, as illustrated in Figure 6.

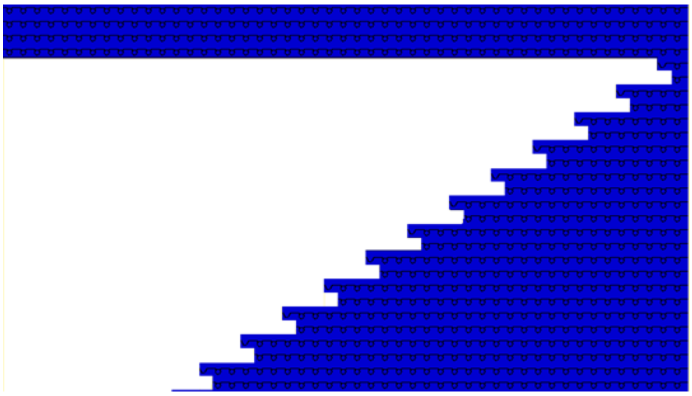
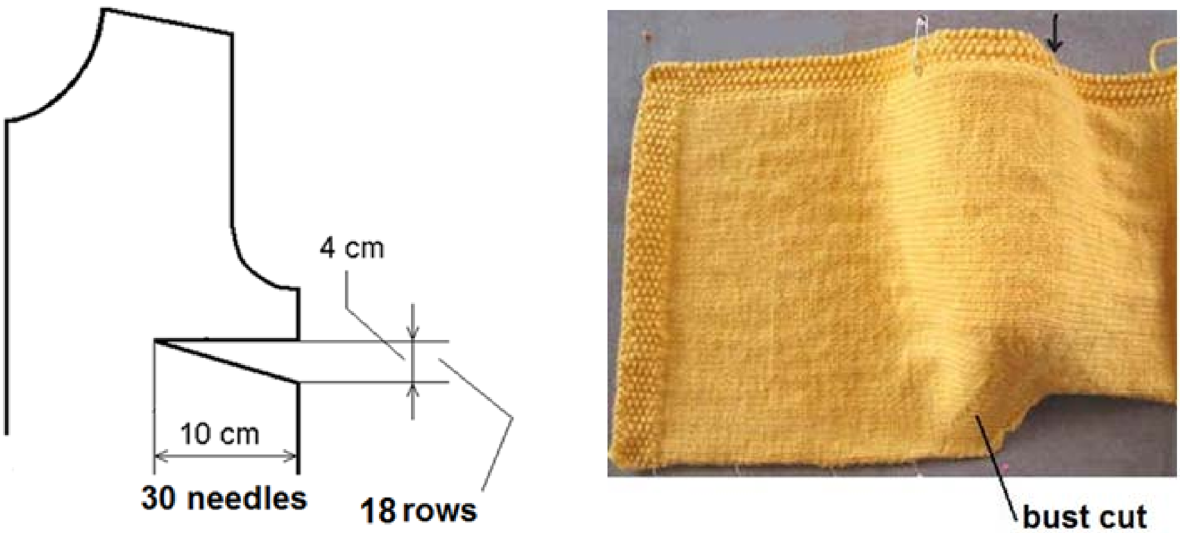


Figure 6: Non-symmetrical fashioning line

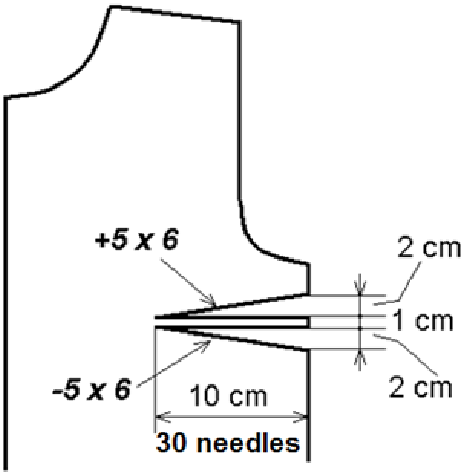
RESULTS

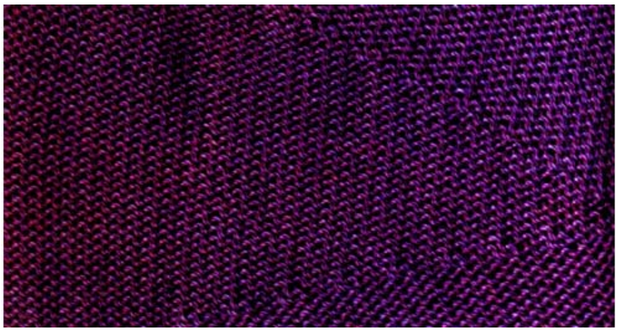
The paper exemplifies the fashioning techniques course wise and wale wise used to shape garments.
In the first case, a curved fashioning line is used to define the horizontal bust cut. The line is non-symmetrical, all needles starting to work at the same time (as illustrated in Figure 4). The horizontal increment is first Δa = 4 needles for 3 steps and Δa = 3 needles for the next 6 steps. The vertical increment is Δr = 2 rows.



a) Position of the fashioning line in the front piece   b) Fabric aspect
Figure 7: Horizontal cut for the bust area

In order to improve the final aspect of deeper horizontal cuts in the garment, a number of complete rows are knitted between the two components of the fashioning line (2 to 4 rows), as presented in Figure 6. A straight fashioning line is used in this case, with an increment Δa = 5 needles and Δr = 2 rows.

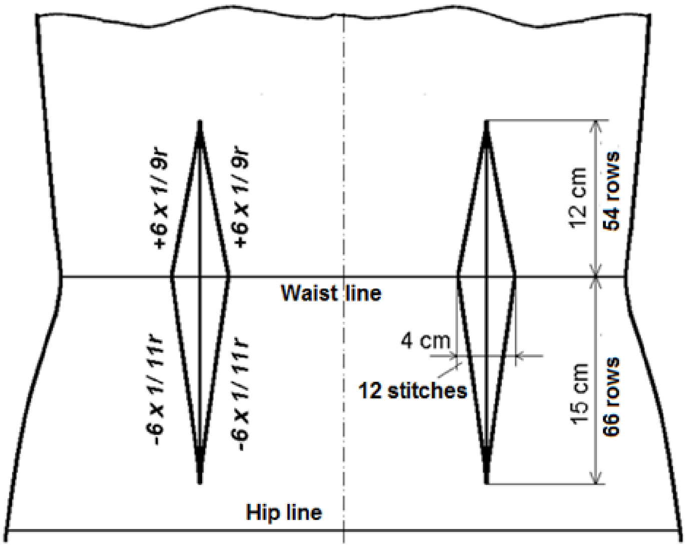




a) Position of the fashioning line in the front piece b) Fabric aspect
Figure 8: Improving the aspect of a deep cut

Vertical cuts are mostly used to model female garments. Their main role is to fit the garment at the waist line, but in the case of knitted garments other constructive effects can be obtained. These effects depend on the form and the position of the cuts, as well as their position in reference to the wearer's body.

Figure 9 presents an example of a vertical cut placed above and below the waist line, that fits the garment (a dress, a blouse, etc.) at the waist line. The stitch transfer is carried out symmetrically (1 stitch for each side) at every 6 rows (11 times, corresponding to 66 rows) and then the fabric is widened by the same 12 stitches - 1 stitch for each side, at every 6 rows (9 times, corresponding to 54 rows). This calculus was done based on the structural parameters of the fabric (vertical and horizontal stitch density).



a) Calculus of the vertical cut b) Aspect of the cut in the fabric
Figure 9: Vertical cut at the waist line

CONCLUSIONS

Fashioning presents an excellent potential for the 3D shaping of complex knitted garments and can be used in producing whole garments through knitting. In today's market, such products present economical advantages that can make a difference for the producers of knitted clothing.

There are several techniques that can be used to obtain the 3D shape of the product, fashioning lines being one of the most important. The knitting on variable number of needles is an efficient technique in producing very complex 3D geometries that can be used for garments, as well as technical products.

The paper exemplifies two types of fashioning - course wise, using fashioning lines and wale wise, using stitch transfer. The examples can be extended to other types of garments, such as skirts, trousers, hats, accessories, etc. They show the potential of knitted fabrics with 3D geometry for garments.

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RESEARCH ON THE TRANSFER OF THE TENSILE PROPERTIES OF YARNS IN THE TENSILE PROPERTIES OF THE DENIM FABRICS

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Abstract: *In this article, the tensile properties of denim fabrics and the tensile properties of the component yarns are described. The study was conducted for two variants of denim fabrics with the weave type twill 3/1 right hand. The yarns compositions are 100% cotton for warp or cotton and Lycra blends for weft. The research performed shows that there is a correlation between the tensile properties of the yarns and the similar tensile properties of the denim fabric. Tensile strength of the woven fabric is not equivalent to the cumulated tensile strength of the total number of constituent yarns in the test direction and also same thing occurs in the case of work to break. This is because of the fact that the number and breaking strength of individual yarns in the cross direction have a strong influence on the strength fabric's.*

Keywords: *denim fabrics, tensile properties of yarns, tensile properties of fabrics, breaking strength, work to break.*

1. INTRODUCTION

Denim fabrics is durable, obtained by weaving indigo warp threads and white weft yarns with twill weave type in such a manner that on the face of the fabric indigo diagonal lines can be seen. Traditionally, denim fabrics were from 100% cotton yarns; nowadays, the yarns are from 100% cotton, but also cotton blended with polyester and Lycra. The main application for this particular fabric is woven to make jeans (trousers). The first pair of jeans was created for the miners in USA, the main goal being that these pants to ensure their comfort and durability. Afterwards, denim jeans were discovered by consumers regularly as casual wear, becoming a fashion product. New techniques and designing were developed to make denim fabrics for desirable and indispensable products. These techniques includes washing, stone washing, cellulase enzyme washing, stone washing with chlorine, ice washing.

The durability and the value of presenting for textiles clothing are very important properties. These properties are primarily due to physico-mechanical properties of the fabrics used. It is known that by repeatedly finishing and washing processes, denim fabrics acquire new properties, such as appearance and touch, particularly different colors [1-3]. At the same time, through these treatments tensile properties of the yarns are modified [4].

Tensile strength of fabrics is one of the most important properties that characterize the quality of fabrics. Tensional properties of a fabric depend on the raw material from which it is made, the structural characteristics of the fabric (weave type, the warp and weft densities) and weaving subsequent treatments such as finishing, washing etc. This paper aims to study how the properties of the yarns namely breaking strength and elongation influence the tensile properties of denim fabric. The study was conducted for two variants of fabrics with the weave type twill 3/1 right-hand. The yarns compositions are 100% cotton for warp or cotton and Lycra blends for weft.

In recent years, various studies have been conducted on how various parameters such as strength and elongation of yarn, density and yarn fineness influences various properties of fabrics [5] and proposing mathematical models based on artificial neural networks or multiple linear regressions [6-8].

In this paper was studied what influence have different finishing treatments on components of denim fabric and how yarns properties are transferred in the tensile properties of denim fabrics.

For this purpose two types of denim fabrics were chosen, all with the same type of weave, but different finishing treatments. For sample 2 it is applied a finishing treatment that is consisted of coating of polyurethane film, which gives the fabric a high elasticity and sample 1 is just washed. The yarns from the composition of these fabrics are the same fineness and composition. Tensile properties of these yarns were analysed in detail: breaking strength, breaking elongation, breaking tenacity, work to break; have been set and the variation coefficients of fineness, breaking strength, breaking elongation, breaking tenacity, work to break. Determination of fabric tensile properties was performed on both the warp and the weft directions.

2. MATERIALS AND METHODS

2.1. Fabric specifications

The denim fabrics used in the study are made in two variants, the type of weave has been twill 3/1 right hand. The difference between the two variants is that the latter has undergone a finishing treatment by applying a polyurethane film. Denim fabric is composed from warp of 100% cotton compact yarns and weft of elastic cotton yarn from 99% cotton and 1% Lycra of 44 dtex.

The main properties of the yarns are shown in Table 1 and for fabrics in Table 2.

Table 1: Properties of the four variants of denim fabrics

Properties	Warp	Weft
Count of yarn, [tex]	33	20
Breaking strength, [cN]	514.6	270.7
Coefficient of variation of strength, [%]	4.62	4.77
Breaking elongation, [%]	7.35	6.65
Coefficient of variation of elongation [%]	4.73	7.78
Breaking tenacity [cN/tex]	15.12	13.11
Coefficient of variation of tenacity [%]	3.73	3.65
Work to break [N.cm]	9.17	4.23
Coefficient of variation of work [%]	9.19	8.64

Table 2: Properties of the denim fabrics

Denim fabrics		Variant 1 and 2
Yarn composition	Warp	100 % cotton
	Weft	99 % cotton / 1 % Lycra
Count of yarn, [tex]	Warp	33
	Weft	20
Density yarn, [ends/cm]	Warp	40
	Weft	23

2.2. Tensile tests

Tensile properties of the yarns have been tested according to ISO 2062, using constant rate of specimen extension (CRE) tensile testers on a Tinius Olsen H5kT. The gauge length was 500 mm and the tensile testing speed was 50 mm/min, adjusted so that yarn break is reached in 20±3s.

The tensile strength test of the fabrics in the warp and weft directions was performed according to EN ISO 13934-1. The tensile testing speed was 100 mm/min and the gauge length was 100 mm. For the tensile properties, the five samples for both variants of fabric were tested, and averages of the test results were calculated. For each variant, five samples on warp direction and five on weft direction were tested.

All tests for yarns and for denim fabrics were carried out after the specimens were conditioned in standard atmospheric conditions (temperature 20±2 °C, 65±2% relative humidity) for at least 24 hours before testing.

The tensile properties for both variants of denim fabrics in warp and weft directions are presented in Table 3.

Table 3. The tensile properties of the denim fabrics in warp and in weft directions

Properties	Variant 1		Variant 2	
	Warp	**Weft**	**Warp**	**Weft**
Count of yarn, [tex]	33	20	33	20
Density [ends/cm]	40	23	40	23
Breaking strength [N]	571.4	283.2	572.2	266.4
Breaking elongation [%]	17.51	20.8	20.46	44.32
Work to break [N.cm]	707	311	697.4	498.5

For breaking strength and work to break of denim fabrics in warp and in weft directions the coefficient of transfer was calculated with the relationships:

$$k_{Swarp} = \frac{S_{fabric(warp)}}{S_{yarn(warp)} \cdot N_{warp}} \cdot 100 \quad , \quad \text{respectively} \quad k_{Sweft} = \frac{S_{fabric(weft)}}{S_{yarn(weft)} \cdot N_{weft}} \cdot 100 \qquad (1)$$

$$k_{Wwarp} = \frac{W_{fabric(warp)}}{W_{yarn(warp)} \cdot N_{warp}} \cdot 100 \quad , \quad \text{respectively} \quad k_{Wweft} = \frac{W_{fabric(weft)}}{W_{yarn(weft)} \cdot N_{weft}} \cdot 100 \qquad (2)$$

Table 4. The coefficients of transfer for tensile properties of the denim fabrics in warp and in weft directions

Properties	Variant 1		Variant 2	
	Warp	**Weft**	**Warp**	**Weft**
Coefficient for breaking strength [%]	55.52	90.97	55.60	85.58
Coefficient for work to break [%]	38.56	63.98	38.03	102.47

3. RESULTS AND DISCUSSION

While the transfer coefficient of the breaking strength in warp direction for both variants can be observed that the average value is approximately constant for transfer coefficient of breaking strength in weft direction it is observed a reduction of 90.97% to 85.58% by treatment of coating. The variation of the individual values is shown in Figure 1.

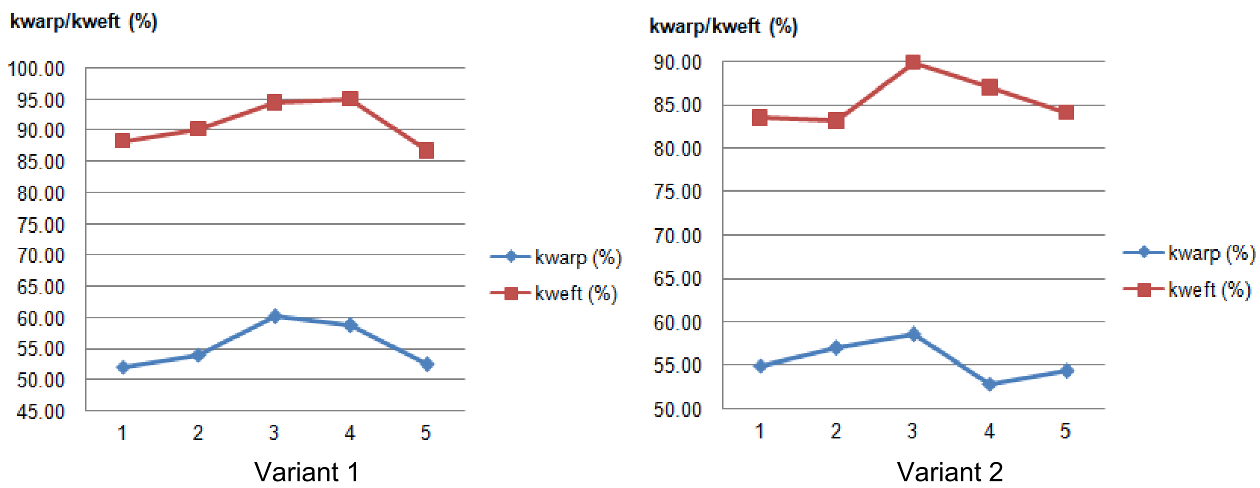

Figure 1: The transfer coefficient of the breaking strength

To the transfer coefficient of the work to break in the warp direction for both variants can be observed that the average value is approximately the same, but the coefficient of transfer of the work to break in the weft direction, it is an increase of 63.98% to 102.47% coating treatment. This is due to the increase of the breaking elongation in the weft direction of the fabric (from 20.8% for uncoated fabric to 44.32% coated fabric) which can be attributed to the application of the polyurethane film. The variation of the individual values is shown in Figure 2.

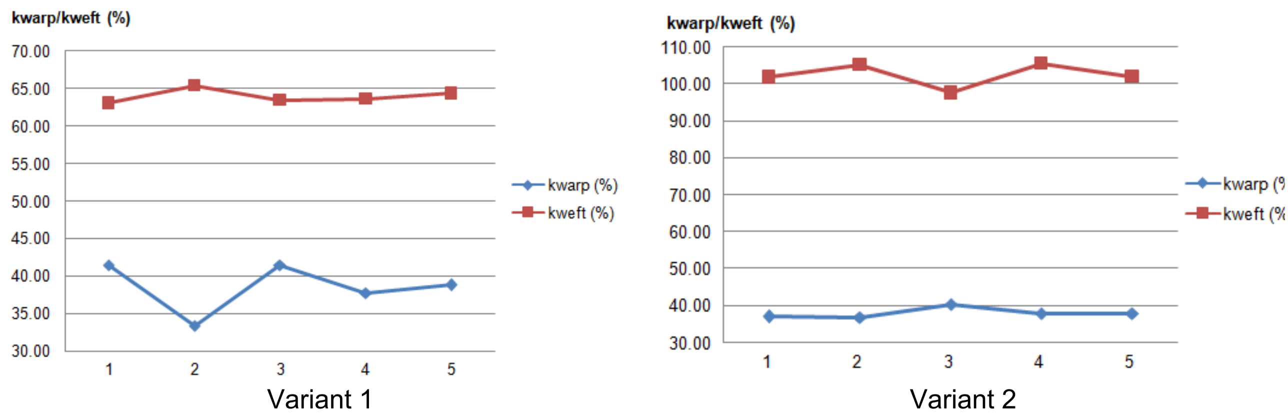

Figure 2: The transfer coefficient of the work to break

4. CONCLUSIONS

Applying on the fabric a polyurethane film led to an increase of the transfer coefficient for work to break in weft direction, fact which to give the product has very good wear behaviour.

The high value of the transfer coefficient of work to break shows a good use of work to break of the weft yarns.

The increase work to break of the coated fabric is determined by increasing the breaking elongation in weft direction fabric coated, as compared with fabric which has been washed only.

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RESEARCH ON THE INFLUENCE OF FINISHING TREATMENTS ON THE TENSILE PROPERTIES OF DENIM FABRICS

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***Abstract:** The aim of this paper is to assess the tensile properties, tearing strength and slippage resistance of denim fabrics before and after finishing treatments. The denim fabrics are made from cotton yarns in warp and cotton and elastane in the weft. The yarns counts are 65 tex for warp and 33 tex for weft, the weave type is twill 3/1 right hand. The treatments applied were finishing and washing. The finishing process comprises treating the material with sodium hydroxide, followed by neutralization with dilute acid. After finishing occurs the washing of the denim fabric, namely desizing, enzymatic washing, rinsing, softening and drying.*

***Keywords:** Denim fabrics, tensile properties, tear strength, slippage resistance, finishing process, washing.*

INTRODUCTION

This study aimed to assess the tensile and tearing properties of denim fabrics before and after treatments such are pre-washing, enzyme treatment and stone washing.

Denim jeans became a common term today in our daily life and clothing items that cannot be missing from anyone's wardrobe. Initially, jeans were marketed as work equipment (overalls) due to their durability. By the middle of last century denim jeans were discovered by consumers as casual wear and have become fashionable. Since then manufacturers have developed new techniques to increase the diversity of denim garments and make them unique. These techniques specific for denim are: washing, stone washing, stone washing with chlorine, ice washing, and cellulase enzyme washing. Because of these specific techniques, the properties of denim fabrics are different from other common woven fabrics, a study in this regard being necessary.

The warp yarn used in denim fabric has a unique technological process compared to conventional fabrics. In contrast to the warp threads, the weft threads are supplied in bobbins, and are not necessary preparatory operations before being placed in the rack of weaving machine, in the same way as conventional fabrics. For warp threads there are several variations of dyeing and sizing, namely: slasher dyeing, beam dyeing, rope dyeing, and sizing. Slasher dyeing works well with lightweight denims. The slasher dyeing technique can be used for other dye types for cotton and thus can produce a wide variety of colors other than indigo blue.

The warp yarn is dyed with pigment blue traditionally obtained from indigo dye, the most important natural dye. At the end of the 19th century were discovered synthetic colors. Indigo color was chosen because of durability and dark shades. In 1894 a synthetic dye process was perfected. The twill weave, which is used for denim fabrics, is constructed by interlacing warp and weft yarns in a progressive alternation, which creates a diagonal effect on the face of the fabric and has a surface of diagonal parallel ridges. Due to the denim's twill construction, one color predominates on the fabric surface. Specific to twill pattern is that the fabric is strong and durable.

Tensile properties of fabrics decisively influence the characteristics of a clothing product, such as durability and presentation value [1]. The tearing strength and slippage resistance are important to denim fabrics given that the main object of clothing that will be made will be jeans trousers, which must be resistant to not only to breaking, but also to tearing and slippage [2-4]. Initially, denim fabrics were made from cotton yarns in both warp and in the weft. Nowadays, due to the trends in fashion and the progress made in realization of the yarn, denim can be made of 100 % cotton or blends or elastane core yarns, with regard to the comfort and durability of clothing items that are expected from denim fabrics [5].

In this paper, denim fabrics have been tested in terms of the tensile properties, tearing strength and slippage resistance, as follows: raw denim fabric, finished denim fabric and washed denim fabric.

EXPERIMENTAL

1. Materials

Denim fabric is composed of warp yarns of 100% cotton and weft yarns 99% cotton and 1% elastane. The denim fabric was produced using an airjet weaving machine from Picanol (Belgium). Table 1 displays the properties of the yarns used in this study.

Table 1: Properties of the warp yarns and the weft yarns

Properties	Warp	Weft
Count of yarn, [tex]	65	33
Twist of yarn [t/m]	529	660
Twist factor [tex]	4266	3792
Breaking strength [cN]	1084.20	454.54
Coefficient of variation of force [%]	16.15	10.72
Breaking elongation [%]	5.37	6.00
Coefficient of variation of elongation [%]	9.41	12.23
Breaking tenacity [cN/tex]	15.65	12.77
Coefficient of variation of tenacity [%]	7.99	10.73
Work – to – break [J]	0.0671	0.0321
Coefficient of variation of work [%]	21.68	19.18

The weave type of denim fabric is twill 3/1 right-hand, which is a weave with the warp effect on the fabric surface. This specific pattern gives a good stability of the yarns in the fabric structure; the aspect on the face of the fabric is blue oblique stripes [6]. Images of these fabrics can be observed in Figure 1.

Figure 1: Images of the denim fabric samples before finishing, after finishing and after washing

Finishing technology consists of immersing the fabric in a bath containing sodium hydroxide and then neutralization with a dilute acid. After the finishing process occurs the wash of the denim material in several stages, namely: desizing, enzyme washing, rinsing, emolliating and drying. Those stages of the washing process aims to create softness, as well as to reach the desired shade of blue [7, 8]. The weaving parameters for the three variants of denim fabric are presented in Table 2.

Table 2: The main characteristics for the denim fabric

Properties of the denim fabrics	Raw fabric	Finished fabric	Washed fabric
Weight [g/m^2]	270	340	370
Width [cm]	174	140	128
Warp density [ends/cm]	28	32	35
Weft density [ends/cm]	17	19	19.3
Warp contraction [%]	17.5	2	2
Weft contraction [%]	30	10	2

After the finishing process, it is expected an increase of density in the warp and weft, due to contraction of warp and weft yarns during the finishing process.

2. Methods

In this study samples were used for investigating the tensile properties for raw fabric, finished fabric and washed fabric. In the first phase were tested the tensile properties of yarns in the fabric (Table 1). After testing yarns, fabrics have been tested in order of treatments that they have suffered: raw, finished and washed. Measurements of the breaking strength and breaking elongation, slippage resistance and tear strength were carried out.

For the determination of the breaking strength and elongation of textile yarns tests were carried out according to ISO 2062:2009 by manual method - specimens were taken directly from conditioned packages. Tensile tests were carried out according to SR EN ISO 13934-1:1999 – by determination of maximum force and elongation at maximum force using the strip method, on a Tinius Olsen H5kT. For the tensile properties, ten samples (five on warp direction and five on weft direction) for each fabric were tested, and averages of the test results were calculated. All tests were carried out after the specimens were conditioned in standard atmospheric conditions (temperature 20±2 °C, 65±2% relative humidity) for at least 24 hours before testing.

RESULTS AND DISCUSSION

The results of the investigations of tensile properties of denim fabrics before chemical treatments and after are summarized in Table 3 in the warp direction and Table 4 in the weft direction.

Table 3: The tensile properties of the denim fabrics in the warp direction

Tensile properties of the denim fabrics	Raw fabric	Finished fabric	Washed fabric
Breaking strength [N]	1148.60	1235.60	977.80
Breaking elongation [%]	24.67	40.04	44.15
Work - to - break [J]	9.876	15.270	29.714
Tear strength [N]	66.75	54.60	67.25
Slippage resistance [N]	314.13	315.03	298.40

As in can be seen in Table 3, in the warp direction, the breaking strength of the finished fabric has the higher value and the lowest is for the washed fabric. On the other hand, the values of elongation at break increases significant from raw fabric to the washed fabric and consequently the work - to - break values. The tear strength of the denim fabric samples decreases for the finished sample and increases for the washed sample and the slippage resistance increases for the finished sample and decreases for the washed sample.

Table 4: The tensile properties of the denim fabrics in the weft direction

Tensile properties of the denim fabrics	Raw fabric	Finished fabric	Washed fabric
Breaking strength [N]	414.44	385.06	305.84
Breaking elongation [%]	21.22	45.58	67.98
Work - to - break [J]	2.3874	3.6952	4.0476
Tear strength [N]	29.25	26.33	30.33
Slippage resistance [N]	242.63	250.60	221.55

In the weft direction, the breaking strength of the raw fabric has the higher value and decreases for finished and washed fabric. The elongations at break values have the same trend and the work - to - break values also. The tear strength of the denim fabric samples decreases for the finished sample and increases for the washed sample and the slippage resistance increases for the finished sample and decreases for the washed sample.

CONCLUSIONS

The tendency observed for the maximum breaking strength achieved is to decrease for the raw fabric to the washed fabric, for both warp and weft directions of the denim fabrics.

After the finishing process, it is expected an increase of density in the warp and weft, due to contraction of warp and weft threads during the finishing process. For this reason, it is expected an increase of the resistance to tear. By applying finishing treatments, a significant change in the average values of the resistance at break, slip and tear can be observed. The tensile strength of the fabric samples became weaker in both directions during the finishing processes, because the sodium hydroxide weakens the strength of the fibres, due to the chemical degradation of cotton. This loss in the durability is gained in the washing process, when the starch and part of the dyestuff from yarns are removed by the chemicals or hot water and thus on both directions it will occur an increase in density.

The washing process of the denim fabrics is very important, because if this process is optimally set, the losing in the strength of the fabric, suffered in the finishing process, can be recovered and the values of tensile properties can even increase.

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STUDY OF NEEDLING PROCESS PARAMETERS INFLUENCE ON NONWOVENS WATER ABSORBENT CAPACITY

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Abstract: *Water absorptive capacity is a very important property of needle-punched nonwovens used as irrigation substrate in horticulture. Nonwovens used as watering substrate distribute water uniformly and act as slight water buffer owing to the absorbent capacity.*
The paper analyzes the influence of needling process parameters on water absorptive capacity of needle-punched nonwovens by using ANOVA model. The model allows the identification of optimal action parameters in a shorter time and with less material expenses than by experimental research.
The frequency of needle board and needle depth penetration has been used as independent variables while the water absorptive capacity as dependent variable for ANOVA regression model. Based on employed ANOVA model we have established that there is a significant influence of needling parameters on water absorbent capacity.
The higher of depth needle penetration and needle board frequency, the higher is the compactness of fabric. A less porous structure has a lower water absorptive capacity.

Keywords: *nonwoven, viscose, polypropylene, horticulture, absorptive capacity, ANOVA*

1. INTRODUCTION

Nonwovens are used effectively for optimising the productivity of crops, gardens and greenhouses. Their protective nature means that the need for pesticides is reduced and manual labour is kept to a minimum.

Water absorptive capacity is a very important property and an important criterion for the performance of needle-punched nonwovens used as irrigation substrate in horticulture [1]. Nonwovens used as watering substrate distribute water uniformly and act as slight water buffer owing to the absorptive capacity. So, the irrigation solution is brought directly to the root zone. At the same time, the using of nonwovens with higher water holding capacity affects the frequency of irrigation which depends by existing environmental conditions. Nonwovens can have a higher water absorbency if contain in the composition cellulose-based fibers. The advantages of using in the fibrous blend of PP fibers include lighter weight, high wet strength, resistance to rot and chemicals and quick wicking action.

Needle punching is a process for converting webs of fibre into coherent fabric structures, normally by means of barbed needles, which produce mechanical bonds within the web [2].

In order to understand more about the influence of needling process parameters on nonwoven water absorbent capacity it is essential to use mathematical modelling which is an investigation method of technological processes based on experimental data collection and processing [3].

ANOVA model allows the identification of optimal action parameters in a shorter time and with less material expenses than the experimental research. One of the attributes of ANOVA which ensured its early was computational elegance. The structure of the additive model allows solution for the additive coefficients by simple algebra rather than by the matrix calculations. The determination of statistical significance also required access to tables of the Fisher function which were supplied by early statistics test [4-6].

2. EXPERIMENTAL

2.1. Materials

A blend of 50% polypropylene (6.7dtex/50mm) + 50% viscose (3.3dtex/38mm) was used for the preparation of needle-punched nonwoven fabrics.

2.2. Methods

Web of polypropylene/viscose fibers was formed by carding and lapping process, respectively. The basis weight of the web was controlled as 150g/m^2. Then the nonwoven fabrics were made by using an Automatex needle loom having 15x18x42x3CBA Foster needles. The experiments took place under pilot unit condition.

Before performing the water absorbent capacity measurements, the samples were conditioned at 65%, relative humidity and 20^{0}C temperature for 24 h. The fabric water absorptive capacity was tested according to ISO 9073-6.
The water absorptive capacity in % was calculated using the following relation:

$$C_a = \frac{M_d - M_w}{M_w} x100(\%) \qquad (1)$$

where:
M_d: mass in g of the dry test sample:
M_w: mass in g of the wet test sample at the end of test.

There is an increase of water absorptive capacity at low values of needle board frequency and depth penetration. A porous structure has a higher absorptive capacity.

Experimental results concerning the needle-punched nonwoven water absorbent capacity were statistically processed using ANOVA model.

3. RESULTS AND DISCUSSION

3.1. Collection, systematization and processing of experimental data

Econometric modelling is performed using numeric variables. In ANOVA regression model were included the following variables:
- dependent variable (Y) representing the water absorptive capacity, expressed in %;
- independent variables representing needle board frequency (X_1) respective needle depth penetration (X_2), expressed in cycles/min respective in mm.

In Table 1 (Figure 1) are indicated the experimental data regarding the influence of independent variables on water absorptive capacity of needle-punched nonwovens comprising PP fibers and viscose fibers.

Table 1: Experimental data

Independent variables		Mean measured value of dependent variable
X_1	X_2	Y
94	6	1850
115	8	1979
165	6	2119
165	9	2102
215	8	2017
236	6	1974

3.2. Hypotheses formulation

H_0: Needle board frequency respective needle depth penetration has not significant influence on mean values of water absorptive capacity;
H_1: Needle board frequency respective needle depth penetration has significant influence on mean values of water absorptive capacity (H_0 is reject)

3.3. Formulation of the regression model

The Anova model is defined by relation:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon \qquad (2)$$

The SPSS (Statistical Package for the Social Sciences) program was used in the modelling process.
The coefficients defined in Table 2 were determined for the established model and the t-test show if the influence of the needle board frequency respective needle depth penetration is "significant" on mean values of water absorptive capacity.

Table 2: Coefficients of ANOVA model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1639.838	123.005		13.331	0.000
	Needle board frequency	0.703	0.359	0.396	1.958	0.039
	Needle depth penetration	35.138	14.832	0.479	2.369	0.032

a. Dependent Variable: Water absorbent capacity

From Table 2 it can be noticed that Sig<0.05, so the H_0 is rejected and H_1 accepted. Hence, the needle board frequency and needle depth penetration has a significant influence on water absorptive capacity.

The estimated ANOVA model has the following expression:

$$Y = 1639.84 + 0.703X_1 + 35.138X_2 \quad (3)$$

3.4. Hypotheses confirmation over errors
3.4.1. M(ε)=0 (errors mean is null)

The hypotheses are the following:

$$H_0 : M(\varepsilon) = 0$$
$$H_1 : M(\varepsilon) \neq 0 \quad (4)$$

The Student t-test for errors (Unstandardized Residual) evaluation was applied as see in Table 3.

Table 3: Student t-test for testing of mean errors

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Water absorptive capacity	93.030	17	0.000	2007.611	1962.08	2053.14
Unstandardized Residual	0.000	17	1.000	0.000	-35.67	35.67

(Sig=1>0.05, so hypothesis H_0 is accepted)

3.4.2. V (ε_i) = ^{2} (homoscedasticity hypotheses)

A non-parametric correlation test is applied between the estimated errors and dependent variable. The correlation coefficient Spearman was calculated and the Student t-test for this coefficient was performed (see Table 4).
The hypotheses are:
H_0: correlation coefficient is insignificantly larger than zero (null hypothesis of Student t-test is accepted);

H_1: correlation coefficient is significantly larger than zero (null hypothesis of Student t-test is rejected).

Table 4: Spearman test for verifying the homoscedasticity hypothesis

Correlations

			Water absorptive capacity	Unstandardized Residual
Spearman's rho	Water absorbent capacity	Correlation Coefficient	1.000	0.720**
		Sig. (2-tailed)	0.000	0.001
		N	18	18
	Unstandardized Residual	Correlation Coefficient	0.720**	1.000
		Sig. (2-tailed)	0.001	0.000
		N	18	18

**. Correlation is significant at the 0.01 level (2-tailed).

The values of sig. for correlations water absorptive capacity – estimated errors (Sig=0.000) are equal and constant. The correlation Spearman coefficient (r=0.720) and Student t-test for this Spearman coefficient are indicated in Table 4. The significance of Student t-test (Sig t=0.000) leads to the decision to reject the null hypothesis of Student test (hypothesis that correlation coefficient is insignificantly larger than zero).Therefore, is rejected the homoscedasticity hypothesis for regression model between the water absorptive capacity and dependent variables (needle board frequency and needle depth penetration)with a probability of 0.95.

3.4.3. εi ~ N(0, ^{2}) – normality hypothesis

Testing normality errors distribution can be done using non-parametric tests like Kolmogorov-Smirnov test, Skewness test and Kurtosis test [7] (see Table 5 and Table 6).

Table 5: Kolmogorov-Smirnov Test

		Water absorptive capacity
N		18
Normal Parameters[a,b]	Mean	2007.61
	Std. Deviation	91.557
Most Extreme Differences	Absolute	0.190
	Positive	0.096
	Negative	-0.190
Kolmogorov-Smirnov Z		0.807
Asymp. Sig. (2-tailed)		0.534

a. Test distribution is Normal.b. Calculated from data.

The Sig=0.534 >0.05, so it is accepted the normality hypothesis (H_0).
Estimates of distribution errors form are the folowing:
- Fisher asymmetry coefficient: sw = 0.924, for a positive asymmetry (sw > 0);
- Fisher vaulting coefficients: k = -0.109 for a flattened distribution (k <0).

Table 6: Skewness and Kurtosis test for normality hypothesis

Statistics

		Water absorptive capacity	Unstandardized Residual
N	Valid	18	18
	Missing	0	0
Skewness		-0.508	0.924
Std. Error of Skewness		0.536	0.536
Kurtosis		-0.222	-0.109
Std. Error of Kurtosis		1.038	1.038

As seen in Figure 1, the parameter estimations indicate a deviation of errors distribution from the normal distribution.

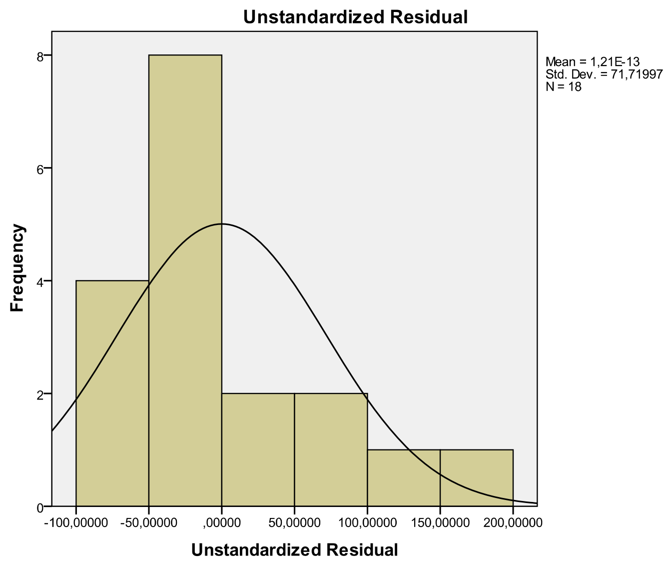

Figure 1: Estimated errors distribution

3.4.4. cov (εi, εi) - testing of errors autocorrelation

The hypotheses are:
H_0: ρ = 0 (the errors are not auto-correlated);
H_1: ρ ≠ 0 (the errors are auto-correlated).
For the verification was used the Durbin-Watson test and the results are presented in Table 7.

Table 7: Durbin Watson test for errors auto-correlated testing

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.783	0.614	0.589	58.663	0.681

The value of 0.681 is compared with test calculated value (dl, du). It is noted that the obtained value is in the range (0, dl) [7]. Therefore, the null hypothesis is rejected which means that the recorded errors have a positive auto-correlation.

The test statistic is the following: $DW = d = 2(1 - \hat{\rho})$ where $\hat{\rho}$ is the correlation coefficient error estimator and fulfilling the following condition: $-1 \leq \hat{\rho} \leq 1$. If $d = 2(1 - \hat{\rho})$, the statistic values are in the range: $0 \leq d \leq 4$. In table 6 is shown the calculated value of Durbin-Watson statistic d_{calc} = 0.681. This value is compared with the critical values, noted d_L = 1.158 (lower limit) and d_U=1.391 (upper limit) which are read from the Durbin-Watson table for a threshold of significance 0,05, for a regression model with two parameters [7].

4. CONCLUSIONS

To establish the influence of independent variables (X_1 and X_2) and dependent variable (Y), a mathematical modelling was performed as described in “Experimental” section.

ANOVA model permits us to evaluate the homogeneous character of population by separating and testing of the effects caused by considered factors. Based on ANOVA model has been established that sig<0.05. So, the hypothesis H_0 is rejected and H_1 is accepted.
Hence, employing ANOVA model on needle-punched nonwovens used in horticulture has revealed that needling process parameters have a significant influence on water absorptive capacity.

It is known that the water absorptive capacity of nonwoven increases with the increasing of proportion of cellulose-based fibers. Even the needling process parameters, namely, needle board frequency and needle depth penetration in web can increase water absorptive capacity until to certain values.

Based on experimental data, it is noticed that an increase of needle frequency and depth penetration have the same effect on nonwoven water absorptive capacity. It is found that 6 mm depth of needle penetration and 165 cycles/min needle board frequency is an optimum combination which might be considered for a maximum value of absorptive capacity because deviation from any of the independent variables may be responsible for the decreasing in absorptive capacity.

In general, with the increase of needle board frequency or depth penetration, absorptive capacity parameter decreases. The higher is fabric compactness, the lower is the number of pores (amount of voids) in structure. A less porous structure has a lower absorptive capacity.
The using of nonwovens with higher water holding capacity affects the frequency of irrigation which depends by existing environmental conditions.

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CONSIDERATIONS ON THE OVERALL ASSESSMENT OF THE QUALITY PROFILE FOR SKIRTS DESIGNED AS READY-TO-WEAR COLLECTION

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Abstract: *A positive effect of the globalized market is the "consumer market without frontiers". In the textile - garments field, this effect has generated a change in the supply chain by means of the international outsourcing contracts, as lohn system. Among other things, in lohn system the manufacturer can work without partnership ties with the inputs supplier and without partnership ties with the distribution of the final goods on the market (lacking the timely feedback from the final customer, which is the wearer). So, issues can occur considering the final quality of the ready-to-wear collections according to the end use, aside from the technological concerns during the garment processing.*
This paper addressed issues referring to accomplish a certain quality profile of designed skirts for ready-to-wear collections, by means of the overall characteristics (comfort, aesthetic and durability), for the end use's features expected and, for the specific perceptions of women.

Keywords: *lohn system, quality profile, skirts, fabrics, coating, lining, sewing threads*

1. INTRODUCTION

One of the positive effects of the globalized market is the "consumer market without frontiers". In the garment manufacture sector, this effect has generated a change in the principles of organizing and carrying out of the supply chain, by means of the emergence of international outsourcing contracts, named the lohn system. In principle, is known among other things, that in the lohn system the manufacturer can work without partnership ties with the fabrics supplier (lacking to quality specifications feedback) and without partnership ties with the distributing company of the final goods on the market (lacking the timely feedback from the final customer, that is the wearer) [1, 2].

Another interesting aspect of the lohn system is the launching way into production orders for the collections designed by the international outsourcing divisions, with which the garments company is not directly linked [1, 2].

The main requirements of a women garment are: adequate durability, a sufficient degree of comfort at wearing and last but not least, to improve the aesthetic appearance of the wearer, now matter what the end use is. In the past, an optimal compromise referring to the above demands relied on the ability of the tailor [1, 3].

This is the context in which, issues can occur do to the lohn system considering the final quality of the ready-to-wear collections according to the end use, aside from the technological concerns during the garment processing. When the apparels' quality for women is defined and measured from the industry perspective, tends to focus on the physical properties that can be measured objectively; nevertheless, a perspective that was received as much awareness is the women perspective, as the consumer's viewpoint of quality [2, 4]
Nowadays the fabrics for the design and manufacturing of women garment should be considered a entity more and more complex, reliant on the garments' layers (coating fabric, lining fabric, etc) ,on threads for sewing, and subjected to the testing methodology to achieve the best tailoring to be employed, based on the physical-mechanical properties [5,6,7].

Furthermore, no matter what niche is targeted, ladies-wear garments designed by means of engineering methods must have good functional and aesthetical features [2, 6].
Previous papers have approached the quality issues of garments for women's by means of the quality level for the major features that are usually involved: the design features (garment design, raw materials,

manufacturing particularities, sewing parameters and finishing techniques) and the performance features for the achievement of some physiological, physical and aesthetic properties [8,9,10].

The "cause and effect diagram'' for the quality of the skirts have been configured for highlighting the main causes which should be considered for improving, as the following: base material, secondary material, auxiliaries and threads for sewing, garment design and manufacturing [11].

This paper addressed issues referring to accomplish a certain quality profile of designed skirts for ready-to-wear collections, by means of the overall characteristics (comfort, aesthetic and durability), for the end use's features expected and, for the specific perceptions of women.

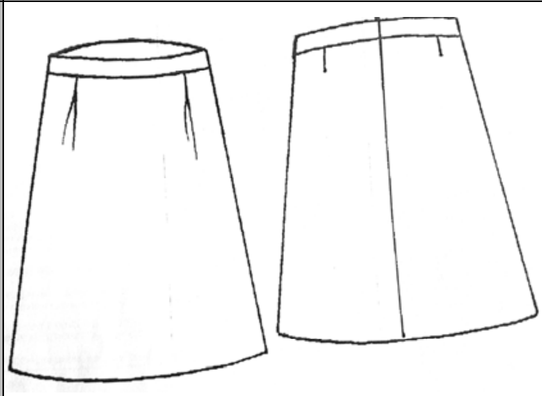
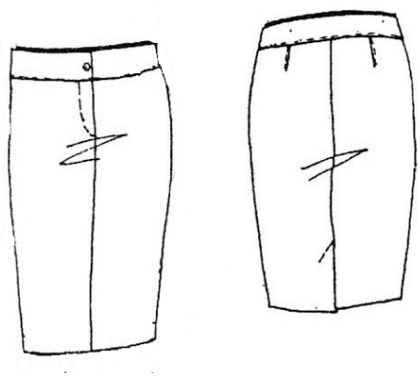
2. EXPERIMENTAL

2.1 Materials

The experiment was carried out, with four fabrics adequate to different end use in skirts, for coating and for lining, proposed in the skirt design stage, of a ready-to-wear collection.
Actually, the ones for coating were used for the trousers and, thanks to the launch of an expanded collections (as often happens in the lohn system), designers have included in the collection, two skirts models from existing coating materials with additional lining materials, not used for the pants.

Designed collection for ladies - casual look, is presented in Table 1 and the main description of the raw material proposed for the designed skirts are presented in Table 2.

Table 1. Designed collection for women- casual look

Product	**Pattern**	
Trousers		
Skirts		
	"A-Line"	"Pencil"
Fabric layers	F1-coating and F2-lining	F3-coating and F4-lining

Usual, in the lohn system, the overall profile of the garment is established and made known to the manufacturer by means of the technological report, which shows the raw materials to be used: coating, lining, all details about the sewing threads and about the stitches.

Table 2. Main description of the raw material proposed for the designed skirts

Fabrics	Fabric symbol	F1	F2	F3	F3
	Skirt layer	coating	lining	coating	lining
	Weave	plain (checked fabric)	twill 2/1	plain (striped fabric)	plain
					
	Raw material	PES64%/CV34%/EL 2%	CA 67%/ PES 33%	PES75%/CV23%/EL 2%	CA 58%/ CV 42%
	Fabric Colors	mixture colors : black, light- brown, grey	pale-brown	black, , light- brown, navy blue	navy blue
Sewing threads (Nt; Ut)*	Thread Ticket /Nominal size	Epic 150 (21 tex)	Epic 120 (24 tex)	Epic 150 (21 tex)	Epic 120 (24 tex)
	Raw material	Polyester corespun	Polyester corespun	Polyester corespun	Polyester corespun
	Color tone	brown	pale-brown	black	navy blue
Stitch	Stitch code	301 504 103	301 504	301 504 103	301 504
	Stitch type	Lockstitch (Nt & Ut) Over edge (Nt & 2 Ut) Blind stitch (Nt)	Lockstitch (Nt & Ut) Over edge (Nt & 2 Ut)	Lockstitch (Nt & Ut) Over edge (Nt & 2 Ut) Blind stitch(Nt)	Lockstitch (Nt & Ut) Over edge (Nt & 2 Ut)
	Needle size	Nm 65-75	Nm 70-90	Nm 65-75	Nm 70-90

* (Nt / Needle thread; Ut /Under thread)

2.2 Methods

The testing methodology deployed after the assessment of the structural characteristics of fabrics (weight M,g/m^2 and thickness g_p,mm), was carried out according to standards, to achieve the following characterization of the fabrics.

Quality evaluation of comfort :water vapor permeability (Pv,mg/24h)

Quality evaluation of durability: breaking force (Fr,N); elongation (Er,%); breaking length (Lr, km); Grab force (F_G,N); Grab elongation (EG,%)

Quality evaluation of aesthetics: drape coefficient (DC,%), crease recovery coefficient (□,%); stiffness (R, mg*cm); flexibility (H,%)

For all selected fabrics in designed skirts, a sampling was carried out to ensure five samples for five single tests each, and when was necessary (for durability and aesthetics), on the warp and on the weft directions. According to SR EN 139:2005, fabrics samples (for coating and lining) were conditioned at 65 ± 4% , relative humidity and 20 ± 2°C for 24 hours, before testing.

3. RESULTS AND DISCUSSION

Table 3 shows the average values of the structural and comfort properties, for each fabric indented to manufacturing the skits. Regardless of what kind of fabric is analyzed, according to the presented data, the water vapor permeability is correlated to the structural properties.

Table 3. Structural and comfort properties, for the layers of skirts

Fabric symbol	F1	F2	F3	F4
Skirt layer	coating	lining	coating	lining
Mass per square meter ,M (g/m^2)	216	69	180	64
Thickness,g_P (mm)	0.43	0.18	0.34	0.1
Water vapor permeability, Pv(mg/24h)	940	880	950	1045

The differences between coating fabrics (F1 and F3) and lining fabrics (F2 and F4), are not big, but significant from the structural and comfort characteristics point of view thus, the designed combinations F1-F2 and F3-F4, it seem to be acceptable (Figure 1).

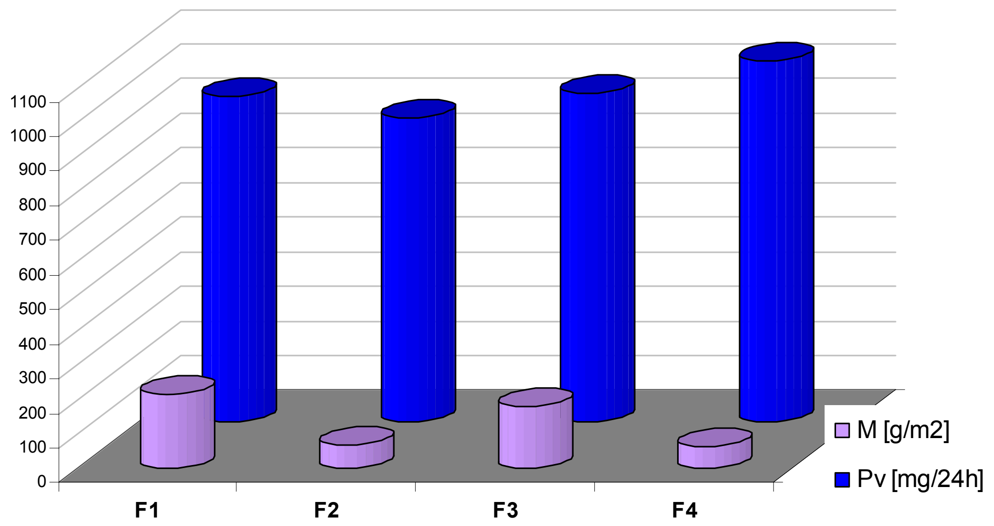


Figure 1: Comfort properties display for the layers of skirts

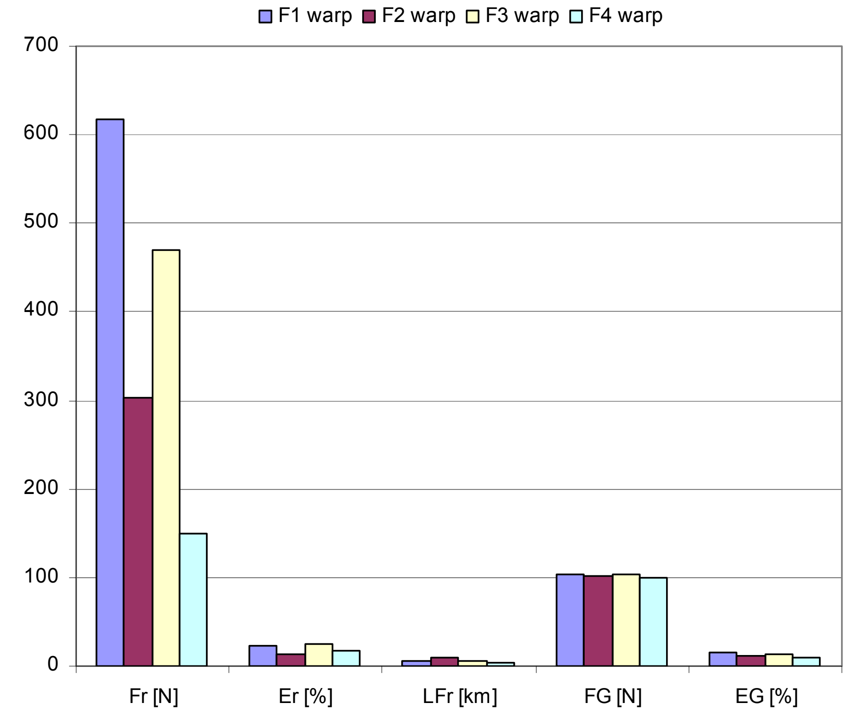
Table 4 shows the average values of the *durability* properties separately for each sampling direction that is also the loading threads, for each fabric indented to manufacturing the designed skits.

Table 4. Durability properties for the layers of skirts

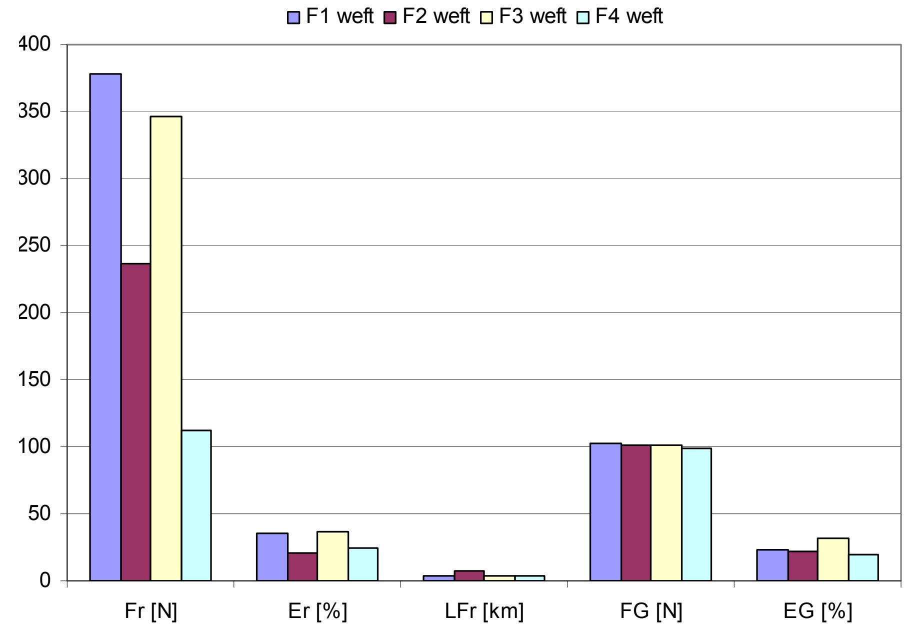
Fabric symbol		F1		F2		F3		F4	
Skirt layer		coating		lining		coating		lining	
Sampling direction		Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft
Breaking force Fr(N)	Average	618	378	303	236	469.5	346.4	150.3	112.1
	CV $_{F,\%}$	5.3	10.4	10.5	20.6	3.9	6.3	7.3	11.1
Elongation, Er (%)	Average	22.8	34.9	13.2	20.9	24.5	36.1	17.8	24.7
	CV ε, %	3.2	7.4	3.8	15.2	2.2	5.3	8.3	9.9
Breaking length, Lr(km)		5.72	3.50	8.78	6.84	5.22	3.85	4.70	3.50

Fabric symbol	F1		F2		F3		F4	
	4.61		7.81		4.53		4.1	
Grab force, F_G(N)	104.05	102.45	102.01	101.22	103.46	101.58	99.08	98.4
Grab elongation,E_G(%)	14.87	23.38	11.12	22.37	13.37	31.25	10.3	19.01

The distribution of the average values for breaking force, elongation, breaking length, Grab force and Grab elongation is shown in the Figure 2.a. (values achieved for the warp threads' loading) and in the Figure 2.b. (values achieved for the weft threads' loading).



a



b

Figure 2: Overall durability properties display for the layers of skirts:
a- Warp threads' loading b- Weft threads' loading

In this part, it is important to keep in mind that the two types of materials chosen for the coating and respectively, the two types of materials chosen for the lining, are close enough in terms of raw materials and patterns (see Table 2). Therefore, the evaluation of the durability parameters reveals that both groups of fabrics (coating, lining) had the similar behaviour to the tensile testing, with variation of the durability in a closer and limited range, with only two exceptions.

These were of the breaking forces obtained for coating fabrics (F1 and F3) for the warp loading and, of the breaking forces obtained for lining fabrics (F2 and F4) for both loading directions (warp , weft).
The coating fabrics F1 and F3 are more resistant on the warp threads' loading and, between them there is a difference of 25 % in support of F1.

The lining fabrics F2 and F4 have dissimilar durability because of the breaking forces, with a difference of almost 50% between them in support of F2, and this behaviour could be attributed to the effects of weight and thickness.

As a result, from the durability point of view (also, assuming that the sewing for the garment and the future requests for the end use) the designed combinations F1-F2 / F3-F4, it seem to be acceptable.
Table 5 shows the average changes in some aesthetic properties of fabrics: drape, crease recovery and stiffness/flexibility, and Figure 3 shows the overall variation of the experimental values.

Table 5: Aesthetic properties for the layers of skirts

Fabric symbol		F1		F2		F3		F4	
Skirt layer		coating		lining		coating		lining	
Sampling direction		Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft
Drape coefficient, DC (%)		24.3		24		21.1		21.5	
Crease recovery	Recovery angle,	157	159	136	146	164	169	120	125
	Coefficient (%)	87.6		78.1		92.4		68.1	
Stiffness R(mg*cm)	Axial	136.76	97.03	73.47	23.29	113.97	73.73	55.14	51.2
	Total	115.2		41.4		91.6		51.13	
Flexibility H(%)		57.77	69.72	45.94	76.33	62.38	70.83	55.66	53.94
		63.74		61.13		66.6		54.8	

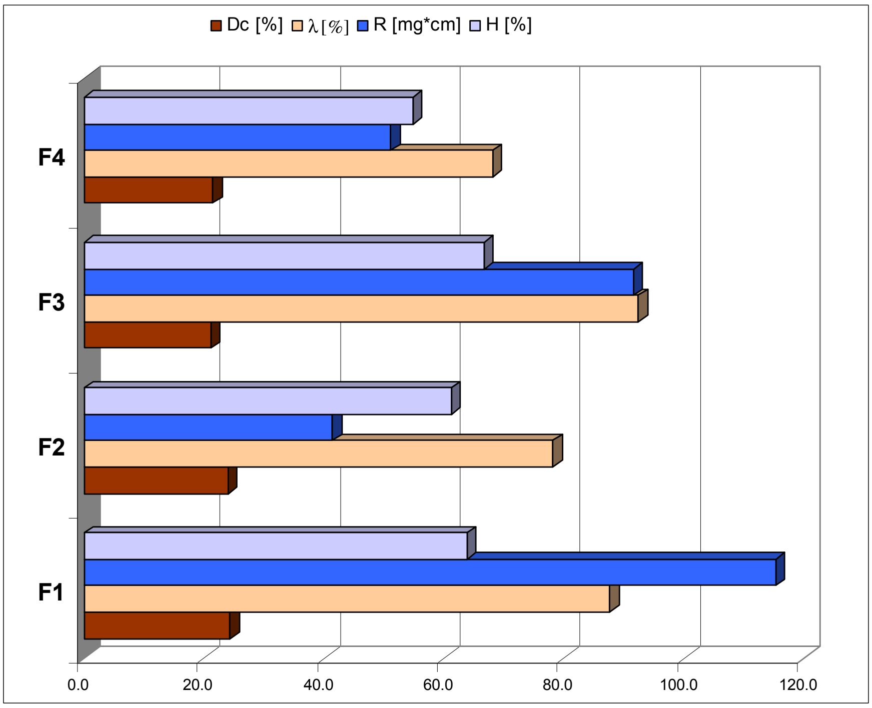


Figure 3: Overall aesthetic properties display for the layers of skirts

Altogether, were observed the following details:

- F3 material for coating has a better drape ability, crease recovery and flexibility compared to the F1;
- F4 material for lining has a better drape ability compared to the F2 and anisotropy to bending, but is a fabric more balanced then F2.

Therefore, it seems that, the designed combinations F3-F4 for the “Pencil” could be more suitable for the “A-Line “skirts.

According to the Table 1, garment silhouette with pattern made of different fabrics for coating and lining would be different on same garment style and is expected that the behaviour during use to depend on that.

The skirts quality requirements are rigorous and intended to guarantee the functional and aesthetic properties when women dress in and, the experimental results showed that for above materials it should be better to change the pattern: instead of combination F1 with F2 for “a-line” pattern to use combination F3 with F4 .

4. CONCLUSIONS

In this study, has been reported an experimental investigation on some fabrics selected as layers for two designed skirts from a ready-to-wear collection.

The main issue for the deploying the manufacturing of women garments by means of lohn system could be the adequate behavior of selected material for a pattern during use, keeping in mind that, every layer has an individual contribution (reliant on the raw material, fabrics’ pattern, finishing) .

Obviously, the quality profile for garments of the same generic category differs depending on the number of fabric layers and their combination within the product, also on the sewing threads, the sewing machine, the needle size, the seam type (for joining and /or over-edging) and last but not least, on the product’s finishing .
In this paper, for the customary textile materials it was necessary to define a quality profile according to the silhouette design of garment with “a-line” or “pencil” pattern.

The outcome of this paper was that, a suitable evaluation strategy according to the end use of the skirts from the ready-to-wear collections, should consider the contribution of all fabrics as combination coating-layers on the certain quality profile, and the manufacturer could redefine the designed product, including in the situation of lohn system, to guarantee the functional and aesthetic properties when women dress in.

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STUDY ON STRENGTH TRANSFER COEFFICIENT FROM ROVING TO GLASS WOVEN FABRICS

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Abstract: *The use of glass fibres as reinforcing medium for composites is a popular choice, due to various benefits such as reduced cost, greater design flexibility and good mechanical properties. Strength transfer coefficient from yarn to woven fabric/textile composite could be a useful index to design and evaluate the influence of weave structure on textile fabric/textile composite mechanical properties. For the present study, two variants of glass woven fabrics with different structural characteristics have been analysed and tested, in order to estimate the influence of fabric structure on the strength transfer coefficient in both warp and weft direction. It was found that, unlike the woven fabrics made of common raw materials (cotton, wool etc.), for which the strength transfer coefficient is greater than unity, for the fabrics that contains technical yarns with very smooth surface, this coefficient can be lower than unity. Further work will focus on the strength transfer coefficient from fibreglass roving to composite structure.*

Keywords: *glass fibres, woven fabrics, tensile strength, strength transfer coefficient.*

1. INTRODUCTION

The vast majority of all fibers used in the industry of composites materials are glass fibres. This is due to various benefits offered by glass fiber such as reduced cost, greater design flexibility and good mechanical properties [1,2]. Glass fibers are the most common reinforcement used in non-aerospace applications to replace heavier metal parts. In woven fiberglass fabrics, continuous glass fibres bundled into rovings are woven into a number of different patterns, each with its own weight and unique strength characteristics [3,4].

The breaking strength of textile composite reinforced with glass woven fabrics depends on fiberglass roving tensile strength, woven fabric parameters and impregnating process. Tensile strength of fiberglass roving is determined by inherent properties of filaments (raw material, internal structure, surface characteristics), number of filaments in the cross section and the finishing treatment applied prior to weaving. Woven fabric architecture influences the tensile strength through roving density (roving/cm) and weave structure.

Because of the stresses imparted during weaving process and due to the woven fabric architecture (weaves structure, yarn density etc.), the breaking strength of an individual yarn is affected after its integration in the fabric. Weave architecture (type of warp and weft roving, their linear densities, the warp and weft densities, weave pattern etc.) influences the mechanical properties of the woven reinforcement.

Tensile strength of individual yarns is changed after their integration into the woven fabric (it increases or decreases depending on various factors). For woven fabrics having traditional yarns made of common raw materials like cotton, wool etc., the friction between yarns gives the structure good stability and coherence.
One can conclude that the tensile strength of individual yarn "increases" after its integration in the fabric and this effect becomes more pronounced with yarn crimp frequency (induced by weave structure and yarns density) [5,6]. For the fabrics woven with multifilament tows like glass, carbon, aramide etc., owing to tow surface characteristics (very smooth), the breaking strength of an individual tow does not always increase after its integration in the fabric.

In order to evaluate strength transfer from yarn to woven fabric/textile composite, a strength transfer coefficient (C) can be defined as the ratio between the initial tenacity of yarn – T_i (before weaving) and the final tenacity of yarn, after its integration in the fabric or textile composite -Tf [7,8]. This coefficient could be a very useful index to evaluate the fabric architecture influence on the breaking strength of glass fabric/composite. In the field of traditional textiles there are some studies concerning the strength transfer coefficient from yarn to woven structure [5,6,7], but there is a lack of knowledge in the field of technical yarns. In the present study, two variants of glass woven fabrics with different structural characteristics have been analysed and tested in order to estimate the influence of fabric structure on the strength transfer coefficient in both warp and weft.

2. EXPERIMENTAL WORK

For the purpose of this study, the strength transfer coefficient (C) is defined as:

$$C = \frac{T_r}{T_{rw}} \qquad (1)$$

where:
T_r is the tenacity of fiberglass roving pulled out from woven fabric [N/cm];
T_{rw} is tenacity of fiberglass roving inside woven fabric [N/cm].

As used in yarn manufacturing and textile engineering, tenacity denotes the strength of a yarn or multifilament tow of given size and it is generally synonymous to *ultimate tensile strength*. The tenacity of roving pulled out from woven fabric can be calculated using the following formula:

$$T_r = \frac{\overline{F}_r}{T_{tex}} \ \text{[N/tex]} \qquad (2)$$

where:
$\overline{F}_r$ is tensile strength of the roving pulled out from woven fabric [N];
T_{tex} is linear density of the roving [tex].

The roving tenacity after its integration in woven fabric can be calculated using the following relation:

$$T_{rw} = \frac{\overline{F}_w}{b \times P \times T_{tex}} \ \text{[N/tex]} \qquad (3)$$

where:
$\overline{F}_w$ is average value of tensile strength of woven fabric specimen [N];
b - width of the woven specimen (b = 5 cm);
P - roving density in direction of the applied load [rovings/cm];
T_{tex} - linear density of roving [g/1000 m].

Replacing the relations (2) and (3) in relation (1), we obtain the mathematical formula for strength transfer coefficient from roving to woven fabric:

$$C = \frac{\overline{F}_w}{b \times P \times \overline{F}_r} \qquad (4)$$

Two variants of fiberglass fabrics woven using 1200 tex and 2400 tex E-glass multifilament roving (supplied by Isola Fabrics) have been studied. Table 1 shows the main structural characteristics and properties of woven fabrics.

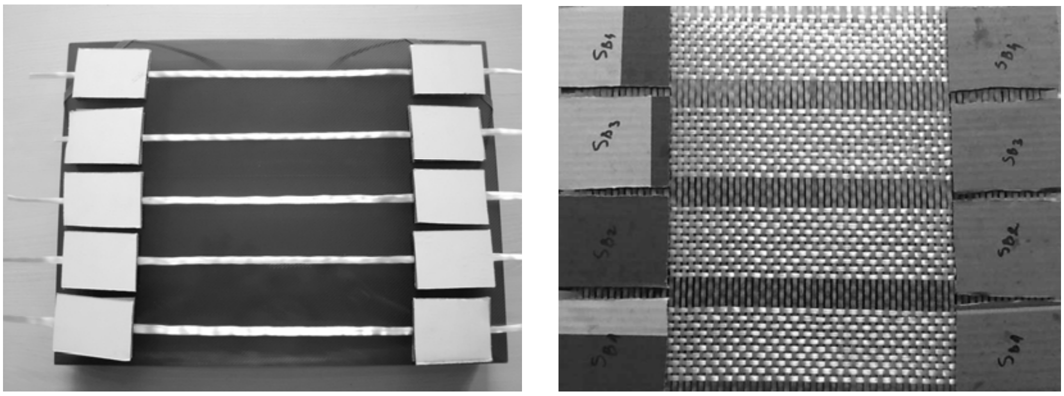
Table 1: Structural characteristics and properties of fiberglass woven fabrics

Characteristics	UM	Variant 1	Variant 2
Linear density of warp and weft rovings	tex	1200	2400
Length/width of roving's cross section	mm	3.5/0.28	5.0/0.37
Warp density	roving/10 cm	22	17
Weft density	roving /10 cm	20	17
Weave structure	-	plain	plain
Cover factor	%	93.1	97.7
Thickness	mm	0.54	0.87
Areal weight	g/m^2	500	800

The first article has a small imbalance between the yarn densities on the warp and the weft direction while the second article has a perfectly square structure. The cover factor of the fabric, defined as a ratio between the area of the plane projection of the yarns and the total area of the woven fabric, is greater in the second article than in the first one.

In order to calculate the strength transfer coefficient from fibreglass roving to glass woven fabric, the tensile strength for both roving and woven fabric was measured on specimens of 200 mm length. Four samples of fiberglass roving from each woven fabric variant, both from warp and weft, were carefully pulled out and prepared according to [9]. Each individual specimen was fixed at the two ends with thick cardboard strips using epoxy resin supplied by Bison®, leaving 200 mm free length for test (Figure 1-a).

Glass woven fabric specimens of 50 mm width, taken from warp and weft, were prepared in the same way, with cardboard strips glued at the two ends, in order to avoid crushing the fibreglass roving at edge of the clamps and to prevent slippage during testing (Figure 1-b). The free distance between the cardboards was 200 mm, according to [10].



a) b)

Figure 1: Preparation of the glass samples for tensile test - roving (a) and woven fabric (b)

The specimens of fibreglass roving and glass woven fabric were tested in similar conditions, using the servo-hydraulic testing system INSTRON 8801 (Figure 3). The testing speed was kept at 10 mm/min, and the gauge length was 200 mm.

Before testing, the fibreglass roving and woven fabric specimens, prepared as mentioned above, were conditioned for 24 hours in standard atmospheric conditions, at 20ºC temperature and 65% relative humidity.

a) b)

Figure 2: Glass woven fabric tensile testing.
a) Testing system INSTRON 8801; b) Glas woven fabric specimen after breaking

3. RESULTS AND DISCUSSIONS

Table 2 presents the results of tensile tests for fiberglass roving pulled out from warp and weft for both glass woven fabric variants. Figure 3 shows typical force/strain curves of fiberglass roving.

Table 2: Tensile strength test results for fibreglass roving pulled out from the woven fabric

Variant	Ultimate tensile strength [MPa]		Ultimate strain [%]		Force max [N]	
	warp	weft	warp	weft	warp	weft
1st	328.1	418.0	1.2	1.7	321.6	409.6
2nd	441.8	485.8	1.5	1.7	817.3	898.8

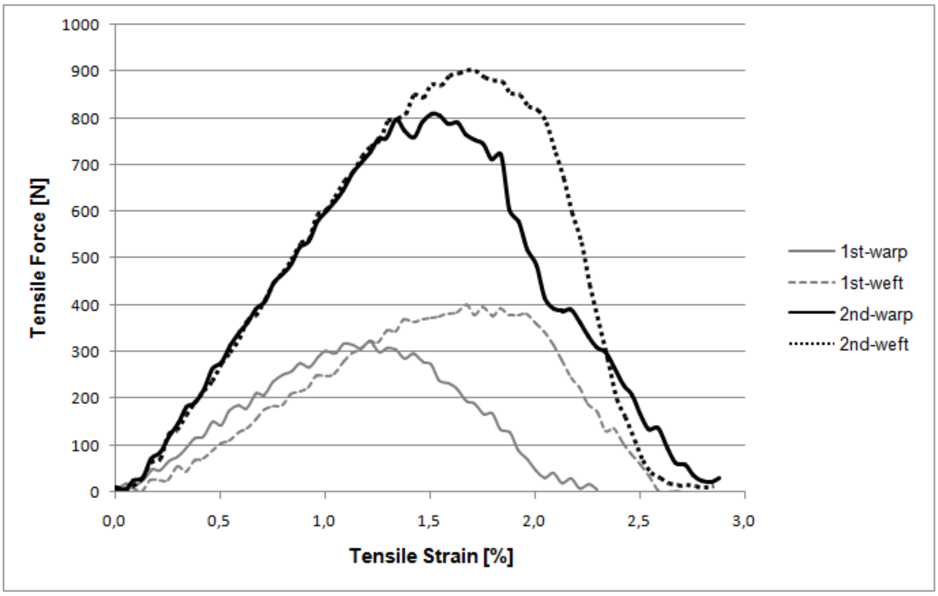


Figure 3: Typical force/strain curves for fibreglass roving

Table 2 and Figure 3 show that for both studied variants of woven fabric, the tensile strength of fibreglass roving pulled out from weft is higher than the value registered for the warp roving. This result can be explained by the higher loads supported by the warp yarns during weaving, comparing to weft yarns. Moreover, the movement of the frames in vertical plane can also cause degradation of warp fibreglass roving, reducing their strength. Both articles show this difference ant the fact confirms the influence of weaving process on the tensile strength of yarns. Analysing the results obtained for fibreglass roving extracted from the two types of woven fabrics, one can observe that the difference between the tensile strength on warp and weft direction is significantly higher for the finest roving (27%), compared to the thicker one (10%).

Table 3 presents the results of tensile tests for glass woven fabrics in warp and weft for both woven variants. Figure 4 shows typical force/strain curves of glass woven fabrics.

Table 3: Tensile properties of glass woven fabrics

Variant	Ultimate tensile strength [MPa]		Ultimate strain [%]		Force max [N]	
	warp	weft	warp	weft	warp	weft
1st	140.5	158.9	1.6	2.0	3789.5	4291.4
2nd	139.3	159.2	2.0	2.1	6059.7	6926.3

Tensile strength of glass woven fabric mainly depends on fiberglass roving strength, but also on woven fabric architecture.

Similar conclusion as for glass roving can be drawn for the strength of woven fabrics: in warp direction, the loss of strenght is biger than in weft direction, for both articles. In terms of percentage, the amounts of strength loss are near for both articles: 13.2% for the first article and 14.3 % for the second one. The curve allures are similar to the curves obtained for the glass roving, but more smooth, without picks.

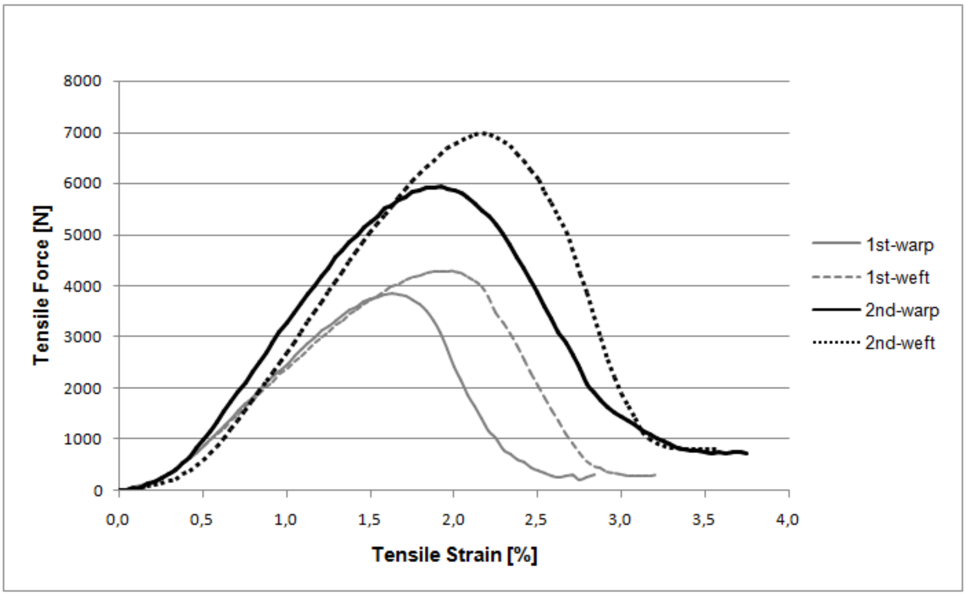


Figure 4: Typical force/strain curves for glass woven fabrics

Table 4 presents the values for tenacity of glass roving and the coefficient of strength transfer from roving to woven fabrics. Graphical representations of the strength transfer from roving to glass woven fabrics is presented in Figure 5.

Table 4: Tenacity for the glass rovings and the coefficient of strength transfer from roving to woven fabrics

Variant	Fiberglass roving tenacity Tf [N/tex]		Fiberglass rowing tenacity inside woven fabric Ti [N/tex]		Coefficient of strength transfer from fiberglass rowing to woven fabric C	
	warp	weft	warp	weft	warp	weft
1st	0.268	0.341	0.287	0.358	1.071	1.050
2nd	0.341	0.375	0.316	0.361	0.927	0.963

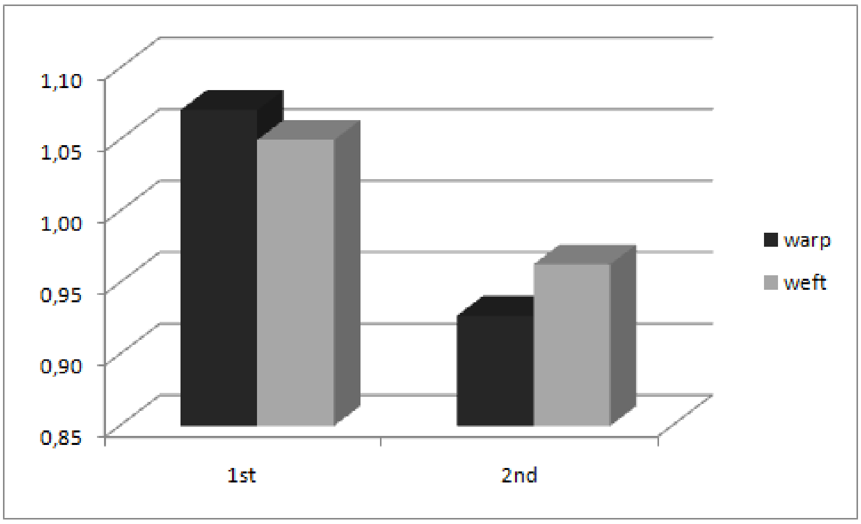


Figure 5: Strength transfer coefficient for the two woven fabric variants

For the first article, the strength transfer coefficient from roving to woven fabrics is bigger than unity, which signifies an increase of individual strength of the fiberglass roving after integration in woven fabric. This shows that mechanical properties of the yarns were well preserved after being integrated in the woven fabric due to well-dimensioned structural parameters.

In the second article, as the transfer coefficient is smaller than unity, there is a reduction of the mechanical properties of the yarns after being integrated. The difference of the cover factor between the two variant of woven fabrics (93.1% for the first article and 97.7% for the second one) could justify the reduced performance of the yarns in the second structure. As the yarns are too clustered together in the fabric structure, this could negatively affect the straightening phenomenon that occurs in the first phase of tensile testing and results in reduced values of tensile strength of the fabric.

CONCLUSION

Two glass woven fabric variants have been studied for the evaluation of the changes that a fibreglass roving undergoes after weaving in order to understand the transfer of strength from a multifilament yarn to the woven fabric.
It was found that increasing the cover factor of the woven fabric reduces the strength transfer coefficient from roving to textile structure.
Further work will focus on the strength transfer coefficient from fibreglass roving to composite structure.

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LINEAR REGRESSION FROM SPSS IN THE HYGROSCOPICITY ANALYSIS OF THE BAST YARNS

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Abstract: *The statistical program SPSS includes techniques and procedures using from simple processes to certain complex statistics, from histograms, percentile values, central tendency (mean, median, mode) and dispersional indicators (minimum, maximum, variance, standard deviation), distribution coefficients (Skewness, Kurtosis), confidence coefficients, statistical techniques exploring correlation among two or more variables to dispersional analysis. The results are presented in the tables and graphics that are easy to follow and use. Over the past years, the hygroscopicity of the bast fibres and yarns has been in the attention of many researchers [1-4] because this propriety influences the processes as well as the behavior in using the textile products. The aim of this paper is to presents the principal facilities of the SPSS programm with examples of the analysis using the linear regression to study the hygroscopicity of the bast yarns.*

Keywords: *data statistics, regression, correlation, bast yarns.*

INTRODUCTION

Obtaining performent and swift results can not be conceived without the use of the electronic microcomputer equipped with a strong and comprehensive software, no matter the type of activity, theoretical research, and practical preoccupation in a technical, economic, social, education or science field. From the resolution of a mathematical theorem, which many times covers hundreds of pages, where the computer is working with the mathematician to verify correctness and completeness of a theory without interruption for extended periods of time, even the order of months, to the planning and tracking of the technological process, even the most simple, or performing basic operations of addition, subtraction, multiplication and/or division. Modern statistical research assumes resolving certain problems of optimizing technical processes in textile industry, not only utilizing powerful PC, but also suitable statistical software packages, accesible user-friendly and with mechanisms on the one hand to keep the experimental data and their processing under appropriate statistical techniques and procedures, and on the other, presenting the results of the computer easy to follow in tables and graphs and implemented in control activities, management and/or prognosis.
This paper is focused firstly, on a presentation of the main facilities provided by the SPSS software in statistical research, and secondly, on the presentation and interpretation of results supplied by the computer analysis using linear regression of hygroscopicity of yarns from flax and hemp.

ABOUT THE DATABASE OF SPSS SOFTWARE

In the context of a certain type of application, a great importance is given to the way of organizing, storage, access and control of data processed. Inserting, removing, searching and modifying data or the connection between them must be based on the application type, optimally with the guarantee security and integrity of the data by protecting them compared to the malfunction of equipment and software in the computer configuration used. In the SPSS software package, preservation of primary experimental data, of the intermediate results and of those obtained from further processing by the computer is done in a directory on the disk, in form of files recognized in an appropriate format that later can be saved on an external magnetic media (CD, memory stick etc.).
After the release of SPSS software in terms of **Data View** or **Variable View** data files with an extension **.sav**, can support operation well known in Computer Science, such as generating, updating whenever necessary, saving regular or erasing outdated information, data accessing as often as desired or listing the content partly or fully.

The **File** command from the SPSS menu includes most of the options (**New, Open, Save, Save As, Print** etc.), to manage a SPSS file, anda user, even as an amateur can orient quickly because the name and structure of commands respects the standard template used in many computer products.
When creating an SPSS file, the following informations are used: the number and the name of the variables analyzed, and mainly, for each variable shall be fixed uploaded data type (numeric etc.), the maximum number of characters in a value, the maximum number of places in the case when the value is real or a summary of its attributes.
The update operation of an SPSS file implies actions to change the value of a measured variable or of a incorrect typeing, to erase variables (columns), to order on the levels of data contained in a variable, to introduce new variable with the values of the level, to order increasing/decreasing data from a variable, to select values of a variable after one or more criteria, to generate a variable with values calculated by **Transform** and **Compute Variables** command, to insert a new variable with the **Edit** and **Insert Variable**, up to rename a variable or to generate a new one.
In an interactive manner involving the Help system and adapted to the context errors to a standardized management system windows, menus, and SPSS files allow a fast and efficient work with many facilities.

STATISTICAL TECHNIQUES IN ANALYSIS OF THE LINK BETWEEN TWO OR MORE VARIABLES

According to the user requirements, with the SPSS program, in the **Viewer window**, it can solve graphic representations by different types, used in the descriptive statistics, the compuation linked to the statistical indicators of the central tendency and dispersal, the testing of some statistical hypothesis, the computation of the confidence intervals or complex problems of dispersal analysis with two or more variables related to the inferential statistics.
Through **Graphs** command and **Legacy dialogs** option [5-6], it can be represented the distribution of absolute, relative or cumulative frequencies as histogram with vertical or horizontal bars, line chart, histogram bars and the theoretical curve of normal distribution, the circular diagram for cumulative frequencies, scatergrama (cloud of points) to determin the correlation between two variables or vertical bar chart, separated on different levels.
With the **Editor Chart**, a graphical representation it can retouch using different shadings and colors for both the figure and background, continuous or discsontinuous lines with different patterns of interruption, broken lines, colored or bold as axes, networks horizontal or vertical lines, various titles for the graph name and desired colors as labels with text both inside and outside the graph.
The option of measure of the central tendency (average, minimum, maximum, median) or dispersion (variace, standard deviation, quartile, squeness or kurtosis coefficent) indicators is obtained with the **Analyze** command and the **Descriptive Statistics** and **Descriptives/Frequencies** options**.**
To test an average value, with the standard deviation known or not, using the t test, with a default value or significance level is activated the **Compare Mean** option from **Analyze** command.
The **Linear Regression** option allows analysis of bivariate linear regression and by subsequent application, easy to follow in tables and graphs, provide information regarding:

- unstandardized and standardized coefficients of the regression equation;
- Pearson's regression coefficient (**R**) and the coefficient of determination;
- the confidence intervals of the unstandardized coefficients with a significance level of 0.05;
- statistical indicators of central tendency and dispersal;
- various graphics.

In a similar manner, were obtained tables with descriptive statistics and with results found relating to analysis of variance, in the case of such a request.
The results file (the **outpu**t) can be kept, saved in files with the extension spo, modified, printed or transferred to a Word document.

HYGROSCOPICITY ANALYSIS OF YARNS FROM FLAX AND HEMP USING LINEAR REGRESSION

It is recognized that a linear model is described mathematically by the regression bivariate equation with the following form:

$$\mathbf{Y = a + bX} \quad (1)$$

where:

a is constant of the regression,
b - regression coefficient,
Y - dependent variable,
X - independent variable.

The formulas used in the SPSS program for finding the regression parameters are well known in statistics, namely:

$$\mathbf{a} = \overline{Y} - b\overline{X} \qquad (2)$$

where: $\overline{Y} = \frac{\sum_{i=1}^{n} y_i}{n}$

$\overline{X} = \frac{\sum_{i=1}^{n} x_i}{n}$ and

$$\mathbf{b} = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{n\sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)^2} \qquad (3)$$

where n is volume of the sample studied, while the sums refers to the measured values of the two variables.

The Pearson's R coefficient that measures the strength of correlation between the studied variables is calculated as follows:

$$\mathbf{R} = \frac{n\sum_{i=1}^{n} x_i ym_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} ym_i}{\sqrt{(n\sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)^2)(n\sum_{i=1}^{n} y_i^2 - (\sum_{i=1}^{n} ym_i)^2)}} \qquad (4)$$

where:

Y_m is dependent variable measured.

The parameter d = R^2 is the coefficient of the bivariate determination, which describes how much of the total variance of the variable y_m is due to the influence of independent variable. The rest up to 100% may be assigned of influence of other variables.

With Student test checks the significance of the coefficient r in the reference population:

$$\mathbf{t} = \mathbf{R}\sqrt{\frac{n-2}{1 - R^2}}$$ **,** with **= n – 2** degrees of freedom (5)

In hygroscopicity analysis of the bast yarns using linear regression, the dependent variable Y is mass of the sample after wetting one minute, five minutes or ten minutes, and the independent variable X is mass of sample in dry stage. Exemplifications of features of the SPSS software refers to: hemp yarns: 40 tex, 55.5 tex and flax yarn 50 tex.

Table 1 shows the regression equations obtained on experimental data. These equations approximates the phenomenon of the water absorption depending on the wetting duration.

Table 1: Resulted Equations of the tested hemp yarns 40 tex, 55.5 tex and flax yarn 50 tex

Type of yarns	Wetting duration	Equations	Coefficients			
			R−Corelation coef.	R Square Determination coef.	Student test value, t for X coefficient	Fisher−Snedecor F 1 and 8 degree of freedom, 95% confidence interval
Hemp yarn 40 tex	1 min	(1): Y = 3.581X−0.072	0.631	0.398	2.3	5.292
Hemp yarn 55.5 tex	5 min	(2): Y= 3.069X-0.041	0.779	0.607	3.515	12.358
Flax yarn 50 tex	10 min	(3): Y=2.752X-0.014	0.765	0.585	3.356	11.263

F_t=5.32 for 1 and 8 degree of freedom and 95% confidence interval [7].

For every regression equation obtained with the SPSS software the analysis was performed by showing statistical data in tables, as follows:

For the regression equation (1): Y = 3.581X −0.072 (1 minute wetting time) were obtained: statistical data in Table 2, Table 3, Table 4, Table 5.

Table 2 shows the independent variable X (as the dry mass of the sample) and the working method − of the smallest squares.

Table 2: Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	X− dry mass of the hemp yarn 40 tex[a]	Y−mass of the hemp yarn 40 tex after 1 minute wetting.	The smallest squares

a. All requested variables entered.
b. Dependent Variable: Y

In Table 3 are specified the values of the correlation coefficient of Pearson's R, which is 0.631 and measures the correlation between the variables studied, respectively the connection is strong and positive.

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std.Error of the Estimate
1	0.631[a]	0.398	0.323	0.00870801

a. Predictors: (Constant), X−dry mass of the hemp yarn 40 tex.

The coefficient of determination (R^2) is 0.398 and reflects that the almost 40% of the total variance of the measured values for the dependent variable (mass of sample after one minute wetting) is due to the influence of the independent variable. This coefficient reflects the predictive power of the studied model. Namely the change of the determination coefficient is not significant when other variables are added in the model. The value of over 5.292 of the test Fisher−Snedecor (see Table 4) as compared to the tabulated value Ft = 5.32 for the same degrees of freedom (df1=1, df2=8) and the same statistical certainty (95%), [7], reflects that the equation (1) no expresses satisfactorily the process.

In Table 4 are specified the components of dispersion ANOVA analysis, the variation of the dependent variable due to the independent variable, the residual variation due to the influence of other variables and all their residual amount which is the sum of squared the differences between the values measured of the dependent variable and its values computed with the equation of regression.

Table 4: ANOVA[b]

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression Residual Total	0.000 0.001 0.001	1 8 9	0.000 0.000	5.292	0.050[a]

a. Predictors: (Constant), X−dry mass of the hemp yarn 40 tex.
b. Dependent Variable: Y−mass of the hemp yarn 40 tex after 1 minute wetting.

Scatergrama in Figure 1 shows the graph of the cumulated probabilities of the standardized residuals, where the points distributed over the line have the tendency to overstate the reality, and those below the line under estimated it.

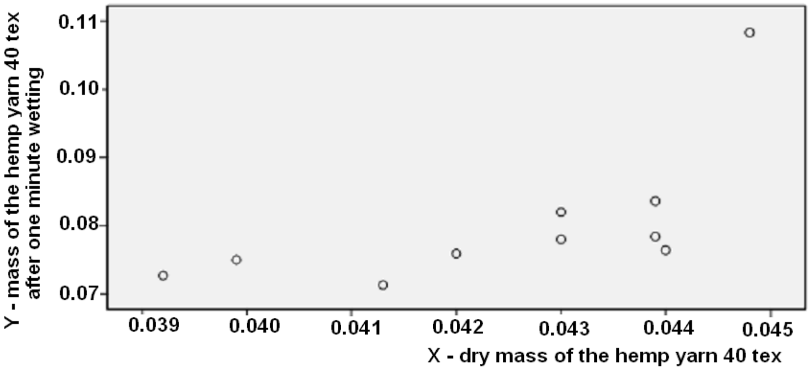

Figure 1: Scatergrama for regression equation (1).

For the regression equation (2): Y= 3.069X-0.041 (hemp yarn 55.5 tex after 5 minutes wetting) the following data was obtained:

Table 5: Model Summary

Model	R	R Square	Adjusted R Square	Std.Error of the Estimate
1	0.779[a]	0.607	0.558	0.02098658

a. Predictors: (Constant), X−dry mass of the hemp yarn 55.5 tex.

Table 6: ANOVA[b]

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	0.005	1	0.005	12.358	0.008[a]
Residual	0.004	8	0.000		
Total	0.009	9			

a. Predictors: (Constant), X−dry mass of the hemp yarn 55.5 tex.
b. Dependent Variable: Y−mass of the hemp yarn 55.5 tex after 5 minutes wetting.

Table 7: Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Conffidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
1 (Constant)	−0.041	0.064		−0.645	0.537	−0.189	0.106
X−dry mass of the hemp yarn 55.5 tex	3.069	0.873	0.779	3.515	0.008	1.056	5.082

a. Dependent Variable: Y−mass of the hemp yarn 55.5 tex after 5 minutes wetting.

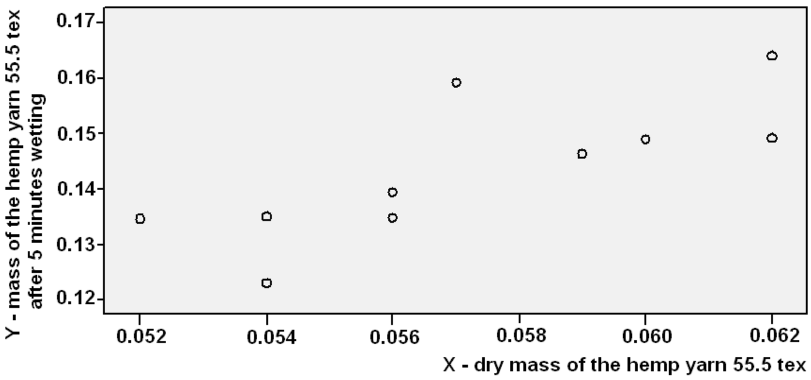

Figure 2: Scatergrama for regression equation (2).

Data analysis in Tables 5, 6, 7 has concluded that equation (2) expresses correspondingly the connection between mass of the yarn 55.5 tex in the dry state and after 5 minutes wetting because the calculated values of tests Fisher−Snedecor and Student exceed the tabulated values for the same degrees of freedom

(1 and 8). Scatergrama in Figure 2 shows the graph of the cumulated probabilities of the standardized residuals, so that, the points distributed over the line have the tendency to overstate the reality, and those below the line under estimated it.

In case of the comparatively analysis of sorption process [8] for the proposed yarns from flax and hemp (see Table 1), regression equations (2) and (3) corresponding of the stationary interval in water of 5 or 10 minutes are adequate, because the value of the Fisher−Snedecor test calculated, in both of cases, is higher than the F_t value listed for the same degrees of freedom, and a statistic confidence of 95%, see Table 1.

CONCLUSIONS

In an interactive manner SPSS files allow a fast and efficient work with many facilities.
The thin yarn of hemp, 40 tex, being more compact due to the twist, water absorption is difficult to the moistening of only one minute. The regression equations (1) no expresses satisfactorily the process because the influence of other factors than the dry weight of yarn exceeds 60%.
For flax and hemp yarns of 50 and 55.5 tex the water content increases proportionally with the dry weight of yarn. The regression equations (2) and (3) corresponding of the stationary interval in water of 5 or 10 minutes are adequate.
Regression parameters established with SPSS software permits mathematical modeling of practical processes.

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THERMOPHYSIOLOGICAL COMFORT PROPERTIES OF SPORTSWEAR PRODUCED FROM ADVANTAGEOUS FIBER TYPES AND FABRIC STRUCTURES

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Abstract: *The aim of the study is to determine thermophysiological comfort properties of 12 different fabric types produced taking into account fiber types and fabric structures, which were determined to be advantageous in previous studies, and to design different T-shirts using these fabric types for active sports.*

Keywords: *comfort, sportswear, moisture management, thermal resistance, water vapor resistance.*

INTRODUCTION

Thermal comfort is a concept related to the heat and moisture transfer properties of the garments necessary for protecting heat balance of the body at different activity levels [1]. Depending on such environmental factors as heat, moisture and air velocity, it is expressed by senses such as hot, cold, dry and wet after contact with the cloth [2]. It consists of the combination of clothing, environment and the physical activity level [3]. Many processes from the properties of the textile material to the procedures it undergoes are effective in the comfort attainment of human body which is in contact with garment. Fiber properties, the structural parameters of yarn and fabric, finishing treatments and clothing design characteristics are quite important for the thermophysiological comfort. Many researchers examined the effects of fiber properties, fabric construction and clothing design on the thermal comfort properties in their theoretical and applied researches [4-10].

The aim of the study is to determine thermophysiological comfort properties of 12 different fabric types produced taking into account fiber types and fabric structures, which were determined to be advantageous in previous studies, and to design different T-shirts using these fabric types for active sports.

EXPERIMENTAL

In this study, it was planned to evaluate the thermal comfort properties of fabrics in five stages. These stages are as follows;

I- Determination of the outstanding fabric structure with evaluation of comfort properties of the knitted fabrics having different fabric structures and same fiber type,

II- Determination of the outstanding fiber type with evaluation of comfort properties of the knitted fabrics having same fabric structure and different fiber types,

III- Selection of the advantageous fiber types and fabric structures taking into account the results of I and II stages, and measurements of thermophysiological comfort properties of these fabrics,

IV- Design of T-shirts combined by the fabrics selected with the help of the results of stage III.

In the stage I, the results of Öner and Okur (2013) have been taken into account. Öner and Okur (2013) have determined advantageous fabric structures in terms of wetness comfort by measuring the liquid moisture transport properties of knitted fabrics with different plain, tuck and float stitches combinations in three different tightness levels [11]. The fabric structures selected for this study are given in Figure 1.

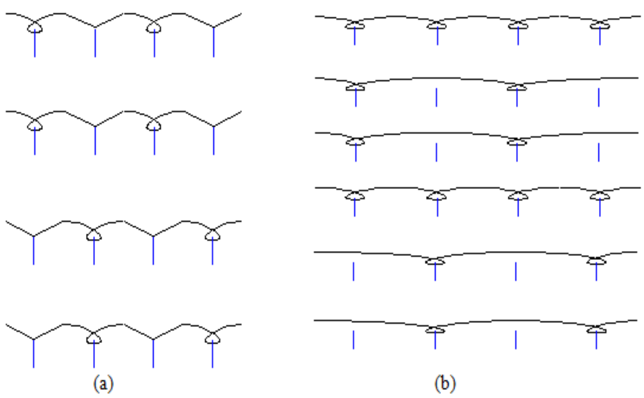


Figure 1: (a) Knitted fabric structure with tuck stitches, (b) Knitted fabric structure with float stitches

In the stage II, the results of the study conducted by Öner et al. (2013) have been considered. They have investigated transfer properties of knitted fabrics having 1x1 rib knitted structure were systematically produced from 20 tex yarns made of natural, regenerated cellulosic, synthetic and functional fibers. According to this study it has been determined that polyester fabrics, cotton/Coolmax fabrics and regenerated fabrics, such as viscose and Tencel, have shown outstanding comfort performance [12].

In the stage III, the fabric types were determined according to the results of first two stages. Knitted fabrics, which have two different fabric structures and six different fiber types, were produced from 20 tex ring spun yarns. All fabrics were knitted on Mayer&Cie Relanit 3.2 II circular knitting machine with 30 inches in diameter, 18 E and 62 feeders at constant machine settings and at the same tension. The physical and structural properties of the produced fabrics, which were measured in accordance with the related standards, are presented in Table 1.

Table 1: The properties of the fabrics

Sample code	Knitting Type	Fiber type	Mass per unit area (g/m^2)	Thickness (mm)	Courses /cm	Wales /cm	Loop length (mm)
1.1	Structure with tuck stitches	100% Cotton	134.75	0.80	11	11	3.03
1.2	Structure with tuck stitches	100% Viscose	150.45	0.88	13	11	3.12
1.3	Structure with tuck stitches	100% Tencel LF	153.26	0.87	12	10	3.32
1.4	Structure with tuck stitches	100% Soybean	158.95	0.89	12	10	3.20
1.5	Structure with tuck stitches	50-50% Cotton/Coolmax	164.92	0.94	12	11	3.38
1.6	Structure with tuck stitches	100% Polyester	157.18	0.93	12	11	3.22
2.1	Structure with float stitches	100% Cotton	148.17	0.65	26	14	2.29
2.2	Structure with float stitches	100% Viscose	188.53	0.69	24	15	2.74
2.3	Structure with float stitches	100% Tencel LF	191.44	0.70	23	15	2.72
2.4	Structure with float stitches	100% Soybean	197.53	0.74	23	16	2.73
2.5	Structure with float stitches	50-50% Cotton/Coolmax	196.19	0.81	24	16	2.71
2.6	Structure with float stitches	100% Polyester	197.88	0.75	24	16	2.77

All fabrics were conditioned for 24 hours at standard atmospheric conditions (20 ± 2°C, 65 ± 2% RH) before the tests. In order to determine the thermal comfort properties of the produced fabrics, the air permeability, wicking, moisture management, thermal and water vapor resistance of the fabrics were measured. Air permeability tests were performed with Textest FX 3300 Air Permeability Tester. Wicking (Velocity of suction of textile fabrics in respect of water) behavior of fabrics were measured in accordance with DIN 53924. The evaluation of moisture management properties of the fabrics was made by Moisture Management Tester – MMT. The thermal resistance (Rct) and water vapor resistance (Ret) measurements of the fabrics were made at M259B Sweating Guarded Hotplate. According to the experiment plan, air permeability, wicking, moisture management, thermal and water vapor resistance of fabrics were measured and the obtained results were evaluated in 95% confidence interval (α=0.05) by using SPSS 19.0.

According to previous measurement results and literature about human thermophysiology, different T-shirts have been designed stage IV.

RESULTS AND DISCUSSION

Air permeability measurements

Air permeability is the capacity of the air to pass through fibers, yarns and fabric structure. It is a usage feature about keeping the air passing through body or transferring it outwards. The air permeability of garments is affected by the fiber and yarn structure, fabric construction and finishing treatments. It is an important property that affects thermal comfort as well as its related to fabric porosity and breathability. The measurement results of air permeability are given in Figure 2.

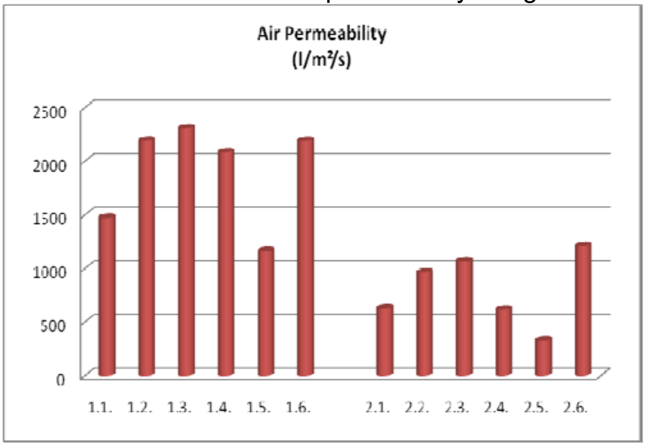


Figure 2: Results of air permeability of the fabrics

When the measurement results of air permeability were examined, the difference between fabric structures takes attention. All of tuck structures have higher air permeability values compared to knitting structures with float stitches. Low tightness level and the tucks in the structure cause the formation of bigger pores, and this situation provides that the passing air amount is higher. When the effect of fiber types is considered, it is seen that regenerated cellulose fibers have the highest air permeability values. Low air permeability values are determined in cotton/Coolmax blends and cotton fabrics. It is thought that this condition is due to the natural hairy structure of cotton yarns.

Wicking measurements

One of the most important properties of fabric, for the absorption of a liquid from skin and spreading into a large area, is wicking. Even though it is known as vertical absorption, a layer which reaches satisfaction in a sample, the bottom end of which is immersed into the liquid, makes liquid transport to an upper layer in this test method. For this reason, the capillary behavior of fabric determined the transport capacity with capillary forces. The results of measurement made on the fabric samples prepared in the Wales direction for 3, 10, 30 3and 60 minutes, respectively, are shown in Figure 3.

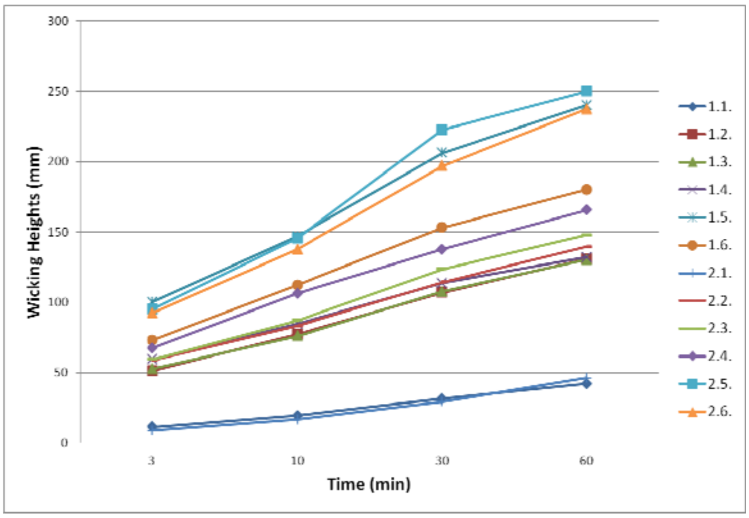
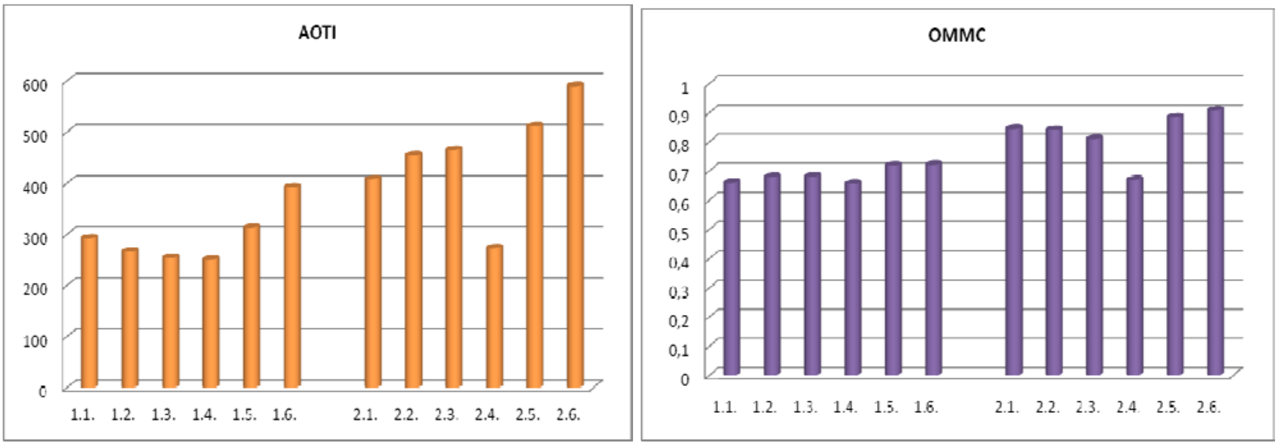


Figure 3: Vertical wicking curves for fabrics

When the test results are examined, it takes attention that fiber type is important in determining the wicking capacity of fabrics. It is seen that cotton fabrics take lower values compared to all other fabrics. Even though float structures take a little higher values compared to tuck structures, it is seen that fiber characteristics determine wicking behavior. It is determined that cotton/Coolmax blends have the highest capillary liquid transport capacity for both knitting types. Polyester fabrics take place after them. It is seen that synthetic fibers and their blends have wicking heights at higher levels compared to others and that this does not change throughout the measurement time. Among regenerated fibers, it is observed that soybean fibers, which are regenerated protein fibers, have higher wicking capacity especially for float structures compared to regenerated cellulose fabrics.

Moisture management measurements

MMT equipment gives many measurement parameters related to moisture management properties of the fabrics. Among these parameters, AOTI and OMMC are more important in terms of making a general evaluation on liquid management performance of fabrics. OMMC shows overall management performance of liquid moisture in fabric and the higher this value is, the better liquid transport performance of fabric is. On the other hand, AOTI is a value that shows cumulative moisture amount difference between two surfaces of the fabric. As AOTI value increases in a positive direction, the transfer of liquid from skin to environment will be that easy and fast. Negative or low AOTI values show that fabric soaks fast and removes liquid late. AOTI and OMMC measurement results of fabrics are presented in Figure 4.



(a) (b)

Figure 4: (a) Results of AOTI of the fabrics, (b) Results of OMMC of the fabrics

When AOTI values are examined, it is seen that float structures have generally higher values compared to tuck structures. It is observed that polyester fabrics have the highest values for both knitting types and that cotton/Coolmax fabrics follow them. While regenerated fabrics generally get low values, soybean fabrics have the lowest value among fabrics structure with float stitches. It is understood that polyester fabrics and the blend of cotton and Coolmax, which is a modified polyester fiber that is advantageous in moisture transfer with its capillary section structure, transfer liquid from one side of fabric to its other side fast.

OMMC values vary between 0.66 and 0.91. This condition shows that it is determined by high liquid moisture management capacity in terms of all fabrics. It is seen that float structures have higher values and that especially polyester and cotton/Coolmax fabrics with float stitches have a very good liquid moisture management capacity.

Thermal resistance measurements

The most important parameter taken into consideration in the thermal comfort of garments is thermal resistance which is the resistance of fabrics against heat flow. As the thermal resistance value of fabric increases, heat transfer from human body to environment decreases and the temperature in the microclimate increases. The results of thermal resistance measured in Sweating Guarded Hot Plate equipment are shown in Figure 5.

When thermal resistance results are examined it is seen that fabrics with float structure have lower thermal resistance values than those with tuck structure. Cotton fabrics take the lowest thermal resistance values in both knitting types. It is thought that this condition results from the fact that cotton fabrics have the lowest thickness and mass per unit area values. It takes attention that the highest thermal resistance values are determined in polyester fabrics. Among regenerated fabrics, soybean fabrics have the highest thermal resistance especially in tuck structures.

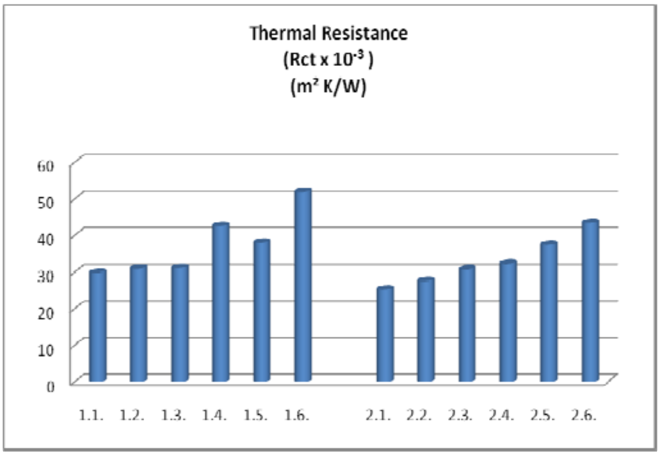


Figure 5: Results of thermal resistance of the fabrics

Water vapor resistance measurements

In the most general sense, water vapor resistance is the endurance that fabric shows against the flow of water vapor. As water vapor resistance of fabrics increases, the transfer of sweat from human body to environment decreases. The measurement results of water vapor resistance are illustrated in Figure 6.

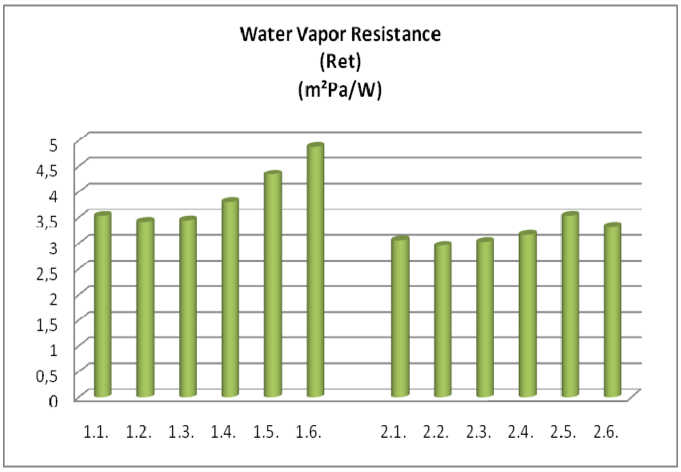


Figure 6: Results of water vapor resistance of the fabrics

As seen in Figure 6, it is determined that knitted structures with tuck stitches have higher water vapor resistance values compared to float structures and that polyester fabrics have the highest water vapor resistance. It is remarkable to see that polyester and cotton/Coolmax fabrics, which come into prominence in terms of liquid moisture transfer, have low water vapor permeability.

T-shirt design

Considering thermophysiological structure of the human body; the regions of the body which can sweat more and the parts which can be formed airflow were determined in light of literatures [13-5] .On the basis of the results obtained in this investigation and taken into consideration thermal behavior of human body, four woman and five man T-shirt designs were determined. The T-shirts were designed to have air channel, which is knitted fabric structure with tuck stitches, and have sweat absorbing surface, which is knitted fabric structure with float stitches. In order to improve ventilate cooling; T-shirts designs have tuck structure fabrics at the back and underarm areas. With the use of float structure fabrics at the base of T-shirts, the sweat can be transported from the body to environment easily. According to the objective measurement results it can be stated that; polyester and cotton/Coolmax fabrics with float structure, which have good liquid moisture transfer properties, and viscose and Tencel LF fabrics with tuck structure, which have high air permeability and low water vapor resistance, can be used in related areas of the T-shirts. Figure 7 shows the T-shirt designs determined in the study.

Figure 7: The t-shirt designs determined in the study

CONCLUSIONS

In this study, air permeability, thermal and water vapor resistance, multi-dimensional liquid transmission of the fabrics which have been different fiber types and different fabric structures, have been measured and these results have been compared. From the results obtained it can be concluded that polyester and cotton/Coolmax fabrics with float structure have good liquid moisture transfer properties and that cotton/Coolmax fabrics will be advantageous in removing liquid sweat from body when it is considered that they will show natural hand and that they have very high capillary absorption characteristics. In the comparison of regenerated fabrics, it is determined that regenerated protein soybean fabrics can be effective in cold weather conditions with their high thermal resistance and good capillary absorption capacities but that they do not have any significant superiority for sports wearing at hot weather. When high air permeability and low water vapor resistance values of Viscose and Tencel LF fibers in their use in tuck structures are considered, it is thought that this will provide certain advantages for breathable fabric design.

As a future work, based on the results obtained, sportswear garments can be produced using advantageous fabrics and their performance studied with wear trials further.

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INVESTIGATION OF AIR PERMEABILITY OF NEW GENERATION FLEECE FABRICS IN DRY AND WET STATE

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Abstract: *In recent time fleece fabrics are being increasingly used for insulating layer in three-layer system of thermoactive clothing. This type of clothing should insure the thermal comfort in all weather conditions and regardless of the activity of wearer. Air permeability is the one of the feature which influence on thermal comfort of garments. Clothing often is getting wet (sweat, humid environment) which can significantly affect the thermal properties, while most of the testing methods performs measurements only in the dry state. Therefore, in the paper were presented the investigation of air permeability in dry, normal and wet state of the different kinds of fleece fabrics. Furthermore, the water absorption of the tested fleeces has been also determined. The presented researches proved that wet clothing significant loses thermal comfort. This phenomenon is exacerbated with increasing moisture content of material and depends on the structure and the filling of test materials.*

Keywords: *thermal comfort, air permeability, wet state, fleece fabrics*

INTRODUCTION

In last decades, increased attention is paid to comfort properties of textiles and garments. Nowadays, well-being and a high level of comfort is the exponent of good quality thermoactive clothing. This fact should not be surprising since it is well known the strong relation between the comfort properties of garment and human sensations. Comfort is defined as “the absence of displeasure or discomfort” or “a neutral state compared to the more active state of pleasure” [1]. There is general agreement that the transfer of heat, moisture and air through the fabric are the major factors of thermal comfort. Many authors have pointed out that the major factors influencing heat transfer through a fabric are the thickness and enclosed air. A decrease in thickness of fabric, together with a corresponding decrease of fabric volume, is generally followed by decrease of air entrapped in fabric structure changing the thermal properties of the fabric [2-4]. Also Obendorf et al. [5] mentioned that the heat resistance increase with the increase of material thickness while thermal insulation increases the density of fabric decreases. Frydrych et al. [6] investigated the influence of fibre morphology, yarn and fabric structures on thermal properties. They found that the high thermal properties of garment can be obtained not only by choice of thickness but also by applying appropriate weaves and appropriate finishing process. Moreover, it was noted that the type of raw materials influences some fabric properties characterizing their thermal and utility comfort. However, all of these and similar publications analyse the phenomenon of thermal comfort, when the research material is in a dry state. Contrary to a commonly accepted theories garments, due to sweat sorption or because of humid, rainy climate are often used in wet state, which has influence on their comfort properties. Thus, the final thermo-physiological comfort is given by two principal components: thermal resistance in wet state and the active cooling resulting from the moisture evaporation from the skin and passing through the garment and from direct evaporation of sweat from the fabric surface. Currently only few publications [7-11] took the fact of wet fabric into consideration. This follows from the fact that current measuring instruments for the evaluation of these fabric properties usually require more than 30 minutes for full reading, thus avoiding the precise determination of fabrics humidity effect on their thermal resistance and cooling heat flow, due to humidity decrease during the measurement.

Fleece fabrics, called "polar" are the materials that have been used mainly as a heat-insulating layer of three layers of sportswear. They can also be used for underwear thermoactive (the first layer), or for the outer layer (the third layer) – see Figure 1. There are also as "stand alone device" which plays the role of all three layers together. Because, for reasons of its properties ensure proper breathability, sweat discharge, are warming, and a barrier against external environment for humans [12].

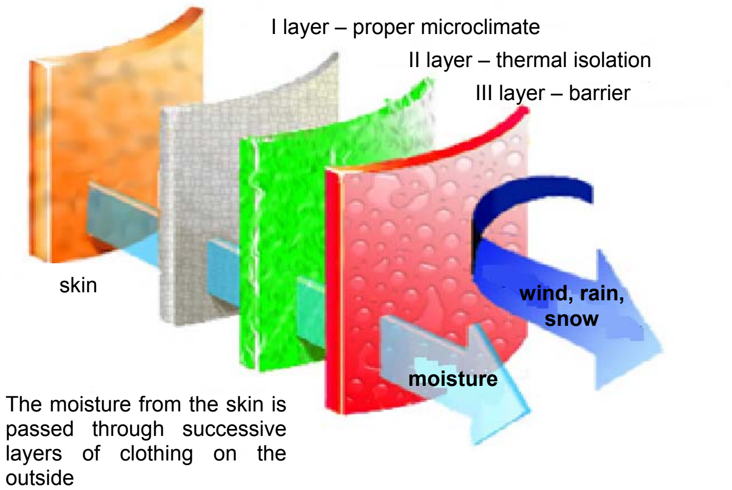
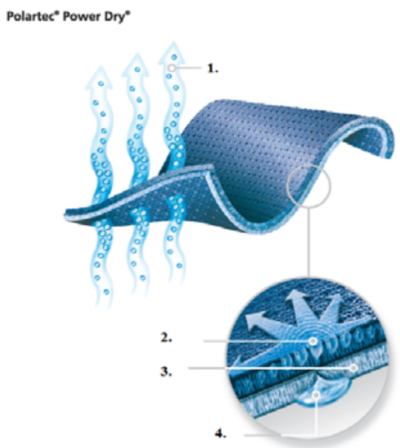


Figure 1: Diagram illustrating the three-layer clothing system [12]

The first fleece fabrics were developed about 20 years ago. The goal for the producers of these materials was to create brand textiles with modern features and universal application. Inspiring the structure of the fur of the polar bear has become the basis for a fleece. Output element was to make synthetic fur bear of hair-like tubules. This is where the air is accumulated to allow the formation of the heat insulating layer. Sweat that is excreted by the body is free to evaporate from the fabric. According to the manufacturers and several publications [13 -15]) Fleece does not absorb moisture, because polyester has hydrophobic properties (fully submerged can absorb water at less than 1% by weight). Additional advantage is that the fleece fabrics (in dry state) are very light. This knitwear has better thermal properties than made from natural fibers, does not absorb odors, does not wrinkle, do not change the appearance after washing and is highly resistant to wear [13]. By mapping the above structure can achieve the ideal protection from external factors, and obtain a highly comfortable sportswear. The fleece material is distinguished by a three-layer structure: outer layer - against cold, draft shield, breathable, resistant to pilling; intermediate layer - insulating and reinforcement; an inner layer - expels moisture from outside [15]. By using various structure of the individual layers is achieved different biophysical and thermal insulation properties (Figure 2).



1. Excellent air permeability and water vapor .
2. Desorption of the second layer of moisture sorption material (polyester) .
3. Layer conduction - diffusion material - moisture transport (polypropylene) .
4. Moisture sorption of the surface of the skin of the user.

Figure 2: The principle of Polartec ® PowerDry ® [14].

In the paper were presented the investigation of air permeability in dry, normal and wet state of the different kinds of fleece fabrics. The new methodology of air permeability measurement will be designed to analyse fabrics in wet state. The investigation proved that wet clothing significant loses thermal comfort compared to dry clothes. This phenomenon is exacerbated with increasing moisture content of material and depends on the structure and the density of tested materials. Furthermore, the water absorption of the tested fleeces has been also determined. These research also show that, the generally considered fleeces as dry materials, in fact, because of the knitted structure, characterized by a high degree of water absorption.

EXPERIMENTAL MATERIAL

In the research the 6 different fleece fabric have been tested. The characteristic of the fabrics shown the Table 1. They were measured in a laboratory with the temperature of 21-23 ºC and 50-55% relative humidity

Table 1: Characteristic of fleece fabrics.

No	Name of fleece fabric	Raw material	Weight, g/m^2	Thick., mm	Density, g/cm^3	Application
1	Polartec®100 Micro®	100% polyester	160	2,70	$5{,}92 \cdot 10^{-2}$	underwear, insulation layer
2	Polartec®ThermalPro® (1)	100% polyester	250	4,14	$6{,}03 \cdot 10^{-2}$	insulation layer
3	Polartec®ThermalPro® (2)	100% polyester	290	4,63	$6{,}26 \cdot 10^{-2}$	insulation layer
4	Tecnopile®	100% polyester	340	4,35	$7{,}82 \cdot 10^{-2}$	insulation layer
5	Polartec®Windblock®	85% polyester 25% polyureth.	320	3,51	$9{,}12 \cdot 10^{-2}$	outer layer
6	Soft Shell®	42% polyamide 39% polyester 10% elastin 9% polyureth.	280	3,26	$8{,}58 \cdot 10^{-2}$	outer layer

Experimental material was obtained from the Laboratory Mountaineering Equipment Adam Malachowski, the manufacturer of high performance thermoactive sportswear.

EXPERIMENTAL METHODOLOGY

Air permeability is a hygienic property of textiles which influences the flow of gas from the human body to the environment and the flow of fresh air to the body. Air permeability depends on fabric porosity, which means the number of canals in the textile fabric, its cross-section and shape. Thermal properties are essentially influenced by air permeability. Air permeability is defined by the equation [16]:

$$A = \frac{V}{F\tau(\Delta p)} \text{ [mm/s]} \qquad (1)$$

where:

V - capacity of the flowing medium,
F - the area through which the medium is flowing,
 - time of flow,
p - drop in pressure of the medium

Air permeability values were obtained by using FX 3300 Labotester III firmy Textest AG according to according to Polish Standard PN- EN ISO 9237:1998. Its principle depends in the measurement of air flow passing through the fabric at certain pressure gradient Δp. Air permeability of fleece fabrics was determined in the three state:

1. dry state - after drying samples in the temperature 60 C during 60 min to get rid of all moisture;
2. normal state – the samples were acclimated in a normal climate for 24 hours;
3. wet state – the samples were soaked in a water bath at 21-23 ºC with a wetting agent to lower the surface tension, to increase their moisture.and drying several times in order to reach different moisture content. The moisture content *U* of the samples was determined by weight, according to the equation:

$$U = \frac{m_w - m_d}{m_d} 100\% \tag{2}$$

where:
U – moisture content, %
m_w – weight of wet sample, g
m_d – weight of dry sample, g

Water absorption is a quotient of the weight of water absorbed by the acclimated sample after immersing in water for a specified time to the surface of the sample (g/m2). Determining water absorption was carried out in accordance with Polish Standard PN- 72/P- 04734 [17].
During the tests specified:
1. Relative water absorption *Ww*, according to the equation:

$$Ww = \frac{m_w - m_a}{m_a} \cdot 100\% \tag{3}$$

where:
m_w – weight of wet samples, g;
m_a – weight of acclimated samples, g

2. Absolute water absorption *Wb*, according to the equation:

$$Wb = \frac{Ww \cdot m_S}{100}, g/m^2 \tag{4}$$

where:
Ww - relative water absorption, %;
m_S – square mass of fabric, g/m^2

RESULTS AND DISCUSSION

The results of reserch of air permeability in dry and normal states are displayed in Figure 3 and 4. From the obtained result can be observed that for the tested fleece fabrics there were differences in the values of air permeability depending on raw materials, structure, weight as well as density, in both dry and wet state. The highest value was characterized Polartec®100 Micro®, which is often used for the first layer – underwear. While the lowest values were characterized by a fleece of groups dedicated to outerwear. As can see, Polartec®Windblock® and Soft Shell® constitute a real barrier to the external environment. Comparing the results of air permeability investigation in dry and normal conditions can register that even a small increase in moisture content of samples decreases slightly this feature. Only in case of sample 4 and 5 can be observed a small increase in value, which may be dictated by the change in the structure of knitted as a result of the drying process (different arrangement of fibres in the yarn).

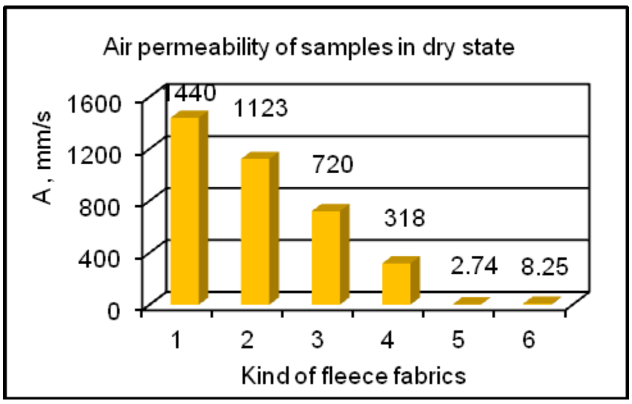


Figure 3: Air permeability of fleece fabrics in dry state.

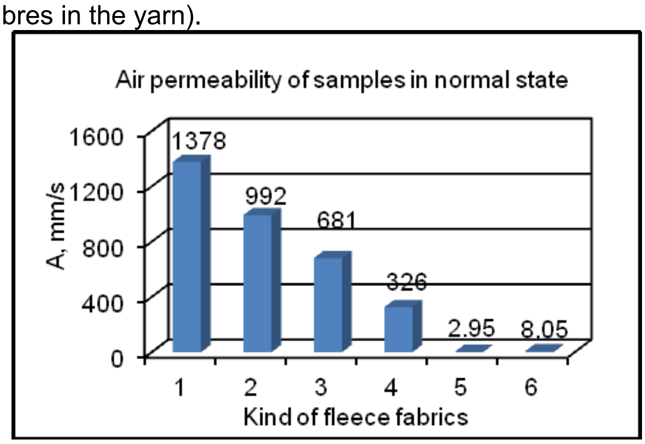


Figure 4: Air permeability of fleece fabrics in wet state.

From Figure 5 and 6 follow, that with increasing the percentage of moisture in the fabric decreasing the air permeability. For all tested fabrics the relationship between air permeability and moisture content of samples had linear character. However, they differed in the value and speed of reduction of this feature, which is illustrated by varying degree of slope of the trend lines. The decrease in air permeability values reached a size ranging from 15 to 60%, which in the case of insulating materials and underwear is very disturbing phenomenon. The study also showed that the air permeability in dry state depends on the density of the tested materials (Figure 5). Together with density of fleece fabric increased the air permeability decreased. This relationship was a polynomial function of the square.

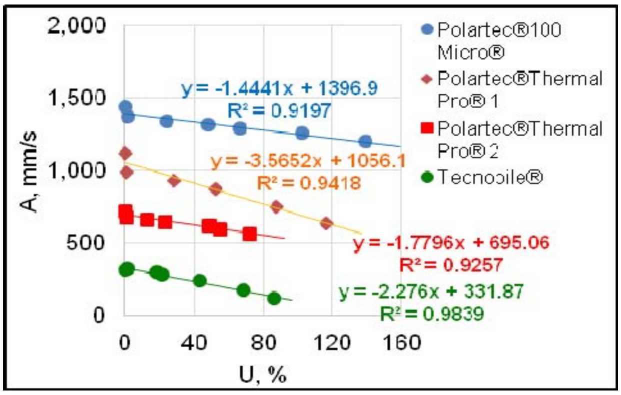


Figure 3: The dependence of air permeability on moisture content of tested samples (Sample from 1 to 4)

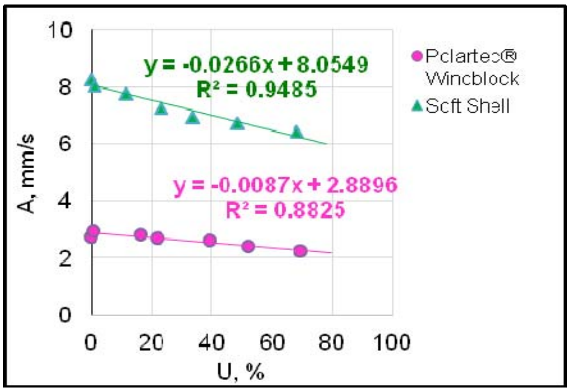


Figure 4: The dependence of air permeability on moisture content of tested samples (Sample 5 and 6)

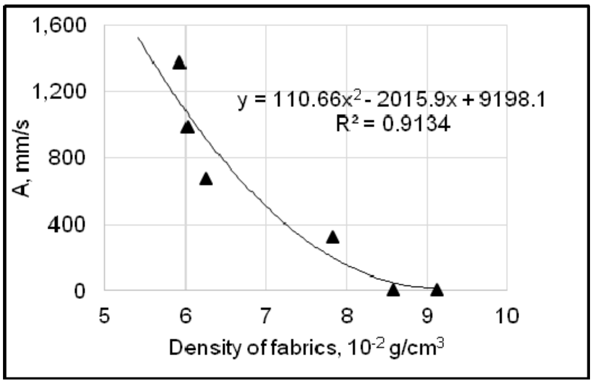


Figure 5: The relationship of air permeability and density of tested fleece fabrics.

In the case of water absorption tests, it was observed that although the fleece materials are considered as a dry (contain of hydrophobic fibres), at a time when they became wet, they absorb a fairly large quantity of water (Figure 6 and 7). In discussed research it was more than 70% to nearly 170%. This phenomenon was caused by a porous, knitted structure and the presence of capillary effect.

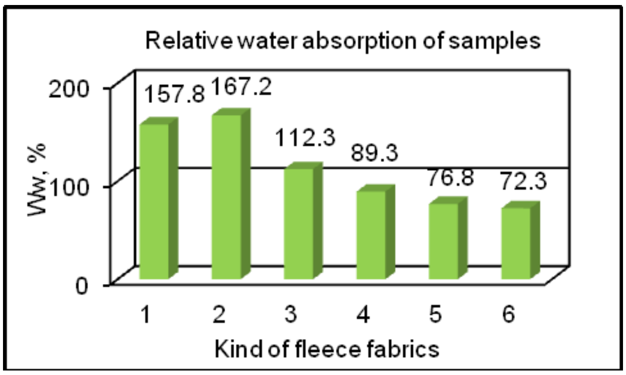


Figure 6: Relative water absorption of fleece fabrics.

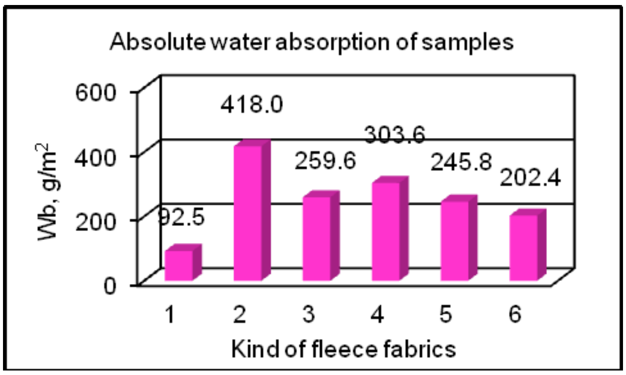


Figure 7: Absolute water absorption of fleece fabrics

Also in this study, a fabric density play an important role (Figure 8). Together with increasing of density of fleece fabric the ability to absorb water decreased. This relationship, just as it was in case of air permeability, was a function of a polynomial in the second power, but with less correlation.

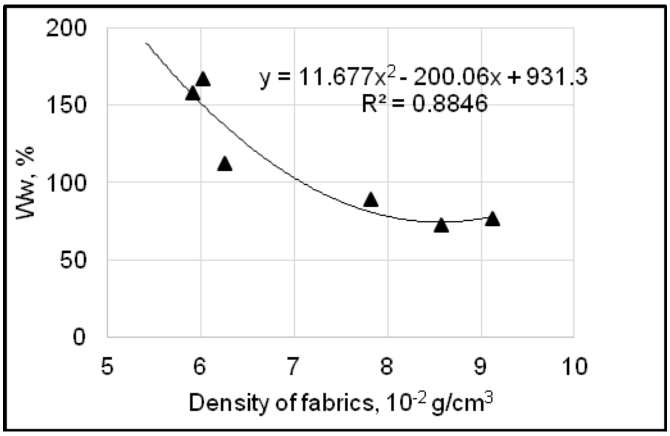


Figure 8: The relationship of relative water absorption and density of tested fleece fabrics.

CONCLUSION

From the presented researches follows, that with increasing moisture content in fleece fabrics significantly worsen their air permeability, which can cause drastic changes in the thermal comfort of the user. These changes are in the range of 20% to even 60%, depending on the kind of fleeces, their structure, weight as well as density of fabrics. The phenomenon of deterioration of the air permeability is caused by substituting of the air in pores by water. The liquid water in wet fabric structure creates the partially continuous film, which limited the transfer of air, as well as reduced thermal comfort because water has much higher thermal conductivity than air. Also deserve attention results of water absorption test. Fleeces, which are treated as a dry garments, due to their hydrophobic raw material, in fact, after dipping absorb a very large amount of water. Depending on the structure (in particular the density) the absorptivity was from 70% to 170% relative to the dry weight of the fabrics. This causes, at the first, a significant increase in the weight, which for the man who fall into the water in such garments is a very dangerous factor, and it may even cause drowning. Secondly, as mentioned previously, water is characterized by a much greater thermal conductivity and, therefore, wet clothing loses its insulation properties, which in the case of fleece clothing is a basic and primary function. Therefore, the physiological properties of fabrics, which are becoming increasingly wet as a result of use, are subjected to sudden changes, which adversely affects the quality of wearing apparel. Knowledge of these phenomena is very important in clothing design and technology, especially sportswear, which are often used in extreme weather conditions with high humidity.
Additionally, studies have shown that the FX 3300 Labotester III firmy Textest AG is suitable for the investigation of air permeability of fabrics in wet state. The measurement time is short enough to preserve the stability parameters of wet fabric, allowing for determination of effect of fabrics humidity on their air permeability.

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MATHEMATICAL MODELING FOR THERMAL RESISTANCE CAPACITY OF THE WOOL PANELS INTEGRATED IN CONSTRUCTION MODULE

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Abstract: *This paper presents mathematical modeling of thermal resistance for nonwoven panels, made from wool fibers, by starting from main factors of variation (humidity, density and thickness of the panels). The work is based on case study analyze for nonwoven wool panels with thickness variation between 20-40 millimeters. For achieving mathematical modeling we have started analyze from the coefficient of thermal conductivity, which is indirect proportional to the thermal resistance.*
The coefficient of thermal conductivity λ is a basic thermo physics characteristic of each material and depends, in the general case on the nature and state of the material, temperature and pressure. The thermal conductivity of the material varies in direct proportion to the density and moisture (as the conductivity of the water is considerably increased - by approximately 20 times - rather than that of air), so the nonwoven fabric made from wool fibers insulate better if it is in a dry stage.

Keywords: *mathematical, resistance, insulation, wool, modelling*

INTRODUCTION
In the market there are already some products, made in New Zeeland, Ireland, and based on wool fibres for thermal insulation made from natural fibers Ecowool and recycled Ecowool. Natural Ecowool insulation is 100% pure New Zealand fine, white wool. Recycled Ecowool is coloured wool sourced from New Zealand woolen product manufacturers [1]. This products wool retains indoor air pollutants such as nitrogen dioxide, and formaldehyde, which are emitted from gas stoves, heaters, and building materials [1]. In Ireland the company Sheep Wool Insulation produces two products: Premium and Comfort for thermal insulation applications in buildings [2]. These products are also suitable for reducing airborne sound transfer in building [2].

EXPERIMENTAL PART

The wool panels analyzed in this paper are produced in a national research project “Researches regarding developing of new technical textile products with regenerate, wool and new fibers content” that is developed in the National Research & Development Institute for Textiles and Leather.

The thermal conductivity λ is materialized by the material’s ability to allow heat transfer between the panel made of woven wool and environment. It varies from material to material and is also in close correlation with the chemical and physical structure of materials.
Insulation made from wool panels is a "greenest" choice of any insulation product on the market. The wool fibers are renewable and sustainable source of raw material.

The main objective of the mathematical modeling is to establish the behavior of the insulation panels with variable thickness. The thermal conductivity of nonwovens wool panels, analyzed in this paper was determined using the equipment "HEAT FLOW METER THERMAL CONDUCTIVITY INSTRUMENT, ANTER CORPORATION, USA.

For 24 wool panels samples were measured thickness, mass and thermal conductivity (Table 2). Thermal conductivity values were reading after 30 minutes. The thickness value was calculated like average, after capture the 10 value of thickness per wool panel (Table 1). The wool panels analyzed don’t present uniformity from view point of surface and voluminous aspects. This is relevant because were obtained different thickness values per wool panel unit.

Table 1 Thickness tests for wool panels for construction

Sample No.	Test1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
1	2.5	2.7	2.4	2.1	2.2	2.1	2.3	2.1	2.4	2.3
2	2.2	2.6	2.1	2.2	2.3	2.1	2.0	2.1	2.4	2.4
3	2.2	2.1	2.2	2.4	2.4	2.7	2.4	2.2	2.2	2.4
4	2.3	2.2	2.2	2.1	2.3	2.2	2.4	2.2	2.3	1.3
5	2.1	2.3	2.3	2.2	2.3	2.2	2.5	2.2	2.1	2.2
6	2.1	2.3	2.3	1.9	2.4	2.2	2.4	2.4	2.3	2.1
7	2.1	2.3	2.2	2.1	2.2	2.6	2.6	2.5	2.7	2.4
8	2.2	2.3	2.4	2.5	2.4	2.6	2.3	2.6	2.7	2.3
9	2.5	2.6	2.5	2.3	2.5	2.5	2.4	2.6	2.4	2.4
10	2.4	2.5	2.3	2.5	2.3	2.4	2.6	2.7	2.6	2.5
11	2.4	2.2	2.3	2.3	2.3	2.5	2.4	2.5	2.5	2.6
12	2.2	2.3	2.2	2.1	2.5	2.5	2.4	2.5	2.5	2.6
13	2.6	2.2	2.2	2.4	2.4	2.4	2.2	2.5	2.6	2.4
14	2.6	2.7	2.4	2.6	2.2	2.3	2.4	2.3	2.4	2.3
15	2.4	2.4	2.3	2.3	2.4	2.5	2.3	2.6	2.4	2.6
16	1.5	1.8	1.9	1.8	2.0	1.8	1.7	1.6	1.8	1.9
17	1.7	1.9	1.7	2.0	1.8	2.0	2.0	2.1	2.2	2.1
18	1.8	1.8	1.8	1.7	2.1	1.8	1.7	1.9	2.0	2.1
19	2.7	2.3	2.6	2.8	2.7	3.0	2.8	2.6	2.4	2.5
20	2.6	2.5	2.6	2.2	2.3	3.1	2.9	2.8	2.5	2.1
21	2.9	2.5	2.8	2.4	2.3	2.3	2.2	2.3	2.6	2.5
22	2.0	2.2	2.3	2.1	2.1	2.3	2.3	2.3	2.3	2.4
23	2.1	2.2	2.3	2.1	2.2	2.0	2.4	2.5	2.1	2.2
24	2.3	2.2	2.0	2.4	2.3	1.9	2.2	2.3	2.1	2.5

Table 2 Average values for thermal conductivity, mass and thickness - wool panels

Sample No.	Thickness [cm]	Mass [g]	Thermal conductivity [W/mK]
1	2.31	34.32	0.0591
2	2.24	34.85	0.063
3	2.32	35.676	0.0672
4	2.15	37.436	0.0661
5	2.24	31.503	0.0652
6	2.24	31.543	0.0585
7	2.37	37.33	0.0645
8	2.43	41.91	0.0782
9	2.47	42.333	0.0542
10	2.48	37.468	0.0725
11	2.4	33.974	0.0774
12	2.38	34.749	0.0604
13	2.39	40.044	0.0769
14	2.42	36.77	0.069
15	2.42	32.773	0.0652
16	1.78	29.14	0.0475
17	1.95	38.78	0.0535
18	1.87	34.3	0.0501
19	2.64	27.36	0.049
20	2.56	21.28	0.0569
21	2.48	25.32	0.0589
22	2.23	36.71	0.0645
23	2.21	32.07	0.0468
24	2.22	33.8	0.0454
AVERAGE	2.3	34.226	0.0612

RESULTS AND DISCUSSIONS

From histogram- figure 1, regarding thickness values per wool panel unit can see that samples presents a high nonuniformity due to the different voluminous areas and compression rate that is different on a wool panel sample.

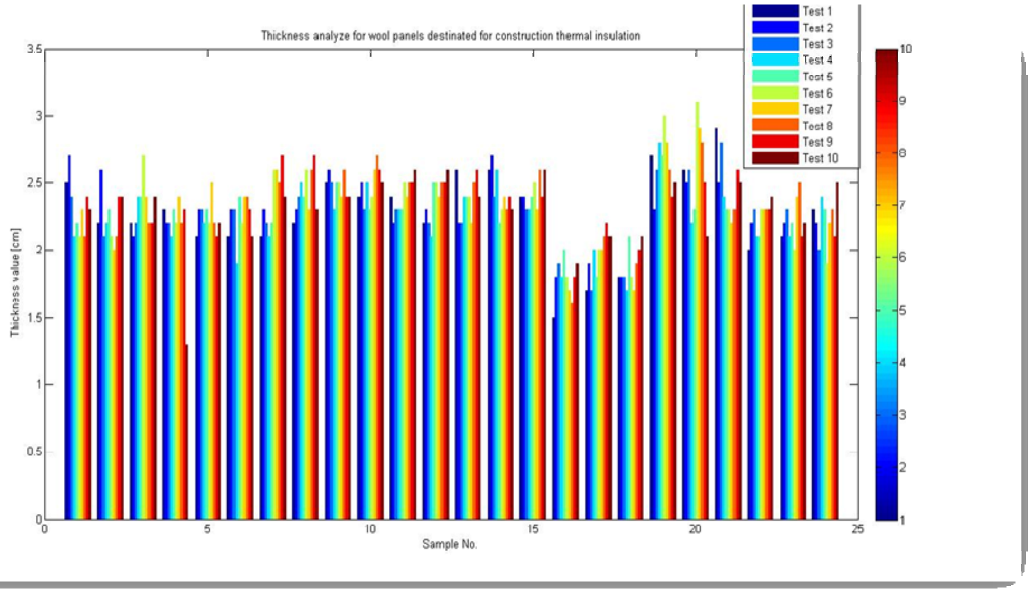

Figure 1: Thickness values analyze- histogram

From thickness and thermal conductivity (figure 2) value can conclude that thermal conductivity is inverse proportional with wool panel thickness. A thickness higher for wool panel means here that the 3D panel have air interstationar in structure, this conducting to the increased voluminosity for panel.

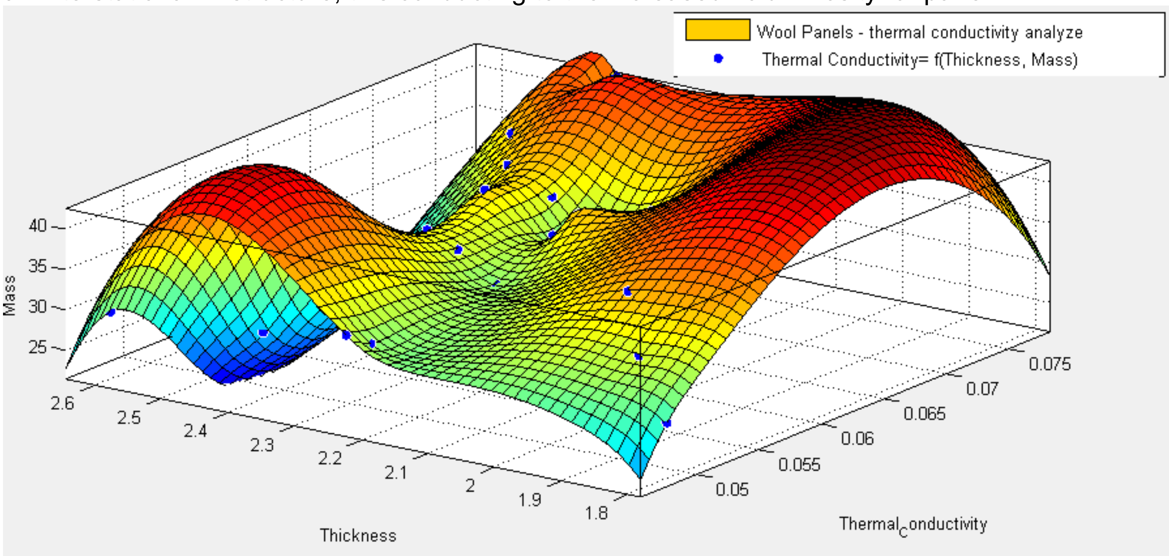

Figure 2: Thermal conductivity 3D representation for wool panels in function of thickness and mass per unit values

From residuals values for thermal conductivity (figure 3) and contour analyze it can remark that don't exist residuals values but the surface resulted don't respect a polynomial interpolation due to the high variability of mass and thickness values. Because for mineral wool, thermal conductivity values are in interval 0.035 ÷0.045 W/mK and the values obtained for wool panels thermal conductivy are higher, this means that wool panels don't have a high thermal resistance like mineral wool panels. Thermal resistance is directly proportional with thickness and inverse proportional with thermal conductivity. In this case high values of thermal conductivity for wool panels are conducting to lower values for thermal resiatnce.

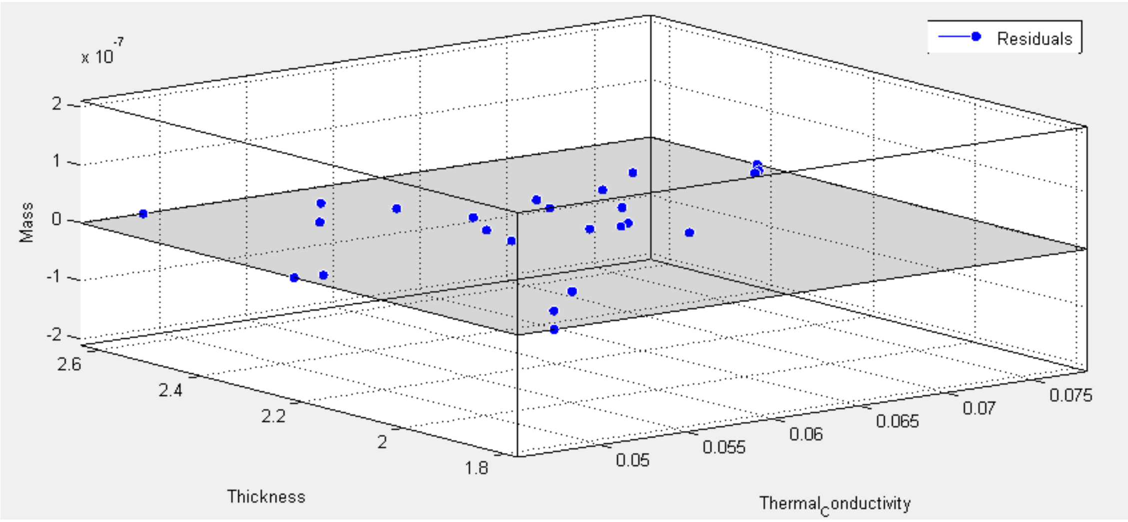

Figure 3: Residuals value for thermal conductivity

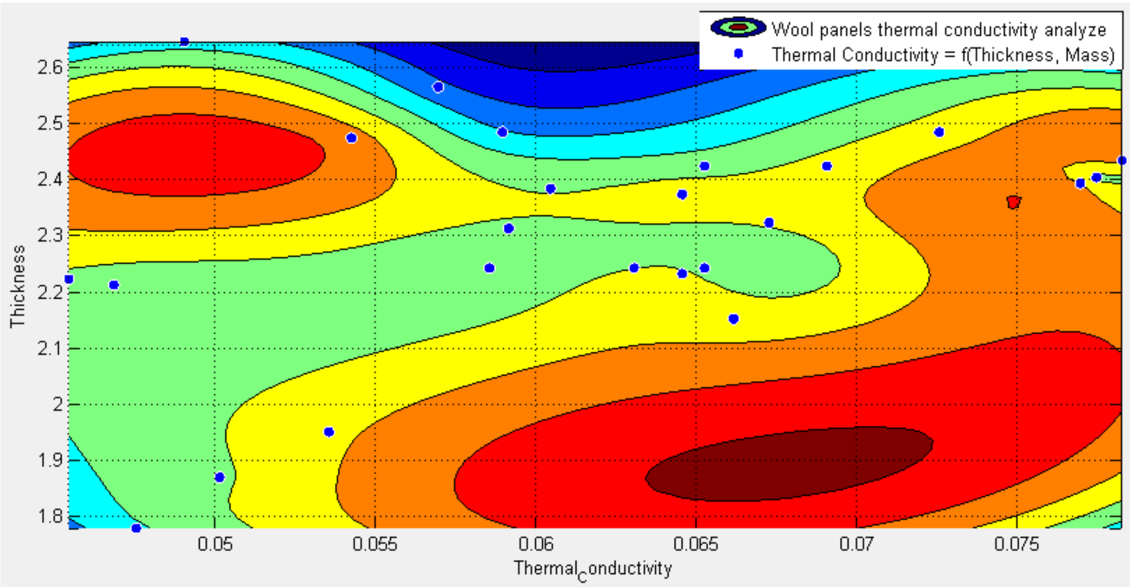

Figure 4: Wool panels- thermal conductivity – contour analyze = f(mass, thickness)

By using experimental data and analyzes, we obtained the linear mathematical model for thermal conductivity in function of thickness and mass values– described by next mathematical formula:

F(x, y) – thermal conductivity
x - Thickness
y - Mass

$$f(x,y) = 0.06001 + 0.02298 * x + 0.0277 * y - 0.01658 * x^2 - 0.1023 * x * y + 0.01516 * y^2 - 0.07456 * x^3 - 0.03142 * x^2 * y + 0.03978 * x * y^2 - 0.03329 * y^3 + 0.03724 * x^4 + 0.3058 * x^3 * y + 0.222 * x^2 * y^2 + 0.01341 * x * y^3 - 0.1012 * y^4 - 0.108 * x^4 * y - 0.2731 * x^3 * y^2 + 0.09269 * x^2 * y^3 + 0.08044 * x * y^4 - 0.03983 * y^5$$

By analyzing thermal conductivity dependence with thickness (figure 5) we can conclude that thermal conductivity is in a strong correlation with thickness, because higher thickness means more interstationar air in 3D wool panel and lower values for thickness can be due to the fibers compression in 3D wool panel structure.

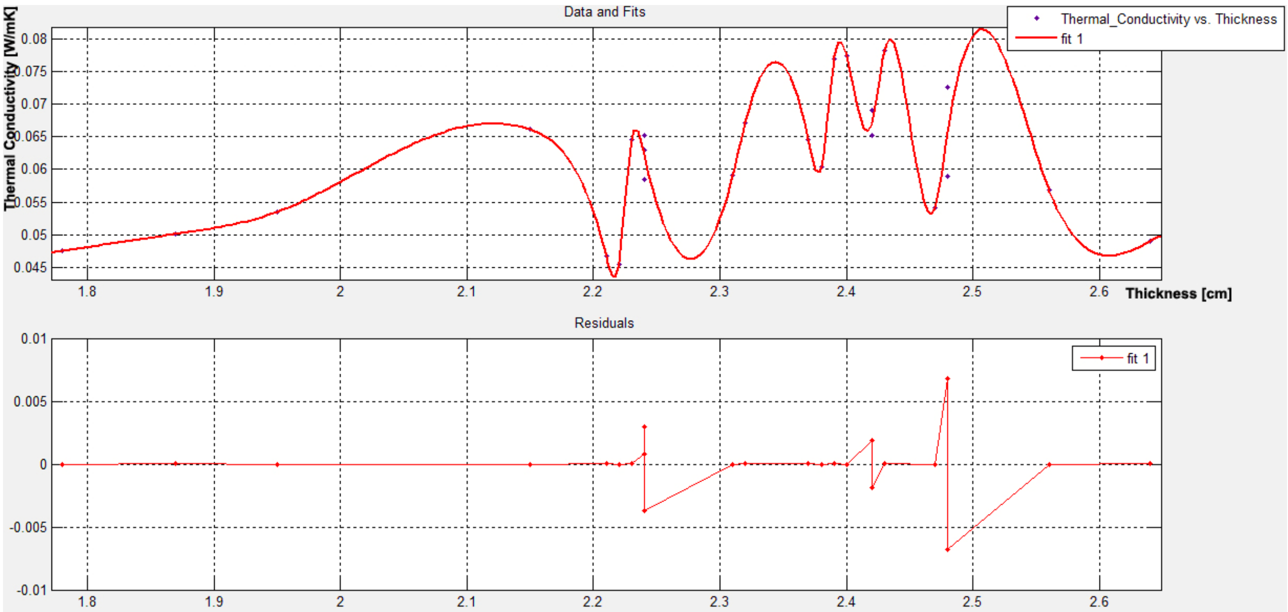

Figure 5: Thermal conductivity analyze in function of thickness values for wool panels values

The fitting data for conductivity obtained after 2D data modeleng – thermal conductivity in function of thickness (figure 5) and thermal conductivity in function of mass values (figure 6), are presented in Table 3.

Table 3. Fitting data obtained atfer 2D data modeling

Sample No.	Mass Xi	Thermal conductivity f(Xi)	Thickness Xi
1	21,28	0,0569	2,56
2	23,3853	0,047947	2,48879
3	25,4906	0,059479	2,48317
4	27,5959	0,044674	2,59869
5	29,7012	0,081956	1,84551
6	31,8065	0,038541	2,225
7	33,9118	0,071925	2,34744
8	36,0171	0,056659	2,29708
9	38,1224	0,10833	2,21597
10	40,2277	0,084281	2,39682
11	42,333	0,0542	2,47

By analizing termal conductivity in function of mass is relevant that residual values are lower and mass don't influence thermal conductivity (figure 6). The important influence factor ifor thermal conductivity is thickness and 3D wool panel voluminosity.

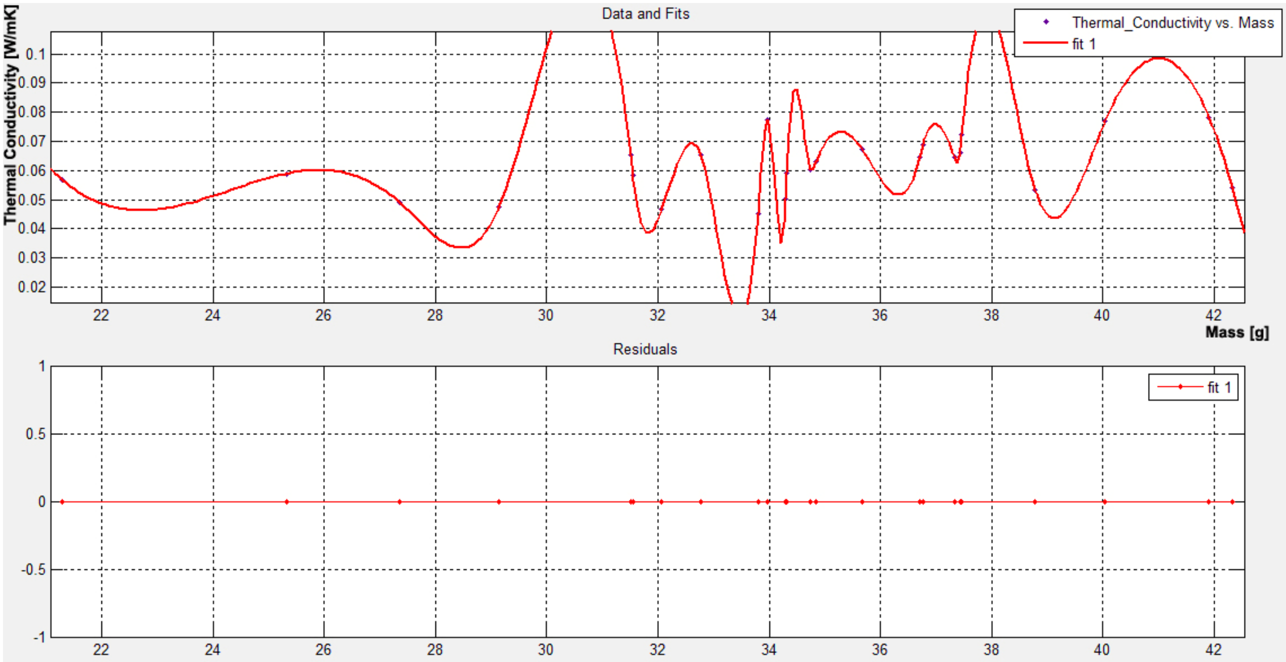

Figure 6: Thermal conductivity analize in function of mass values for wool panels

CONCLUSIONS

The advantages of using wool panels in construction are:

- Is nontoxic for the workers that manipulate this products when make building insulation.
- The values for thermal conductivity are relative good
- Thermal conductivity values are in inverse proportional rapport with thickness values
- Thermal resistance is direct proportional with thickness and voluminosity values.
- Mass values don't influence in a high way the thermal conductivity or resistance values.

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Oral presentation

STUDY ON LIQUID MANAGEMENT PROPERTIES OF CELLULOSE BASED KNITTED FABRICS

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The present article represents a brief study on the measurement, evaluation and classification of liquid moisture management properties of knitted fabrics made out of natural and artificial cellulose. Different percentages of natural and artificial cellulose, as well as, small quantities of elastomeric fibres, were taken into consideration for the objective testing of the measurement of the liquid moisture management properties of the fabrics. For this purpose, the testing equipment used was a Moisture Management Tester (MMT). The test method used focuses on the transport of liquid moisture in the flat state and can be applicable to the evaluation of fabrics as they would be exposed to liquid moisture present on the surface of the human skin. For each sample of knitted fabric, the following parameters were measured and calculated: wetting time, absorption rate, spreading speed and overall Moisture Management Capability (OMMC). The results obtained with this test method are based on water resistance, water repellency and water absorption characteristics of the fabric structure, including the fabric's geometric and internal structure and the wicking characteristics of its fibres and yarns.

Keywords: *moisture management, wetting time, absorption rate, knitted fabrics*

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PLAIN STRUCTURE WITH FLOAT AND TUCK STITCHES

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Abstract: *The main objective of the paper is the development of weft knitted structure group with tuck stitches based on one-on-one miss stitch.*
In its base version, this range of structures requires three possible paths in three successive steps taken by a knitting needle. There are possible two variants: one float loop and single course tuck stitch (ORD/1) and one tuck and single float stitch (ODR/1), both considered to be complex structural elements type I.
This group of structures allows the creation of another type of complex structural elements, type II. For type II structures there are necessary different needle paths, especially tuck loop and float loop, applied to several adjacent needles. For example, in the case of four needle/wales ratio there can be identified six kinds of yarn evolutions on the row direction: two of these evolutions are used for one-on-one miss stitch and four of these containing one complex element with tuck loop and float loop. The analysis for the knitted structure products described above indicates that the plain knitted structure with double float loop and single tuck loop is similar to the single cross tuck knit.
These structures formed with one-on-one miss stitch with tuck stitches, can be developed by choosing the characteristics of the pattern: dimensions (width, height), distribution on the surface of the knitted fabric and structure elements. In the case of asymmetric drawings the structure can be balanced by changing the direction of structure elements orientation. A different approach to develop the structures formed with one-on-one miss stitch with tuck stitches and obtain complex patterns is to use yarns with different characteristics.
The combinations of the specific weft knitting technique represent a good modality for the knitted structure development and also for the utilization of the technological possibilities of the knitting machines.

Keywords: *weft knitted structure, one-on-one miss stitch, float stitch, tuck stitch, tuck loop, held loop, complex structural elements.*

1. INTRODUCTION

Knitting technique allows the realizing of diverse knitted structure, both behaviour point of view and especially on the aesthetic characteristics, thanks to the extended technological possibilities of the knitting machines. Combining these capabilities open new perspectives in the field of technology creation, resulting in getting special structure elements different from conventional structures. Thus, there are considering the different paths of the needle, and the possibility of combining of these trajectories.
Main objective of the paper represent the development of weft knitted structure group with tuck stitches, beginning with one-on-one miss stitch.

2. STRUCTURE CARACTERISTICS

2.1. Plain structure with float stitch

Plain structure with float stitch, (realized on plain knitting machines or single jersey machines or one bed of a two bed knitting machine) consists in the combination of two plain primary base structures on selected needles, between the stitches of the first plain fabric are placed the stitches of the second plain fabric. In this case a complete knitted row is obtained in two stages [1] [2], so that between the stitches obtained in that two knitting circle appeared a half high stitch difference on vertical (wale) direction
The most common plain structure with float stitch is one-on-one miss stitch, with minimum ratio (b=2, h=1), being known as: CROSS Miss 1x1 (E) [1] or R-L hintergelegt (G). Similarly can be realized plain structure with float stitch 1x1x1, known under the name Cross miss 1x1x1 or Diagonale hintergelegt. Analyzed in

terms of purely theoretical, one-on-one miss stitch is a plain structure which contains one float loop, with uniform distributions. It contains only float stitches obtained after two needle path [1] [3], one for normal stitch (S-I-B) and another for float (S). This aspect may justify eliminating the structure one-on-one miss stitch from the fundamental group of structures (plain primary base structures) described in specialized literature.

2.2 Different types of structural elements

The analysis of the plain structure with float stitches combined with tuck allows the identification of various types of structural elements with modified evolution, outside the established structures made in one or two successive stages: normal stitch (S-I-B), tuck stitch (S-I-B, followed by S-In-B), float stitch (S-I-B, than S) considered structural element type 0 (zero). Usually [4], a normal stitch is obtain after one needle path using clearing cam (needle at clearing height), as S-I-B, one tuck loop on the needle at tucking height so the needle path is S-In-B, and one float on the needle at low-run ("miss" height), S, when the old loop is extended one knitting cycle (needle course) and the needle is maintained with its head near by knock over edge.

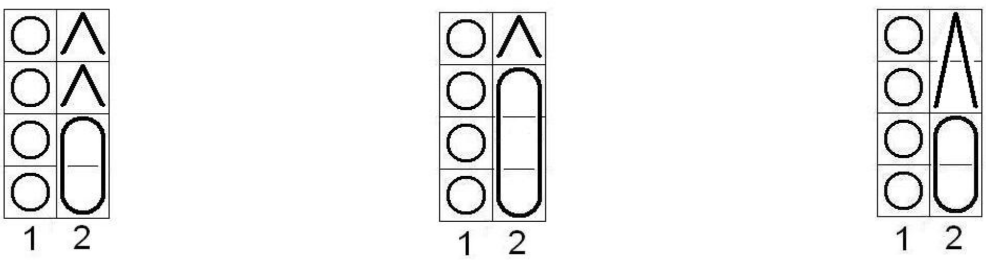
2.2.1 Complex structural elements type I (CSE I) – stitches with modified evolution

Using three possible needle paths in three successive steps taken by a knitting needle (needle 2, figure 1), allow the formation of the different type of stitch: one float loop and single tuck loop (ORD/1, figure 1.a.) and one tuck stitch and all (held loop with one tuck loop) extended one knitting cycle more (ODR/1, figure 1.b).

a. b.

Figure 1: One float stitches and one tuck stitches

Repeating one of the two modified paths will lead to the formation the following stitches (needle 2, figure 2): one float loop and double tuck loop (OR1D2, figure 2.a), double float stitch and one tuck loop (OR2D1, figure 2.b), or one float stitch and one tuck loop which is maintained one knitting cycle more on the needle (OR1Dr1, figure2.c).
The difference between these stitches consists in the number of float or tuck in one stitch.



OR1D2 OR2D1 OR1Dr1

a. b. c.

Figure 2: Double float stitches and double tuck stitches

This reasoning can be applied also in the case of increasing the number of repetition of those modified needle paths/needle trajectory, considering the variety of the possibilities of combining on vertical direction.
Textile literature [2] presents two structure which are consisting in only one tuck stitch and all (held loop with one tuck loop) extended one knitting cycle more (ODR/1, figure 1.b). when the ratio dimension is b=h=3 respective o combination of normal stitch, tuck stitch and float stitch in case of ratio dimension b=h=4. In this case the diagonal orientation of the knitted elements permitted the realizations of Twill effect.

2.2.2 Complex structural elements type II (CSE II*)* – stitches with modified evolution.

For the formation of these complex structural elements type II, are used different path for more consecutive knitting needles.
A. The complex structural element (Ec) type "tuck-float" (figure 3) contains one tuck extended on two adjacent needle (two adjacent one cross held loop) which appear as a tuck loop (Bn) for needle 2 and as a float loop (Fl) for the needle 3. The newly created element is an asymmetric one, making intermeshing points with the stitches belonging to 1-4 wales. In this case those two needle (2 and 3) go through the different trajectories so that the needle 2 goes through tucking height, its trajectory being S-In-B, and the needle 3 at low-run ("miss" height), its trajectory being S

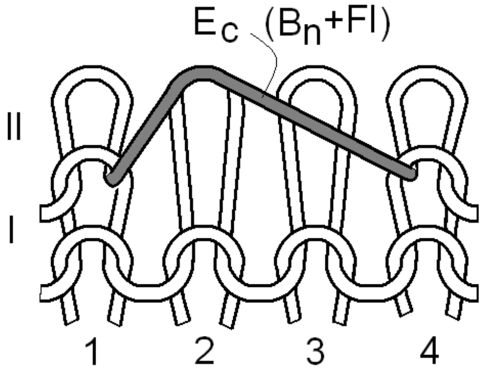


Figure 3: Complex structural element type "tuck-float"

B. The complex structural element has three kinds of modified evolution for three consecutive knitting needles when there are used three different techniques: needle loop stitches transfer, float loop and tuck loop (a new loop becomes a tuck loop besides a held loop). By permutation of these compound elements, result in a new type of complex structural element consists of:
- tuck loop (Bn) – float loop (Fl) - first knitted loop (Bi), (figure 4.a);
- tuck loop extended on two adjacent needle (Bn+Bi) – float loop (Fl), placed either tuck loop (figure 3.b), or after tuck loop (figure 3.c).

The complex structural element consists of extended tuck loop-float loop is similar with structural element consists of float loop – extended tuck loop, but the comparative analysis highlights the major differences between the two situations (surface appearance respective knitted fabric behaviour)

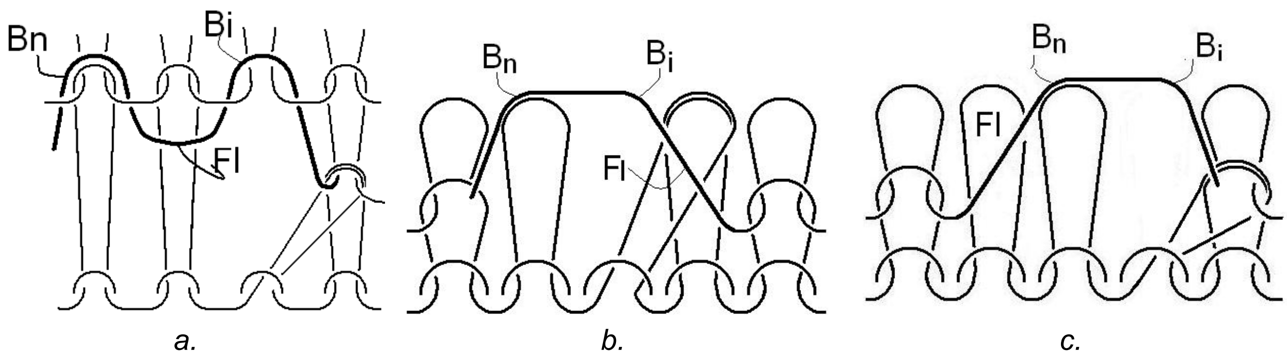


Figure 4: Complex structural elements type II

3. ONE-ON-ONE MISS STITCHES WITH TUCK LOOP

3.1. Knitted yarn evolutions type

The principal idea of previous discussions shows us that the group of the complex structural elements is extremely vast, reasoned statement of: primary base structure, the type of complex element structural (determined by knitting technique applied and the number of the consecutive knitting needles), ratio of the pattern (dimensions and distribution on the knitted fabric surface).

For example were chosen one-on-one miss stitches, structural element consists of tuck loop-float loop and four wales/needles width ratio. In these conditions may be identified six type of knitted yarn evolutions on row direction, two of them for one-on-one miss stitches (a, b) and anther four evolutions included the complex structural element (a_1, b_1, a_2, b_2).

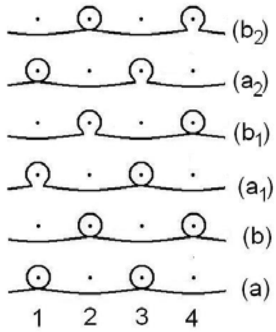


Figure 5: Knitted yarn evolutions type for one-on-one miss stitch with tuck loop, b=4

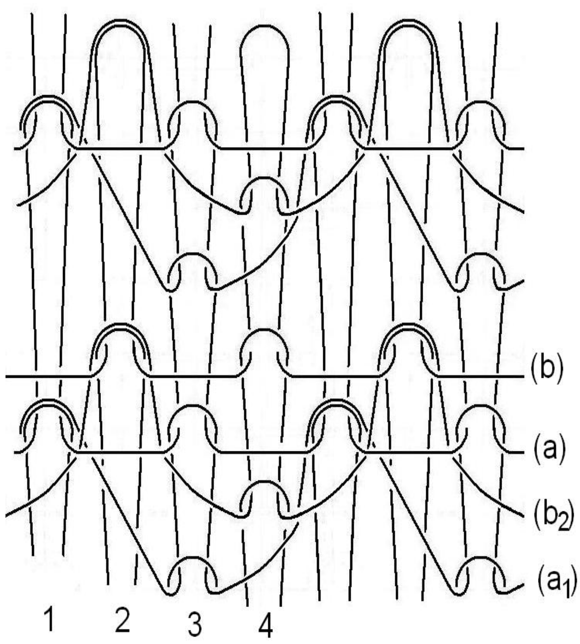
All type of yarn evolutions (a, b, a_1, b_1, a_2, b_2) can be identified on the height pattern ratio, with or without repetition, but not all the combination between the different types of yarn evolution are available in practice, from technological point of view.

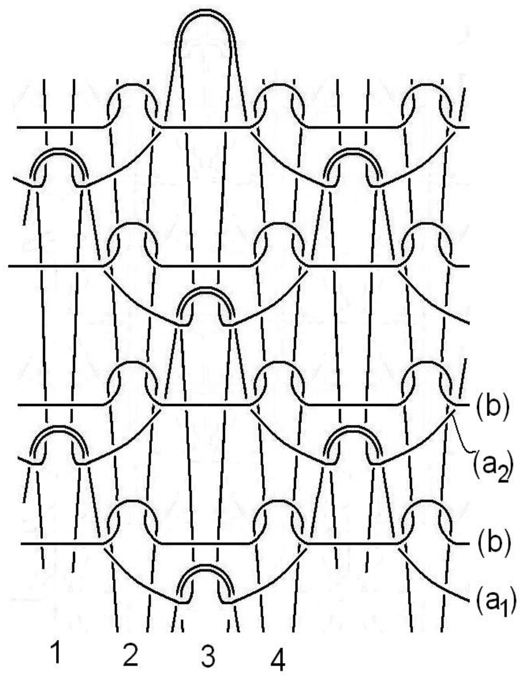
3.2. Examples of structures

From the large number of structure variants were chosen two of them characterized through a minimum height pattern ratio, b = 4.

Variant 1.

This variant has a specific combination of the knitted yarn evolution *a – b - a_1 - b_2*, which assure yarn feeding as a tuck on two consecutive knitting needles in different stages, the result being the formation of ***OR2D1*** stitch type. It is interesting to observed that in this knitted structure the tuck loops of the tuck stitches are different from usually tuck loop, so the these may be either symmetric (2,6 wales), or asymmetric (1,5 wales) tuck loop because of the different positions of their intermeshing point with structure elements.





a. *Variant 1* **b.** *Variant 2*

Figure 6: Yarn evolution for one-on-one miss stitches with tuck loop, b=4

Variant 2.

Variant 2 has another specific combination of the knitted yarn evolution $a_1 - b - a_2 - b$; for this variant the result is an alternation of wales with tuck stitches belonging to ***OR2D1*** stitch type and one-on-one miss stitch. For this version structure is more balanced, because all the tuck loops are symmetric.

4. EXPERIMENTAL

For knitted structure one-on-one miss stitch with tuck loop, ***Variant 3***, (Figure 7.), in the design phase was chosen a pattern with another specific combination of the knitted yarn evolution $a_1 - b_2 - a_2 - b_1$, so that each of the four needles are knitting in three stages, forming: normal stitch (needle at clearing height), one float loop (needle at "miss" height) and one tuck loop (needle at tucking height).This structure consists of only OR2D1 stitch type, which makes it similar with single cross tuck knit. The complex structural element presents an asymmetric position; its succession in order float-tuck determined the longest branch orientation to the right side. Changing the succession of the elements, tuck-float, it is registered the orientation to the other side.

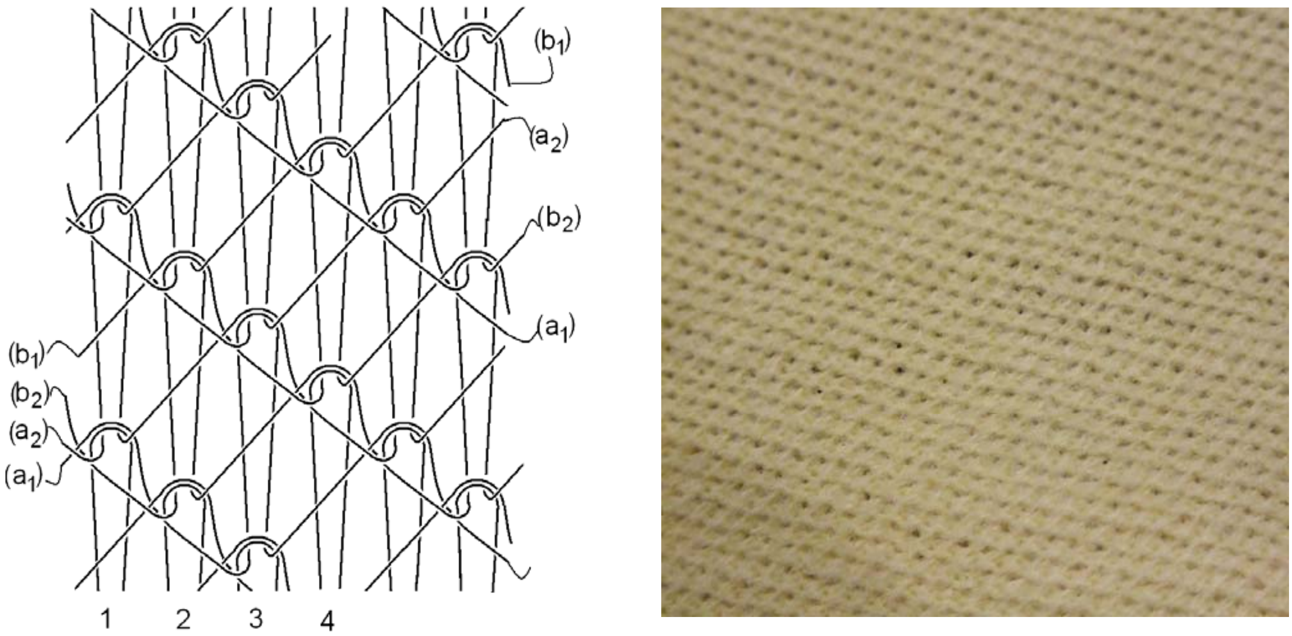


Figure 7: One-on-one miss stitch with tuck loop (OR2D1)

The knitted fabric was realised with CMS STOLL weft knitting machine, K=12E, PAN 100%, 2x28 Tex. The back side of the knitted structure (Figure 7b.) is an interesting one because of emphasizing the tuck loops arranged on the diagonal direction; so it is recommended the back side to be used as technical face of fabric.
Analyzed through extensibility characteristic, it can be appreciated that the fabric is stable in both, horizontal and vertical, directions and also have a good resistance on the diagonal direction, which allows us to recommend to be used this knitted structure in technical textile domain. This structure creates the margin rolled effect.

5. CONCLUSIONS

In conclusion, we can make some general considerations:

- the combination of the weft special knitting technique represented on one side a good modality for knitted structure development and on the other side the capitalization of the technological possibilities of the knitting machines so it was possible the creation of the complex structural element type I and type II, composed of tuck loops and float loops;
- the plain knitted structure group with float and tuck respective one-on-one miss stitch with tuck stitches, can be extended by choosing different the characteristics of the pattern as: dimensions, distribution on the surface of the knitted fabric and structure elements; the structure can be balanced by changing the

direction of structure elements orientation; another possibility of development aimed at complex pattern, using threads with different characteristics;

it is estimated that knitted structure one-on-one miss stitch with tuck loop, similar with single cross tuck knit, due to particularly advantageous characteristics this knitted structure will require and it will be found multiple uses.

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Section 4: Functional Textiles and Clothing

TEXTILES COMPOSITES WITH NANO-STRUCTURED FUNCTIONAL COATING

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Abstract: *The paper summarizes the results of some projects where the research team was involved. Two variants of textile composites have been produced. The same textile support (plain weave, 100% cotton) has been coated applying two different techniques: (i) deposit of nano-structured thin films and (ii) coating with a PU membrane with zeolites. With advanced investigation techniques, the structural and morphological characterization of the textiles composites was fulfilled.*

Keywords: *functional, coating, nano-structured, thin films, zeolites.*

1.INTRODUCTION

Usually, the coatings are applied as multi-layers systems (from four to six layers). Each layer performs certain, specific function, so that its properties are influenced by other layers from the system [1, 2]. The interactions between the different layers and the interface phenomena play an important role in the multi-layer systems performance (Figure 1).

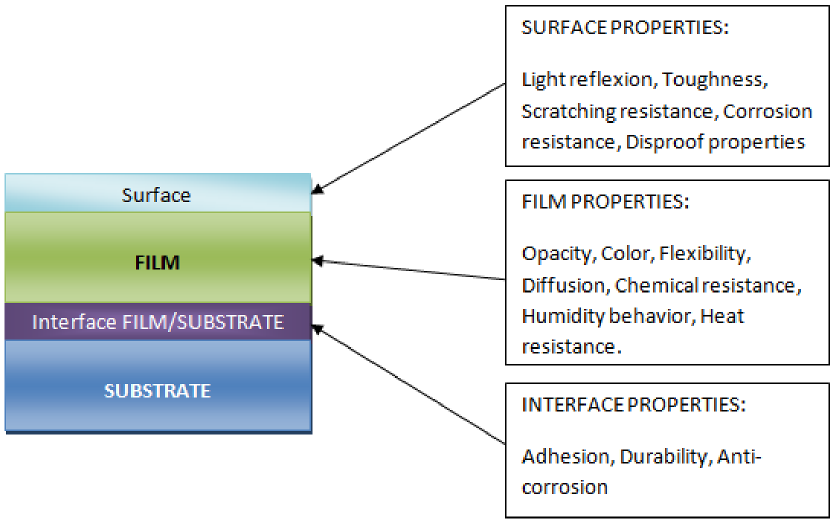


Figure 1: Functional coating – properties of components

Typical examples of functional coatings are: self-cleaning, easy–to-clean, anti-graffiti, antifouling, soft feel, and antibacterial (Figure 2).

2.TEXTILE COMPOSITES WITH NANO-STRUCTURED COATINGS - PRODUCTION METHODS

The research was focused on two groups of textile composites:

1. Composites with thin films, respectively: metallically thin films of Ag and Ti, thin oxide layers of TiO_2 and SiO_2, and multi-layer structures of Ti/TiO_2, $Ag/SiO_2/TiO_2/$ $SiO_2/TiO_2/Ag$ deposited on textile substrate;
2. Composites with PU - zeolite particles coating layer (membrane).

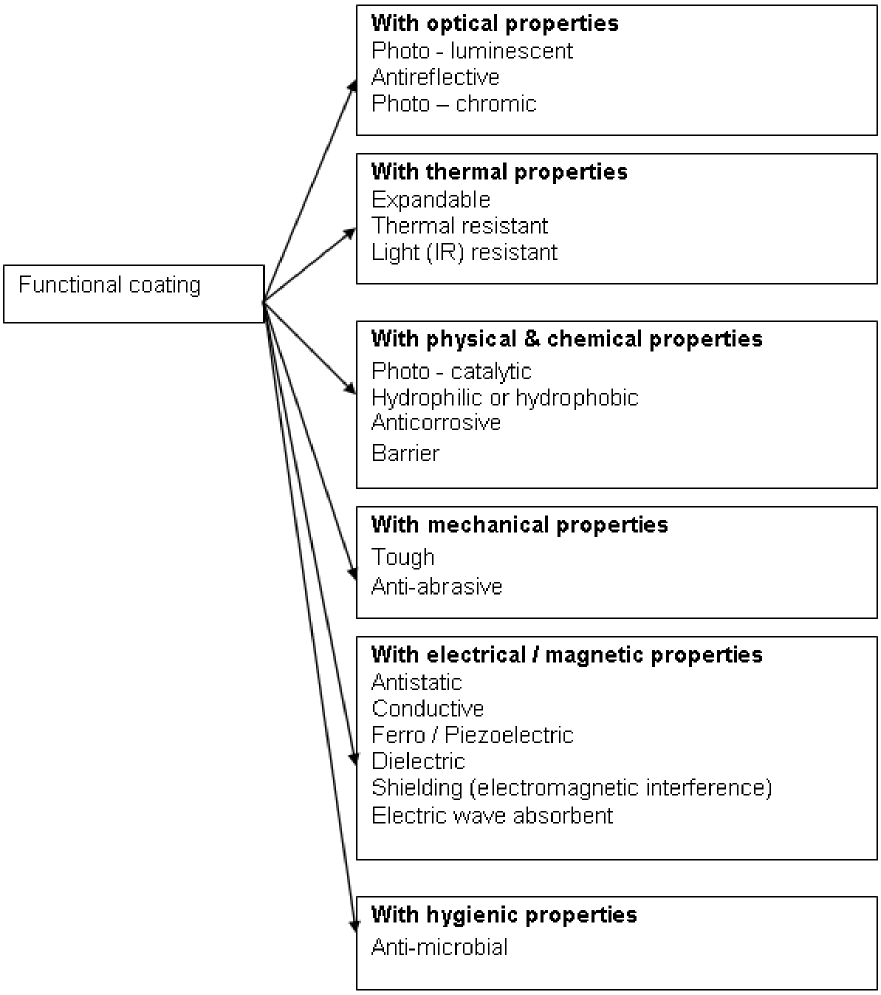


Figure 2: Functional coatings

2.1.Methods for metallically, oxide, and multi-layer thin films coating of a textile substrate

The goal of this research was to produce thin films, reflective and semitransparent. This is the reason to use, simultaneously, glass and textile as substrate [3, 4, 5].

Thin Ag metalic layers have been coated on textile and glass substrate using the method of vacuum thermal evaporation. The thickness of the layer under 100nm was checked, using deposition times between 6s - 40s. A cotton plain weave has been used as textile material. For multilayer structures coating, the optical properties of the Ag metalic layers were checkedand the ones obtained for deposition times between 6s - 20s were considered good. Thin layers of TiO_2, SiO_2, were coated, on textile and glass substrate, respectively TiO_2/Ag/glass, using the RF magnetron sputtering (P= 150W) method.

For the TiO_2 coating the following conditions were used: p = 6.10^{-3}mbar, a TiO_2 target of 99,99% purity; a blend of Ar, O_2 gas (flow Ar= 4sccm, flow O_2 = 0,4 sccm). The textile substrate, glass, Ag/textile and Ag/glass was not heated. The distance target substrate was kept at 4cm. The deposition time was of 60min, the result being layers of 150nm thickness. For the SiO_2 thin layers the following conditions were used: p = 6.10^{-3} mbar, target SiO_2/(111) Si; blend Ar, O_2 (flow Ar = 4sccm, flow O_2 = 2sccm). The substrate was not heated. The deposition time was of 60min, for 200nm.

A textile (plain weave, 100% cotton) and a glass substrate have been coated with Ag thin film, using the vacuum thermal evaporation. The thickness control has been realized up to 100 nm, using deposition times between 6 and 40 sec. Before the multilayer structure deposition, the optical properties of the metallic Ag layer were investigated. The acceptable results were getting for deposition time between 6 and 20 sec.

2.2.Methods for PU-zeolites composite membrane

The properties of zeolite particles and those of PU membranes have been collaborate in the resulted multi-functional, composite material. The textile substrate was a plain weave in cotton. The used zeolites are: the synthetic zeolite ZSM-5, Fe-ZSM-5 and the natural zeolitic tuff with 95% clinoptilolite, NaCLI. The conditions to process the composite structure textile – PU – zeolite particles are synthetically presented in Table 1.

Table 1: Process parameters

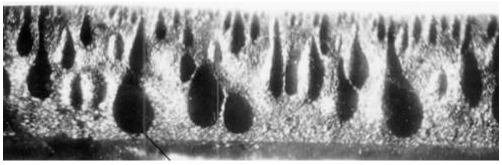
Zeolite / PU 0,05	Wet phase inversion		Evaporation	
	T (C)	t (h)	T (C)	t (h)
ZSM-5	45	1/3	25	24
FeZSM-5	45	1/3	25	24
NaCLI	45	1/3	25	24

T (^{o}) is the temperature of the precipitation system by phase inversion, and t (h) is the drying time, in hours. The textile substrate has been immerse 24 hours in poli(etilendietilenedipat)diol / dimetilformamide /zeolite solution. In the next stage, the precipitation reaction according to the parameters from Table 1 has been produce. The used zeolites have different Si/Al ratio and different channel systems. The ZSM-5 zeolite is hydrophobic in comparison with NaCLI zeolite.

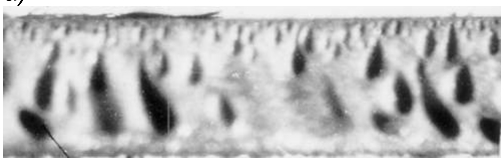
The polyurethanes PU are a unique class of thermoplastical elastomers made of short and rigid sequences of urethan or urea (chrystalline rigid segments) chained by flexible polyether chains (soft amorfus segments). Due to the very good mechanical propreties and the biocompatibility of the poyurethans, they are used in a great number of biomedichal applications. The asymetrical porous PU membranes can be obtained using the method of phase inversion of the PU, DMF and/or WATER system poured and precipitated in water. The membrane structure is heavily afected by the composition of the poured solution and the preparation conditions of the membranes.

A clear distinction is necessary between the thick polymeric membranes, the phorous and the colloidal membranes. The composition that is poured and the conditions of the pouring process influences the thickness and the porosity of the membranes. The optimum porous structure is obtained with 30:70wt% H_2O:DMF as liquid used for precipitation (Figure 3). The first way used for reducing the micropors is to change the solvent/nonsolvent sistem. This will significantly change the diffusion ratio solvent/nonsolvent (DMF/H_2O). The temperature change between 25 -60 C lead to membranes with uniform pors structure and with a better resistance (Figure 4).

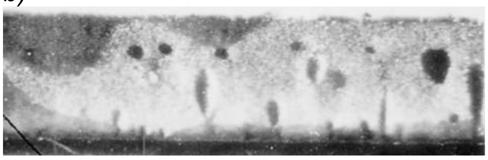
Figure 3: Micrograph SEM (30x) of the PU membranes obtained by phase inversion in water at 25^{o}C [2, 3].
1 - contact surface with nonsolvent (water); 2 - substrate surface; 3 - micropors.



a)



b)

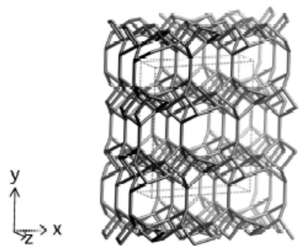
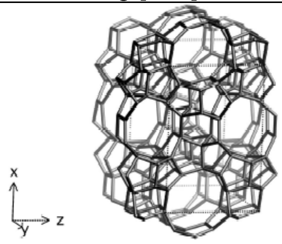


c)

Figure 4: Membranes morphology dependence of the precipitation temperature [2, 3].
a) 250C; 0.3 kgf/mm2 (tensile strength); b) 400C; 0.5 kgf/mm2; c) 600C; 0.72 kgf/mm2 (15x)

The used zeolites have different Si/Al ratio and different channels. The ZSM-5 zeolite is hydrophobic compared to NaCLI zeolite. In order to ensure a high degree of purity the natural zeolitic tuff was treated with acid and bring to the Na shape. The important parameters of the zeolite materials used as microcrystalline powders are presented in Table 2.

Tabel 2: Parameters of the used zeolites

Zeolite	Characteristics of the basic cell Pors topology	3D - Structure
Clinoptilolit	$\|Ca^{2+}_4 (H_2O)_{24}\|$**[**$Al_8Si_{28}O_{72}$**]-HEU** a = 17.718, b = 17.897, c = 7.428 Å = 90.0, = 116.42, = 90.0 ° monoclinic, Cm (# 8) SBU: 4-4=1 T atom: T_1-T_5 Canale:{[001] **10** 3.1 x 7.5* + **8** 3.6 x 4.6*} <-> [100] **8** 2.8x 4.7* (fluctuating due to skeleton flexibility) (2 - dimensional)	 View along [001]
ZSM-5	$\|Na^{+}_n (H_2O)_{16}\|$**[**$Al_nSi_{96-n}O_{192}$**]-MFI** n < 27 a = 20.07, b = 19.92, c = 13.42 Å = 90.0, = 90.0, = 90.0 ° ortorhombic, Pnma (# 62) SBU: 5-1 T atom: T_1-T_{12} C: {[100] **10** 5.1 x 5.5 <-> [010] **10** 5.3 x 5.6}*** (3 - dimensional)	 View along [010]

3.STRUCTURAL ANALYSIS OF THE TEXTILE COMPOSITES WITH NANO-STRUCTURED COATINGS

3.1. Structural analysis of thin films coating of a textile substrate

The resulted textile composites have been characterised from structural and morphologic point of view, using the XRD, and SEM methods. For SEM studies, the SEM VEGA II LSH (TESCAN, 30 kV, $1x10^{-2}$ Pa) with EDX detector QUANTAX QX2 (ROENTEC) has been used.

The quality of the coated layers was verified with AFM method, respectively the transmision and optical reflection of the substrate coated on glass. The AMF images of the thin Ag layers shown flat and nanostructured aspect (Figure 5).

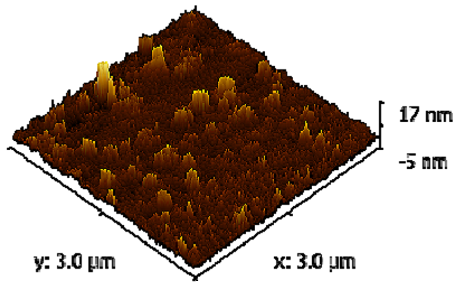


Figure 5: AFM image of a thinAg/glass substrate coated for 16s.RMS = 1,53 nm

The optical transmition studies emphasied that the most suitable layers are the ones with a deposition time of 16s, with a transmition bigger than 90% (Figure 6).

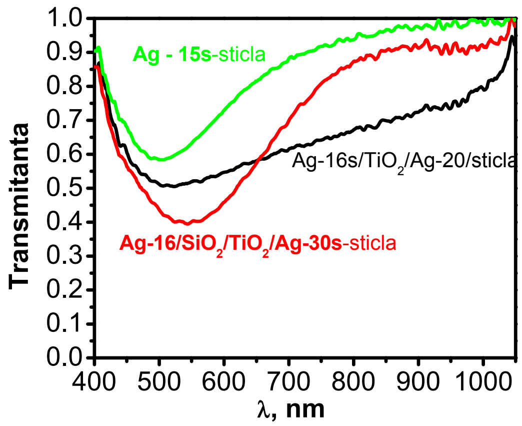


Figure.6: Transmitance of some nanolayers structures on glass

These were coated on cotton textile support, respectively on Ag/cotton, using RF magnetron sputtering (P= 150W) method, nanolayers of Ti, TiO2, SiO2. Targets of Ti, TiO_2, and SiO_2/Si, 99,99% pure were used. The distance target substrate was of 4 cm. The pressure in the instalation was of $6x10^{-3}$mbar. An Ar athmosphere was used for thin layers of Ti and a blend of Ar+O_2 gas for the thin oxide layers.The following flows were used for the thin layers of TiO_2: Ar= 4sccm, O_2 = 0,4 sccm. The textile, glass substrate, respectively Ag/textile, Ag/glass were not heated. The deposition time was of 120 min for the Ti layer, respectively 60 min for the oxide one, for layers of 150 nm thick. The following conditions have been used for the thin layers of SiO_2: p = 6.10^{-3} mbar, target of SiO_2/(111) Si; Ar, O_2 blend (flow Ar = 4sccm, flow O_2 = 2sccm). The substrate was not heated. The deposition time was of 60 min for layers of 200 nm thick.

The quality of the coated layers was verified with AFM method, respectively the optical transmision method. (Figure 6). Thin layers of TiO_2 and SiO_2 have been chosen beause these are translucent materials, with different refractive index (Table 3) and with a big zone of the forbiden area.

Table 3: Layer characteristics

Material	Refractive Index	Translucent Area (nm)	Energy of the Forbiden Area(eV)
SiO_2	1.56	200 -3000	3.35 - 4.3
TiO_2anatas	2.59 2.52	450 -5000	3.2
TiO_2 rutile	2.93 2.73	450 – 5000	3.0

By coating different substrats with pairs of SiO_2/TiO_2 the result is excelent refractiveness between 400 -600 nm. The oxide thin layers coated on a glass substrate studied with AFM method are nanostructured, flat and adherent to the substrat. The AFM studies of the thin layers emphasied the presence of nanocrystallites oriented in an amorphous matrix (Figure 7). The roughness of the surfaces is low, of nanometers range.

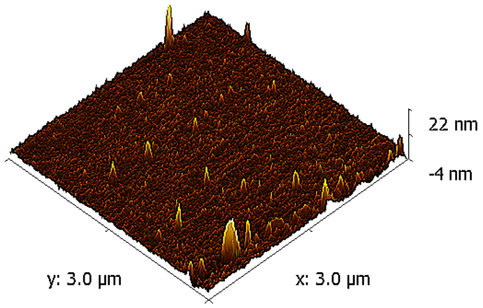


Figure 7: AFM Image of a TiO_2 thin layer coated on glass. RMS = 1,19 nm.

Photonic devices used in the information transport or radiation filtration can be obtained by controlling the thin metalic and insulating layers dimensions. Translucent, semitranslucent or reflecting surfaces can be obtained by controlling the thin metalic dimensions in order to obtain the desired function.

Acording to this, multilayer structures were coated with $Ag/SiO_2/TiO_2/SiO_2/TiO_2/Ag$. The multilayer structure was made by coating a thin Ag layer on a textile cotton substrate, for 16 s, by thermal evaporation in vacuum method, followed by coating succesive thin oxide layers, using RF sputtering method, and finaly another Ag layer coated identically with the first one.

3.2.Structural analysis of PU-zeolites composite membrane

The composite materials have been structural and morphoogical characterized using XRD, SEM and EDX methods. The difractograms obtained with the difactometer DRON2, using CuK radiation for the composite structure poyurethan+ZSM-5+fabric, regardless the precipitation by inversion method (wet or dry), emphsize the semicrystalline structure of the kevlar weave, respectively cotton and less the zeolite structure (Figures 8 and 9).

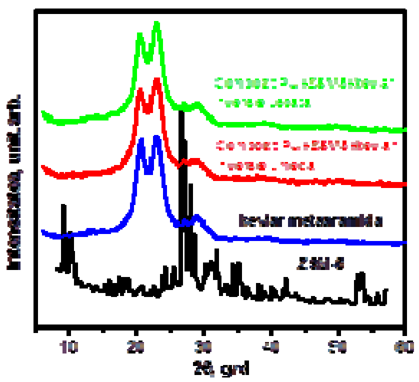


Figure 8: Difractograms of the compositestructrures PU+ZSM-5-kevlar obtained with the two methods compared with kevlar weave and zeolite ZSM-5

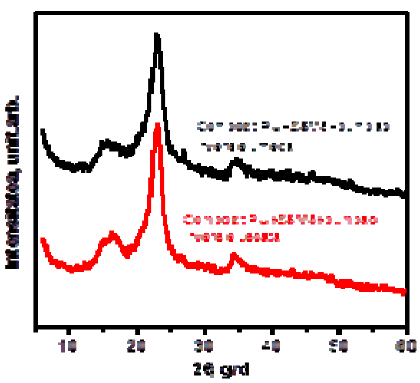


Figure 9: Difractograms of the composite structrures PU+ZSM-5 +cotton weave, obtained with the two precipitation methods

The semicrystalline structure of the polyurethan (emphasized by the membrans difactograms obtained with the same methods in Figure 10) from the composite structure lead to decreasing the peaks associated with the ZSM-5zeolite structure, respectively with the weave. Never the less, some peaks associated with the crystalline phase of the zeolite can be noticed. As it can be noticed from figures 11 and 12 the difractograms of the composite structure emphasize the semicrystalline structures of the textile substrates next to some little peaks due to natural NaCLI zeolite.

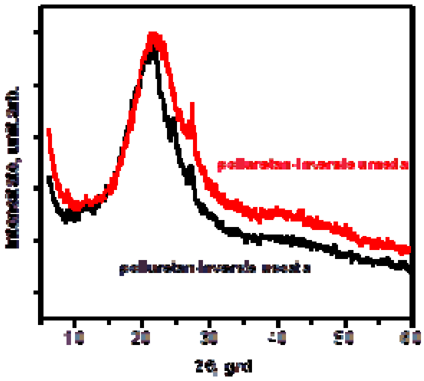


Figure 10: Difractograms of the polyurethane membranes obtained using precipitation by inversion method in wet and dry phases

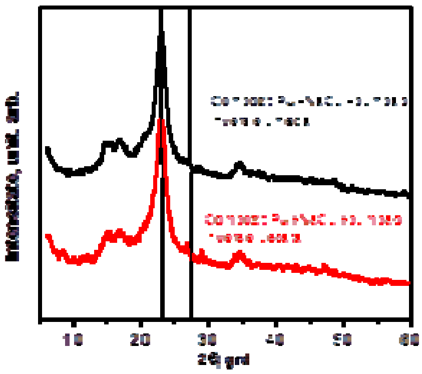


Figure 11: Difractograms of the composite structures PU+NaCLI+ kevlar weave, obtainedusing the two methods

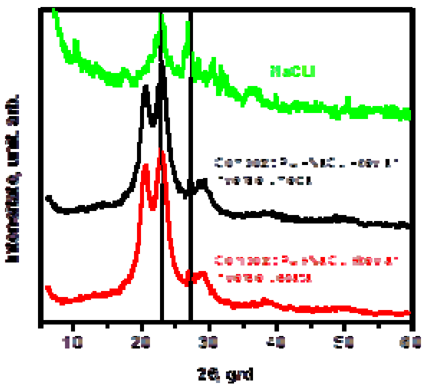


Figure 12: Difractograms of the composite structures PU+NaCLI+cotton weave, obtained using the two methods

SEM and EDX studies were made using the SEM VEGA II LSH (TESCAN, 30 kV, 1x10^{-2} Pa) equipment with a EDX QUANTAX QX2(ROENTEC) detector. The study of the composite structure morphology using the electronic scaning microscopy emphasized great diferences between the two obtaining methods. Comparing the SEM imagines for the polyurethan+zeolite+kevlar composite coresponding to the two obtaining methods (figures 13 and 14) it can be noticed that the composite structure obtained by the precipitation by inversion method in wet phase is homogeneous, the zeolite microcrystalles being embedded in the polyurethans pors, and the one obtained by the precipitation by inversion method in dry phase has microcrystalles agglomerated on the surface. The extrusion of the zeolite microcrystalles confirms the hypotesis that when the precipitation by inversion in dry phase is used the structure of the composite is more compact comparing to the wet phase.

Figure 13: SEM image of the PU+ZSM-5+kevlar composite obtained using the inversions method in dry phase

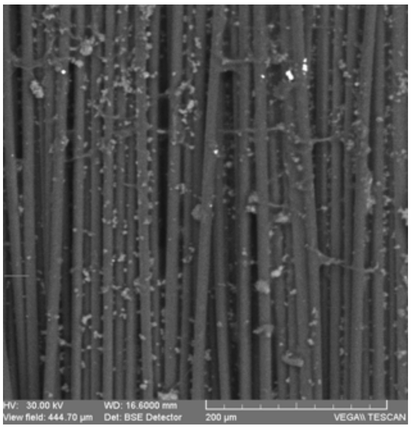


Figure 14: SEM image of the PU+ZSM-5+kevlar composite composite obtained using the inversions method in wet phase

The maps of the distribution of the chemical elements specific to the weave, polyurethan and zeolite, obtained using the EDX analyse shows a more homogeneous distribution of the zeolite chrystals (Si, Al,Na) in the composit, in the wet phase case (Figure 15) and the agglomerations on the surface in the dry phase case (Figure 16).

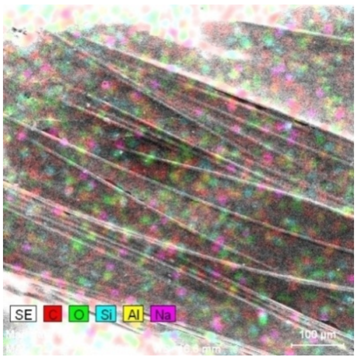


Figure 15: Map of the specific elements distribution for PU+ZSM-5+kevlar composite obtained using the inversions method in wet phase. The Si and Al distribution shows the ZSM-5 microcrystalls distribution

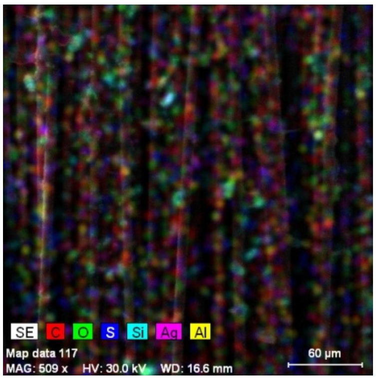
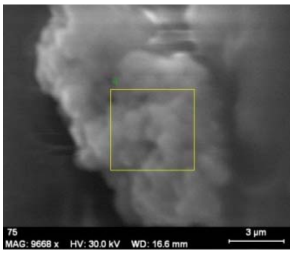


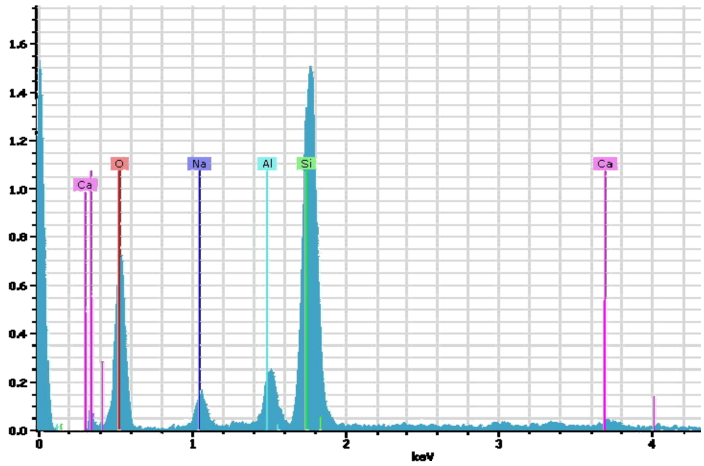
Figure 16: Map of the specific elements distribution for PU+ZSM-5+ kevlar composite obtained using the inversions method in dry phase



a)

Elements:

Si:	21.73%-at
Na:	5.30%-at
Al:	3.60%-at
Ca:	0.50%-at
O:	68.84%-at



b)

Figure 17: EDX study of the composite obtained using the inversions method in dry phase. EDX spectrum (b) coresponding to the SEM image in the frame (a) and the resulted chemical composition

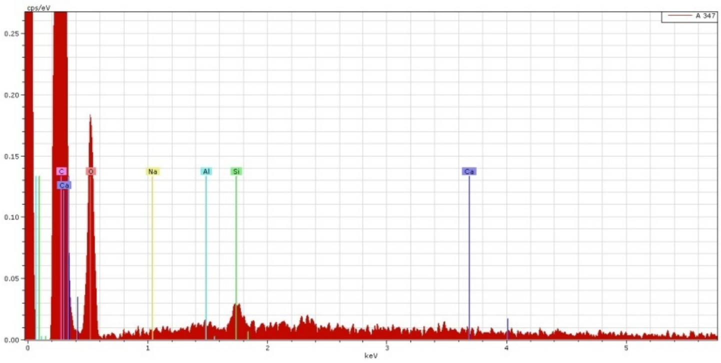


Figure 18: EDX spectrum of the PU+ZSM-5+kevlar compositestructureobtained by inversions method in wet phase

In Figure 18 is presented the EDX spectrum coresponding to the SEM image from figure 14, respectively Figure 15. The elements microanalyse distinguised 5% of zeolite. The experimental results, obtained for a weaved made of cotton, are alike. In Figure 19 is presented the SEM image of the composite structure. It can be noticed again the agglomerations of the zeolite microcrystalls on the composite's surface.

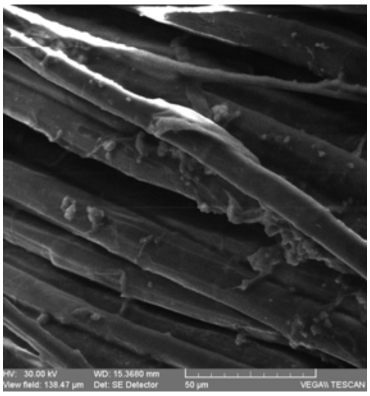


Figure 19: SEM image of PU + ZSM-5 + cotton weave composite structure

CONCLUSIONS

The experiments showed that, by using the same work parameters, composite structures with the same physical – chemical properties can be obtained.

The composites with metallic and dielectric thin films could be used for photonic devices for information transport or in radiations filtering. The destination is determinate by the thickness (nm) of the thin film.

The control of the metallic layers it could be obtained transparent, semi-transparent or reflecting surfaces, which can confer to the composite structure the desired function.

The SEM analysis of the composites points out, for each variant, a homogenous, porous structure. The zeolitic crystallites are included in the polyurethane pores.

The inclusion of metallic ions (ex. Fe) in the channels of the zeolite could produce the electrical resistance reducing and could confer catalytic properties to the composite. The composite could be used as sensor (for humidity or different types of organic compounds).

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TEXTILE STRUCTURES WITH METALLIC INSERTIONS FOR EMI SHIELDING

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Abstract: *Recent research on the influence of electromagnetic fields on living organisms has shown that they interfere in a highly complex way with intracellular phenomena, cells, organs and the whole body. The interactions between the living organism and the environment, as well as its internal functions are influenced by the characteristics of the external electromagnetic field. The paper presents the results of research on the insertion of an amorphous micro-wire with magnetic properties in certain textile structures. The micro-wires have been produced of FeBSi alloy coated with thin glass layer. The high magnetic permeability and the small diameter (20-40 μm) recommend these wires as absorbent or reflecting element on high frequency, tens GHz range.*

Keywords: *EMI shielding, textile structure, ferromagnetic micro-wire.*

1.INTRODUCTION - FUNDAMENTAL ASPECTS

EMI shielding can be defined as the reflexion and/or adsorption of electromagnetic radiation (EM) by a material that works as a protective shield against these waves. When the EM radiation (especially high frequency one) interferes with electronic devices, the EMI protection of the susceptible devices, as well as the EMI sources is required [1-5]. EM fields consist in two orthogonal components: the magnetic field (*H*) and the electric field (*E*) propagates along a normal direction to the plan containing the vector *s* of both component fields [7-12]. The ratio of the intensity of the two fields *E/H* is called wave impedance *Z*( ) and it is an important parameter, specific for a given electromagnetic field and depending on two factors: the source type and the distance to the source.

In the case of EMI protection, two shielding regions must be considered – the near-field and the far-field, that are defined as follows (Figure 1):

- If the distance from the source to the shield is higher than /2 , where is the wave length of the source, then the shielding is in the far-field region, and the plane-wave shielding theory is applied;
- If the distance from the source to the shield is lower than /2 , then the shielding is in the near-field region, and the electric and magnetic dipoles theory is applied.

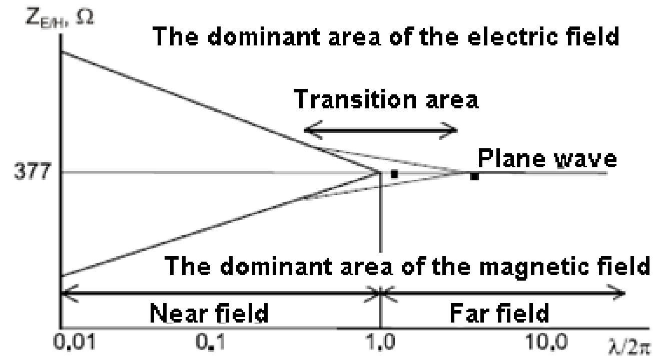


Figure 1: Representation of the regions around the EMI source

In the region near the EM field, the impedance Z depends also on the propagation characteristics of the environment and on the shield characteristics: electric and magnetic permittivity, electric conductivity, shield thickness (Figure 2).

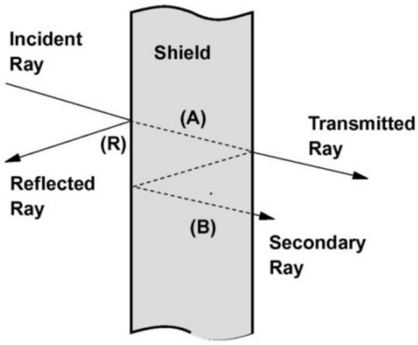


Figure 2: Physical phenomena occuring when an EM wave passes through shielding

Several equations can be used to describe these phenomena (eq. 1 – 4) [12, 14]:

$$\gamma = \sqrt{f\varpi\mu\,(\sigma + f\varpi\varepsilon)} \quad (1)$$

$$Z = \sqrt{f\varpi\mu / \sigma} \quad (2)$$

$$\gamma_0 = f\varpi\sqrt{\mu_0\varepsilon_0} \quad (3)$$

$$Z_0 = \sqrt{\mu_0 / \varepsilon_0} \quad (4)$$

where:
= 2 is pulsation;
and $_0$ – dielectric permittivity;
and $_0$ – magnetic permittivity;
and $_0$ – propagation constants;
Z and Z_0 – the impedance of the propagation environment;
- the electric conductivity;
d – material thickness.

Shielding can be defined as a ratio between the intensities of the EM field measured before and after the EM shield. The shield is a plan with infinite dimesions placed between the EM source and the measuring device [8 – 14]. The main characteristic of the shield is the shielding effectiveness (EE) that is defined as a measure of the decrease of the EMI intensity for a given frequency caused by the propagation of a incident wave through the shielding material.

The loss (attenuation) of the incident EM wave caused by the shield depends on the characteristics of the shielding material. Shielding is basically generated through three different mechanisms: reflection, absorption and multiple reflection.

In order for a shield to reflect the incident EM wave, it has to have stationery and moving charges (electrons or spaces) that interact with the EM field [14]. As a result, the shield must present not necessary values of electrical conductivity. Usually, a 1 cm volume resistivity is enough, even though the conductivity is not a EMI selection criteria, especially when the connection to a system directioning the electrical charge is required. Metals are the most used materials for EMI shielding; they work using the reflection mechanism due to the presence in their structure of free electrons. The shields are produced by (electochemical, electroless) plating of large fibrous or particulated surfaces. The main disadvantage is the low resistance of these shields when using or to skretching.

Absorption is another EMI shielding mechanism. For a good absorption shielding, the material must have in its structure electric and/or magnetic dipoles that interact with the incident wave. Electric dipoles can be found in materials with high dielectric constant, such as $BaTiO_3$, while magnetic dipoles are specific to high magnetic permettivity materials, egg. Fe_3O_4. In this case the magnetic permettivity can be increased through the use of multilayer magnetic films. The absorption loss represents another chateristics of the material, as reflection loss and is described with: $_r$ - relative electric conductivity in relation to Cu and $_r$ – relative magnetic permettivity. If the refection loss depends on the ratio of the two chracteristics, the absorption loss depends on their product.

Another EMI mechanism is multiple reflections that refer to the numerous reflection phenomena that occur within the shielding material as well as on its interfaces. The multiple reflections mechanism requires large surfaces/interfaces, such as porous materials, foams, or even composites with fillers with large contact surface. The multiple reflections loss is considered neglijable when the distance betweenthe reflection surfaces or interfaces is high in refernce to the thickness of those interfaces. The intensity loss of the incident wave, caused by any of these shielding mechanisms are experessed in dB. The sum of all losses consitutes the shielding effectiveness (EE).

The previous researches [14 - 19] show that there are three types of yarns with conductive characteristics that can be processed using classic textile technologies:

1. Carbon yarns or with fibres with metallic particles (Ag, Cu, Ni).
2. Yarns made of fibres covered with polymers (polytiophenes and polyanilines) or conductive metals.
3. Yarns with thin metallic fibres.

2. TEXTILE STRUCTURES WITH METALLIC INSERTIONS FOR EMI SHIELDING - PRODUCTION METHODS

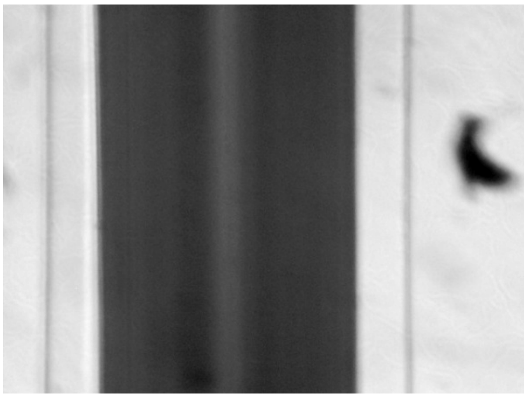
2.1.Production of the metallic insertion

The metallic insertions representing the conductiv material were produced by ICPE-CA Bucuresti [6, 12, 14]. In the first stage, two types of Cu materials and a FeBSi composite were selected. The micro-yarn is made of a metallic core (a thin cylinder of metal, alloy, semimetal, semiconductor or combinations) and a continous glass isolating sheath.

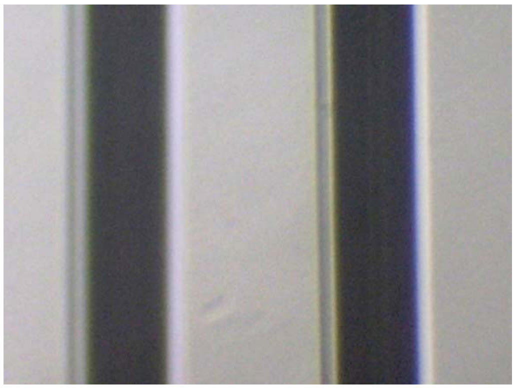
The micro-yarns were obtained using the Ulitovsky–Taylor method (Figure 3). The micro-yarns can be produced using pure metals (copper, gold, silver, platinum, cobalt, nickel and others), semiconductors (silicon, germanium) and alloys based on the metals, semimetals and semiconductors mentioned above (in restricted amounts other chemical elements can be used: barium, carbon, phosphorus, chrome, wolfram, molibden, indium, gallium, etc.). The Institute currently produces micro-wires with magnetic characteristics using FeBSi and Cu microfibres based alloys. The glass sheath gives the yarns a high dielectric rigidity and the possibility of using them in a large range of temperature, from -80º to 250ºC [12].

Figure 3: Production equipment for the microyarns (INCDIE ICPE-CA)

Two filament variants were analysed – with different thickness, respectively nominal diameter of 18 µm and 68 µm. The images show that both filaments are have a uniform thickness. It also demonstrated that the glass sheath was continuous along the filament length (Figure 4 – a,b).



a



b

Figure 4: Microscopic aspect of the filament, before processing - a) 68 µm; b) 18 µm

The filament thickness was determined using the optical method of microscopic micrometry. This an accurate and reproductible method. The analysed samples suffer no strains during the measurements. For each filament, the thickness of the core and of the sheath was determined according to the diagram in Figure 5.

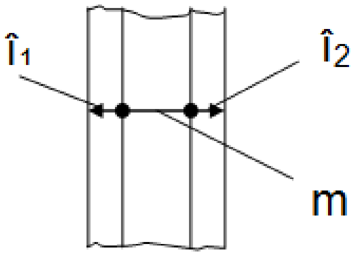


Figure 5: Schematic representation of the measurements carried out on the filament

The average results of the measurements - core thickness and sheath dimensions- are presented in Table 1.

Table 1: Dimensional values for the filaments

Filament type (nominal diameter)		Sheath		Core thickness	Filament thickness
		$î_1$	$î_2$		
18 µm	Transversal dimension	2 µm	2 µm	14 µm	18 µm
	Componentpercentage	39.50 %		60.50 %	100 %
68 µm	Transversal dimension	10	10	54 (72.9%)	74 µm
	Component percentage	46.75		53.25	100 %

The component percentages indicated in Table 1 refers to the volume of each component in the filament. One must observe that the average measured transversal dimension of the filament corresponds to the nominal value given by the producer for the 18 µm filament, but for the 68 µm filament, nominal value, the real value is 74 µm which is approx. 8%. In order to design yarns reinforced with such filaments, their thickness must be considered using specific indexes for textile fibres and yarns. Therefore, 10 segments of 100 mm each in the case of the 68 µm filament and 10 segments of 1000mm each for the 18 µm were weighted.

2.2.Production of the metallic core yarns

The filaments under study can be considered a textile product due to their structure - core spun filaments. The denomination core spun is generally given to the sheath-core yarns, where the core can be a (mono or poly) filament or short fibres, while the sheath is made of staple fibres with a different nature from those in the core [14]. The ferromagnetic fibres can be used to obtain yarns similar to the ones illustrated in Figure 6, for which the core is the ferromagnetic filament and the sheath is made of natural or chemical staple fibres.

Figure 6: Schematic presentation of core yarns

Such fibres can be produced on a ring spinning machine using special devices for the drafting mechanism that allow its simultaneous feeding with both the filament and the roving. The roving is fed normally, while the filament is introduced by the special device, under the superior feeding rolls, where it overlaps the drafted fibres. When exiting the drafting mechanism, the fibres and the metallic filament are consolidated through torsion.

The experimental data shows that the 18 μm filament can be included in the core-sheath structure of the yarn. The winding must present a good stability so that there is no slippage between the yarn coils. Many times, the yarn structure presented more filaments that migrated on the yarn surface, as illustrated in Figure 7.

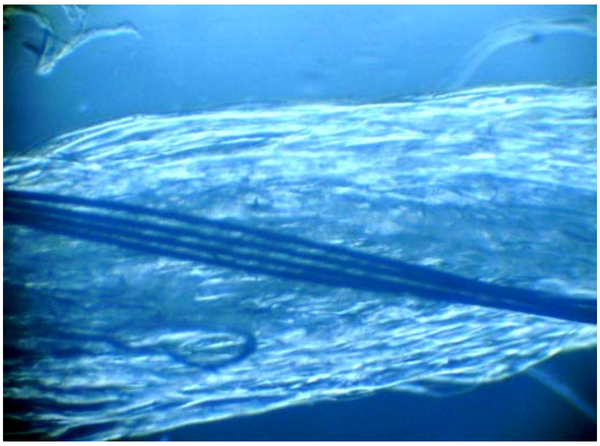


Figure 7: Microscopic aspect of the spinnes yarns with the 18 μm filament

2.3.Production of the knitted structures with metallic insertion

The metallic yarn was used to produce the a 1x1 rib knitted fabric with weft in-lay, considered to be suited for the purpose and represented in Figure 8.

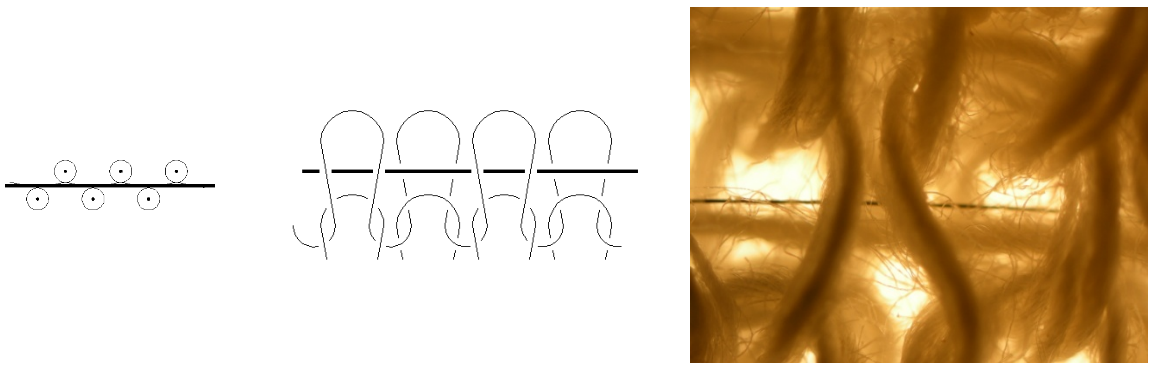


Figure 8: Structure of the 1x1 rib fabric with weft in-lay

The metallic yarn was introduced in the fabric using in-laying because this way the micro-yarns are not subjected to bending strain, thus eliminating the risk of breaking the glass cover. The weft yarn is placed in each row. It is observed that the weft in-laying of the filaments causes a 5.8-14.2% increase in fabric thickness.

Raw material:
1. Ground structure –100% cotton, Nm 60/3
2. Weft in-lay
   Metallic filament and fibrous external layer (variant V1)
   Two-ply yarn, metallic filament (micro-yarn) and textile yarn (variant V2)
   Textile yarn and metallic filament (micro-yarn) (variant V3)

Structural parameters (Table 2):
There were no significant differences between the structural parameters of the three variants. The following parameters were measured according to BS 5441 standard:
1. Horizontal density $D_o' = D_o''$ and vertical density D_v
2. Stitch length $l_{stitch}$and the length of the weft in-lay per stitch l_{weft}
3. Fabric weight (±5%)
4. Fabric thickness g_t

Table 2: Structural parameters

Variant	$D_o' = D_o''$ *[wale/5cm]*	D_v *[row/5cm]*	l_{stitch} *[mm]*	l_{weft} *[mm]*	M/m^2 *[g]*	g_t *[mm]*
V1	24	24	7.3	2.0	240	1.49
V2	24	24			240	1.61
V3	24	24			250	1.58

3.TESTING OF EMI SHIELDING CAPACITY

The testing of the EMI shielding parameters was carried out in the laboratory of the Faculty of Medical Bioengineering. The equipment for testing the EM properties in the microwave region is presented in Figure 9 [7 – 11, 14].

The testing equipment is formed by a microwave signal generator with 8.7 GHz frequency and a horn antenna receiver [15]. Between the generator and the receiver there is a semi-free space - because the experiment took place in the lab - where the textile material is positioned. The fabric is placed on a rectangular frame made of plastic, in the middle between the generator and the receiver.

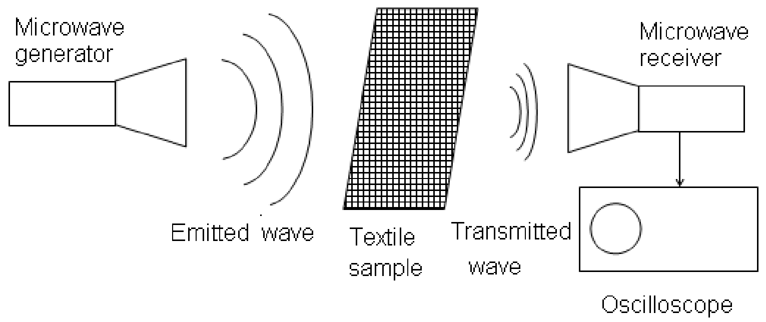


Figure 9: The diagram of the equipment used to measure the shielding coefficients

The fabric was so positioned that the metallic filaments were parallel to one of the frame edges. The power of the source is 4.5 mV. The antennas (of the receiver and of the source) were placed so that the electric component *E* corresponds to the vertical direction. The measurement of the EM field referred to the electric tension obtained at the outing of the detector with the receiver characteristic.

In the first stage, the signal from the receiver was measured, without the textile fabric. In the second stage of the test, the textile fabric was introduced with the metallic filaments parallel to the *E* vector and the tension is determined. The shielding effectiveness is given by the ratio between the two tensions. In the third stage, the fabric was rotated with 90^0, maintaining the distance *d* between the two antennas, so that the metallic filaments are perpendicular to the *E* vector. The ratio of the two tensions will give the loss coefficient. The experimental results are presented in Table 3, while the testing equipment is illustrated in Figure. 10.

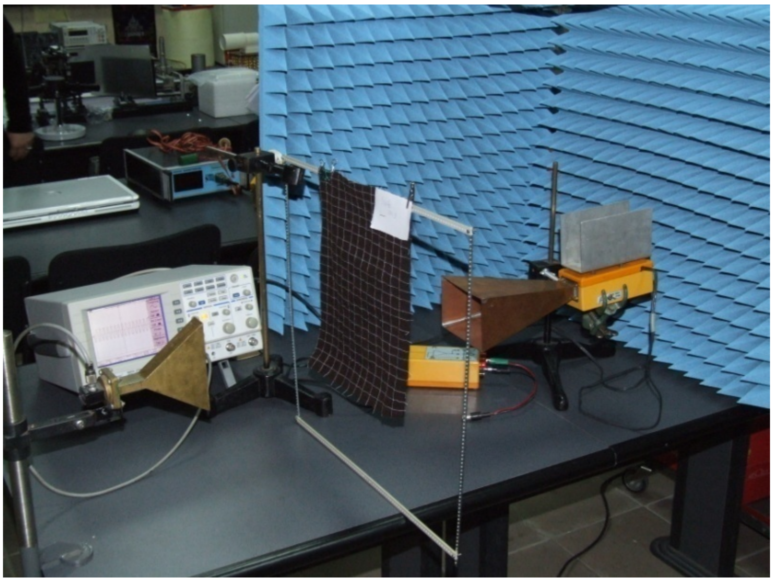


Figure 10: View of the measuring equipment

Table 3: Experimental results – shielding coefficients

Sample variant	Knit, V1	Knit, V2	Knit, V3
Simple sample, Paralell yarn, (mV)	11.5	22	9
Simple sample, Perpendicular yarn, (mV)	174	175	175
Double sample, Paralell yarn, (mV)	1.6	1.5	1.5
Double sample, Perpendicular yarn, (mV)	170	165	170
Signal in the field (mV)	185	185	185
Loss factor, Paralell yarn, simple/double	0.062 / 0.0086	0.119 / 0.0081	0.048 / 0.008
Loss, (dB)	24.1 / 41.3	18.48/ 41.83	26.37 / 41.93
Loss factor, Perpendicular yarn	0.94 / 0.91	0.94 / 0.89	0.945 / 0.919
Loss, (dB)	0.53 / 0.81	0.53 / 1.01	0.49 / 0.73

CONCLUSIONS

The loss factor depends on the in-lay ratio for the metallic filament. The samples with low loss factors are the ones with a low in-lay ratio for the metallic filament (further experiments have been done with 1:3 and 1:5 in-lay ratio).

The loss factor is approx. 40 dB for the double layered samples, representing a very good result.

Consequently, the shielding effect obtained with inserted metallic filaments in textile fabrics was described. The fibrous structure of the fabrics is of no importance, but the in-lay ratio of the metallic filament is significant.

The positioning of two fabric layers with paralell directions for the metallic filaments lead to the idea that inserting the filaments both on warp and weft directions is advantageous.

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NEW PERSPECTIVES IN PLASMA TREATMENTS FOR TEXTILE FUNCTIONALIZATION

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Abstract: *This paper presents new perspectives in plasma oxygen using for development of advanced, highly functional textiles and textiles with higher added value. The increasing concerns in textile finishing process due to the use of textile in technical fields, determinate the need of advanced surface treatment by using low cost and eco friendly technologies. The conventional textile finishing techniques provide wet chemical modifications where water and chemicals are used in large quantities and wastewaters have an increased toxicity and this conduct to highlighting the ecological impacts to the environment and effects to human health. The environmental concerns and starts from need of environmentally friendly processing of textiles conduct to use of suitable method like plasma nanotechnology. Plasma is the fourth state of matter. It is a gas with a certain portion of ionized as well as other reactive particles, e.g. ions, electrons, photons, radicals and meta-stable excited particles.*

Keywords: *functionalization, plasma, textile, nanotechnology, friendly environment.*

INTRODUCTION

Low-pressure plasma and air atmospheric corona plasma were used for textile surface activation. The plasma processes can create hydrophilic, hydrophobic, cleaning and roughness character increasing.
The treatments conducted by using plasma nanotechnology can improve the textile surface for submission of antimicrobial agent – colloidal Ag.
Recently silver-containing products were marked as subtance against AIDS, cancer, infectious diseases, parasites, chronic fatigue, acne, warts, hemorrhoids, enlarged prostate, and many disorders. In the speciality literature it is knows the antimicrobial capacity of colloidal Ag.

EXPERIMENTAL PART

For developing the experimental part standard samples were treated by using oxygen plasma nanotechnology for 10, 20, 30 and 90 minutes [3]. The comparative analyze for parameters modification before plasma treatment was conducted by using the standard samples data from table 2 and table 3.
After the surface preparation, by using absorption method according to ISO 20743:2007, was inoculated microbial Trichophyton interdigitale and Candida albicans suspensions directly on the samples analyzed. After this the samples were treated by using colloidal Ag [3].
Untreated and plasma-treated textile substrates were additionally modified by submission colloidal silver during dyeing process and morphological, chemical and physical properties of plasma-treated textile substrates were studied using microscopy (SEM).

The dyeing process was used for submission of colloidal silver onto textiles. Before applying nanoparticles to material, the textile surface needs to be adequately prepared and chemically and morphologically analyzed. The functionalization of textile surface by using plasma nanotechnology creates the conditions for qualitative deposition colloidal silver for increasing the antimicrobial properties.
In table 1 for antimicrobial evaluation was calculated the microbial reduction potential (R) in function of the initial number of collonies formator units - Trichophyton interdigitale from textile material untreated (control samples).

In table 2 for antimicrobial evaluation was calculated the microbial reduction potential (R) in function of the initial number of collonies formator units - Candida albicans. The results shows that for PES textile surface treated with colloidal Ag, the microbial reduction is 100%.

Table 1 [3]

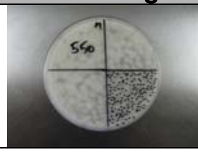
Sample	Rezults	SEM Image	Sample	Results	SEM Image
Sterility Control medium	T_0=0 UFC/mL T_{24}=0 UFC/mL		Control *Trichophyton interdigitale*	T0=1.1x10^4 UFC/mL T24=1.1x10^4 UFC/mL	
Fabric - PES 100% (M)	T0=1.1x10^4 UFC/mL T24=1.1x10^4 UFC/mL R=*0%*		Fabric PES+Ag	T0=1.1x10^4 UFC/mL T24=2.2x10^2 UFC/mL R=*98%*	

Table 2 [3]

Sample	Rezults	SEM Image	Sample	Results	SEM Image
Sterility Control medium	T_0=1.5x10^3 UFC/mL T_{24}=0 UFC/mL		Control *Candida albicans*	T0=2.4x10^4 UFC/mL T24=2.4x10^4 UFC/mL	
Fabric - PES 100% (M)	T_0=2.4x10^4 UFC/mL T_{24}=0 UFC/mL R=*100%*		Fabric PES+Ag	T_0=2.4x104 UFC/mL T_{24}=0 UFC/mL R=*100%*	

The textile material analyzed had the following characteristics:
- ➔ Composition 100% PES
- ➔ Mass -128 g/m²
- ➔ Width textile material 149 cm
- ➔ Density in U - 92,3 threads/cm and density weft - 25,7 threads/cm

Table 3

Maximal tear force on warp direction [N] ISO 13934-1					
Sample No.	**Standard sample**	**Samples treated in oxygen plasma**			
		10 minutes	**20 minutes**	**30 minutes**	**90 minutes**
1	1448	1451	1498	1489	1450
2	1459	1462	1469	1460	1430
3	1460	1465	1472	1470	1456
4	1400	1412	1429	1420	1400
5	1460	1469	1471	1450	1425
6	1480	1489	1492	1456	1426
7	1443	1448	1451	1449	1440
8	1448	1449	1452	1450	1425
9	1457	1459	1469	1460	1430
10	1488	1491	1512	1500	1490
11	1468	1471	1499	1490	1460
12	1498	1521	1529	1520	1500
13	1486	1489	1494	1490	1440
14	1400	1450	1468	1460	1430
15	1416	1455	1469	1465	1435
16	1468	1488	1498	1490	1450
17	1439	1459	1471	1470	1456
18	1441	1460	1496	1450	1430
19	1400	1440	1498	1490	1440
20	1481	1491	1521	1500	1460
Average	1452	1465.95	1482.9	1471.45	1443.65
ST DEV	29.66302	23.85145919	24.94815677	23.93076637	22.96054969
CV	2.0429%	1.6270%	1.6824%	1.6263%	1.5905%

Table 4

Abrasion resistance on warp direction - Martindale method ISO 12947-2					
Sample No.	Standard sample, Number of abrasion cycles	Samples treated in oxygen plasma			
		10 minutes	20 minutes	30 minutes	90 minutes
1	72000	72300	73000	70000	66000
2	68333	69000	71000	70500	70000
3	47500	57017	57300	57200	57050
4	85000	86000	87000	86000	80000
5	80000	80100	81000	80000	70000
6	61250	62000	62900	62000	60000
7	85000	85600	87000	85000	67000
8	75000	76000	78000	75000	70000
9	70000	71000	72000	70000	65000
10	60000	61000	63000	60000	57100
11	66000	66900	67000	57500	57320
12	75000	76320	79000	76000	57123
13	53750	57340	57550	57500	57350
14	92500	92600	93000	91000	57200
15	37800	57350	57650	57600	57400
16	54878	57425	57800	57700	57500
17	70000	70100	71000	57300	57100
18	65000	66000	67000	57400	57300
19	58000	60000	63000	57300	57200
20	55000	57350	57400	57100	57050
Average	66600.55	69070.1	70130	67105	61734.65
ST DEV	13580.74017	10895.91337	11075.07158	11490.88769	6659.013743
CV	20.3913%	15.7752%	15.7922%	17.1237%	10.7865%

RESULTS AND DISCUSSIONS

By analyzing the values for tear force and abrasion resitance for standard samples (figure 1 and figure 2) and samples treated in oxygen plasma for 20 (figure 3 and figure 4) and 90 minutes (figure 5 and figure 6), we concluded that optimized parameters for treated samples can be obtained after 20 minutes oxygen plasma treatment for samples with 100% PES composition.

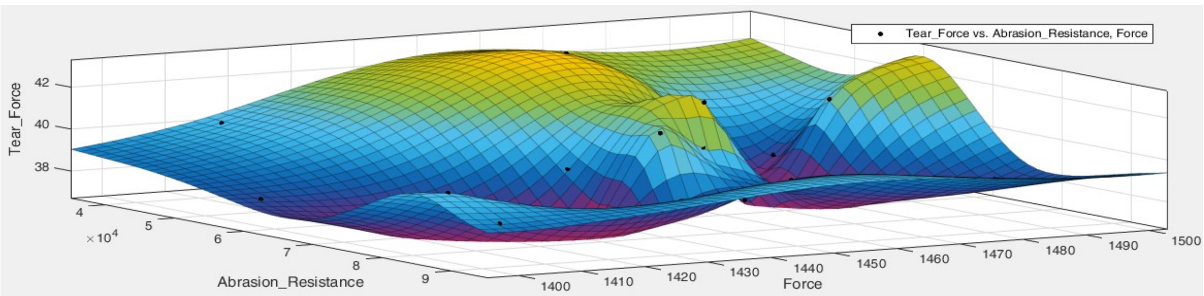


Figure 1: 3D representation for tear force –warp direction– standard samples

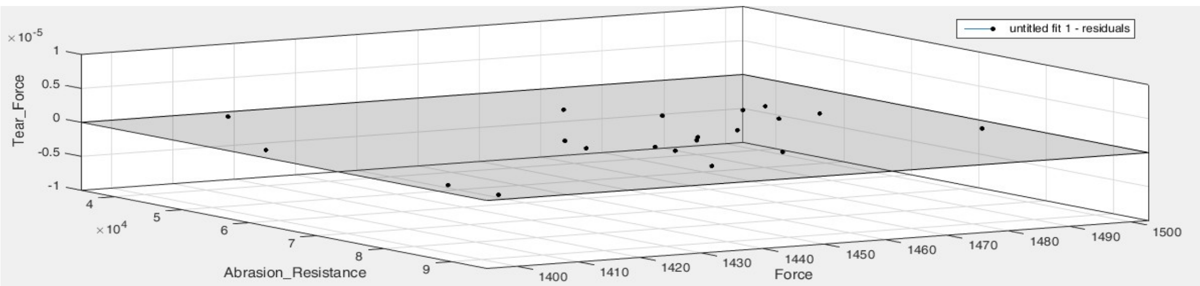


Figure 2: Residuals value -warp direction- standard samples

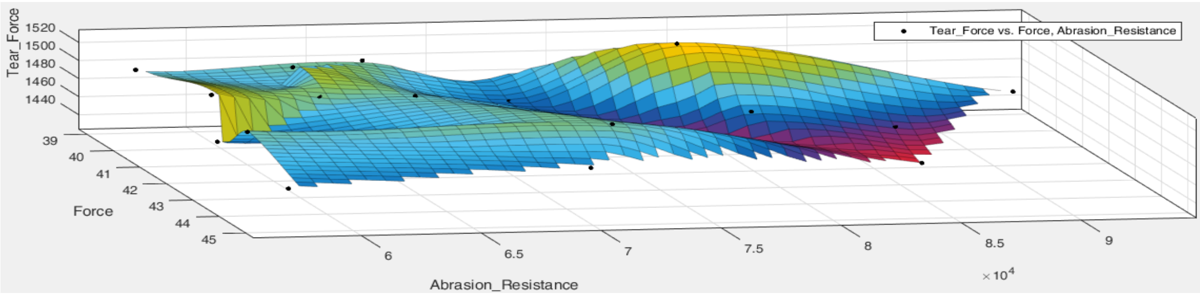


Figure 3: Tear force representation values –warp values– sample treated in oxygen plasma 20 minutes

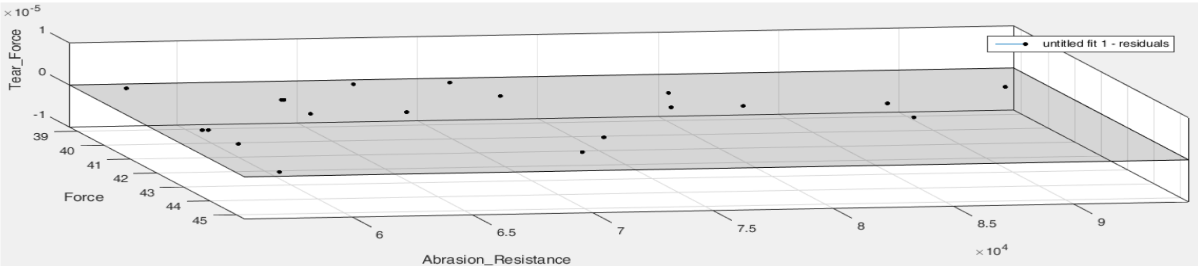


Figure 4: Residuals values -warp values- sample treated in oxygen plasma for 20 minutes

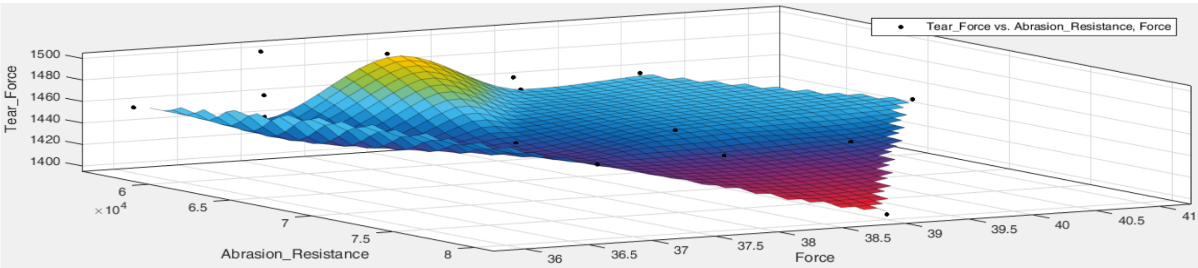


Figure 5: Tear Force – sample treated in plasma for 90 minutes

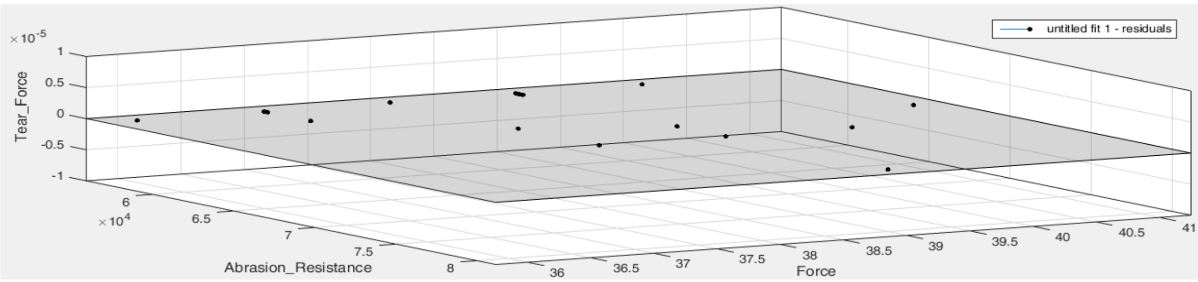


Figure 6: Residuals values – samples treated in plasma for 90 minutes

Data about plasma treatments were represented comparative with data about control standard samples by using histograms (figure 7 and figure 8) and it can see that the maximal tear force value are obtained after 20 minutes oxygen plasma treatment and this means that we have increasing values with maximal pointed after 20 minutes treatment and decreasing values till 90 minutes, due to the depolymerisation process started after 20 minute treatment.
Analyzing data for tear force on warp and weft direction, we can see that values don't present uniformity and the analysed direction don't have influence for increase or decrease in values on warp and weft direction. The maximal tear force values for weft or warp direction it was also obtained after 20 minutes oxygen plasma treatment.

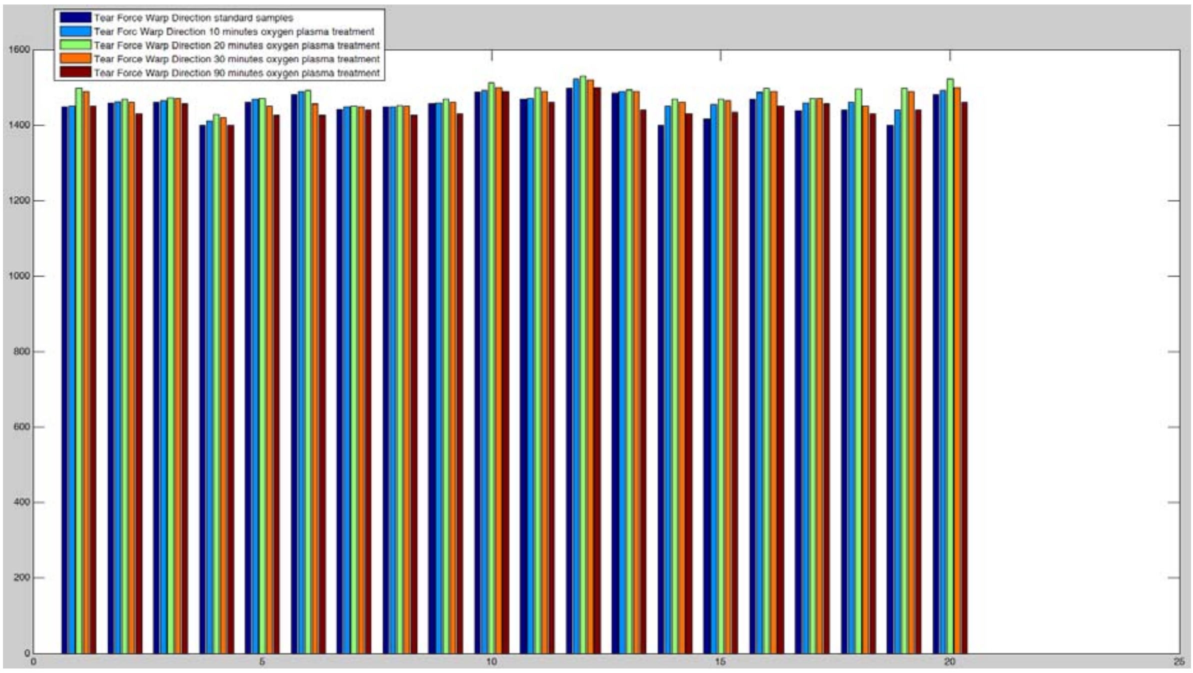


Figure 7: Tear force values – for samples analyzed on warp direction

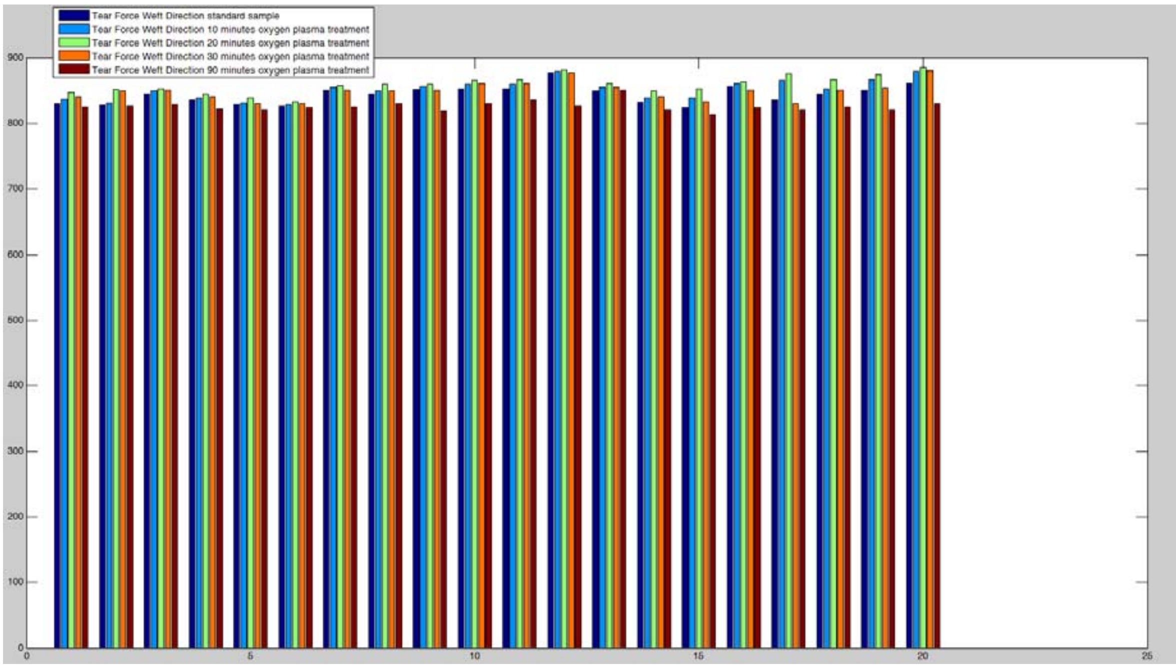


Figure 8: Tear force values – for samples analyzed on weft direction

In figure 9 are represented data about abrasion resistance by using histogram. From histogram it can see that the green value corresponding for 20 minutes oxygen plasma treatment is the highest values. This means that maximal abrasion resistance is after 20 minutes treatment.

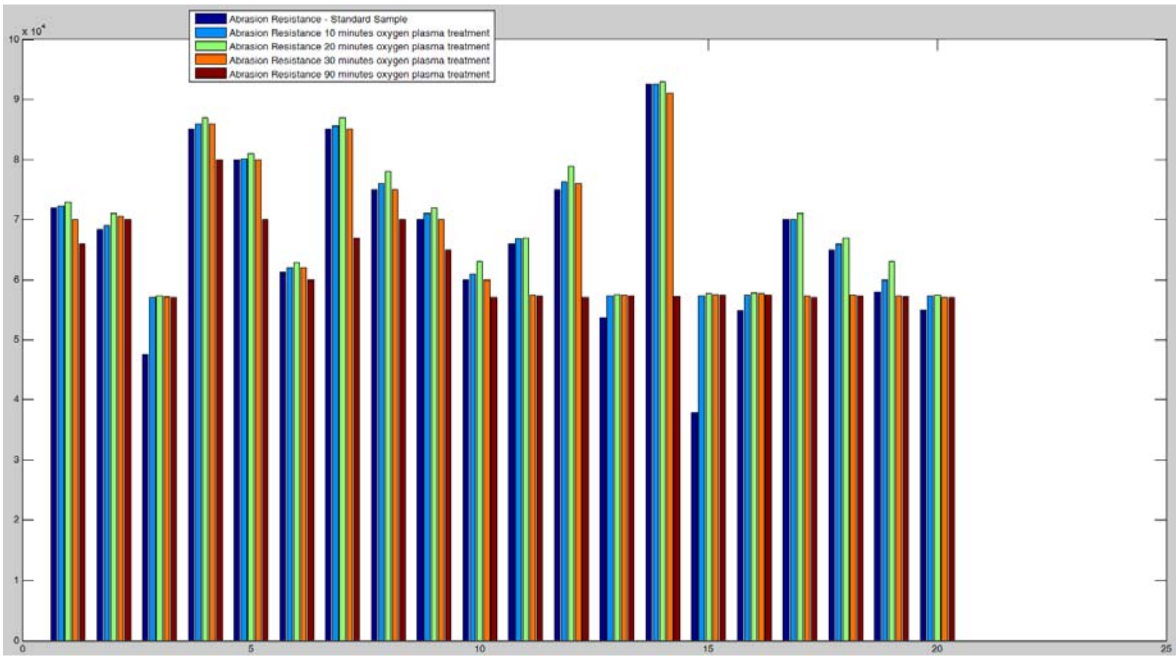


Figure 9: Abrasion Resistance – samples treated in plasma for 10, 20, 30 and 90 minutes

CONCLUSIONS

The oxygen plasma treatment advantages are:

- increasing tear force value and abrasion resistance after 20 minutes
- surface activation for antimicrobial agents submission

By submit colloidal Ag on treated samples was obtained a microbial reduction for Trichophyton interdigitale with 98% and a microbial reduction for Candida albicans with 100%.
This means that by using PES samples treated in plasma for 20 minutes and treated with colloidal Ag it can be obtained textile surface with improved physical properties and with high antimicrobial characteristics.

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TEXTILE FUNCTIONALIZATION PLASMA PROCESSES MODELING FOR CHITOSAN SUBMISSION

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Abstract: *This paper presents the modeling activation process aspects of textile surfaces (used like medical textile) by using oxygen plasma nanotechnology to achieve a high degree of surface optimization for chitosan submission. Acetylated chitosan is a derivative of chitin which is obtained by alkaline treatment and disintegration of the acetyl groups of the chitin. Medical textiles are used for the prevention, relief and treatment of diseases, given the health problems caused by an aging population. The scope of medical textiles includes all fabrics used in health and hygiene applications used in the medical field. This work presents plasma activation modeling process for the fabrics cleaning surfaces and to improve antimicrobial properties (by chitosan submission). Variants of fabrics have undergone preliminary preparation processes before applying special treatments.*

Keywords: *textile, plasma, nanotechnology, chitosan, process modelling*

INTRODUCTION

The research shows that chitosan, produced by deacetylation of chitin (natural polysaccharide), is non-toxic, biodegradable, biofunctional, and biocompatible [1]. Chitosan have many useful characteristics for medicine area: antimicrobial, hypocholesterolemic, immunity-enhancing and antitumor effects [1]. Chitosan is used in food and drink industry, drug delivery, and biotechnology [1].
For improving the textile surface characteristics, for chitosan submission, is required a modification of surface properties of a substrate and/or to produce coatings on a substrate is to submit the substrate to a low pressure plasma treatment [2]. By using the plasma treatments on textile surfaces can be obtained the cleaning effect and the increase of microroughness [3].
In the plasma literature is highlighting the advantage of using oxygen plasma treatments for improving cotton capillarity [4].
Some researches confirm that the sterilization by the low pressure plasmas oxygen on bacteria-inoculated (various concentrations of staphylococcus Aureus) on cotton fabrics investigated can conduct to a surface completely sterilized [5, 7, 8, 9].

EXPERIMENTAL PART

The experimental part consist in treatments of cotton knit samples by using oxygen plasma for surface activation and chitosan submission for increasing textile antibacterial characteristics. The knit samples usage area is for medical knitted bandages.
The antibacterial character for textile product was determined by ASTM -E 2148-01 against Gram-positive bacteria S. aureus (ATCC 6538) [6]. The samples had a very good antibacterial activity was maintained after 50 washing cycles (with an efficiency of > 90%) [6]. If chitosan is covalently bound to the polymer is not dissolved, the viscosity of the dispersion particles is low even with a high content of chitosan. The particles are in the nanometer size range, ultra slim and form a layer on the textile surface [6]. As a result, the feel and appearance of the fabric are not affected very much by the coating. After plasma treatment, the air permeability is reduced by the deposition of chitosan, due to reduced pore size of fabrics and tear and tear resistances were improved. In Table 1 are presented standard samples ratings for pilling effect, force values and strings density. In Table 2 are presented data about samples treated in oxygen plasma for 10 minutes: force values, strings density and ratings for pilling effect.

Table 1 Standard textile samples characteristics

Sample No.	Standard sample density [strings/cm]	Standard sample force [N]	Standard sample pilling effect Ratings
1	13.7	173	2.96
2	14	183	2.56
3	13.6	169	2.95
4	13.7	196	2.56
5	14	190	2.46
6	13.7	180	2.89
7	14	167	2.93
8	13.8	180	3.11
9	13.8	169	2.98
10	14	190	2.97
11	14	165	2.93
12	14	191	2.98
13	13	193	2.97
14	13.5	150	2.96
15	14.2	187	3.12
16	14	203	3.15
17	13.5	190	3.14
18	14	200	3.18
19	14	161	3.17
20	13.5	172	3.19
21	14	159	3.19
22	14	195	3.19
AVERAGE	13.82380952	180.4761905	2.958
ST DEV	0.279114245	14.92521038	0.210227946
CV	2.019%	8.270%	7.1071%

Table 2 Textile samples characteristics after oxygen plasma treatment for 10 minutes

Sample No.	Sample treated in oxygen plasma 10 minutes Density [strings/cm]	Sample treated in oxygen plasma 10 minutes - Force [N]	Sample treated in oxygen plasma 10 minutes Pilling Efect Rating
1	13.5	179	3.52
2	13.6	185	3.51
3	13.1	171	3.56
4	13.6	199	3.54
5	13.7	199	3.58
6	13.2	188	3.57
7	13.8	169	3.59
8	13.5	189	3.54
9	13.5	172	3.56
10	13.7	198	3.54
11	13.8	169	3.29
12	13.5	195	3.58

13	12.9	197	3.68
14	13.4	155	3.59
15	13.9	189	3.44
16	13.8	205	3.68
17	13.5	199	3.69
18	13.5	210	3.44
19	13.8	169	3.89
20	13.2	178	3.98
21	13.5	165	3.98
22	13.4	199	3.98
AVERAGE	13.51904762	185.7142857	3.5885
ST DEV	0.258106659	15.38552195	0.149464835
CV	1.909%	8.285%	4.1651%

Table 3 Textile samples densities before and after 10 minutes oxygen plasma treatment

Sample no.	**Standard sample strings/cm**	**Standard sample rows /cm**	**Sample treated in oxygen plasma (10 minutes) strings/cm**	**Sample treated in oxygen plasma (10 minutes) rows /cm**
1	13.7	18	13.5	17.5
2	14	18	13.6	17.6
3	13.6	18	13.1	17.9
4	13.7	18.1	13.6	17.6
5	14	18	13.7	17.7
6	13.7	18.2	13.2	17.8
7	14	19	13.8	17.9
8	13.8	18.2	13.5	18
9	13.8	19	13.5	18.5
10	14	18	13.7	17.8
11	14	18	13.8	17.9
12	14	18	13.5	17.4
13	13	18	12.9	17.6
14	13.5	18	13.4	17.6
15	14.2	18.5	13.9	18.4
16	14	19	13.8	18.9
17	13.5	19	13.5	18.7
18	14	19	13.5	18.6
19	14	19	13.8	18.7
20	13.5	18.5	13.2	18.3
21	14	18.6	13.5	18.4
22	14	19	13.4	18.9
AVERAGE	13.82380952	18.43333333	13.51904762	18.1047619
ST DEV	0.279114245	0.447586118	0.258106659	0.479036732
CV	2.019%	2.428%	1.909%	2.646%

RESULTS AND DISCUSSIONS

The discussion will be made on two directions:

- Analyzes of oxygen plasma treatment influence on material surface characteristics after 10 minutes treatment (pilling effect – after chitosan submission, tear force, strings density)
- Analyzes of oxygen plasma treatment influence on the string/rows density and knit elasticity on longitudinal and transversal directions (figures 5 and 6).

The results used in discussion are collected after and before oxygen plasma treatment.

By tear force modeling in function of pilling efect and strings density, before oxygen plasma treatment, it is observed that occurs some residuals values (figure 1 and figure 2).

For knit sample treated for 10 minutes on oxygen plasma it was observed the dicreasing of residuals values – this is showing that the oxyden plasma treatment conduct to the textile surface uniformization (figure 3 and figure 4).

After plasma treatments it was observed a knit length increasing on row and string directions (figure 5 and figure 6). This means that strings density and row density is decreased on both directions and this conduct to observation that the knit sample lose about 2% of his elasticity on longitudinal and transversal direction.

The ratings obtained for pilling effect for standard samples (table 1) and for samples treated in oxygen plasma for 10 minutes (table 2) highlight the aspect that by using plasma treatment the pilling efect is lower for knit samples treated in plasma.

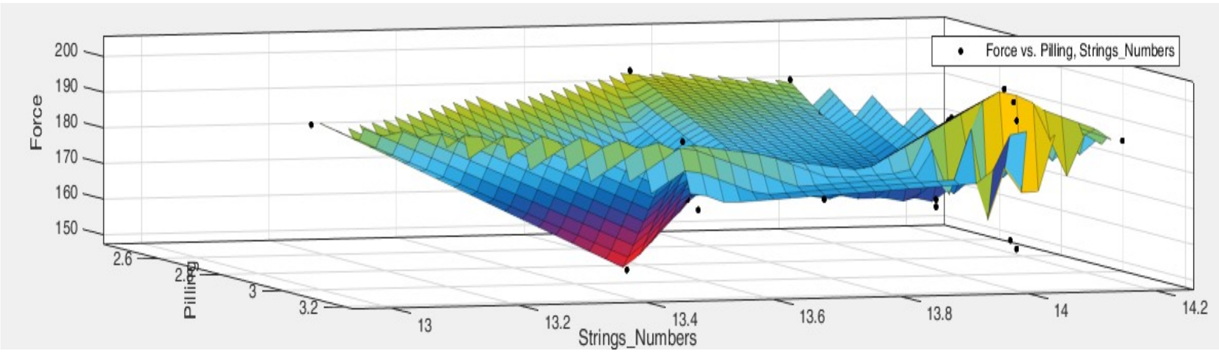

Figure 1: 3D graphical representation force in function of pilling and strings density values – standard sample

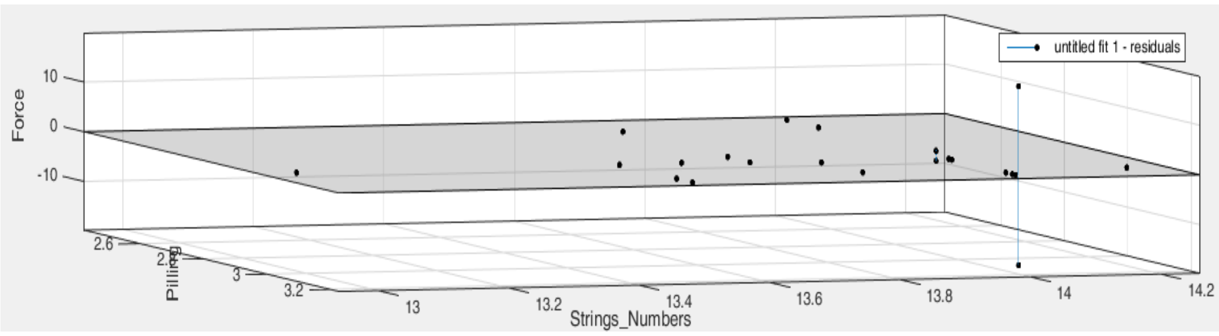

Figure 2: Residuals values for knit standard sample

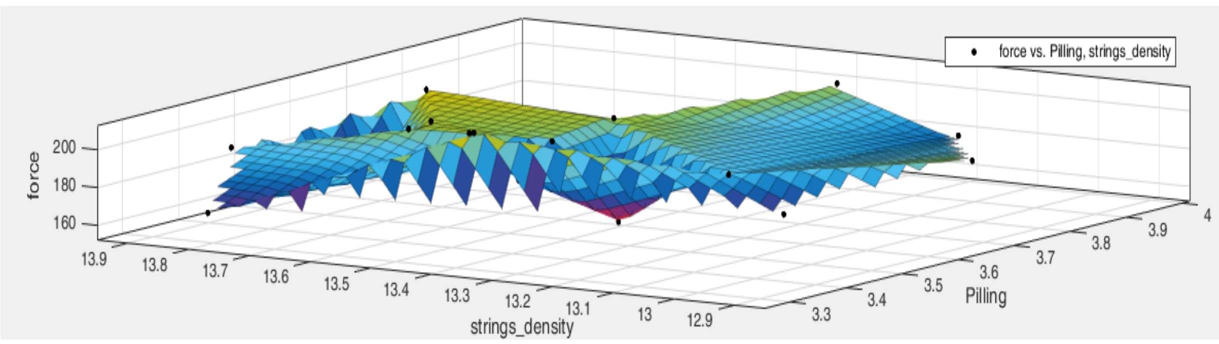

Figure 3: 3D graphical representation force in function of pilling and strings density values - sample treated on oxygen plasma for 10 minutes and with deposition of chitosan by foulard method

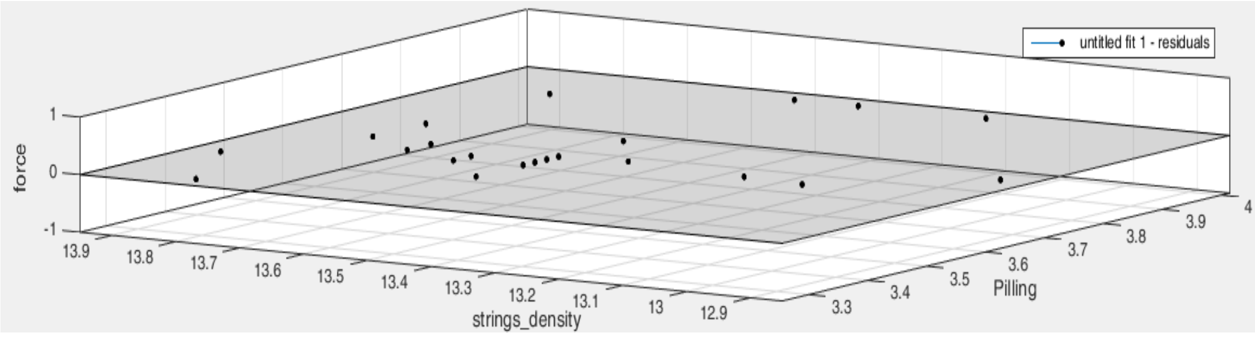

Figure 4: Residuals values for knit sample treated on oxygen plasma for 10 minutes and with deposition of chitosan by foulard method

By analyzing histograms data – figure 5 and figure 6, it can conclude that after 10 minute oxygen plasma treatment it's observed dicreasing values for densities on warp or weft directions. This phenomen can be due to depolymerisation process started and to the knit relaxing process. In this way the knit lose from his elasticity and increase the elongation surface on both direction longitudinal and transversal.

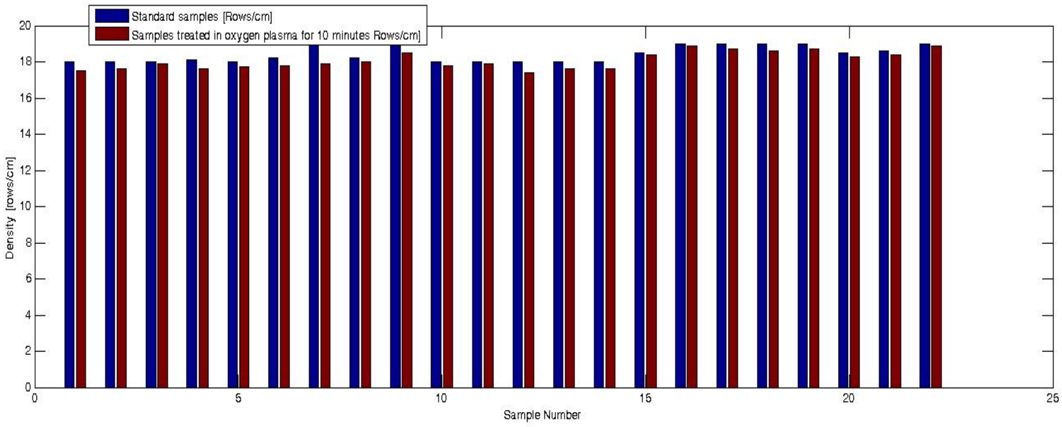

Figure 5: Rows densities analyze before and after 10 minute plasma treatment

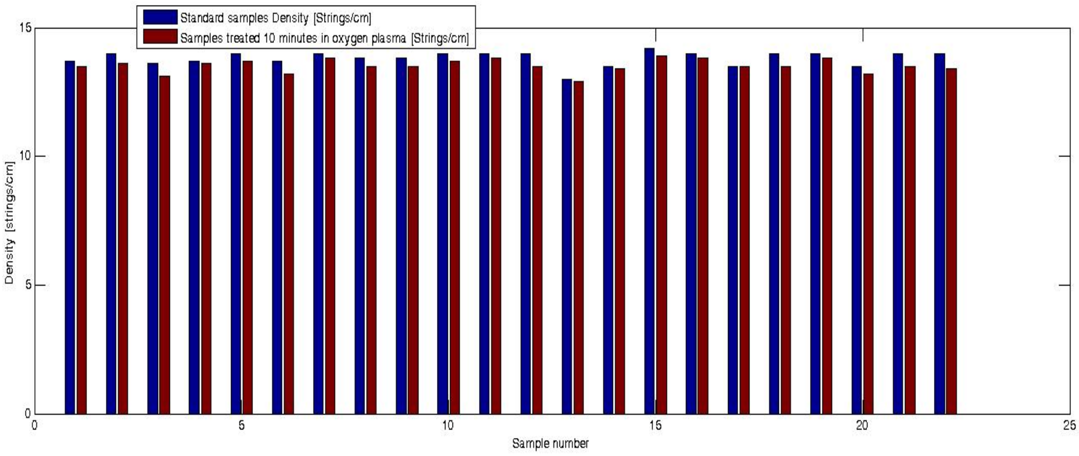

Figure 6: Strings densities analyze before and after 10 minute plasma treatment

CONCLUSIONS

The advantages of treat the cotton knit samples on oxygen plasma are:

- Cotton capillarity and hydrophilic characteristic improvement ➔ surface preparation for chitosan submission is optimized.
- Pilling effect lower ➔ superficial fibres existent on surface area of the knit sample are eliminated ➔ positive part consist in economy on chitosan substance submission and low residuals values.
- The decreasing number of strings/rows /cm density can be the effect of depolymerisation and electrostatic energy eliminating (knit relaxing).

- After 10 minutes oxygen plasma treatment is observed an increasing of knit elongation on longitudinal and transversal direction.
- After 10 minutes oxygen plasma treatment knit density on transversal and longitudinal direction is decreased and also the knit elasticity is decreased. On this case the strings/rows density is direct proportional with elasticity and inverse proportional with knit elongation on longitudinal and transversal direction. This can conduct to observation that 10 minute of plasma treatment can affect the knit dimensional stability on row and string directions.

The advantages of using the chitosan submission consist in increasing textile antibacterial characteristics.

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TECHNICAL TEXTILES PERFORMED BY PLASMA TREATMENT

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Abstract: *INCDTP-Bucharest performs research for accomplishing technical textiles based on plasma treatment. Aim of this research is to evidence the improvement of the fabrics functionalities based on plasma treatment. Two types of functionalization were envisaged, the improvement of the hydrophobic and of the hydrophilic properties of the fabrics.*
The hydrophilic effect was obtained in order to improve the dye ability of the fabrics, while the hydrophobic effect was destined for specific applications. As final applications for technical textiles we envisaged MEDTECH articles (hydrophobic surgical gowns) and BUILDTECH articles (emergency shelters from resistant fabrics).
The hydrophilic plasma treatment was performed by means of Oxygen gas, while hydrophobic treatment with Hexafluoropropane gas. Experiments were performed with different plasma treatment parameters: frequency range (kHz/MHz), Power (Watt), Time (s), Pressure (mTorr), on 100% raw cotton fabrics. Both effects were evidenced by means of contact angle measurement, electronic microscope images (SEM) and physical-mechanical properties.

Keywords: *plasma, hydrophobic, hydrophilic, BUILDTECH, MEDTECH*

INTRODUCTION

Plasma treatments for accomplishing technical textiles is an innovative method for producing high value added textile products.
The research studies in this field are in a development phase, due to the fact that plasma treatments for textiles are yet introduced into the industry.
INCDTP- Bucharest performs several research studies in the field of plasma treatments, within the trans-national ERA-NET project MULTITEXFUNCTION.
INCDTP is endowed with a roll-to-roll low pressure laboratory plasma equipment.
The main result of the MULTITEXFUNCTION project is the design of an industrial prototype of plasma equipment as starting point for the implementation on large scale of plasma processing in the textile industry.

Figure 1 – Laboratory plasma equipment in INCDTP

EXPERIMENTAL

Two main plasma based functionalization on two types of materials have been conducted within our laboratory experiments: hydrophilic and hydrophobic functionalization.

These type of functionalization was evidenced by means of contact angle measurement and SEM images. The contact angle measurement was performed with a VCA Optima Contact angle equipment from ASD products. A droplet of water forms with the analysed material a contact angle, in correlation with its surface energy. The measurement of the contact angle reflects the wettability property of the material [1]. The contact angle measurements were performed accordingly to the standard ASTM D7490-08.

Table 1 – Key elements of the plasma treatment analysis

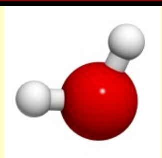
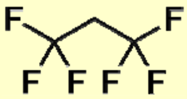
Type of plasma treatment	*Gas*	*Chemical formula*	*Raw materials*	*Contact angle measurement*
Hydrophilic treatment	O2		cotton 	
Hydrophobic treatment	C3H2F6		 PES	

Table 2 - Functionalization description

Hydrophilic treatment	Hydrophobic treatment
Has been accomplished in order to improve the wettability effect of the fabrics. The wettability effect has as consequence a better behavior of the fabrics within the subsequent liquid finishing treatments. Such treatments include mainly dyeing, but other special treatments can be also improved, like fireproofing, anti-microbial or anti-putrescent finishing. The hydrophilic plasma treatment has as consequence the cleaning of the materials surface.	Is required for textile articles, such as: waterproof surgical gowns and bed linen (MEDTECH), emergency shelters for extreme weather conditions (BUILDTECH). The hydrophobic character of a fabric ensures an inner side which remains dry and clean, with the possibility of protection. The hydrophobic plasma treatment has as consequence a rough, activated surface, with asperities on the fibers, which block the passing trough of liquids. The gas is deposited on the fabric surface, improving the hydrophobic effects.

Table 3 - PLASMA treatment parameters

Parameters	*Hydrophilic treatment*	*Hydrophobic treatment*
Type of gas	Oxygen (O2)	Hexafluoropropane (C3H2F6)
Frequency range generator	kHz	MHz
Power of generator	50 W	20 W
Process time	300 s	900 s
Pressure	20 mTorr	20 mTorr

Several plasma treatment parameters were applied. Here are the optimum parameters for best results regarding the two functionalization.

RESULTS

Table 4 - Physical-mechanical properties of raw fabrics

Type of test		V1-RAW	V2-RAW	Standard
Fibrous composition		100% cotton	100% PES	ISO 1833:1995
Mass / surface, g/m^2		133	133	EN 12127:1999
Fabric width, cm		138	165	SR EN 1773:2002
Fabric weave		Plain weave	Satin	SR 6431:2012
Fabric thickness , mm		0,47	0,32	SR EN ISO 5084/2001
Fabric density No. Yarns /10 cm	Warp	180	758	SR EN 1049/2:2000
	Weft	197	404	
Air permeability, l/m^2/s; 100Pa		994, 4	149,9	SR EN ISO 9237/1999
Water vapor permeability, %		35,4	25,1	SR 9005-1979
Abrasion resistance, abrasion cycles		12.089	21.379	SR EN ISO 12947-2:2002
Breaking force, N	Warp	454,7	1054	SR EN ISO 13934-1-2004
	Weft	269,7	1244	
Breaking elongation , %	Warp	13,45	40,6	SR EN ISO 13934-1-2004
	Weft	11,89	33,2	
Tear resistance, N	Warp	27,60	47,2	SR EN ISO 13937-3-2002
	Weft	29,46	71,7	

Contact angle measurements

Table 5 – Contact angle measurement for Hydrophilic treatment

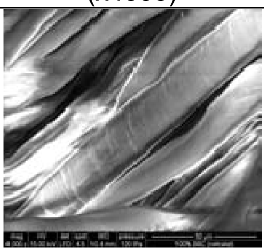
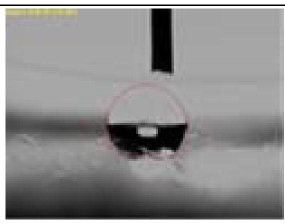
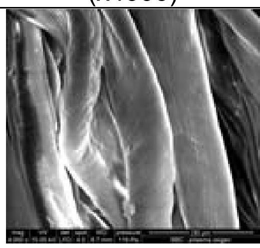
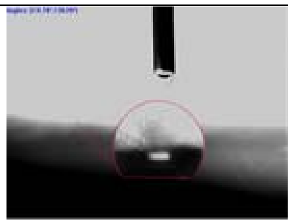
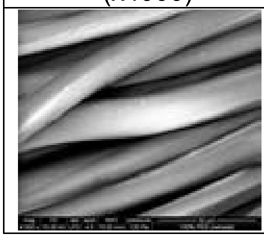
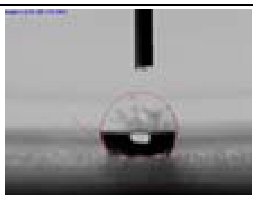
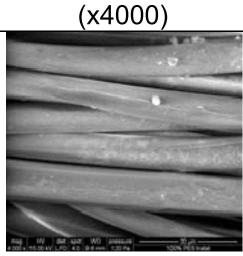
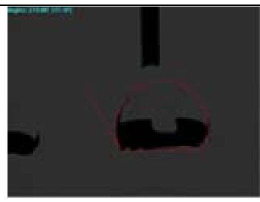
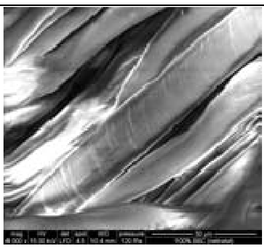
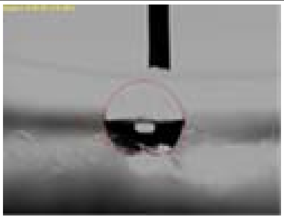
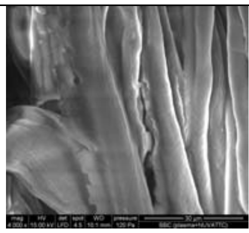
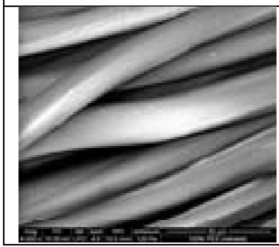
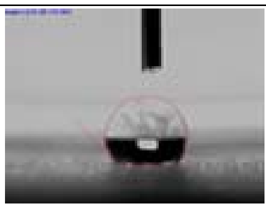
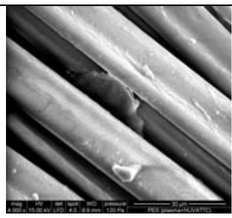
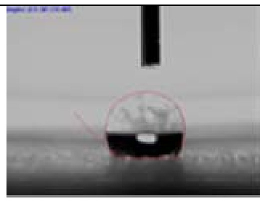
SEM + Contact angle 100% cotton			
Without Plasma		With Plasma	
SEM (x4000)	Mean Contact Angle: 139.4°	SEM (x4000)	Mean Contact Angle: 130.9 °
			
Contact angle 100% polyester			
Without Plasma		With Plasma	
SEM (x4000)	Mean Contact Angle: 131.1 °	SEM (x4000)	Mean Contact Angle 126.2 °
			

Table 6 – Contact angle measurement for Hydrophobic treatment

Contact angle 100% cotton			
Without Plasma		With Plasma	
SEM	Mean Contact Angle: 139.4^o	SEM	Mean Contact Angle: 146.7^o
			
Contact angle 100% polyester			
Without Plasma		With Plasma	
SEM	Mean Contact Angle: 131.1^o	SEM	Mean Contact Angle: 136.1^o
			

DISCUSSION

The physical-mechanical properties of the two fabrics show us the basic characterizing parameters. These fabrics were chosen for their special properties regarding mass / surface: 133 g/m^2 in raw state. This is suitable for comparison reasons.

From the SEM images and the contact angle images, we can see the effect of the plasma treatment for:
- Hydrophilic effect (Table 5)
- Hydrophobic effect (Table 6)

The treatment with Oxygen gas has as consequence the cleaning of the material's surface and thus an increasing of the surface at micro / nano-scale: SEM images. The contact angle of a droplet of water on the surface – both for cotton and polyester – is decreasing (Standard ASTM D7490-08). The increase of the contact angle is of aprox. 8^o. These values prove the hydrophilic effect of the Oxygen gas plasma treatment (parameters Table 3).

The treatment with Hexafluoropropane gas has as consequence the deposition on micro / nano-scale of fluorine particles on the surface of cotton and polyester. The fluorine particles have a very low surface energy, determining a hydrophobic effect on the fabric's surface. The fluorine particles are visible in the SEM images. The contact angle is increasing with aprox. 5-6^o. These values prove the hydrophobic effect of the Hexafluoropropane gas plasma treatment (parameters Table 3).

CONCLUSIONS

The research envisaged as final applications the hydrophobic effect on technical textiles, such as:
- BUILDTECH articles: emergency shelters manufactured from 100% cotton. However, for the shelter we have used a cotton fabric with 430 g/m2, also treated in plasma for hydrophobic effect
- MEDTECH articles: barrier surgical gowns manufactured from 100% polyester. For this end product we have used the polyester fabric with 133 g/m2, presented in Table 4. This fabric was treated in plasma for hydrophobic effect.

Figure 2: 100% cotton / BUILDTECH

Figure 3: 100% Polyester / MEDTECH

The hydrophilic effect can be used for the improvement of the wettability effect. Thus, better finishing treatments can be applied on the fabrics, for the fabrics surface is cleaned. Such finishing treatments could be also for:

- Hydrophobization
- Anti-microbial
- Fire-proofing etc.

The special finishing treatments confer to the final textile end-products a multi-functional character and a higher added-value.

Both of the hydrophobic and the hydrophilic effect obtain with plasma treatment is useful for producing more competitive technical textiles products. However, these modern nano-technologies offer a large domain for further research and for a wider implementation of plasma technologies in the textile industry.

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STUDY REGARDING MEDTECH ARTICLES WITH ANTI-MICROBIAL PROPERTIES

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Abstract:
This paper presents the improvement of the anti-microbial character of MEDTECH articles based on woven fabrics, obtained within the ERA-NET Crosstexnet Project MULTITEXFUNCTION. The woven fabrics (100% cotton and 100% polyester) were cleaned in Oxygen plasma and treated by padding with silver and chitosan particles. Aim of our research was to quantify comparatively the anti-microbial effect of both substances. The fabrics are destined for healthcare applications: special covers for humans in emergency situations (cotton), respectively surgical gowns (polyester).
The anti-microbial effect was evidenced by the following investigations: dyestuff affinity, SEM images and anti-microbial tests. The dyestuff affinity is better after plasma cleaning. The SEM images prove the presence of silver and chitosan. The anti-microbial tests were performed with two fungi: Candida Albicans and Tricophyton Interdigitale. The obtained anti-microbial effect and was considerably higher and with biocide properties for both type of treatments compared to the raw fabrics.

Keywords: *MEDTECH, anti-microbial, cotton, silver, chitosan*

INTRODUCTION

The competition on the textile market sets the development of new products with improved multi-functional properties. In this regard, the improvement of anti-microbial functionality of textile materials means performing of products with high value added. We study in this article the anti-microbial character of MEDTECH articles, such as: covers for emergency situations from cotton and surgical gowns from polyester.

Aim of this study is to quantify the anti-microbial effect on the selected samples in order to improve the performance of the final MEDTECH products. The following investigations were performed in order to analyse the aim of this research:

1. Physical-mechanical tests for the raw fabrics
2. Dyestuff affinity on the finished fabrics with and without plasma cleaning
3. SEM images of the fabrics with and without anti-microbial finishing
4. Anti-microbial tests accordingly to the standard AATCC 90028 with the following bacteria:
   a.Candida albicans
   b.Trichophyton interdigitale

The approach of this research study is characterized by:
- 2 types of fabrics (V1 – 100% cotton Nm 27/2; V2 – 100% PES dtex168,3)
- 2 types of anti-microbial substances: colloidal silver and chitosan
- 2 types of anti-microbial tests: Candida Albicans, Trichophyton interdigitale

EXPERIMENTAL

The fabrics were subjected to the following manufacturing process:

I. Weaving process
II. Preliminary finishing of the fabrics
III. Plasma surface cleaning

IV. Anti-microbial finishing

I. The two fabrics (from cotton and polyester) were manufactured in the INCDTP micro-production station on UNIREA and SOMET weaving machines. The fabrics were designed in order to met the requirements of the final end-products. The physical-mechanical properties of the raw fabrics are evidenced in Table 1.

Table 1 – Physical-mechanical properties of the 100% cotton and 100% polyester fabrics

Test type		V1	V2	Standard Method
Fibrous composition		100% Cotton	100% PES	ISO 1833:1995
Finesses of the yarns from the fabrics	Warp Tex (Nm) (den)	37,4x2 (26,7/2)	8,31 (74,8)	SR 6430/2012, Method A
	Weft Tex (Nm) (den)	37,3x2 (26,6/2)	16,83 (151,5)	
Mass / surface, g/m^2		302	133	EN 12127:1999
Fabric width, cm		160	165	SR EN 1773:2002
Fabric weave		Plain weave	Satin	SR 6431:2012
Fabric thickness , mm		1,06	0,32	SR EN ISO 5084/2001
Fabric density No. Yarns /10 cm	Warp	107	758	SR EN 1049/2:2000
	Weft	82	404	
Air permeability, l/m^2/s; 100Pa		219,1	149,9	SR EN ISO 9237/1999
Water vapor permeability, %		32,6	25,1	SR 9005-1979
Abrasion resistance, abrasion cycles		20000	21379	SR EN ISO 12947-2:2002
Thermal resistance (R_{ct}), $m^2 \cdot K/W$		0,01336	0,01181	SR EN 31092 ISO 11092/1997
Water vapor resistance (R_{et}), $m^2 \cdot P_a/W$		5,502	5,813	SR EN 31092 ISO 11092/1997
Breaking force, N	Warp	1153	1054	SR EN ISO 13934-1-2004
	Weft	425,1	1244	
Breaking elongation , %	Warp	17,95	40,6	SR EN ISO 13934-1-2004
	Weft	9,58	33,2	
Tear resistance, N	Warp	120,2	47,2	SR EN ISO 13937-3-2002
	Weft	61,7	71,7	

II. - Preliminary finishing of the fabrics

Table 2 - Preliminary finishing of the fabrics

100 % cotton	*100% polyester*
Raw fabric	Raw fabric
Kier-boiling	Dry heat setting
Washing	
Rinsing	
Drying	
Bleaching	
Washing	
Rinsing	

III. Plasma treatment parameters cleaning and activating the surface for dyestuff affinity:

Process parameters:

- Generator frequency range: kHz
- Generator power: 50 W
- Process time: 240 s
- Pressure: 20 mTorr
- Temperature: 295 K

Figure 1 – Plasma roll-to-roll low-pressure installation in INCDTP

IV. The anti-microbial finishing was performed with two different substances:

- Colloidal silver
- Chitosan

Figure 2 - Colloidal silver

Silver has in form of colloidal solution a high degree of purity and represents a natural and efficient treatment for many diseases, especially infections. Its biological action is oriented on the cellular structure. It has a large range of applications: water filters in aircrafts and space shuttles, germicide for water pools, medicine – it is lethal for more than 650 types of bacteria, viruses, fungi and parasites

Figure 3 - Chitosan

Chitosan is the most widespread polymer in nature after cellulose. It is obtained by alkaline treatment of chitin and disaggregation of the acetyl groups. Chitin can be found in organisms, such as: crustaceans, insects, mushrooms and algae. Chitosan has a large number of industrial and medical applications: biotechnologies, photography, cosmetics, food processing, wastewater treatment for removing metallic ions and dyes.

RESULTS

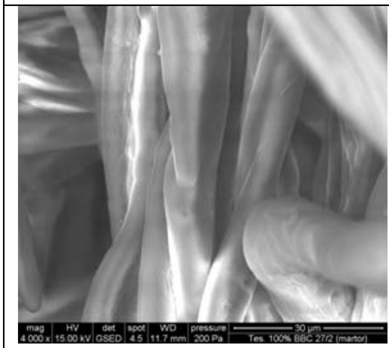
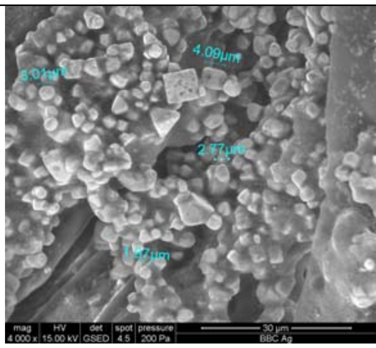
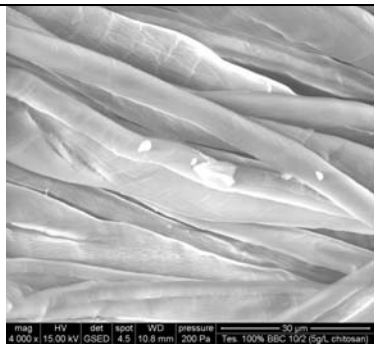
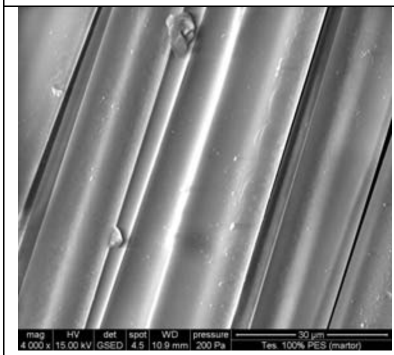
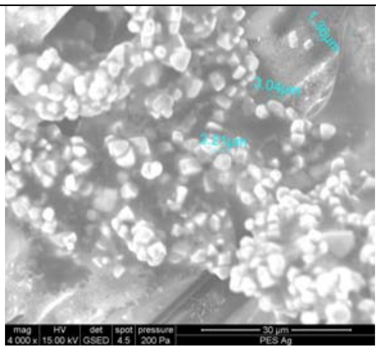
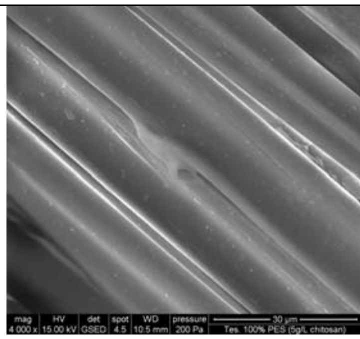
After the plasma treatment, the dyestuff affinity of the fabrics is improving. The following tests show better results for plasma treated fabrics:

Table 3 – Effect of plasma treatment to the fastness (both on V1 and V2)

	Without plasma (Grade)	With plasma (Grade)
Washfastness (SR EN ISO 105- C 06 : 2011)	1-2	3-4
Fastness to perspiration (SR EN ISO 105-E04: 2013)	4	4-5
Fastness to rubbing (SR EN ISO 105- X 12 : 2003)	4	4-5
Fastness to water (SR EN ISO 105- E 01 : 2003)	4	4-5
Fastness to light (SR EN ISO 105- B02 : 2003)	4	4-5

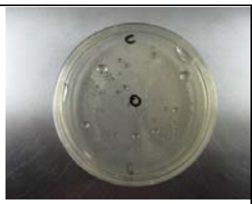
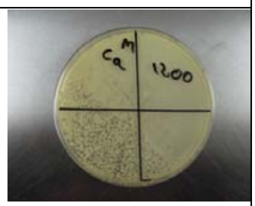
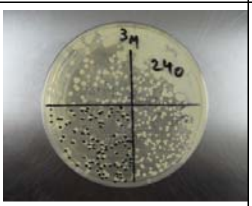
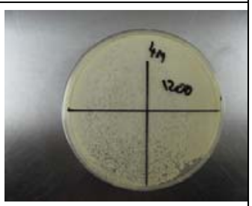
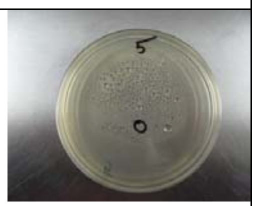
The SEM images with a magnitude of (x 4000) show a substantial content of both anti-microbial substances:

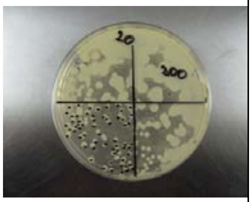
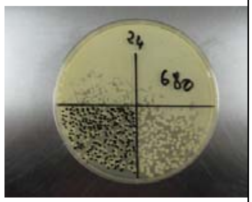
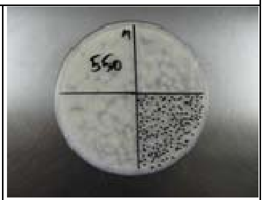
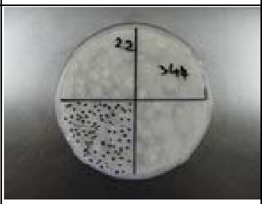
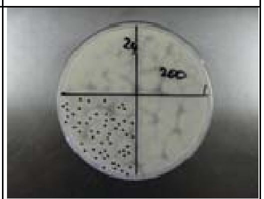
Table 4 – SEM images (x 4000) of V1 and V2 with treatment of Silver and Chitosan

Raw	Silver treatment	Chitosan treatment
V1 - 100% cotton		
		
V2 - 100% PES		
		

Anti-microbial tests were performed on the fabric samples with two bacteria, accordingly to the standard AATCC 90028.

Table 5 - Anti-microbial tests accordingly to ISO 20743:2007

Fabric sample	**Results**	**Image**	**Fabric sample**	**Results**	**Image**
Candida Albicans					
Control for medium sterility	T_0=0 CFU/mL T_{24}=0 CFU/mL		Control *Candida albicans*	T0=2.4x10^4 CFU/mL T24=2.4x10^4 CFU/mL	
100% cotton fabric, untreated	T_0=2.4x10^4 CFU/mL T_{24}=2.4x10^4 CFU/mL R=*0%*		100% PES fabric, untreated	T_0=2.4x10^4 CFU/mL T_{24}=2.4x10^4 CFU/mL R=*0%*	
100% cotton fabric +Ag	T_0=2.4x10^4 CFU/mL T_{24}=0 CFU/mL R=*100%*		100% PES fabric +Ag	T_0=2.4x10^4 CFU/mL T_{24}=0 CFU/mL R=*100%*	

Fabric sample	Results	Image	Fabric sample	Results	Image
Candida Albicans					
100% cotton fabric +5g/L chitosan	T0=2.4x10^4 CFU/mL T24=4x10^3CFU/mL R=*83%*		100% PES fabric +5g/L chitosan	T0=2.4x10^4 CFU/mL T24=1.36x10^4CFU/mL R=*43%*	
Trichophyton interdigitale					
Control for medium sterility	T_0=0 CFU/mL T_{24}=0 CFU/mL		Control *Trichophyton interdigitale*	T0=1.1x10^4 CFU/mL T24=1.1x10^4 CFU/mL	
100% cotton fabric, untreated	T0=1.1x10^4 CFU/mL T24=1.1x10^4 CFU/mL R=*0%*		100% PES fabric, untreated	T0=1.1x10^4 CFU/mL T24=1.1x10^4 CFU/mL R=*0%*	
100% cotton fabric +Ag	T_0=1.1x10^4 CFU/mL T_{24}=2.4x10^2 CFU/mL R=*99.5%*		100% PES fabric +Ag	T0=1.1x10^4 CFU/mL T24=2.2x10^2 CFU/mL R=*98%*	
100% cotton fabric +5g/L chitosan	T0=1.1x10^4 CFU/mL T24=6.88x10^3 CFU/mL R=*37.45%*		100% PES fabric +5g/L chitosan	T0=1.1x10^4 CFU/mL T24=4x10^3 CFU/mL R=*63.63%*	

DISCUSSION

The physical-mechanical properties of the raw fabrics (V1 – 100% cotton and V2 – 100% polyester) show the basic characteristics, related to the end applications: covers for humans in emergency situations and surgical gowns.

The values for dyestuff affinity show a better impregnation of the plasma cleaned fabrics with finishing substances (both preliminary finishing and anti-microbial finishing). The increasing of the note for washfastness from 1-2 to 3-4 is relevant for the improvement of the finishing with plasma treatment. The other properties for fastness (perspiration, rubbing, water, light) present only a slight improvement of the note from 4 to 4-5. These values prove the effect of the cleaning of the fabrics in low-pressure plasma.

The SEM images on the finished fabrics show the presence of particles from the treatment substance (silver, chitosan) on the surface fibers of cotton (V1) and polyester (V2), which proves the anti-microbial character at nano-scale.

The anti-microbial tests were performed accordingly to the Standard ISO 20743:2007 - absorption method. We have the following charts for the efficiency of the anti-microbial finishing:

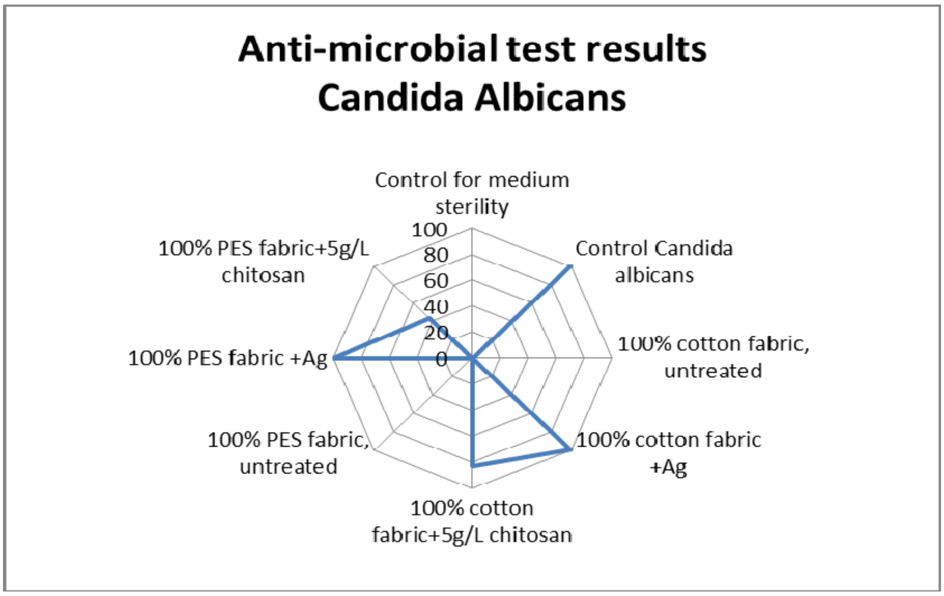


Figure 4 – Anti-microbial efficiency on V1 and V2 with Candida Albicans

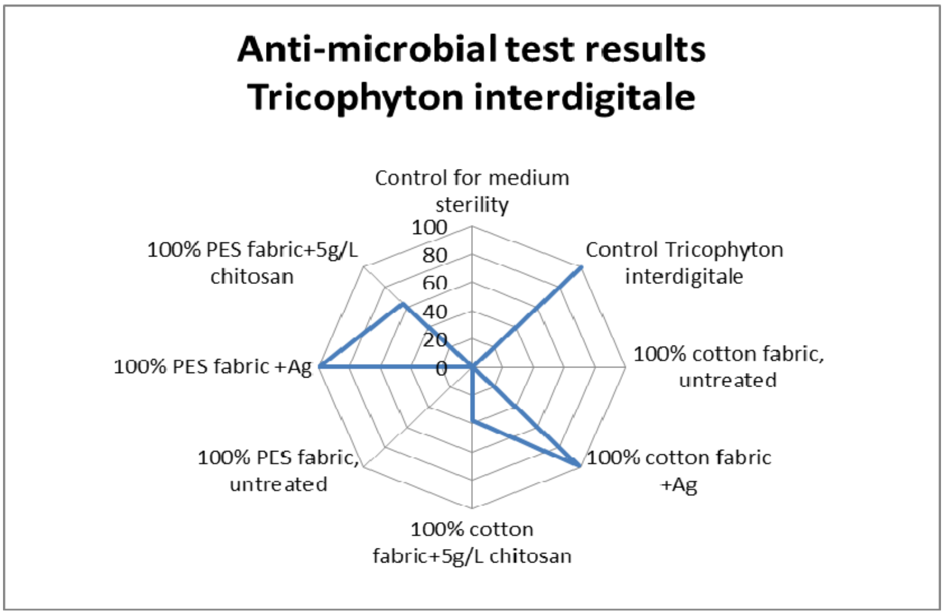


Figure 5 – Anti-microbial efficiency on V1 and V2 with Tricophython interdigitale

The V1- 100% cotton fabric shows very good anti-microbial effect when treated with silver (a reduction up to 100%) both with the fungi Candida Albicans and Tricophython interdigitale. V1 has a moderate anti-microbial effect when treated with 5 g/l of chitosan: 83% with Candida Albicans and 37,45% with Tricophython interdigitale. These were compared to untreated control materials, with a starting concentration of inoculated microbes of 2.4 x 104 CFU / ml (CFU = Colony Forming Units). The untreated control materials presented no degrees of microbial reduction.

The V2 – 100% polyester fabric shows as well a very good anti-microbial effect when treated with silver (up to 100%) whit both fungi. V2 has a lower anti-microbial effect when treated with 5 g/l of chitosan: 43% and 63,63%.

Hence, both silver and chitosan have good anti-microbial properties on the fabrics. However, silver has a better effect compared to chitosan.

Having in view the complex character of anti-microbial testing and the nature of the anti-microbial finishing substances tested, there are some factors which can significantly influence the tests results:

- the mechanical retention of the microbial cells on textile materials, depending on the materials surface, leading to a non-collection of the total cells on the textile material surface
- the dispersion degree of the anti-microbial finishing substance on the materials surface, at small concentrations of substance, decreasing the contact surface of the substance with the microbial cells;
- the presence of pre-treatment compounds from the bleaching and dyeing processes;

- a variation of the hydrophobic / hydrophilic character of textile materials, which may influence the contact degree of the microbial inoculum with the textile material.

CONCLUSIONS

The performed tests showed that our presumptions are proven:

- Improved dyestuff affinity through Oxygen plasma treatment of the fabrics
- improved anti-microbial character of the treated fabrics

We envisaged the following MEDTECH end application from the three fabrics:

1. Covers for humans in emergency situations form V1 – 100% cotton fabric with Silver or Chitosan
2. Surgical gowns from V2 – 100% PES fabric with Silver or Chitosan

Figure 6. Covers for humans in emergency situations

Figure 7. Surgical gowns

The applied method for obtaining these products proved to be efficient. The plasma cleaning with Oxygen of the two types of fabrics is improving the subsequent basic finishing and anti-microbial finishing with silver and chitosan. This manufacture method of MEDTECH articles is innovative and represents a eco-friendly method for the environment, but most of all an efficient protection for the human body and human health. These products contribute to an improved therapeutic protection and thus, these multi-functional products have a high added-value and a better potential to be put on the market.

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INITIAL STUDY: DYEING, FASTNESS AND UV-PROTECTION PROPERTIES OF COTTON FABRIC DYED WITH ORANGE PEEL

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Abstract: *Ultraviolet radiation (UVR) is considered a major factor causing skin and eye diseases. Human beings must protect themselves against the harmful effects of the ultraviolet radiation. Textiles have been considered a primary tool in shielding UVR. This paper discusses the ultraviolet protective properties of cotton fabrics using fruit dyes extracted from orange peel. The direct dyeing method and one-bath mordant dyeing method with aluminum sulfate , iron sulphate and copper sulphate as mordant were preferred for dyeing cotton with orange peel. Different mordant concentrations (1%, 2%, %3) were also applied. A positive correlation was observed between the concentration of mordant and their UV protection factor (UPF). It was also found that iron mordanting agent imparted the greatest UV-protection property. According to the experimental results, it was found that orange peel can be used in textile dyeing as UV-protection agent for cotton.*

Keywords: *UV protection, textile, natural dye, cotton, dyeing, mordant*

1. INTRODUCTION

The negative effects of ultraviolet radiation on human health are a subject gaining importance day by day[1]. Ultraviolet radiotion (UVR) is considered a major factor causing skin cancer and other skin and eye diseases. As the UV dosage and the outdoor activity increased over years, a fair amount of genotoxic and cytotoxic effects of UVR on human have been reported. Overdose of UV can cause various skin, eye and even DNA damages. Ultraviolet consists of there parts; UV-A, UV-B and UV-C. Overdose of UV-A (320-400 nm) can cause chronic reactions and damages such as an acceleration of skin ageing, a promotion of photodermotosis, and phototoxic reactions with various materials, and is a possible carcinogen. Overdose of UV-B (280-320 nm) can acute chronic reactions and damages such as skin reddening or sunburn, increase risks of melanoma, eye damage, and even DNA damage in case of high dosage. UV-C is intercepted by ozona layer and cannot reach to the earth surface. Although UV- A was considered less harmful than UV-B, UV- A can penetrate on skin deeper and can cause DNA damages in wider range of cell types. Therefore, it is need to develop a proper mean to protect human skin and eye from both UV-A and UV-B radiation [2].

To avoid these health risks, it is important to reduce personal UV exposure. The use suncreens and UV protective clothing has gain popularity[3]. The use of natural dye in textile application is growing in popularity because of quality of natural colour obtained as well as enviromental compatibility of the dyes. It is reported that some natural (vegetable) dyes not only dye with unique and elegant colours, but they also provide antibacterial and UV protective functions to fabrics[4].

Very recently, it was reported a novel application of orange peel as a new natural dyestuff with good UV protection property of wool fabric[5]. However, no study has investigated the UV protection properties of vegetable fiber dyed with orange peel. In this study, it was investegated the UV protection property of cotton fabrics, is most commanly used making summer clothes, dyed by natural dye which was extracted from orange peel.

2. EXPERIMENTAL

2.1 Materials

In this study, cotton plain knitted fabric (supreme 163 g/ m^2) was used. All experiments were carried out by using pure water. Three different mordanting agents; aluminium potassium sulfate dodecahydrate

(AlK(SO4)2.12H2O), ferrous(II) sulfate heptahydrate (FeSO4.7H2O) and copper(II) sulfate pentahydrate (CuSO4.5H2O). were used. Different mordant concentrations (1%, 2%, %3) were also applied.

2.2 Extraction of dye

Orange peel (200 g) was soaked 1 L water. Subsequently the solution was heated to boiling temperature and boiled for 2 hour and afterwards filtered.

2.3 Dyeing

100 ml of filtrated dye extract was used to provide the liquor ratio of 1:10 for 10 g material. Dyeing was carried out at extract solutions own pH value. Dyeing experiments were performed on Termal HT Dyeing Machine. Comparing to pre-mordant and post-mordant dyeing methods, one-bath dyeing method is a one-step dyeing process and therefore could save time, water and energy. As a result of this, the direct dyeing method and one-bath mordant dyeing method was used.The dyeing method used is shown *Figure 1* . At the end of dyeing, the dyed sample was removed and rinsed throughly in tap water and allowed to dry in the open air.

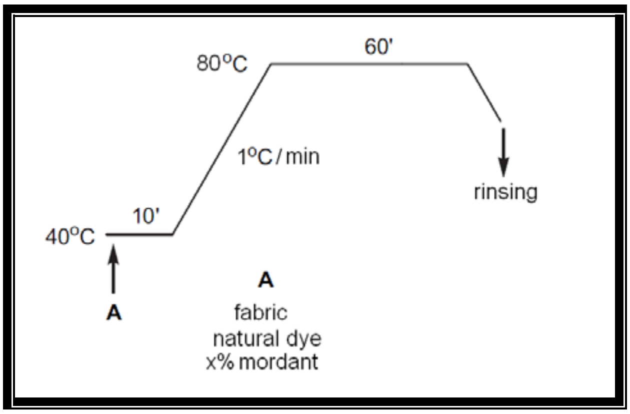

Figure 1: Dyeing method

2.4 Measurement

UPF's were measured using a labsphere® UV-100 F Ultraviolet Transmission Analyzer according to Standard AS/NZ 4399:1996 . Fabrics with a UPF value in the range 15 – 24 were classified as having "Good UV Protection"; when the UPF values were between 25 and 39 fabrics were classified as having "Very Good UV Protection" and "Excellent UV Protection" classification was used when the UPF was 40 or greater.

Color characteristic values, L*, a*, b*, C*, h^o of the dyed samples were evaluated by Gretag Macbetch Color-Eye 7000 A using an illuminant D65 and 10° standard observer. The dyed cotton fabrics were folded into two layers and four different positions were measured and averaged. L*, a*, b*, C*, h^o and are lightness, redness-greenness, yellowness-blueness, saturation and hue, respectively.

Colorfastness to washing with detergent (ECE B) was evaluated according to ISO 105-C06:2010-A1S. Multifibre adjacent fabric (DW) was used and washed in detergent solution (4 g/L) at 40°C for 30 min. The staining of multifibre adjacent fabrics and colour change of the dyed cotton fabric samples were determined. Colorfastness to wet and dry rubbing were evaluated following ISO 105-X12:2001.

3. RESULTS and DISCUSSION

UPF, UV-A(% T) and UVB(% T) values of dyed samples are listed in *Table 1*. All dyed samples had significantly higher UPF value than the undyed reference sample. In addition, the UVA (%T) decreased dramatically after dyeing, hence offering higher protection against harmful UV radiation than the undyed reference sample.

Table 1: The UV- protection properties of the cotton fabrics before and after dyeing

Mordant	Conc. %	UPF Mean	UVA (% T)	UVB(% T)	UPF Rate
Undyed fabric	-	7.18	21.13	12.57	5
Without mordant	-	31.38	5.01	3.03	25
Aluminum sulfate	1	40.90	4.18	2.39	30
	2	45.12	3.44	1.98	45
	3	51.53	3.39	1.89	40
Copper sulphate	1	51.32	2.83	1.86	40
	2	56.32	2.57	1.69	50
	3	59.45	2.59	1.60	45
Iron sulphate	1	56.50	2.59	1.68	50+
	2	75.59	1.94	1.28	50+
	3	81.46	1.76	1.17	50+

According to the variance analysis, it was determined that while mordant type has a statically effect on UPF, UV-A(% T) and UVB(% T) values. When mordant concentration was increased, UPF was increased. When *Table 1* is examined, it can be said that the best results are obtained iron sulphate.

The colour of fresh OP (orange peel) mainly comes from phenolic compounds. Phenolic components may be contributed by the cleavage of hydrogen bonds in the phenolic molecules during which ultraviolet rays could provide sufficient energy[5]. Therefore, OP extracts can provide not only shades but also protection from UV for cotton fabrics.

As can be seen from *Table 2* by using orange peel as natural dye colours were obtained on cotton according to the mordant usage and its type.

Table 2: Colorimetric data of dyed fabric

Mordant	Conc.%	L*	a*	b*	C*	h°	Obtained colour
Without mordant	-	87,90	-0,82	12,40	12,43	93,79	
Aluminum sulfate	1	89,61	-3,28	18,54	18,83	100,04	
	2	89,61	-3,83	20,61	20,61	100,53	
	3	89,80	-3,16	18,39	18,66	99,74	
Copper sulphate	1	84,16	-4,09	23,31	23,66	99,94	
	2	82,61	-4,24	24,44	24,81	99,84	
	3	83,19	-4,74	21,61	22,12	102,36	
Iron sulphate	1	78,13	0,64	14,61	14,62	87,50	
	2	74,41	1,10	16,08	16,21	86,10	
	3	73,23	1,03	15,61	15,64	86,24	

Washing and rubbing fastness values of dyed samples are listed below in Table 3.
Table 3: Washing and rubbing fastnesses of dyed samples

Mordant	Conc.%	staining						change in colour	Rubbing	
		Acetate	Cotton	Nylon	Polyester	Acrylic	Wool		Dry	Wet
Without mordant	-	5	5	5	5	5	5	3	5	5
Aluminum sulfate	1	5	5	5	5	5	5	2	5	4-5
	2	5	5	5	5	5	5	2	5	5
	3	5	4-5	5	5	5	5	1-2	5	5
Copper sulphate	1	5	5	5	5	5	5	3	5	5
	2	5	5	5	5	5	5	3	5	5
	3	5	4-5	4	5	5	5	3	5	5
Iron sulphate	1	5	5	5	5	5	5	1-2	5	4-5
	2	5	4-5	5	5	5	5	1	5	4-5
	3	5	5	5	5	5	5	1	5	4-5

According to the variance analysis, it was determined that effect mordanting type and concentration have not statically effect on washing fastness values. As can be seen from, the best results were obtained copper sulphate.

According to the variance analysis, it was determined that effect mordanting type has statically important effect on wet fastness. On the other hand, mordanting type and concentration have not effect dry fastness values.

4. CONCLUSIONS

In this study it was determined that orange peel can be used in textile dyeing as UV-protection agent for cotton. The fastness properties of the sample were good to very good. The cotton fabrics dyed with orange peel extract with or without metal mordants have good to excellent UV protection properties. However, undyed fabric cannot be rated as offering any degree of protection. In summary, cotton fabric can be successfully dyed with orange peel extract dye solution with or without metal mordanting and can be used in the development of UV protective fabric.

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DEVELOPMENT OF CONCRETE WITH GLASS YARN REINFORCEMENT

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Abstract: *Textiles present an excellent potential as materials for buildings, from the simple glass wool used for thermal insulation to complex 3D textile materials used for structural applications. One of the most interesting domains is the production of textile reinforced with concrete/cement matrix. Fibre reinforced concrete is a type of material well known to civil engineering, used mainly for pavements and for strength elements in buildings (in combination with steel fibres).*
Previous studies have shown the influence of the glass fibres on the mechanical behaviour of concrete, the amount of fibres to be incorporated and the fibre length. The use of fibre reinforcement presents certain issues regarding processability and uniform dispersion within the composite element. Previous studies by the authors have revealed that the process must be conducted so that it avoids fibre clumping and snagging.
The paper presents a different approach to the fibre reinforcement. It proposes the use of yarns (rovings) instead of fibres, in the same required amount. The use of glass yarns presents two advantages: it eliminates the problems regarding fibre processability during FRC production and it allows for fibre directionality within the composite. The yarns were placed to form rectangular grids and were introduced in the concrete in differently layers. The samples were tested to determine the flexural strength and comparisons were drawn with the flexural strength of FRC made with the same glass fibre.

Keywords: *fibre reinforced concrete, yarn grids, mechanical behaviour.*

1. INTRODUCTION

Textile reinforced composites are currently a common material used for a large diversity of technical applications, including civil engineering. Such composites are made of textile reinforcement (fibres or textile fabrics) and cement/concrete matrix. Their use in building elements leads to improved mechanical characteristics while reducing the mass of the elements. Studies have shown that the presence of textiles in the concrete reduces the internal strains caused by differences in temperature, drying and the initial contraction of the concrete [1, 2]. The textile reinforcement not only controls the static strength of the concrete elements (flexural, tensile and compression strength), but it also improves the response to dynamic stresses, such as impact [3] Other advantages of the textile reinforced concrete are [4, 5]:

- improved energy efficiency for the buildings, reducing the energy loss
- lower production costs, due to the reduction in raw materials and also the reduction of production times
- improved resistance to corrosive substances at the surface of the concrete element
- reduced friction wear
- increased life duration (less corrosion)
- improved behaviour when the cracking phenomenon occurs (at failure).

Concrete can be reinforced with fibres, known as FRC or with textile fabrics, mostly woven and warp knitted grids (TRC). The advantage of the TRC is that the textile fabrics can be used so that certain directions are reinforced (controlled anisotropy), according to the direction of the strain during use. The use of textile fabrics with 3D geometry also allows producing concrete elements with complex shapes.

In both cases, the most common raw material is the glass fibres. Other fibres used are high tenacity PES and PP. Carbon is rarely used, only when the strength required is at a superior level, due to the high costs. The fibres must have good strength, good elasticity module, chemical stability, and good adherence to the matrix (concrete) [6,7,8].

The use of fibre reinforced concrete is well studied in the literature. The fibres, cut to specified dimensions are mixed with the concrete so that they are uniformly distributed. There are references indicating the length of the fibres and the percentage to be used in the concrete mix.

The production of fibre reinforced concrete present certain problems regarding the distribution of the fibre within the mix that affect the quality of the composite [5]. The paper starts with the idea of replacing the fibres with yarns in exactly the same amount (up to 2% of the total mass). It is easier to introduce them, the yarns can be positioned in different preferential directions, the problems related to mixing are eliminated and the percentage of fibres can be further increased.

The paper contains a study regarding the production of such yarn reinforced concrete and the mechanical behaviour in reference to simple concrete and to fibre reinforced concrete.

2. MATERIALS AND METHODS

The yarns were used in a concrete with flying ash, as the current trend is to replace cement as much as possible, preferable with recycled materials, such as ash. Ash is the main by-product from energy plants and is cheap and easily available. The literature indicates that the presence of the ash to a certain percentage in the mix does not affect the mechanical behaviour of the concrete, especially due to its silica components.

The concrete was produced by mechanical mixing. The concrete components are presented in Table 1. The Portland cement used in the mix was produced according to SR EN 197-1 A1:2007.

Table1: Concrete components

Components		Mass
river aggregate	sort 0 - 4	20.2 kg
	sort 4 - 8	9.6 kg
	sort 8 - 16	14 kg
Cement CEM I 42.5R		8.1 kg
Water		4.5 l
Flying ash		0.9 kg
Plasticiser		0.122 l

The grids were produced using glass roving, 2400 tex, from Vetrotex (Owens Corning). The yarns were cut to the dimensions of the samples and grids were formed with the yarns positioned at 90^0. In order to fix the yarns in position, they were glued to a board frame, as illustrated in Figure 1.

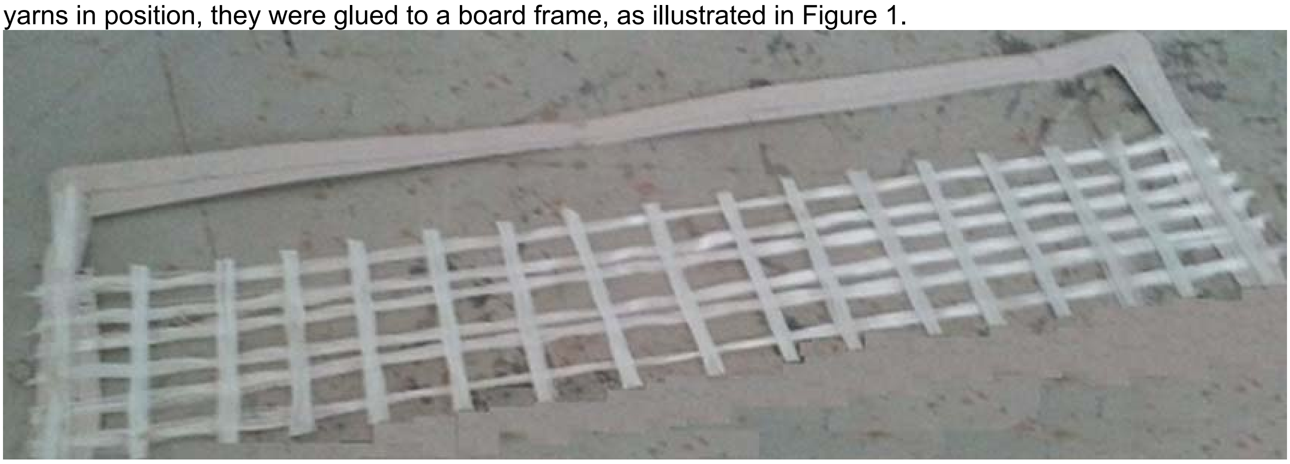

Figure 1: Grid made of glass yarns

The grids were introduced in the samples while the concrete was poured in, as shown in Figure 2. The samples were produced according to the Romanian standards for flexural strength [9]. The samples were prisms with 100 x100 x 550 mm.

Two types of samples were produced, coded as follows:

BCFS 1 for concrete samples with 1 grid introduced
BCFS 2 for concrete samples with 2 grids introduced

For comparison purposes, similar samples were produced without grids.

a)

b)

Figure 2: Positioning the grids in the samples

The aspect of the samples with one and two grids is illustrated in Figure 3.

Figure 3: Samples of concrete reinforced with yarn grids

Figure 4: Aspects of the samples after testing

After 24 h, the samples were taken out and stored for seven days in a water container so that the samples were completely immersed. After that, they were taken out of water and kept in laboratory conditions for 21 days, in order to ensure proper drying before testing. Three samples were tested for each experimental variant.

3. **RESULTS AND DISCUSSIONS**

The mechanical behaviour of the concrete samples was evaluated through flexural strength R_{ti}. The tests were carried out using a hydraulic press, where the breaking force was recorded. The breaking of the samples was complete, as shown in Figure 4. The circled areas contain the broken glass yarns.

The strength was calculated according to SR EN 12390-3, part 5 [9] with the following relation:

$$R_{ti} = 3Pl/ 2bh^2 \qquad (1)$$

Where:
Rti - flexural strength [N/mm^2]
F – breaking force [N];
l – distance between [mm];
b – average width of the cross section [mm];
h – average height of the cross section [mm].

The results for the flexural strength are presented in Table 2.

Table 2: Flexural strength of the yarn reinforced concrete

		R_{ti} (N/mm^2)	$R_{ti\ m}$ (N/mm^2)
BCFS1	Test 1	3.65	3.58
	Test 2	3.51	
	Test 3	3.59	
BCFS2	Test 1	3.91	3.91
	Test 2	4.01	
	Test 3	3.82	
Witness		3.11	3.11

The results shown in Table 2 indicate that the presence of the yarn grids have a positive effect on the flexural strength. In comparison to the witness (concrete without yarns), the flexural strength increases with 15% for the samples with one grid and with 25% for the concrete samples reinforced with two grids. The presence of the second grid improves significantly the flexural strength of the samples.
In relation to the behaviour of the fibre reinforced concrete, previous studies conducted by the authors indicate an interval for the flexural strength (3.36÷4.18) N/mm^2 for different fibre length and percentages. These values are similar to the ones obtained using yarn grids, especially the samples with two yarn grids. This shows that the flexural strength can be improved by using more grids.

4. CONCLUSIONS

The paper presents a study concerning the mechanical behaviour of concrete reinforced with yarns (grids). Such grids are similar to the woven or knitted grids but their processing is simpler. The grids were made using glass roving, 2400 tex. The amount of yarns used for the grids is similar to the amount of fibres used to produce fibre reinforced concrete.
The tests show that the presence of the yarn grids improves the flexural strength of the concrete, up to 25% in reference to witness samples. The data indicates that the mechanical behaviour can be further improved by using more grids.
In comparison to fibre reinforced concrete made from the same fibres, the flexural strength of the yarn reinforced concrete is similar, toward the superior limit for the samples with two grids.
Future research can include the mechanical response when more grids are introduced and the positioning of yarn under different angles.

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FUNCTIONALIZATION OF TEXTILE MATERIALS BY TEA TREE ESSENTIAL OIL APPLYNG

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Abstract: *The aim of this work is to obtain antimicrobial textile materials. Because often, for antimicrobial treatments are preferred topical administration of biologically active compounds, we chose a liquid form for matrix / biologically active compound system presentation. Beeswax is inactive ingredient and does not have direct physiological effects on humans. It is therefore used as an matrix for biologically active compound entrapped. In this study we used as active compound Tea Trea (extract of Melaleuca Alternifolia) essential oil. To obtain an emulsion, besides beeswax and Tea Tree essential oil we used solubilizers (water, glycerin) and emulsifier (Tween 80). Experiments in this paper were conducted in several steps that followed the optimal beeswax / essential oil system establish, characterization and application of emulsions on textiles materials; qualitative and quantitative determinations for controlled release of biologically active compound and antibacterial testing.*

Keywords: *Tea Tree essential oil, beeswax, antibacterial test, controlled release*

1.INTRODUCTION

The last years collaboration between the specialists from the medical field and the ones from the textile industry, let to a multitude of innovative applications from the biofunctional tesxtiles field. Most of the times, for the antimicrobial treatments, is preferred the topical local administration of the biological active compounds. For the topical utilization, are used the liquid forms (solutions, lotions, emulsions, suspensions, tinctures, aerosols, foams), semisolid forms (ointments, rigid foams, semisolid liniments) or the solid forms of presentation of the active system (powders, microspheres, tablets, granules) (5.6).

Compounds from plants, such as essential oils, have attracted a considerable interest in the last years. Many of theme have been used as traditional medicines against various pathogens and some have been reported to have antibacterial activity against pathogenic bacteria. (7). The Tea Tree essential oil it`s being studied for a very long time because of its antibacterial effects. It degrades the cell membrane of the Gram-negative bacteria and also of the Gram-positive one.

The ensuring of a good therapeutic action depends a lot on the choosing of the vehicle-the substance that cases the active compound penetration (8-9). Textile materials have air and vapor permeability and, through contact with skin, can act as a delivery system (11). To ensure the controlled release of the biological active principle , are being used different embedding compounds. There are some papers about the application of beeswax in the food industry (edible films and coatings for the preservation of the fruits and vegetables) and pharmaceutic (that hops to ensure a controlled rate of dissolution, storability and safety of the active compound) (10.11). in the textile field, according to our knowledge, research regarding the use of the beeswax as shell is only at the beginning. Beeswax doesn`t have direct physiological effect on humans. Therefore it is used as an inactive ingredient.

This paper has as aim the obtaining of some textile fabrics with antibacterial properties, obtaining by applying on their surface the beeswax/Tea Tree essential oil system. From the presentation forms of the means with topical applications, we have chosen the liquid one (beeswax/essential oil emulsion) and regarding the solvent`s composition, the emulsions that we obtained were water-glycerol solutions. Beeswax was used as coating material and as core material we used Tea Tree essential oil (ttoe), well-know for its antioxidant, antimicrobial, antiseptic and anitiinflamatory activity.

2.EXPERIMENTAL PART

2.1.Materials

For the obtaining of the emulsions were used : Bee wax (procured from a private apiary in the North East region of Romania), Chitosan (molecular weight 100.000-300.000 and degree of deacetylation 85%; it was obtained from Fluka Chemie GmbH- Switzerland); Sage essential oil-extract of Salvia Offcinalis L, (purchased from Fares SA Romania); Tween 80 was supplied by Merck-Germany; 99,5 purity vegetable glycerine was purchased from SC. Elemental SRL, Romania.

2.2.The obtaining and the application of the beeswax/essential oil emulsion on the fabric

Beeswax in the concentration range of 1.65 – 14.29% was melt at 80^0C in a termostated water bath. Beeswax was added to the water phase heated at a temperature by 5^0C to higher than the melting point of wax, allowing sufficient time to equalize the temperatures of both phases. Emulsifier (Tween 80) were added to the beeswax mixture. Glycerin solution was added to the heated mixture which was stirring 10 minutes. After complete homogenization, the mixture was cooled to 60^0C degrees and Tea Tree essential oil was dropwise under stirring. The treatments variants are presented in table 1.

Table 1: Chemical composition of emulsion

Variants	Raport masic beeswax:Tea Tree essentialoil	Beeswax (% w/v)	Glicerina (% w/v)	H_2O_2 (% w/v)	Tween 8 (30%) (% w/v)	Tea Tree essential oil (% w/v)
1	**0.1:1**	**1.65**	**16.39**	**49.18**	**16.39**	**16.39**
2	**0.3:1**	**4.77**	**15,87**	**47,62**	**15,87**	**15,87**
3	**0.5:1**	**7.71**	**15.38**	**46,15**	**15.38**	**15.38**
4	**1:1**	**14,29**	**14.29**	**42.84**	**14.29**	**14.29**

The cotton knited fabrics were padded with mixtures to a wet pick-up of 100% and drying.

2.3.The analysis of the obtained emulsions

The optima recipe was estabilished based on the analysis of those four emulsions. The obrtained emulsions were analyzed microscopically and turbidecally. The microscopical evaluation of the emulsions was determined using an optical microscope (KRUSS) and the photomicrographs were transferred for a computerized analysis using a digital camera (Nikon, Coopix P 5100). The turbidity of the emulsions was calculated used the next formula:

$$\tau = -\frac{\ln\left(\%\frac{T}{100}\right)}{L}, (cm^{-1}) \qquad (1)$$

Where:
t- turbidity parameter; T- transmittance, real on the spectrometer; L- the lengh of the spectrometer`s tanks side, cm.

2.4.Scanning electron microscope (SEM) observation

It was studied the surface morphology of the blank sample as well as of the treated ones, by scanning electrons microscopically with Analytical Scanning Electron Microscopes – VEGA Tescan LMH II. The working distance used to obtain the images was kept between 16 and 18mm, for a better accuracy.

2.5.The release profile of the biologically active compound

For the determination of the cumulative quantity of essential oil released in time, a known quantity of treated knitted fabrics was added in 50mL of solvent for parenteral use (saline) and were incubated at a temperature of 20^0C , by slowly and constantly stirring (40 rpm). At established periode of time (1h-4h), the solution were filtered three times at room temperature, using quart cuvettes of 2 mm.

2.6.Antimicrobial analysis

The testing of the antimicrobial activity of the suspensions created with essential oils, was made by the Clinical and Laboratory Standards Institute (CLSI)using the standard method Kirby-Bauer. This method is frequently used for the antimicrobial testing of other types of materials. The testing of the antibacterial activity is made in comparison with different standardized bacterial suspensions: Gram-positive and Gram-negative. The evaluation of the sensibility degree consist on the appearance and the determination of the inhibition zone around the sample to be tested.

Many bacteria are able to develop a changes in their sensitivity but Staphylococcus aureus and Escherichia coli have been recognized for the increasing resistance to conventional antibiotics (14-15). The antimicrobial testing was made on the Staphylococcus aureus ATCC 29213 and Escherichia coli ATCC 25922 standardized strains, both being CLSI recommended for the agar diffusion method, from the collection of the Microbiology Laboratory, Public Health department from the Faculty of Veterinary Medicine, Iasi, Romania.
For this, were obtained 24 hours young cultures in liquid growth medium (nutrient broth). The bacterial inoculums was brought to the standard density of 0,5 Mc Farland at which , for most of the bacterial species, 1mL od suspension contains 1-2×10^8 ufc/ml (colony forming units)
As a nutritional medium, was used the Mukker Hunton agar (Oxoid), medium that has a nutritional value which allows the optimal development of a big variety of germs and doesn't contain inhibitors for the action of the antimicrobial substances. After melting and cooling at 45*C, was partitioned into 9 ml in Sterile Petri plates, which were originally field bacterial culture.
From the fabrics treated with different essential oils, were taken disc-shaped samples with 1,5 cm diameter (similar to the disc diffusion method).

The samples were arranged roundly and equal distances on the Muller Hinton solid surface medium. The plate were incubated in the thermostat at 37*C the results being interpreted after 24 h. The evaluation of the antimicrobial effect consisted in the measurement of the diameter of the inhibition zone that was made around the fabric disc.
This is proportional with the sensitivity of the reference bacterial strain, so, as the substances from the essential oil are more active, as the inhibition zone (in which bacterial colonies don't develop) is wider.

2.7.Statistical analysis

The data of the present study were subject to the analysis of variance test (ANOVA) as complete randomized design. The least significant differences (LSD) at the 5% level of probability were determined using PASW Statistics 18-SPSS program.

3.RESULTS AND DISCUTIONS

3.1.The analysis of the wanted emulsions

The microscopic appearance of those four emulsions obtained according to the recipes presented in table 1 is shown in figure 1.

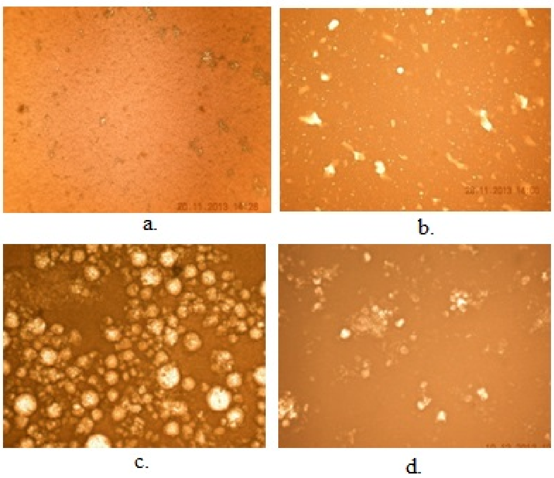
a. b. c. d.

Figure 1: The micrographs of the emulsions

From the micrographs presented in figure 1 it results that the emulsions prepared according to those four treatment recipes (Tabel 1), only the emulsion obtained according to the mass ratio: beeswax: Trea Tree essential oil 0:5:1 presents a relative unimodal distribution of the size of the particles, which ensure stability in time.

The study of stability in time of the emulsions obtained according to those four variants (Tabel 1) was realized by reading of the extinction and of the transmittance on the CarWin 50 UV-VIS spectrofometer to determin the turbidity, watching its modifications at maximum wavelength λ max. The turbidity was calculated with the formula 1. For this, about 0,5 ml sample of diluted emulsion (1:600, v/v) was put in the spectrophanetric quartz tank that had a lid, having the length of the spectrophometric tank's side of 1 cm, and wich were stored at room temperature (at 20 *C) for 25 houres.The obtained results are presented in figure 2.

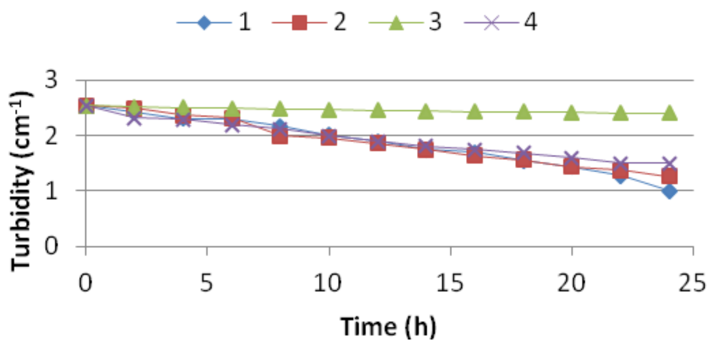

Figure 2: The turbidity of the emulsions

According to the results presented in figure 2, the emulsion obtained for the mass ratio beewax: Tea Tree essential oil 0:5:1 has the best stability, result which is confirmed also by the microscopic images

3.2.Scanning electron microscope observation

SEM pictures of the untreated and treated samples (Figure 3) were compared to observe how the beeswax/essential oil systems were laid on the textile substrate.

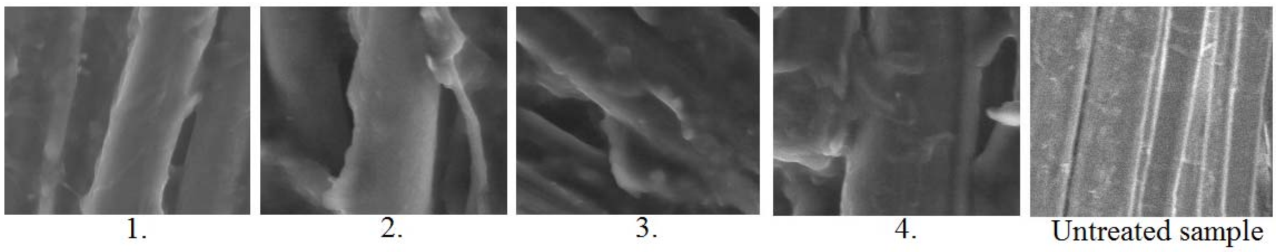

Figure 3: SEM aspect of treated (1- 4.) and untreated knitted cotton substrate; scale bar=100 μm

From SEM pictures presented are seen as applied emulsions coats the fibers, but do not affect the aspect of the yarn, as illustrated in Figure 3.

3.3.The study of the release capacity of the essential oil

The concentration of the Tea Tree essential oil released at moment t, was calculated from the line's standard equation (Figure 4), where x represents the concentration of the biological active compound and y is the absorbance given by the UV spectral analysis. Using the data given from the standard curve, it was calculated the quantity of essential oil realeased between 1 hour and 4 hours.

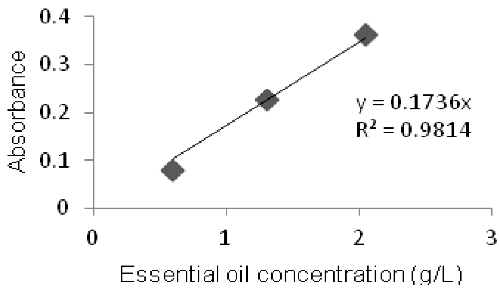

Figure 4: The standard curve for Tea Tree essential oil

The release profile of Tea Tree essential oil was presented in figure 5.

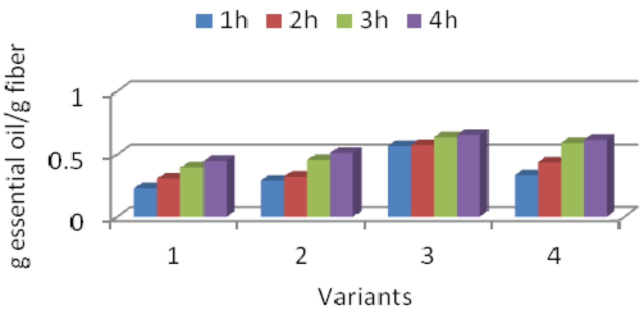

Figure 5: The release profile of Tea Tree essential oil

Beewax/Tea Tree essential oil system is a matrix type sytem, in wich the release of the biological active compound is being controlled by diffusion. According to the results obtained in figure 5, the sample treated according to the version 3 (mass ratio beewax/ Tea Tree essential oil 0:5:1) has the highest release, which confirms the fact that the emulsion obtained using the third version is the optimal variant.

3.4.The antibacterial testing of the samples treated with emulsions

The results of the testing of the samples of fabrics treated with Tea Tree essential oil is presented in figure 6.

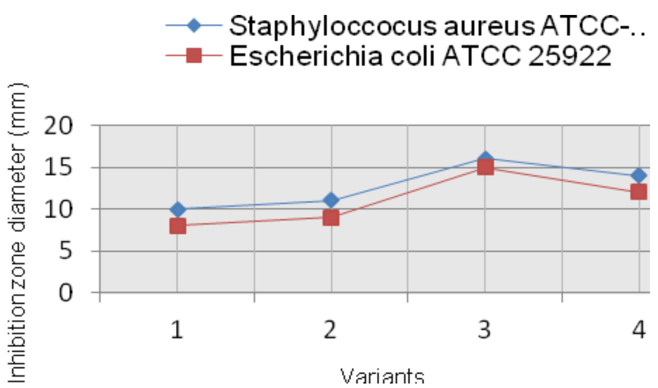

Figure 6: The diameter of the inhibition zone for the treated samples.

According to the results of the antibacterial strain testing, at the action of Tea Tree essential oil from the four treated samples, the species Escherichia coli ATCC 25922 and Slaphylococcus aureus ATCC 29213 have shown medium rapor beewax/biological active compound (0:5:1).

4.CONCLUSIONS

Results data from research have proved the antimicrobial effect and the controlled release of Tea Tree essential oil from the cotton knitted fabrics. Another important aspect of the research is given by the inter dependence beewax the antimicrobial effect, controlled release and the optimal ratio beewax and Tea Tree essential oil. So, the best mass ratio between beewax and the biological active compound is 0:5:1.

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TEXTILES WITH ANTIMICROBIAL PROPERTIES

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Abstract: *Microorganisms play an important role in toxic metal remediation through reduction of metal ions. These particles can be incorporated in several kinds of materials. Cellulose fabrics is one of the most frequently used because they have ability to absorb moisture, but under certain conditions of humidity and temperature they can be subjected to microbial attack. In this case one of the most popular and best known antibacterial agents is silver, which serves as a potential antibacterial material acting against an exceptionally broad spectrum of bacteria including activity against antibiotic-resistant bacteria.*
In this paper we have obtained cellulose fabrics with antimicrobial properties. We got the desired effect through a crosslinking with silver nanoparticles and ACRILEM® IC79 copolymer, we fixed on the surface of a textile material. Silver nanoparticles, were obtained by reducing silver ions Ag NO_3 solution by various methods. Textile material surface characterization was performed using scanning electron microscopy (SEM) and energy dispersive X ray analysis (EDAX) methods using Low-Vacuum SEM QUANTA 200 3D. The results indicated that Ag NPs were integrated successfully and dispersed uniformly in the matrix. Its content (1.01–4.25 wt%) were depending on the different concentration of acrylic acid and the time of exposure to UV.

Keywords*: ACRILEM® IC79, Antimicrobial activity, Cotton, Silver nanoparticles*

1.INTRODUCTION

In the course of the history, textiles have demonstrated vital role in the evolution of human culture from the forefront both the point of view of technological development and artistic works. Indemnifying aspects of textiles have been an essential condition for innovative developments in the industry [1-2]. Antimicrobial activity of silver has been recognized by clinicians still 100 years ago. Anyway, it is well known that in the recent years mode of action of silver as well as antimicrobial agent has been studied rigorously [3-4].
Metallic silver is not reagent but when it is exposed in aqueous media is free silver ion Ag^+. The silver salts are very soluble in water and have been used as anantiseptic agent. Species of silver ion can also be carried out by ion exchange using complexes of silver with other inorganic materials (for example, complexes of silver-zeolite [5- 6]). It was also demonstrated that it has anti-microbial properties against bacteria and viruses. For that silver to take antimicrobial effect, free water must be present. Depending on the source of silver ion, processes ion exchange demonstrates an activity delayed compared with those derived and water-soluble salts. Activity seems to increase with temperature and pH.

Studies have proved that the silver nanoparticles give toxicity to micro-organisms such as Bacillus subtilis and Klebsiella mobilis [7] , Staphylococcus aureus and Escherichia coli [8], Pseudomonas aeruginosa and Klebsiella pneumonia [9], Streptococcus pyogenes and almonella typhi [10] it is considered that it would be two mechanisms by means of which the silver nanoparticles can act as antimicrobial agent interfered in respiratory metabolism of the organism. Bacterial cell membrane has plenty of protein containing sulfur with which silver nanoparticles may react leading to inhibit functions or by enzymatic inactivation multiplication DNA in which nanoparticles interacts with fragments of phosphorus [11-12]. Formation of free radical on the surface of the silver nanoparticles may be considered to be another mechanism through which cells will be destroyed. These free radicals have the ability to damage the cell and converts it into the tissue to quantify may result in the end the death of the cell [13-15].

Antimicrobial finishes have been developed due to propagation of micro-organisms in textile materials. The anti-microbial infestations of textile materials represents an unreasonable threat of harm to life, being microorganisms which is located in the raw of textile materials, in their appearance in the processes of wet processing , for the storage of finished products, transport and during use as finished products. Unpleasant odors arising on textile articles worn directly on the body spreading disease and affect your garments, which are effects of germs harmful organisms [16].

Customers are more and more aware of healthy life-style and hygiene in such a way that there is a necessity, and waiting for a diverse range of textile products with anti-microbial finish. Microorganisms are part of our daily life. Inert properties of textile fibers provide for increasing microorganisms and structure of underclass and chemical processes may induce an increase in germs and the problem is worsening in humid atmosphere and warm. Infestation with germs cause infections in the case in which the material is worn on the skin. The results have been demonstrated attacks by the disappearance of original color of the fabric as well as textile substrates loss of performance. Therefore, in order to protect the user and textile substrate is applied on antimicrobial finishes textile materials. Textile properties of materials can be improved further in terms of performance as well as durability and increasing the degree of comfort and hygiene which makes them so much fun to wear [17].

2.EXPERIMENTAL PART

2.1.Methods and materials

Cotton material prepared previously by alkaline cleaning has been treated with 10% solution of Acrilem and 7% $AgNO_3$ 0.01 M. The solution obtained has previously been UV irradiation for 7 minutes. Still samples of cotton have been immersed in the solution, and then raced to a degree of squeezing GS of approximately 80 %. After padding followed by drying at 80^0C and then heat treatment at 140^0C for 3 minutes. Samples thus obtained have been the subject of analysis.

2.2. Antimicrobial testing

The microbiologic investigations have been performed at Microbiology-Immunology Laboratory of the University Centre of Medical and Veterinary Researches, within the Faculty of Veterinary Medicine of Iasi, Romania.

Accordingly, the antimicrobial evaluation was carried out with respect to standardized stems of Staphylococcus aureus ATCC 29213 and Escherichia coli ATCC 25922, both stems being recommended by the Clinical and Laboratory Standards Institute (CLSI, previously NCCLS) for the method of diffusion in agar. With this aim in view, young cultures of 24 h obtained in the liquid culture medium (nutritive broth). The bacterial inoculus was brought at the standard density of 0.5 Mc Farland at which, for most of the bacterial species, 1 ml solution contains (1÷2) x 10^8 cfu/ml (colony forming units).

Muller Hinton agar (Oxoid) was used as nutritive solid medium, which posses a nutritive value that permits the optimal development of a large variety of germs and does not contain inhibitors of some antimicrobial substances. After melting and cooling down to 45^oC, samples of 9 ml were distributed on sterile Petri dishes in which had been previously deposed by 1 ml of tested bacterial culture from the dilution tube.
From the textile materials treated with $AgNO_3$ and ACRILEM® IC79 were taken with side of 1 cm (like in the disk diffusion method). They were cut in aseptic conditions in the bacteriological vapor hood with laminar flow, in order to avoid additional contamination of the samples, which could corrupt the results.
The samples were disposed circularly at equal distances on the surface of a solidified Muller Hinton medium. The plates were incubated in a thermostat at 37^oC, the results being interpreted after 24 hours.

2.3.FTIR-ATR analysis of samples of cotton treated with $AgNO_3$ and ACRILEM® IC79

FTIR analysis of samples of cotton treated with $AgNO_3$ and Acrilem has been conducted on multiple internal reflectance accessories (SPECAC, USA) with ATR crystal KRS-5 bromine-iodine, featuring 25 reflexions and an angle of investigation of 45°. Beaming recording will be absent with 250 scans in the range 4000-600 cm^{-1}. After registration, absorption spectra have been superposed using OPUS software and are shown in Figure 1.

Antimicrobial effects of durability has been tested by repeated washings and were determined in agreement with the standard SR EN ISO 105-C06:1999, samples treated subject from one to four repeated washings.

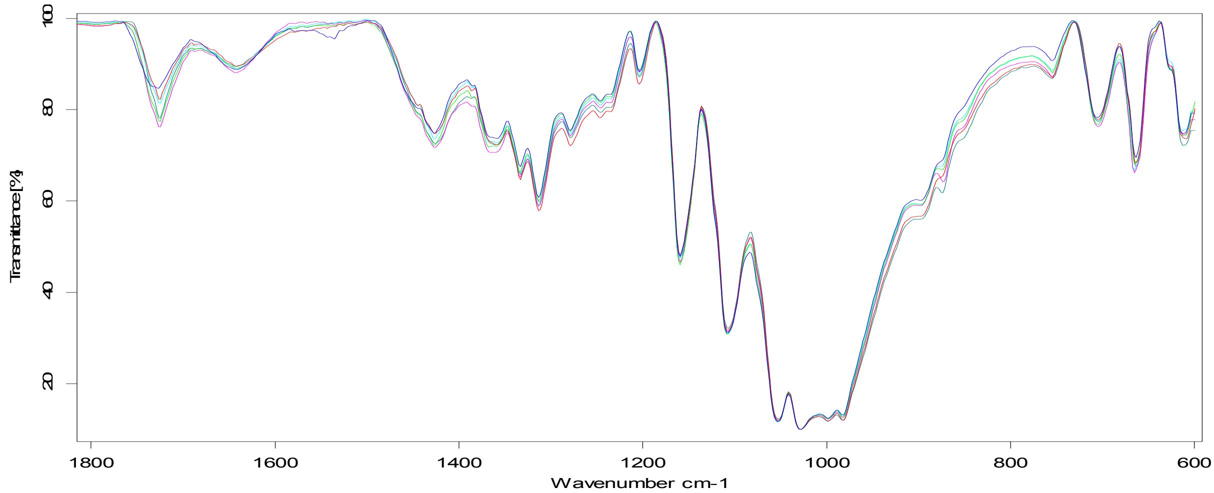


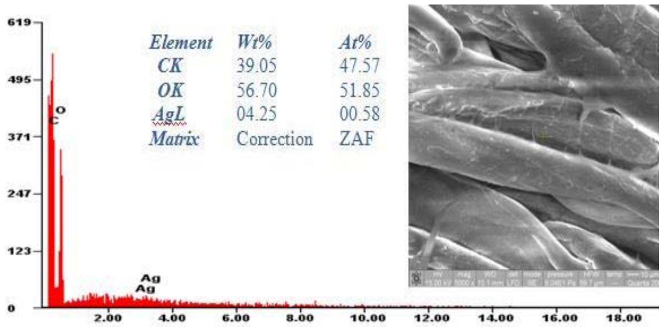
Figure 1. Spectra FTIR-ATR

---treated sample and unwashed ---treated sample after the first wash
---treated sample after the second washing ----treated sample after the third washing
---treated sample after the fourth washing

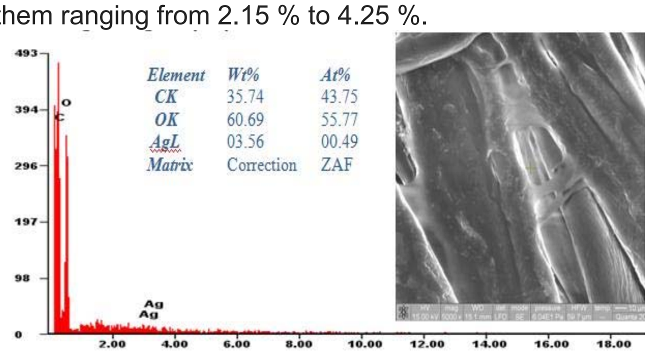
For cotton fabric treated with components: Acrilem (ACR), $AgNO_3$ (Ag) followed by repeated washings, FTIR-ATR spectra are similar and following washes differences are observed in the field 3600-2800 cm^{-1}. Differences in the field referred to indicates that there has been established chemical links between cotton and Acrilem IC79 spanning different and silver ions. FT-IR spectra confirm the presence of Acrilem IC79 copolymer in processed fabrics and the presence of silver ions by change in the intensity of the absorption bands.

2.4.SEM-EDAX analysis of samples of cotton treated with $AgNO_3$ and ACRILEM® IC79

The antimicrobial finishing samples were analyzed by electron microscopy (SEM) and images are shown in Figure 2. From these images it is to be noted that on the surface of fibers was fixed polymer Acrilem IC79 which has packed and silver ions in the fleet of dealing with exposed UV.
EDAX analysis shows that in addition to fixing the polymer is also fixing the silver ions on the fabric. It can be established as a result of these analyzes that by this method durability treatment is good. So the content of silver ion is maintained on fabric and after 4 washes them ranging from 2.15 % to 4.25 %.



a)



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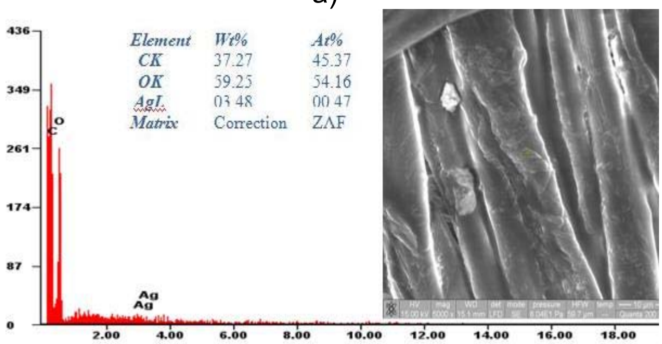

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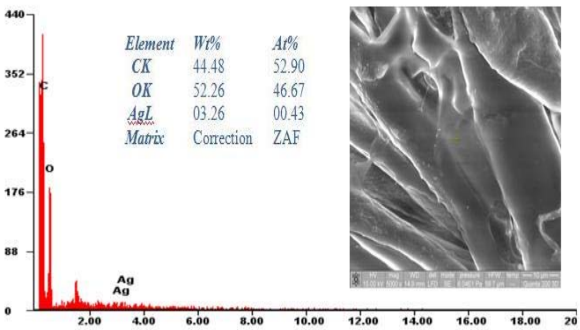

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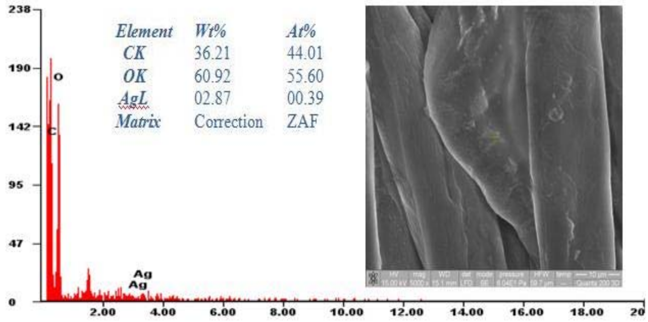

e)

Figure 2 :. SEG-EDAX images of the samples of cotton treated with $AgNO_3$ and ACRILEM® IC79 exposed to UV light for 7 minutes :a) treated sample and unwashed, b)treated sample after the first washing, c) treated sample after the second washing, d) treated sample after the third wash, e) treated sample after the fourth washing

2.5.Antimicrobial activity

The results of the tests have shown antimicrobial action of the fabric treated with Acrilem and $AgNO_3$ even after the four washes but in the blank test antimicrobial effect is absent. It was found a differential sensitivity of the two micro-organisms from woven fabric treated which might be correlated with different composition and ultrastructure of the cell wall to the two species, which prints a hydrophilic character in the case of bacteria Gram negative (*Escherichia coli*) and a character hydrophobic in the case of bacteria Gram positive (*Staphylococcus aureus*).

Table 1. Antimicrobial activity

Antimicrobial Test		
Sample	**Staphylococcus aureus ATCC-29213**	***Escherichia coli* ATCC 25922**
Sample of untreated cotton	-	-
Sample of cotton treated and unwashed	++++	++
Sample of cotton treated after the first wash	+++	++
Cotton treated sample after the second washing	+++	+
Cotton of cotton treated sample after the third washing	+++	+
Sample of cotton treated after the fourth washing	+++	+

Legend:
-: no inhibition zone
+: inhibition of poor crop development
++: inhibition of the growth medium culture
+++: good inhibition of crop development
++++: very good inhibition

3.CONCLUSIONS

The results of the application of antimicrobial treatment with Acrilem and $AgNO_3$ in this work shows that the content of silver ion who can find on the fabric indicates a durability of washes. This durability is directly responsible for the antimicrobial properties of the fabric because the silver nanoparticles confers on the final product properties report thanks to high bacteriostatic silver ion/surface area.

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EFFECT OF FATTY ACID ESTERS ON ANTIFUNGAL TREATMENT OF COTTON FABRIC

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Abstarct *The aim of this paper was the synthesis of some esters of fatty acids by the addition reaction of epichlorohydrin to lauric, palmitic and respectivly stearic acid and the application of these esters on celullose fibre materials. The application treatment of esters on cotton fabrics was carried out in two steps: in the first stage the impregnation with emulsion was performed at 70ºC followed by pad squeezing (in order to remove the excess of emulsion). In the second step the fabric treated with emulsion was subjected to the following operations: impregnation in NaOH solutions (10 g/L), pad squeezing (squeezing degree 100%), rolling, wrapping in polyethylene sheet, maintaining for 6 hours at room temperature, drying for 20 minutes at 70°C, curing at 120˚C for 20 min. In the presence of NaOH catalyst, 3-chloro -2-hydroxypropyl carboxylates react with hydroxyl functional groups of cellulose.*
The esters were tested in order to evaluate their antifungal activity against the following species of cellulolytic fungi: Chaetomium globosum, Trichoderma viridae and Phanerochaete chrysosporium. For this purpose, the seven days inoculum of the fungal cultures was applied on a solid culture medium specific to each breed (Haynes medium for Chaetomium globosum and Sabouraud medium for Trichoderma viridae and Phanerochaete chrysosporium). The fabrics were subsequently fixed on the cultures medium containing the fungal species that were mentioned above. The degradations made by the action of the fungi on the fabric were highlighted by the texture changes due to the cellulolytical action of the tested fungi as it results from the microscopically images and from the statistical analysis of the measurements that were made. The antifungal action was influenced by the type of the tested fungus as well as by the nature of the fatty esters that were used for the treatment

Keywords: *Fatty acid esters, cotton fabric, fungus, antifungal activity*

INTRODUCTION

Cotton fabrics can degradate under the action of fungs, the degradation degree being influenced by several factors: the degradation degree of the fungs; their crystallinity, the structure of the pores and the cellulolytic substrate`s accesible internal area. In this way, due to the action of fungs on cotton fabrics ca appear coloured stains on their surfaces, dyed fabrics can discolor, the polymerization degree can be lowered and the tensile strength can be lowered, also (in extreme cases, the cellulose can decompose completely). In most of the cases, the modifications that appear under the action of the microorganisms can lead also to specific smels [1-3].

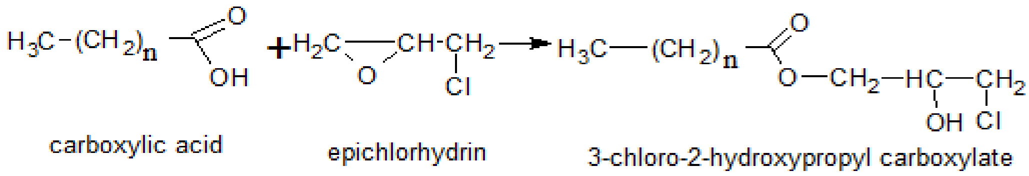
The microbiological degradation of the fabrics is affected also by the substances added on the fabric, such as: dyes or other chemical compounds used in the finishing operations applied to the fabrics. These can be a food source for the microorganisms or can have a negative effect on their development [4]. In the present, big efforts are made to control the infection caused by the microorganisms, existing a continue preoccupation regarding the making of antimicrobial treatments for fabrics, treatments capable of avoiding the degradation of the fibers, the generation of the smell and other unpleasant aspects [5-11].

This paper has as aim the study of the antifungal activity of the fatty acids (lauric, palmitic and stearic) applied on a cotton fabric towords the cellulolytic fungs: *Chaetomium globosum, Phanaerochete chrysosporium* and *Trichoderma viridae*.

EXPERIMENTAL PART

1. The synthesis and application of esters on the fabric

For the experiments were used fabric samples of cotton 100%, cleaned and bleached. The esters of the fatty acids used in the treatment of the samples were obtained from the reaction of the corresponding fatty acids with the epichlorhydrin [12].



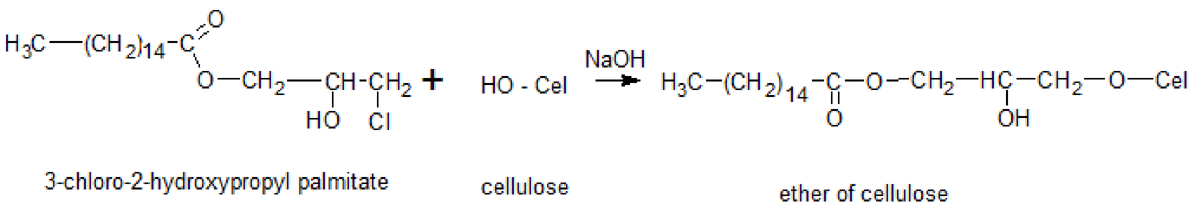
Scheme 1. The obtaining of the fatty acids esters

The synthesized esters were emulsified in the presence of the neionic surfactant (Tween 80)at 70^{0}C. the cotton samples were impregnated in the obtained emulsions, squeezed (to remove the exces of emulsion), impregnated in NaOH solution (10g/L) squeezed (squeezing degree 100%), rolled in polyethylene wrap, stored 6 hours at room temperature, drying for 20 minutes at 80°C and then fixed at 120^{0}Cfor 20 minutes. The concentrations of the treatments with esters are presented in table 1.

Table 1. Work conditions

Proba	Concentraţia de ester
CHPL	3-chloro-2-hidroxypropyllaurate (60 g/L)
CHPP	3-chloro-2-hidroxypropylpalmitate (60 g/L)
CHPLS	3-chloro-2-hidroxypropyllaurate (20 g/L) + 3-chloro-2-hidroxypropylstearate (40 g/L)

In the presence of NaOH , as a catalyzer, the esters react with the functional OH group from the cellulose, forming on ether (scheme 2)



Scheme 2. Reaction 3-cholo-2-hydroxypropyl esters with cellulose fibers.

After the treatment, the samples were washed with water at 70^{0}C to remove the unfixed products that were not fixed on the cellulose fiber, and then they were dried.

2. Antifungal activity

The fabrics that were treated with esters, were tested in order to evaluate their antifungal activity against three species of cellulolytic fungs: Chaetomium globosum, Phanaerochete chrysosporium and Trichoderma viridae. For this purpose, the seven days inoculum of the fungal cultures was applied on a solid culture medium specific to each breed (Haynes medium for Chaetomium globosum and Sabouraud medium for Trichoderma viridae and Phanaerochete chrysosporium). The fabrics were subsequently fixed on the culture medium containing the fungal species that were mentioned above.

RESULTS AND DISCUSSIONS

It was studied the influence of the nature of the esters applied on the fabrics surfaces over the different fungs that can degradate the fabrics made of cellulose fiber,

1. FTIR analysis

The presence of the esters on the surfaces of the samples was proved with FTIR analysis. As a representative example were chosen on untreated cotton sample (curve 1) and another one, treated with 3-cholo-2-hidroxypropylpalmitate (curve 2) from figure 2.

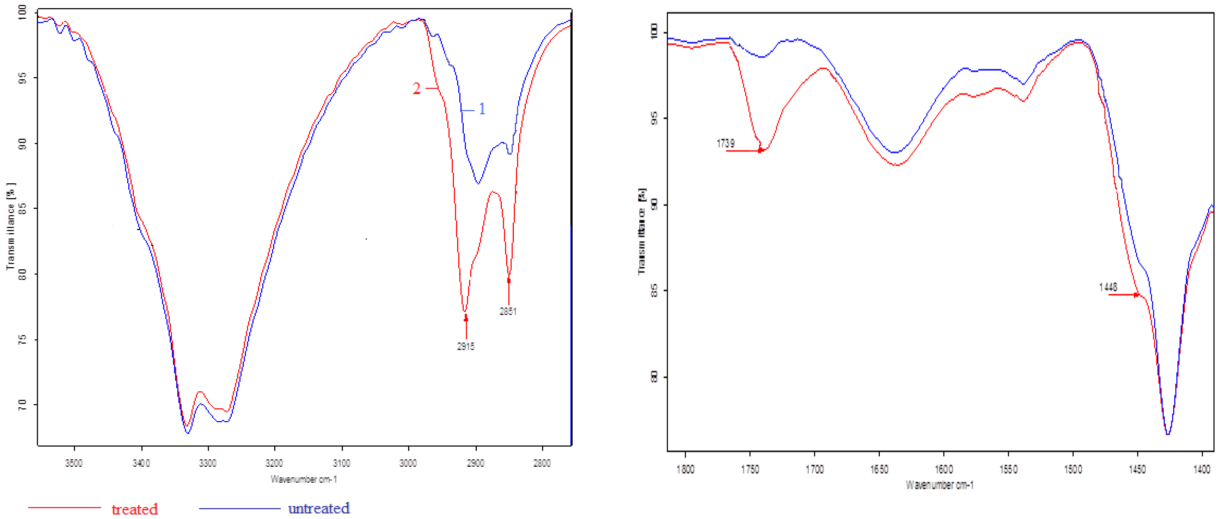
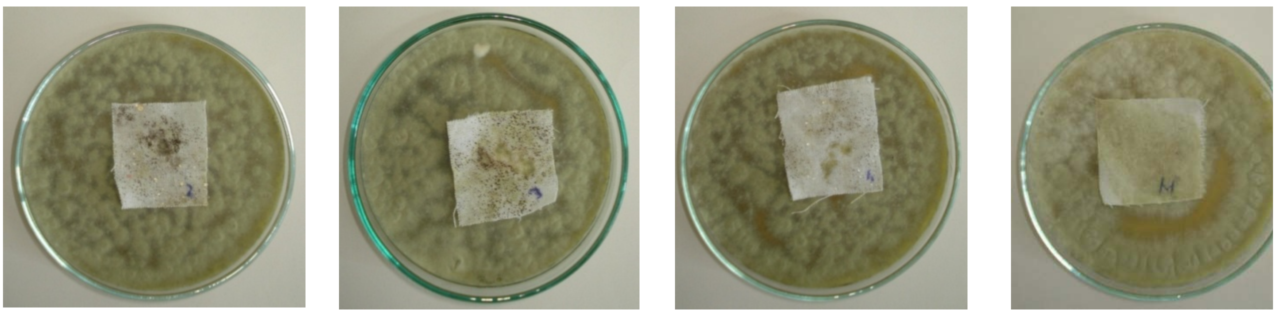


Figure 2. FTIR analysis

Grafting of 3-cholo-2-hidroxypropylpalmitate on cellulosic fiber is also highlighted by the appearance of peaks from 2915 cm^{-1} and respectively 2851 cm^{-1} that correspond to symmetric and antisymetric stretching of CH_2 group from the hydrocarbonate chain of ester and by absorption bond located at 1739 cm^{-1} that corresponds to the esteric group of 3-choloro-2-hidrxypropylpalmitate.

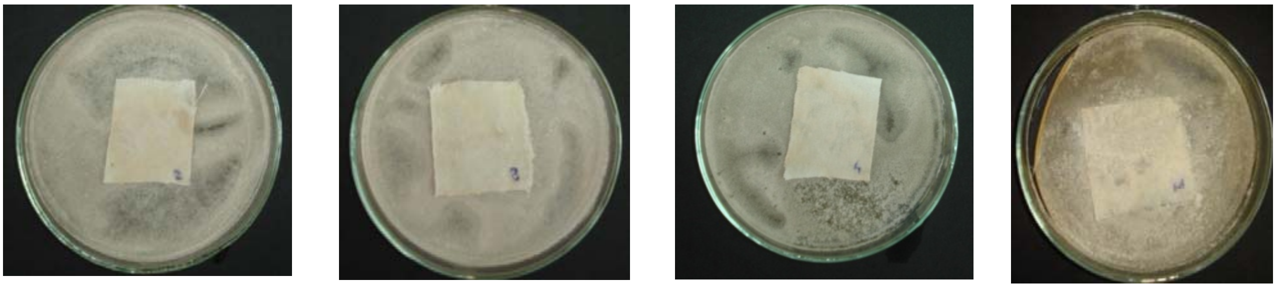
2. Antifungal activity

The untreated cotton samples and the treated ones, inoculated with the three types of fungs for 7 days were washed with 4g/L detergent (Ariel) at 60^0C for 30 minutes and then dried at 70^0C. The colour changes that appear by the inoculation with fungs can be observed from the microphotos presented in figures: a, b, c, d.



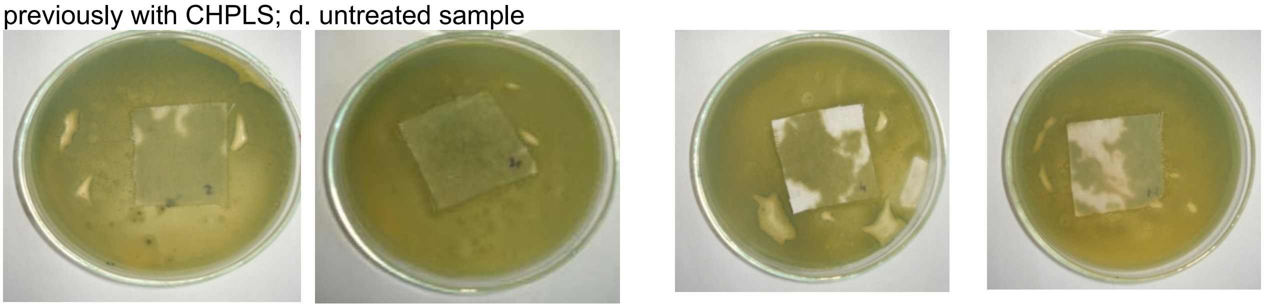
a. b c d

Figure 3. Samples incubated in Haynes medium for 7 days with *Chaetomium globosum*: a. the sample treated previously with CHPL; b. the samples treated previously with CHPP; c. the samples treated previously with CHPLS; d. untreated sample.



a. b c d

Figure 4. Samples incubated in Sabouraud medium for 7 days with *Phanaerochete chrysosporium*: a. sample treated previously with CHPL; b. sample treated previously with CHPP; c. sample treated previously with CHPLS; d. untreated sample



a. b c d

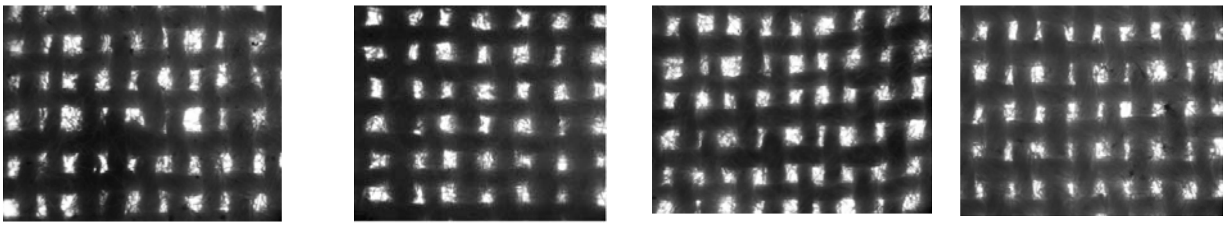
Figure 5. Samples incubated in Sabouraud medium for 7 days with *Trichoderma viridae:* a. sample treated previously with CHPL; b. sample treated previously with CHPP;c. sample treated previously with CHPLS; d. untreated sample**.**

● The sample treated with the fatty acids esters and inoculated with the CG fungus present only brown spots (points) comparative to the blank samples, which is almost entirely colored (because of the development of the fungae micels). The least colored points-which indicate the best antifungal effect can be observed in the case of the sample treated with CHPLS.

● The samples treated and inoculated with PC are colored only a little in comparing to the untreated sample, the best antifungal effect can be observed in the case of the sample treated with CHPSL.

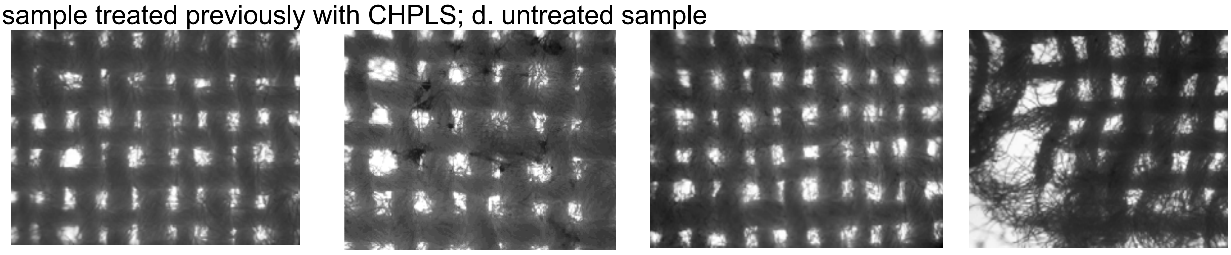
● For the samples treated with TV, the results weren`t the wanted ones. The photomicrographs regarding the color of the samples inoculated with this fung don`t give us exact indications referring to the degradation of the cotton samples.

The texture of the cotton samples treated with those 3 esters and the blank samples after the CG, PC and TV fungs were incubated, are presented in figures 6, 7 and 8:



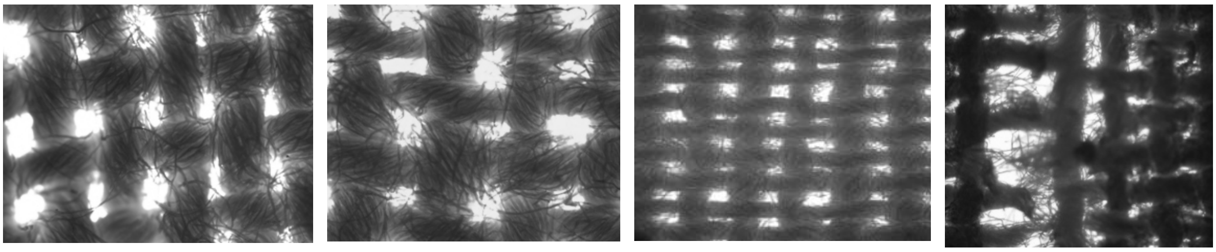
a. b c d

Figure 6. Photomicrographs of samples incubated in Hynes medium for 7 days with Chaetomium globosum: a. the sample treated previously with CHPL; b. sample treated previously with CHPP; c. sample treated previously with CHPLS; d. untreated sample



a. b c d

Figure 7. Photomicrographs of samples incubated in Sabouroud medium for 7 days with Phanerochete chrysosporium: a. the sample treated previously with CHPL; b. sample treated previously with CHPP; c. sample treated previously with CHPLS; d. untreated sample.



a. b c d

Figure 8. Photomicrographs of samples incubated in Sabouroud medium for 7 days with Trichoderma viridae: a. the sample treated previously with CHPL; b. sample treated previously with CHPP; c. sample treated previously with CHPLS; d. untreated sample

Analyzing the photomicrographs, one can observe that the surfaces of the samples treated with the esters of the fatty acids are partial covered with the fungs spores, comparative to the blank sample which is completely covered by spores. Comparing the three fungs, one can observe that the most aggressive fung is the PC one, the blank samples being partial destroyed.
The action of the fungs on the cotton samples, treated and untreated, was appreciated also through the measurement of the medium diameters of the warp threads of the fabric after their incubation with those three types of fungs and also after the removal of the fungs through washing (the tabel).

Table 2. Representative values for the medium diameters of the warp threads

The fung		The sample treated with CHPL	The sample treated with CHPP	The sample treated with CHPLS	Untreated sample
CG	Before washing	322.72	303.52	328.76	342
	After washing	286.9	234.07	316.14	260.2
PC	Before washing	319	311.19	343.12	250.59
	After washing	316	309.46	311.22	238.9
TV	Before washing	308.77	271	297.86	300
	After washing	297.67	293	310	320.15

The liquid growth medium of the CH fung was observed more by the blank sample which leads to an increase of the threads diameters in comparing to the treated samples, which are more hydrophobes and for which the cultures medium was partial absorbed. Through washing, the fung is removed the diameters of the threads treated with the esters of the fatty acids are bigger than those of the blank sample which indicate less degradation of the treated threads in comparing to the untreated ones.
In case of the samples inoculated with PC, the diameters of the treated samples are bigger than those of the blank sample before and after washing. Because of the distinctive configuration of the TV fung, the date`s weren`t concludent for the medium diameter either.

Table 3. Weight loss

	CHPL	CHPP	CHPLS	M
CG	7.35	7,78	6.41	8.81
PC	10.52	11.69	7.52	27.7
TV	10.73	15.07	5.52	30.9

Analyzing the results presented in the table, one can conclude that the most severe degradations, evaluated through weight loss, were produced in the cases of PC and TV fungs.

3.CONCLUSIONS

Antifungal activity of esters lauric, palmitic and stearic acid applied to cotton samples was studied. The fungal activity of Chaetomium globosum, Phanaerochete chrysosporium and Trichoderma viridae after the treated and untreated samples was evidenced by photographic images, photomicrographs and weight loss. The most aggressive fungs as against fabric cotton was Phanaerochete chrysosporium and Trichoderma viridae (weight loss and respectively) confirmed by photomicrographs which give destruction of fibers. The best antifungal activity against of the three fungs was obtained for the sample treated with CHPLS.

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CONTROLLED RELEASE OF A DRUG FROM CYCLODEXTRIN COMPLEXES TO DERMIS

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Abstract: *The objective of the study is to developing a sustained-release drug delivery system grafted on cellulose surface. The paper addressed to the cutaneous diseases (psoriasis) solved by the medical textiles and it estimates the possibility of applying on a textile surface of a cyclodextrin polymer / composite which form temporary reservoirs by complexing and subsequent releasing the drug under the action of cutaneous stimuli. In the paper one has obtained cellulose fabrics with antipsoriasis properties. It was used a complex monochloro triazinyil-beta-cyclodextrin (MCT-β-CD):hydrocortisone acetate (HCr) which releases the drug under physiologically conditions (solution of perspiration kit at 37°C).*

Keywords: *psoriasis, knitted cellulose fabric, cyclodextrin, hydrocortisone.*

1. INTRODUCTION

The paper is a part of the general concerns of the field by developing new textile fabrics with special functions, used in various fields, including health by solving diseases with high prevalence and increased discomfort.

Psoriasis is a common inflammatory disease, chronic, affecting approximately 2%-3% of the population. Clinical manifestations are cutaneous squamous well defined erythematous plaques usually on the elbows, knees and scalp and are the result of hyperproliferation of epidermal keratinocytes consisting in a premature and incomplete keratinization, which causes thickening of the epidermis [1]. Psoriasis affects the quality of life and the use of hands, walking upright position, standing for long periods of time, sexual function and quality of sleep. Does genetic predisposition combined with environmental triggers, such as trauma in the form of bodily injury or violent emotional shock [2,3].

The paper performs a textile fabric with medical application that meets the following characteristics: curative, biocompatibility, lacking toxicity and finally proposed to clinical tests. There is a major interest concerning the use of textiles for skin therapies to avoid the oral or topical way of applications with their specific disadvantages which require time specific conditions of application and drug losses.

A variant technically accessible and studied mainly in recent years is the use of CDs. Application of CDs on the textile surface has once established, but probably in 1970-80 appeared the first communication. Method using the support CD for controlled release of active principle is similar for skin diseases topical therapy, widely used in dermatological applications, namely the use of drugs included in creams, gels, dressings, which creates a local transfer especially in chronic diseases. The originality lies in that it is attempted prolongation release covering therapeutic duration and the diffusion flow of clinical medicine prescribed. The novelty lies in getting a system fixation pharmaceutical active principles textile structure to adjust the amount depending on the amount released so forced physiologically needed, but it also represents a temporary reservoir substance covering the entire healing period.

2. EXPERIMENTAL

2.1. Materials

One used a knitted cotton fabric with yarns of Nm=60/1. Basic procedures to prepare the textile surface consists in: alkaline boiling, bleaching (sterilizing) and drying stages.

MCT-β-CD, is used as CD reactive reagent applied by grafting on cellulose of cotton (pad-dry-cure) procedure. The equipments used are: - oven Venticell 55, 2009 with performances: temperature domain =

20-300^oC, adjustable time, ventillation and humidity; - NanoDrop spectrophotometer ND-1000, 2007 company NanoDrop Technologies Inc.; UV-VIS spectrophotometer JK-VS-721N Shanghai Jingxue, China, 1999.
HCr is used under the 100% powder shape provided from pharmaceutical market.
In Figure 1 is illustrated the molecular structure of the HCr.

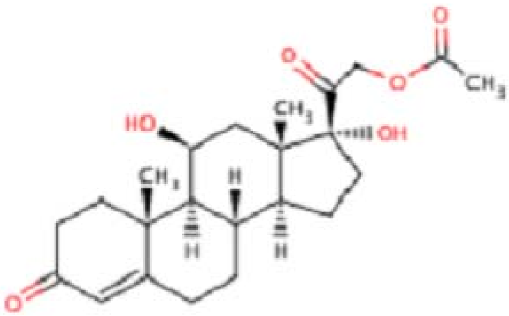


Figure 1. The molecular structure of the HCr [4]

2.2. ChemAxon MarvinSpace soft

To include HCr in the hydrophobic cavity of the cyclodextrin were required specific conformations, and assess the dimensions of antipsoriatic active ingredients to see if the parameters fit the overall to dimensional inner diameter of the CD. The inclusion of the active principles in the hydrophobic cavity of CD assessing specific conformations and dimensions of this drug. Measurements for size molecules were made its using ChemAxon software MarvinSpace 5.4.0.0 for length, width and branching chemical structures.

2.3. Determination of HCr absorbance with NanoDrop

One prepared a solution of HCr (100 ml) solution containing 100 µg/ml HCr acetate and ethanol in the pure state. The absorbance of this solution was measured (3 determinations were carried out), to obtain the maximum solubility at a certain wavelength (252 nm). From the basic solution was prepared diluted solutions to buildup calibration curve. The Nanodrop apparatus has the advantage to use low amounts of solutions to determine the concentration of reagents starting from a calibration curve.

2.4. Determination of HCr absorbance by an analytical method with UV-VIS spectrofotometer

It has been prepared a solution of HCr (100 ml) solution containing 100µg/ml HCr acetate and ethanol in the pure state. Determination of the absorbance was performed spectrophotometically using the below redox system [5]. HCr is oxidized to an acid derivative by the reduction of a ferric salt to the ferrous salt with the appearance of yellow colour of solution, colour which can easily be enhanced by forming a compound potassium hexacyanoferrate greenish blue hue [5].

$$\underset{\text{colourless hydrocortisone}}{R\text{-}C{=}O} \longrightarrow \underset{\text{colourless acid}}{R\text{-}COOH} \qquad (1)$$

$$Fe^{3+} \xrightarrow{+1e} Fe^{2+} \qquad (2)$$

$$K_3Fe(CN)_6 + Fe^{2+} \longrightarrow KFe[Fe(CN)_6] + 2K^+ \qquad (3)$$

Were prepared 5 working solutions, 4 standard solutions, and one control sample. In all five glasses added in each one 2 ml of sulphuric acid, 2 ml of ferric chloride solution, 0.5 ml of potassium hexacyanoferrate. In the four standard solutions were added different amounts of standard solution HCr, amounts ranging between 0.5-2ml. The glasses are maintained, in a water bath 15 minutes at 70 °C.

2.5. Preparation of inclusion complex. Method 1 using UV-VIS spectrofometer

One used five textile samples (100% cotton knitted fabric, alkaline boiled, bleached with hydroxyde peroxyde, dried and grafted with MCT-β-CD) [6] with same size of 5 x 5 cm. HCr solution was applied on samples of fabric material by immersing the material in a solution for 24 hours at room temperature. After the

HCr absorption, the fabric samples are dried 24 hours at room temperature. After drying, the samples were setted in the oven at 40℃ for 5 hours [6].

2.6. Preparation of perspiration kit

For fabrics with drug included on surface are used perspiration kits which simulate the artificial sweat pH and the content of human perspiration to initiate HCr release from cavity. Four dosage forms of human perspiration were prepared in accordance with International Standard (ISO 105-E04-2008), American Association of Textile Chemistry and colorful (AATCC 15-2002) and British Standard (BS EN1811-1999), with pH range from 4.3 to 8 [7,8]. In this study was prepared a solution of perspiration kit, according to ISO 105-E04-2008, at a pH of 5.5. The solution contains the following compounds: sodium chloride, L-histidine monochloride and sodium dihydrogen orthophosphate dihydrate accordingly with standard prescription.
The 5 samples of the material were immersed each in a solution of 40 ml of perspiration kit, after which it is placed in the oven at 37 ℃, for 1h, 2h, 3h, 6h, 24h.

2.7. Preparation of inclusion complex. Method 2 using UV-VIS spectrofometer

One use a sample of a 100% cotton fabric, treated, bleached and grafted with MCT-β-CD. The method differs from the first one method by the fact that here it use a single sample of material (5 x 5 cm) as the average of three values**.** The sample was immersed in HCr solution and stored for 24 hours at room temperature. After 24 hours the sample material was dried at room temperature, and the remaining solution was used to determine the absorbance of HCr. After drying, the sample material was subjected to a final drying in the oven at 50 ℃ for 4 hours. The sample of the material after drying was immersed each in a solution of a 40 ml perspiration kit at different times (1h, 2h, 3h, 6h, 24h), at a temperature of 37 ℃, with the drying of the fabric between the periods.

3. RESULTS

3.1. ChemAxon Marvin Space Soft

Maximum values of the length and width of the basic structure of HCr using ChemAxon software MarvinSpace 5.4.0.0. are: length=11.29(Å), width=5.75(Å). Since the dimensional characteristics of beta-CD are: inner diameter = 6.2 Å, height = 7.8 Å according to the literature [9,10], hydrocortisone is suitable in terms of dimensional availability of penetration into the CD cavity. Whatever the form of HCr acetate or butyrate as a basic drug molecule have the appropriate dimensions to complex inside the cavity of CD.

3.2. Tests on HCr absorbance (NanoDrop)

Were determined the values for the absorbances at a wavelength of 252 nm of the concentration of HCr acetate ranging from 10^2 up to 10 mg/L, the domain of absorbance was between 0.780 → 0.588, carrying out each experiment, three measurements for obtaining the standard curve. The main regression equation was y=0.0022x+0.5575, R^2=0.9964.

3.3. Determination of HCr absorbance (UV-VIS spectrofotemeter)
At a wavelength of 780nm, the standard curve was plotted, where is the change in the absorbance of the concentration standard solution HCr. The regression equation was y=0.0076x+0.0356, R^2=0.984.

3.4. Preparation of inclusion complex. Method 1 (UV-VIS spectrofometer)

The five remaining solutions after immersing of 5 samples of fabrics are established to determine the absorbance of HCr using a spectrophotometerically method.The reggresion of equation y=0.0757x+0.035 was R^2=0.9998. From the regression equation of the calibration curve was determined the quantity HCr solution of hydrocortisone in solution:

$$y = 0.0076x\ 0035 \quad (4)$$

Where y is the measured absorbance of the five solutions, and x is the concentration of HCr acetate solution remaining after removal of the fabric samples(mg HCr/g textile fabric). According to calculations was determine HCr detained after immersing the fabric samples in the standard solution of HCr. The 5 samples of the material after drying were immersed in each of 40 ml of kit, after which they are placed in the oven at

37 °C, for periods of 1h, 2h, 3h, 6h, 24h. It was determined the HCr concentration of remaining solutions after samples of material is removed. Concentrations were determined by the same method for determining the absorbance at 780 nm, using 4 ml of each of the remaining solution kit. From the regression equation of the calibration curve for kit solutions was determined the quantity of HCr kit solution.

$$y = 0.0301 \text{ x } 0.032 \quad (5)$$

Diagram shows on Y coordinate the absorbance and X amount of the solution HCr kit.
Results of calculations to determine the amount of HCr adsorbed fabric are illustrated in fig.2.

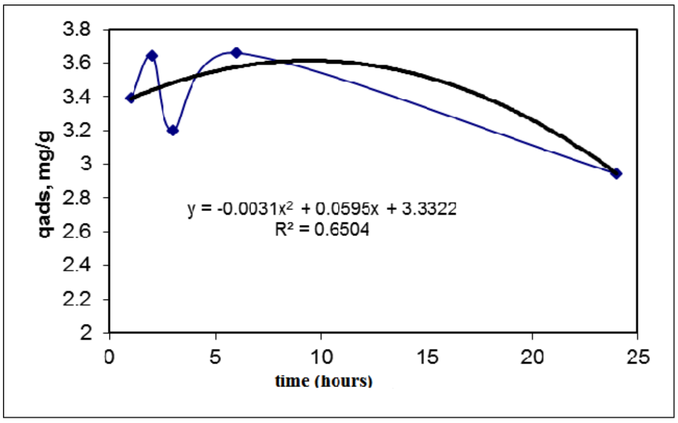


Figure 2. Adsorption curve HCr acetate absorbed on textile fabric after immersion in the solution of perspiration kit.

In figure 3 are illustrated values of HCr desorbed with time from the textile fabric immersed in perspiration kit solution.

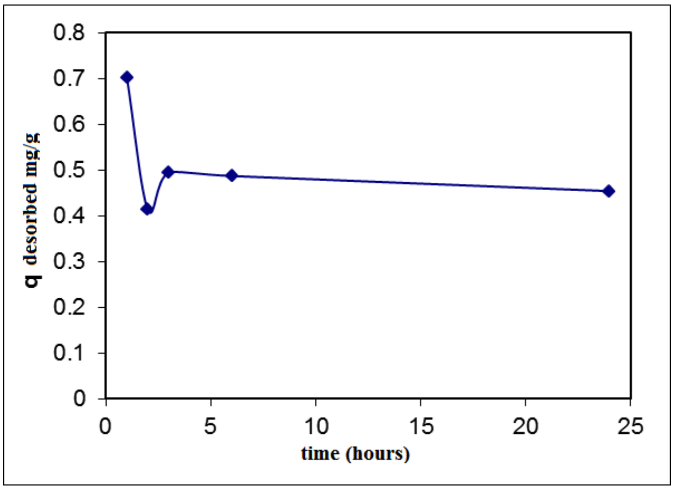


Figure 3. Desorption curve of the HCr released under action of perspiration kit solution.

3.5. Preparation of inclusion complex. Method 2

This method differs from the first method by the fact that here we use a single sample of material (5x5 cm) as the average of three values. Was obtained the following desorption curve.

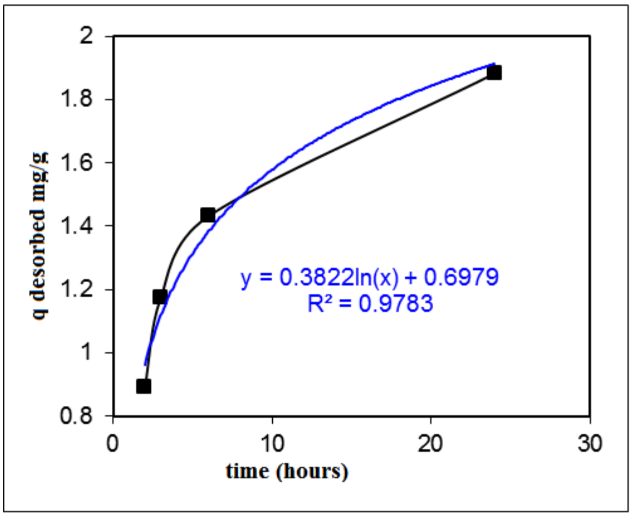
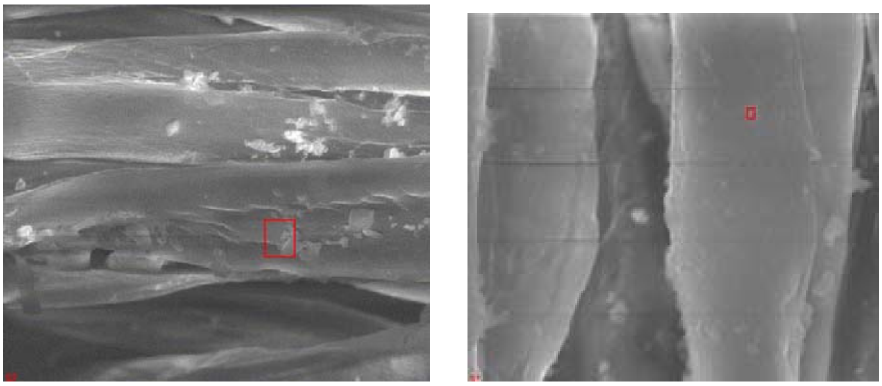


Figure 4. HCr desorption curve of the fabric in the solution kit

3.6. Characterization of complex

The textile material grafted with MCT-β-CD and with active principle absorbed in the cyclodextrins cavity is investigated by EDX and SEM. The results are illustrated in the images from figure **5a** and **b**.



a) b)

Figure 5.SEM images of a textile sample with MCT-β-CD and HCr.
a) HCr absorbed on cotton surface;
b) HCr remained on textile surface after release under action of kit perspiration.

According to Figure 5 a) and b) the application of HCr determines appearance of temporary reservoirs of drug. On the textile surface, the image of drug reservoir forms a rectangular shape as is illustrated in fig.5a). The release of the drug from CD cavity, under the action of perspiration, the solution involves the existence of a high amount compared to the volume of the cavity of CD molecules; morphological organization of drug deposits on the surface of the cotton fibers changes to an oval shape; maybe a detersive effect of perspiration kit solution determine this geometrical shape under the test conditions.

4. DISCUSSIONS

Using the Nanodrop for determination of HCr absorbance one can conclude that for the same solution is obtained different values of absorbance measurements were carried out at the same time even in short periods of time (few seconds). Also, for this solution the absorbance was measured after one hour obtained again for the same solution, different values.
The different values of absorbance shows that HCr is unstable at UV light, fact which is in agreement with literature data [11]. According to the literature [11], photodecomposition acetate can be avoided by using a filter that eliminates range 190-300 nm UV wavelength with high energy or to use the experimental procedure in dark conditions.

Another possibility to avoid the instability of the HCr solutions in the UV field is the formation of a redox system of iron hexacyanoferrate salt which gives a greenish blue color detectable at 780 nm, which is in visible domain of wavelenghts. Comparing the two methods of determining one concludes that major absorbance values HCr is obtained according to the analytical method; the values are constant at least 2 hours.
According to the kinetic modeling that has been obtained starting from an initial concentration of 4.91 mg HCr desorbed/g textile sample; one can estimates from data obtained the HCr is released with a rate of 0.35 mg HCr/g textile fabric up to about 35 hours. To get a longer desorption optimize subsequent experiments, either by increasing the initial concentration of HCr, either diminish the diffusion flow of HCr by functionalization of the fabric.

5. CONCLUSIONS

Molecular dimensions of HCr acetate are fitted to inner diameter of beta-CD.
For high accuracy of HCr release data from cotton fabric one needs firstly to form a complex CD-drug then complex grafting on textile surface.
The use of NanoDrop technique in the case of HCr acetate tests needs additional restrictions: working in dark conditions, using filters to remove the UV component or an analytically method which is much longer as time procedure.
To obtain a characteristic curve for HCr releasing according with real conditions of a patient who wears a cotton garment with HCr on textile surface or with literature data needs applying method 2 [12] with the same textile fabric which is immersed in perspiration kit solution, dried and again immersion, drying and so on.

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DOSING AND CONTROLLED RELEASE SYSTEMS OF A DRUGS FROM A TEXTILE TO SKIN

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Abstract: *The aim of the study was to obtain cotton material functionalized with various host compounds that included tacrolimus (TAC) for cutaneous disorders. TAC is a product of newer generation and is more effective as a medium potency steroid, because used classical glucocorticoid (hydrocortisone acetate and butyrate) therapy offers various therapeutic effects, but unfortunately and many side effects too. Different approaches were under study in order to obtain a temporary reservoir on a cotton textile material able to include the drug (TAC). The use of a cyclodextrin derivative and hydrogel based chitosan to include TAC, failed.*

Keywords: *tacrolimus, cotton knit, skin disorders, controlled release systems*

1. INTRODUCTION

Controlled release technique allows precise and reproductible improvement of an agent diffusion in a specific environment over an extended period of time with significant advantages: one avoids the excretory and digestion way; one covers general toxicity, oddour and taste [1]. Beyond the economic and financial aspects, the engine of this area is a challenge due to the occurrence of low molecular weight drugs and bio-macromolecules with low solubility in water or with poor tissue diffusion [2]. Systems with these features allow more efficient therapy and is eliminating the potential for overdose and reduce the frequency of drug administration, because the concentration of drug is maintaned in the desired therapeutic range [3]. Drugs requires for transport an optimized way. Action or effect of the drug is determined not only by its properties, but also by the transport system. Conventional transport systems and application methods are evolving paving the way for many new processes based delivery systems, with greater efficiency and effectiveness, better stability with minimized toxicity and side effects.

Paper is dealing with possibilities of releasing the drug according with different performancies based on specific structure of lypophilic guests, therapeutical during time and difusional ratio. One focused on clinical requirements to specific cutaneous disorders. One presented limits and achievements of drug release taking into account hydrophilic and hydrophobic balance, dimensional attributes [4]. The procedure has got the target the immune disorders settled on dermis level. In comparison with the topical administration of ointments, creams and / or lotions, discussed the use of alternative fabric impregnated with the product by way of performing the controlled release of the drug from the temporary reservoir formed adjacent to the dermis, and the fiber polymer structure, is evident in terms of higher control the amount and uniformity over time. The characteristics of the product, the specific mode of action and therapeutic performance was expected to choose one of controlled release systems: 1. Cyclodextrins 2. Hydrogels 3. Covalent polymer-drug system. For the complexation of the CD, the drug must be lipophilic and have small molecular size characteristic than the inner diameter of the inner cavity. Drugs can be molecular structure both lipophilic as well as hydrophilic functional groups, linear or branched. Inside the cavity are adsorbed only the lipophilic portion, but must to matching with the inner diameter dimensional. In order to promote adsorption near ambient temperatures are used and larger times. High temperatures, enhancing thermal agitation, makes for adsorption an disadvantage. Hydrogels are used as surgical sutures, artificial organs, soft tissue prostheses, hemodialysis membranes and contact lenses [5,6]. Hydrogels have therapeutic potential for skin diseases but the application to the textile support is not yet comunicated in the literature. The release of drug from the hydrogel is a micromolecular level diffusion, in fact, through the mesh network, or three-dimensional morphological configurations such as pores. Ringsdorf systems have the advantage for controlled release of a highly toxic drugs or with severe side effects.

2. EXPERIMENTAL

2.1. Materials

One used a simple interlock knit cotton structure, which has already suffered some chemical finishes (alkaline boiling, bleaching and sterilizing stages).
Monochloro triazinyil-beta-cyclodextrin (MCT-β-CD), is used as cyclodextrin derivate (CD) reactive reagent applied by grafting on cellulose of cotton (pad-dry-cure) procedure.
TAC is a lipophilic drug, with a molecular weight of 822.05 Da. Pharmaceutical dosage forms are injectable, capsule, ointments. It is as effective as a medium potency steroid, because used classical glucocorticoid (hydrocortisone acetate and butyrate) therapy offers various therapeutic effects, but unfortunately and many side effects too. [7]. TAC has a low reversible nephro and neuro toxicity and is 100 times more potent than cyclosporine A [8].
In Figure 1 is illustrated the molecular structure of the TAC.

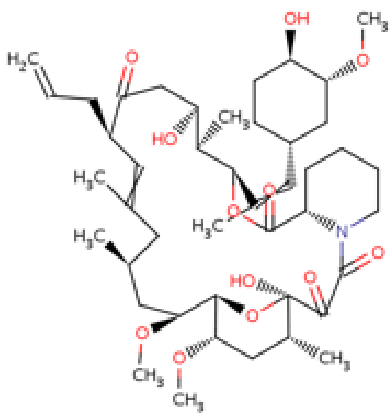


Figure 1. The molecular structure of the tacrolimus [9]

Chitosan (CS) is a natural biopolymer and has been frequently proposed for pharmaceutical and biomedical applications [10], due to biocompatibility and biodegradability conditions. In medicine, it may be useful in bandages to reduce the bleeding and like antibacterial agent too [11]; it can also be used to contribute to the transfer of drugs into the skin [12]. The CS has been used as a drug for sustained release, and for improving the bioavailability of hydrophobic drugs.
The equipments used are: - oven Venticell 55, 2009 with performances: temperature domain = 20-300 ^{o}C, adjustable time, ventillation and humidity; - NanoDrop spectrophotometer ND-1000, 2007 company NanoDrop Technologies Inc; Hettich Zentrifugen Universal 320 R 15000 rot/min; FTIR spectrometer; EDAX apparatus; SEM equipments.

2.2. TAC Inclusion on a textile fabric by use of a cyclodextrin

2.2.1 ChemAxon MarvinSpace soft

To include TAC in the hydrophobic cavity of the cyclodextrin were required specific conformations, and assess the dimensions of the principle active ingredients to decide if the parameters fit the overall to dimensional inner diameter of the CD. The inclusion of the active principles in the hydrophobic cavity of CD assessing specific conformations and dimensions of this drug. Measurements for size molecules were made its using ChemAxon software MarvinSpace 5.4.0.0 to evaluate size of length, width and branching chemical structures.

2.2.2 Experimental part

One used a simple interlock knit structure, which has already suffered some chemical finishes to be as a handle and hygienico preformances apropriate to be worn directly to dermis. Grafting cyclodextrin on the textile product aims include of TAC. It used a solution of 0.1% TAC in alcohol. For this solution solution was determinated the absorbance at NanoDrop at a wavelength of 258 nm. Of this solution are made its 5 dilutions solutions to obtain calibration curve. Sample knit with MCT-B-CD is immersed in the solution of TAC. After treatment the application of the TAC, fabric sample is dried for 24 hours at room temperature. After drying, the sample material was subjected to a final drying in the oven at 55 ℃ for 4 hours. The solution remaining after removal of sample material is used to evaluate the amount of TAC in the supernatant and from the calibration curve to calculate the amount of TAC retained on the fabric.

2.3. TAC inclusion on textile fabric by use of hydrogels

Previously were determined the swelling kinetics of the cotton fabric in the mixture of ethanol/water 80/20. A sample of a knit cotton 10x10 cm was immersed in a CS hydrogel and was mantained for 30 minutes.
In the study was using a CS-based hydrogel. CS hydrogel was prepared at 50 °C at acid pH (pH=5 using acetate acid).
We have used three types of hydrogels, namely recipes:
solution I: 0.5 g material/0.5 g CS;
solution II: 0.5 g material / 0.75g CS;
solution III: 0.5 g material / 0.3 g CS.
Fabric samples were immersed in a crosslinking solution and stored for 3 hours at room temperature. Finally, the sample was removed and washed with distilled water until the crosslinking traces not remain on sample. Was determined the degree of load and degree of swelling of the fabric sample with hydrogel. The textile material grafted with CS hydrogel is investigated by EDX and SEM. Was prepared a solution containing TAC disolved in a mixture 100 ml of a (80/20 ethanol / water). For this solution was determinated the absorbance at Nanodrop at a wavelength of 228 nm. Of this solution are made its 5 dilutions solutions to obtain calibration curve. The 100 ml drug solution was divided; 50 ml for material cover with CS hydrogel and 50 ml for a sample fabric that does not contain hydrogel, sample standard referred to as sample E. The cotton sample treated with CS hydrogel and crosslinking was immersed in the TAC solution under stirring at room temperature and the absorbance was determined at different points at Nanodrop ND-1000 Spectrophotometer at a wavelength of 228 nm.
Starting from 3 minutes, and continued up to 3 days, solution samples of supernatant were taken for determining the absorbance at Nanodrop. The same method was applies for the sample E.

2.4. The inclusion of TAC in the polymer-drug conjugates

Was preparing a complex of CS and TAC stirring at room temperature. This complex is precipitated with a NaOH solution to form a precipitate. This final solution was washed several times with distilled water and placed in the centrifuge for 10 min at 5000 rot / min. The resulting precipitate was separated and dried at room temperature for 24 hours, followed by drying in vacuum.

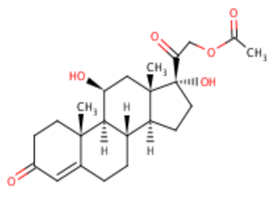
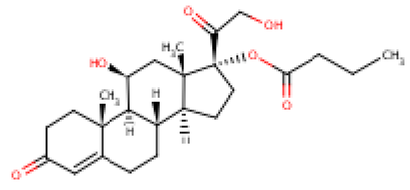
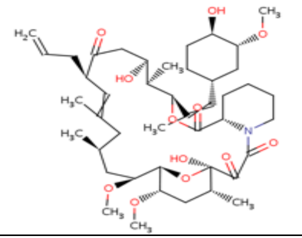
3. RESULTS AND DISCUSSIONS

3.1. Comparisons between tacrolimus and corticosteroids therapy

In table 1 is illustrated the comparative values of physical drug properties.

Table 1. Comparative values of physical drug properties

	Hydrocortisone acetate	Hydrocortisone butyrate	Tacrolimus
Maximum length, (Å)	11.29	12.23	14.65
Minimum width, (Å)	5.75	5.75	10.17
Solubility in water (g/L)	Insoluble	insoluble	insoluble,1 µg/mL
Solubility in ethanol	Slightly soluble 750 g/l	soluble	Good solubility

Chemical structure			

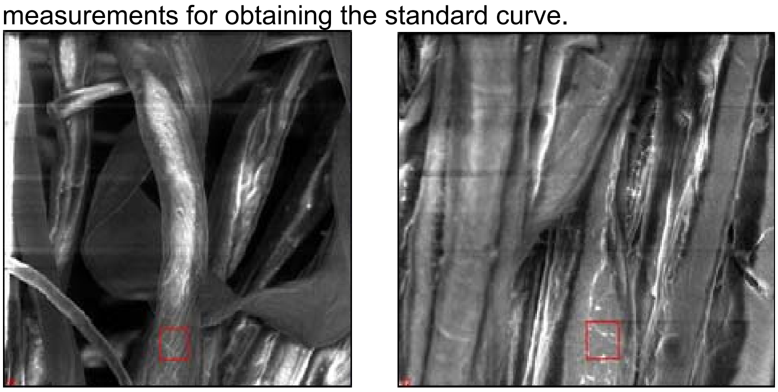
In Table 1, are shown solubilities and chemical structures of the drugs under study. There is an obvious lack of solubility in water and in ethanol the solubility of three drugs.
Hydrocortisone acetate and butyrate has a core consisting of a lipophilic part and a hydrophilic part fused hydrocarbon formed by the acid portion acetate butyrate, respectively. Conformational size of the two drugs hydrocortisone fit inside the cyclodextrin cavity volume.
A different situation occurs when an immunosuppressive drug tacrolimus is a newer generation with greater potency.The higher molecular weight derivatives such as hydrocortisone and relatively circular conformation, and that the presence of pyridine gives the cyclohexane ring voluminozitate of dimensions that exceed the dimensions of the inner cavity of the cyclodextrin. We notice the absence of the possibility of folding structural causes due to a large volume of the subcomponents.
The three levels of drugs are potent and different structures, methods of application on the textile, also different.

3.2. Inclusion of TAC through the fabric by cyclodextrins

Maximum values of the length and width of the basic structure of TAC using ChemAxon software MarvinSpace 5.4.0.0. are: maximum length (angstroms, Å)=14,65 minimum width (angstroms, Å)=10.17.
Since the dimensional characteristics of beta-CD are: outer diameter = 15.4 Å, diameter = 6.2 Å, height = 7.8 [13,14], TAC does not match to the volume and molecular conformation with higher dimensional parameter as the inner diameter of the cyclodextrin. Despite of these conformational details, one tried to determine experimentally to include TAC in the hydrophobic cavity of CD.
Were determined the values for the absorbances at a wavelength of 258 nm of the concentration of TAC ranging from 10^{-1} mg/ml to 10^{-2} mg/ml; the domain of absorbance was between 0.789 → 0.650, carrying out each experiment, three measurements for obtaining the standard curve.
According to the results obtained from the determination of the absorbance of the supernatant solution, the absorbance of the solution remains unchanged, which means that the sample material was not retained TAC. Following the experimental measurements and software as Marvin Space, TAC may not be included in the cyclodextrin.

3.3. Inclusion and release TAC on fabric through hydrogels

According to SEM images, in Figure 2 (a) is show that cotton fibrils are distinguished for untreated control and in Figure 2 (b), the fibrils are interconnected by a film of the hydrogel polymer. Were determined the values for the absorbances at a wavelength of 228 nm of the concentration of TAC ranging from 10^{-1} mg/ml to 10^{-2} mg/ml; the domain of absorbance was between 0.091 → 0.060, carrying out each experiment, three measurements for obtaining the standard curve.



a b

Figure 2. SEM images
a. SEM image (Mag = 2,33 K x) of a ungrafted knit
b. SEM image (Mag = 1,50 K x) of a grafted knit with hydrogel

The main regression equation was y=0.370x+0.0565, R^2=0.999.
One determined the absorbance of the supernatant at different times from three minutes standing up to three days, and from the equation of the calibration slope, was determined the concentration of TAC loaded onto fabric.
However, following determinations was observed that the absorbance of the supernatant does not change even after three days, concluding that TAC does not include fabric. A cause can be a saturated textile TAC support. The cotton textile with TAC learned in aqueous solution set a balance between the material and the solution, respectively. The same results are obtained for the standard sample containing no CS hydrogel According to the experimental determinations one can conclude that inclusion of TAC on material grafted with and without hydrogel can not be included on the fabric. One perspective would be to reach tacrolimus-chitosan complex through polymer-drug conjugates.

3.4. The inclusion of TAC in the polymer-drug conjugates

The film which contains TAC and SC has been applied to determine the Schiff base which could evaluate by means of FTIR method. The technique is used to obtain an infrared spectrum of absorption, emission, photoconductivity or Raman scattering of a solid, liquid or gas. An FTIR spectrometer simultaneously collects spectral data in a wide spectral range.
From the literature [15,16], C = N comprises the Schiff bases is ranging between in 1656 to 1670 cm^{-1}, and the other source showed that the IR absorption bands is around to1600 cm^{-1}.

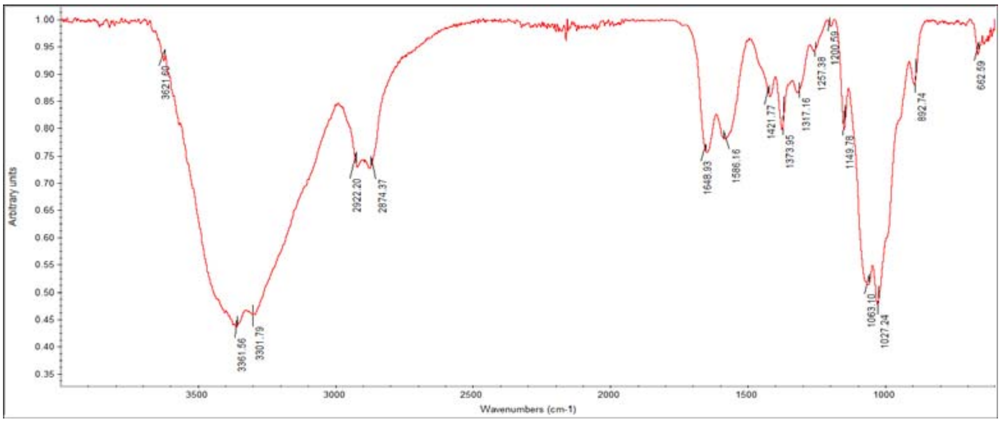


Figure 3. Diagram corresponding FTIR spectrum film CHT-TAC

FTIR diagram presented in figure 3 shows a band at 1648.93 cm^{-1} value corresponding Schiff base formed between CS and TAC.

4. CONCLUSIONS

Tacrolimus inclusion inside of cyclodextrin cavity can not be achieved, because dimensions of this drug does not match to the volume and molecular conformation having larger dimensional parameters as the inner diameter of the cyclodextrin.
Tacrolimus can not be included in the hydrogels formed from chitosan because molecular volume is larger than pores diameter of hydrogel lattice.
A perspective would be to reach tacrolimus-chitosan complex through polymer-drug conjugates, a method currently under in progress.

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SWIMSUIT DESIGN FOR PEOPLE WHO SUFFER FROM URINARY INCONTINENCE

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Abstract: *This research comes up within the framework of a master thesis in Design e Marketing, that aims of conceiving and designing a swimsuit for people who suffer from urinary incontinence. The loss of urinary control is a common condition experienced by millions of people around the world. People with urinary incontinence problems have been denied of using the hydrotherapy treatments, practice swimming, and using public pools. The products available in the market for incontinents are not efficient for water sport. Among the main features of this new swimsuit is to allow the absorption of involuntary loss of urine, and to be tight enough in the junction zones of the body, in order to be sealed as well as being focused on the comfort parameters. Also allow to combine the functional and technical characteristics of the materials with the aesthetics features as not to stigmatize these patients.*

Keywords: *urinary incontinence; swimsuit; comfort properties; waterlightness*

INTRODUCTION

Urinary Incontinence is a problem that affects over 200 million people worldwide. In Portugal there are approximately 650.000 people who suffer from this problem, mostly women after childbirth, elderly people, and men after prostate surgery, among others. Some of these patients hide this limitation by shame or because they assume that urinary incontinence is a natural problem caused by the age increasing and thus do not seek for clinical help [1]. They also feel deprived to practice swimming in public pools or use the hydrotherapy treatments, because of their problem.

Urinary Incontinence can be described as any involuntary leakage of urine [2]. It is a pathological condition that results from the inability to store and control the passage of urine. These losses are presented in a diversified way, can range from mild and occasional breakouts, to most serious and regular losses [3].
There are different types of urinary incontinence, the most common are:

a) Urinary Incontinence by effort: consists in the involuntary loss of urine associated with effort or physical activity, such as coughing, sneezing, laughing, climbing stairs, running, among others.
b) Urinary Incontinence by urgency: is the involuntary loss of urine associated with a sudden and strong urge to urinate (includes from small losses to a loss that leads to complete bladder emptying). The bladder has sudden contractions, causing urgent urination. This type of incontinence may be related to aging, but also emerges in younger ages, associated with neurological diseases or non identifiable causes.
c) Urinary incontinence “mixed”: is the involuntary loss of urine associated with both, the effort and also with a sense of urgency.
d) Continuous Urinary Incontinence: is the continuous loss of urine [3].

There are some products to support incontinents available in the market, from adult diapers, with different absorption capacities, incontinence pads of various sizes. There are products for everyday use which ensure to absorb urine, compounds of protection systems with flakes of superabsorbent gel, fluid diffuser, anti-leak barriers, among others. Also washable and reusable undergarments which guarantee the absorption of urine. Regarding to bathing suits for water activities and hydrotherapy treatments is possible to find some few options like latex underwear, waterproof diapers, and some bathing suits. But there is not evidence of the effectiveness of these products preventing urine leakage in water in sports conditions, besides not having a good aesthetic appeal, in a way that stigmatize the users.

People with Urinary Incontinence (UI) problems may not practice swimming nor use the hydrotherapy treatments, which is currently a physical therapy resource that has been increasingly used in the medical field as an extra resource to obtain a faster recovery in skeletal-muscular diseases. The movement in the water is accomplished more easily than outside water. The effects of turbulence and buoyancy, combined with the heat, help reduce muscle spasm and pain, promoting relaxation. In addition, hydrotherapy provides joy and pleasure which enhances confidence and self-esteem of the patient, making these complementary aspects of the rehabilitation program.

The swimsuits have evolved significantly over time. Initially they were made from raw materials such as wool and cotton knits that provided discomfort due to activities such as swimming and even bathing in the sea or pool. Today the materials have evolved and are continuously evolving, there are many advancements for competition swimsuits where technology applied to swimsuits manufacturing aims to provide the lowest rubbing between the fabric and the water, improving athletic performance [4].

In the 1950s arises the fabric Helanca, and then in 1958 Lycra (spandex trade name), materials were created by DuPont in order to replace the thick and heavy fabrics used for swimsuits. And the most popular fabrics in the swimwear market are today blends of spandex and polyamide, which contains good properties of elasticity, comfort, durability and drying [5].

This research aims the conceiving and designing of a swimsuit for people who suffer from urinary incontinence, in the way they don’t feel stigmatized. The objective is to create a swimsuit that absorves the urine without leaking with the pool water, using the proper textile materials. In a way the users feel confident and confortable to practice their activities in water without worrying of their problem.

2. METHOD

To approach and solve this problem this research starts by a study and characterization of Urinary Incontinence, which will assist in defining the technical, aesthetic and functional characteristics of the swimsuit. It was also conducted a market study about the products available on the market for incontinent people , also regular swimsuits, as well as study some technologies applied to the manufacturing of sportswear such as cycling, diving, surfing, etc..

The main objective of this work is to create a swimsuit which is able to absorve the urine without allowing to mix or leaking from the swimsuit to water. The first part of this work is to develop the swimsuits concept to a female target, and later to be extended to the male target audience. This product in addition to fulfilling its fundamental function (watertightness) also has to have some aesthetic appeal. This study is not concluded and this paper is the first conception of the product design.

The study includes the choice of raw materials most suitable to be used in different layers and parts of the swimsuit:

• Absorbent materials and fabrics that are in contact with the body
• Materials that act as watertight barrier
• Materials to be used in the outside layer of swimsuit
• Sealing materials of liquid for the junction zones terminals in the legs and waist

3. RESULTS

For the swimsuit design the first proposal is the one presented in figure 1. The main fabric material (outlayer) for the swimsuit is 80% Polyamide and 20% Spandex, as it is a good material for swimwear and beachwear with flexible propertites, durability, comfort, and allows the implementation of the PTFE membrane applied at the bottom of the swimsuit until the cutout waist. All seams are welded by thermo welding in order to block entry or leakage of water in areas of the legs and waist.

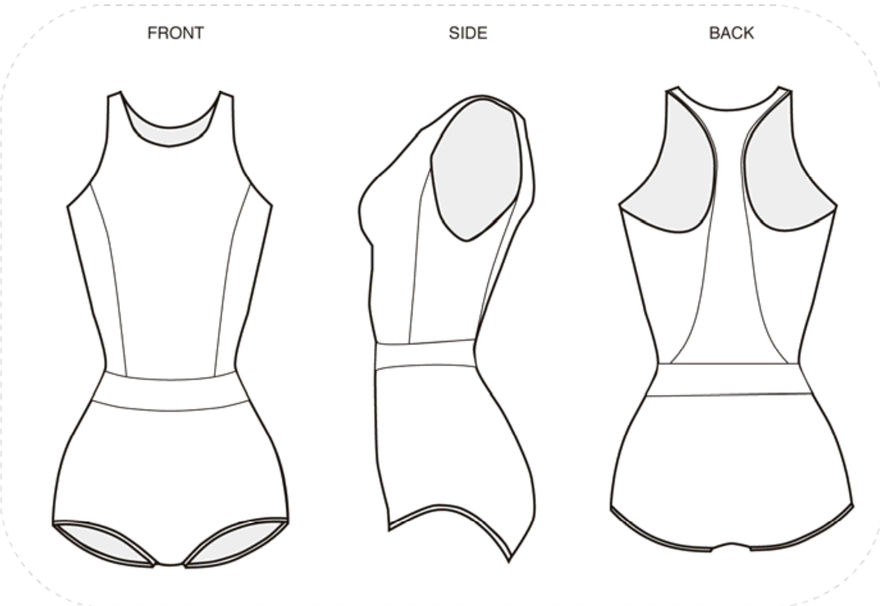

Figure 1: Proposal of swimsuit design and the front, side and back view technical drawings

The first layer or the fabric in contact with skin made with absorbent material 100% polyester microfiber with three absorbent layers as shows figure 2 c) and d), which are widely used in reusable diapers because has great absorbent features and durability. Also an application of silver nitrons with antibacterial effect and anti odors, through plasma and coated bamboo cotton fabric, it is an absorbent material, in addition provides a good touch, which is pleasant because it is in direct contact with the skin.
The watertight barrier layer is a membrane laminated to the main fabric and will not allow the output of liquids as an invisible membrane applied the third layer. It is applied just on the bottom part of the suit until the waist cut as shows on figure 2 e) because is the part that can not leak. This membrane is like GoreTex, hydrophobic and breathable, is made of polytetrafluoroethylene (PTFE) which is similar to the chemical composition of Teflon and is punctuated with microscopic holes. These perforations are about 20,000 times smaller than a drop of water, and higher than the vapor molecules of water, and in this way allows perspiration. It can be applied to almost all types of tissues, and the membrane also prevents the entry of bacteria [6].

Finally, the material for liquids sealing will be the application of a silicone band gripper on the areas of junction terminals waist and legs as shows image 2 a), it is the way of blocking the entry of water from the pool it prevents the liquids mixing. As studied in the cycling suits, it has a silicone gripper around the leg as a security to keep the shorts in place, and a small tension around the legs and waist to prevent leaks. The finishes have silicone water repellency and flexibility [7]

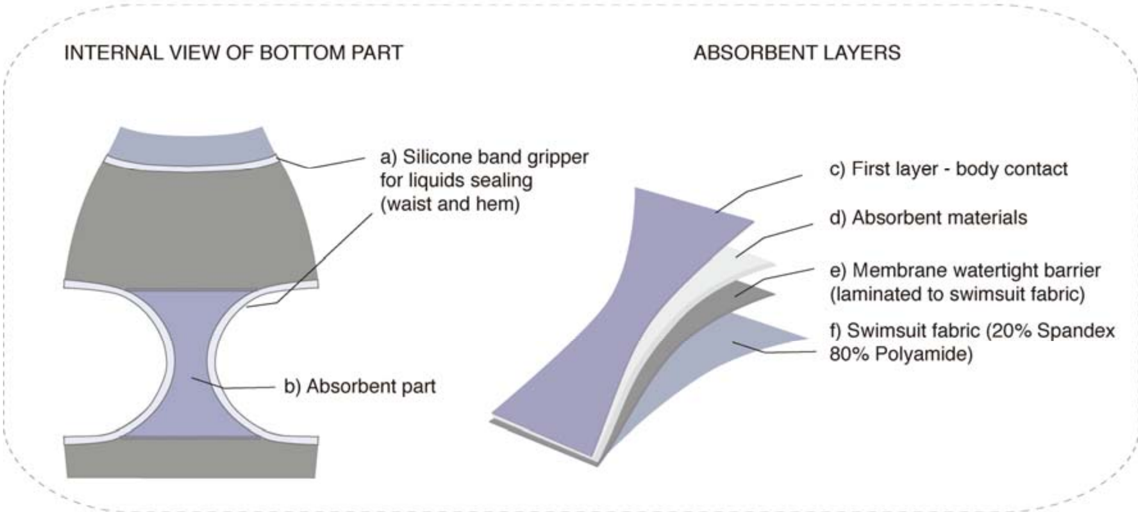

Figure 2: Internal view of bottom part of swimsuit and absorbent layers

4. CONCLUSIONS

For the sucess of this study, its importance to ensure that people suffering from urinary incontinence can be able to practice water sports and activities in water without having to worry about their problem, feeling more secure and confident.

Today new technologies in textiles making, coatings and finishing can be used for various applications. This study involves the stages of design and development of new products, as well as the study of textile and applied technologies.

This study is being developed, and for the future perspectives, it will be tested with patients who suffer from urinary incontinence to validate the final product, not only in terms of evaluating its performance but also its comfort properties in both physically and psychologically level.

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CONSIDERATIONS REGARDING THE MANUFACTURING PROCESS OF PROTECTIVE PRODUCTS MADE FROM SPECIAL MATERIALS

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Abstract: *Protective clothes are designed to allow the worker to do all the needed movements according to the type of work, with maximal amplitude but with minimal energy consumption. The dressed body must be in thermal equilibrium with the environmental conditions in order to be able to meet the physical requirements of the job.*
For this reason, the materials used in manufacturing protective clothing must have a minimal bending stiffness and maximal elasticity, because the effort needed to overcome the resistance of this kind of clothing is not supposed to cause exhaustion (additional fatigue) to the worker. Also, the garment structure must allow the transfer of toxin and humidity excess in order to ensure hygienic conditions for the human body. The appearance and use of materials with special membranes in the manufacturing process of personal protective clothes offers a solution to some of the problems mentioned above and some considerations concerning these aspects are presented in this paper.

Keywords: *environmental conditions, comfort, membrane, protective clothes*

INTRODUCTION

The main purpose of the functional designing process of a garment is a good simulation of the mechanisms which control the level of the human body functions (from a general point of view) and the specific skin mechanisms (from a particular point of view). For protective clothes or individual protective clothes it is important to extend these functions, to diversify them or to add new ones in order to protect the body. In the first instance, the usual functions (which allow the adaptation of the body to a normal environment) are simulated in a passive way, by using the properties of the textile layers.

Nowadays, in a working environment, the types of factors are very different one from another and for this reason, the individual protective clothes must fulfil special protective requirements, which the body cannot meet by itself. The environmental conditions (low temperatures, heat, rain, wind) influence the body balance, its comfort, regulation mechanism, health condition, etc. and so for a good comfort it is necessary to reduce or eliminate these negative influences by using proper clothes with an adequate structure.
The development of a new type of fibres or materials offers the possibility of improving the protective clothes properties and of reducing the influence of the environmental factors on the body.

The new materials with membrane are frequently used to manufacture protective or casual clothes because these materials have special properties, such as:
-Waterproof, so that no water penetrates the garment under rain or snow conditions.
-Windproof, to protect the body against low temperatures.
-Breathable, i.e. the perspiration is channelled out as water vapour, while the skin is able to breathe.

Furthermore, the functional and/ protective clothing is expected to be fashionable nowadays, a requirement which is not difficult to meet though, as the inner membranes provide invisible protection against the weather, allowing the outer fabric to be designed in the desired manner.
The characteristics and properties of the membranes vary in basic, lining or interlining material.

The hydrophilic membrane **Sympatex** is made of polyester and has no pores. Waterproofing against moisture from the outside is achieved by using a closed surface. The moisture-absorbing molecules transfer the perspiration outwards. The temperature difference between the body and the outer air ensures that the process takes place in the desired manner.

Gore-Tex is a microporous membrane made from a synthetic material, such as Teflon (polytetrafluroethylene). Gore-Tex is microporous with around 1.4 billion microscopic openings in each single square centimetre. They prevent the moisture from the outside (rain or snow) from permeating inwards, because a drop of water is 20,000 times larger than the membrane openings. However, the water vapour particles are much smaller than these openings. Therefore, the perspiration evaporating from the skin in the form of water vapour can easily permeate through the pores.

Furtech is a membrane garment which acts like a waterproof skin. The problem is that the membrane stops breathing when it is chilled, trapping liquid water inside. This leaves you cold and damp and your membrane clothing system dries slowly. Animals do not wear their skin on the outside because their fur or feathers have unique properties that prevent water from getting in while allowing water vapour to escape. Fur Technology continues to breathe in persistent wet weather and dries incredibly fast.

eVent fabrics are patented as a waterproof membrane. Its unique composition allows millions of tiny pores to breathe at their full potential. Sweat vents directly to the outside of the fabric in one easy step. eVent fabrics simply let the sweat out. Most common waterproof/ breathable technologies do not literally "breathe". Instead, they move sweat in two slow steps by a process of diffusion through a Polyurethane (PU) layer. In the first step, the perspiration is condensed and absorbed into the PU layer on the inside of the fabric. Because PU absorbs and retains perspiration, the inside of the fabric becomes wet. Then, the body heat begins to push that dampness towards the outside of the fabric where it can finally evaporate - a very inefficient process.

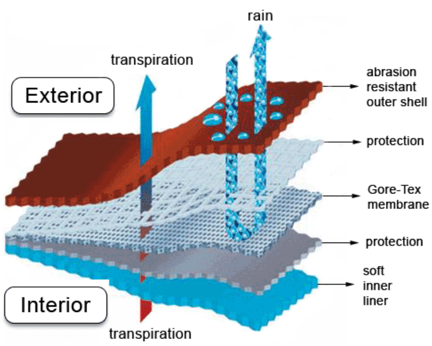
Lowe Alpine Triple point® XL is a durable, waterproof, windproof and very breathable membrane. Triple point fabrics are guaranteed to keep bodies dry and comfortable. Triple point® XL uses an advanced combination of outer face fabrics, barrier membranes and liner technologies to provide the best balance of waterproof/ breathable performance for garment use. 3-layer version has three layers laminated together for a maximal durability. 2-layer versions have an internal mesh or hanging fabric liner to protect the membrane.

Schoeller c_change is a wind and waterproof membrane that independently reacts to changing temperatures and activities. As a result, this membrane always ensures a pleasant body climate. In fact, it copies the similar effect of a fir cone opening and closing in response to different weather conditions. The c_change™-membrane reacts to different prevailing conditions. In doing so, not only the temperature but also the air and body moisture are well-balanced. At high temperatures or during aerobic activity, the structure of the c_change™-membrane opens as body moisture levels rise. The heat in excess can easily escape to the exterior. Due to the lower level of body moisture development in cold weather or during inactive periods, the structure of the membrane condenses, retaining the heat directly on the body. Shivering and chilling are effectively prevented.

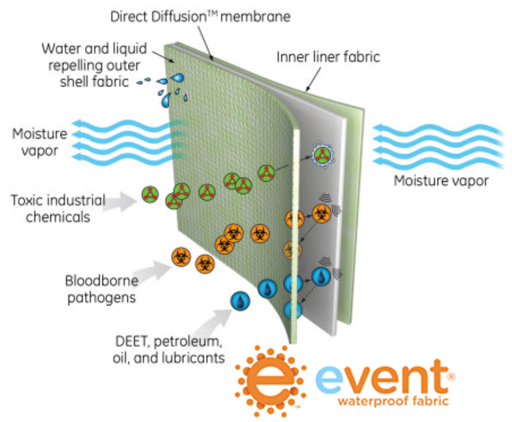
CONTENT

Clothing equipped with such types of membranes provides good protection against the weather, rejecting both wind and water. Membranes help to create a pleasant body climate, as they allow the perspiration to pass unhindered. Depending on the type of protection, different methods of processing the membranes are used.

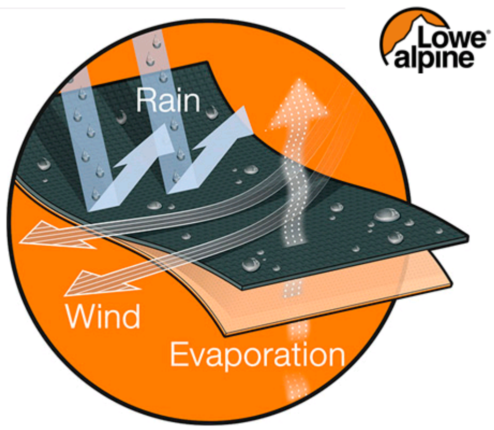
Sympatex Membrane



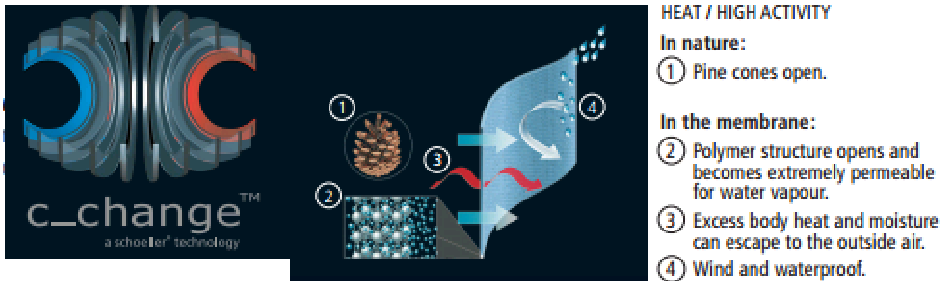
GORE-TEX membrane



eVent membane



Lowe Alpine Triple point® XL membrane



Schoeller c_change membrane

Figure 1: Examples of materials with membrane

These materials are used to manufacture different types of goods, such as: clothes (casual, sport or protective), boots, tents, seat belts, sleeping bags or different accessories.

Garments, which have layers with membranes in their structure, are more and more used in manufacturing protective clothes (for firefighters, for cold weather conditions, protective work wear, in the military field, golf clothing), footwear and accessories, as it is shown in figures 2 and 3.

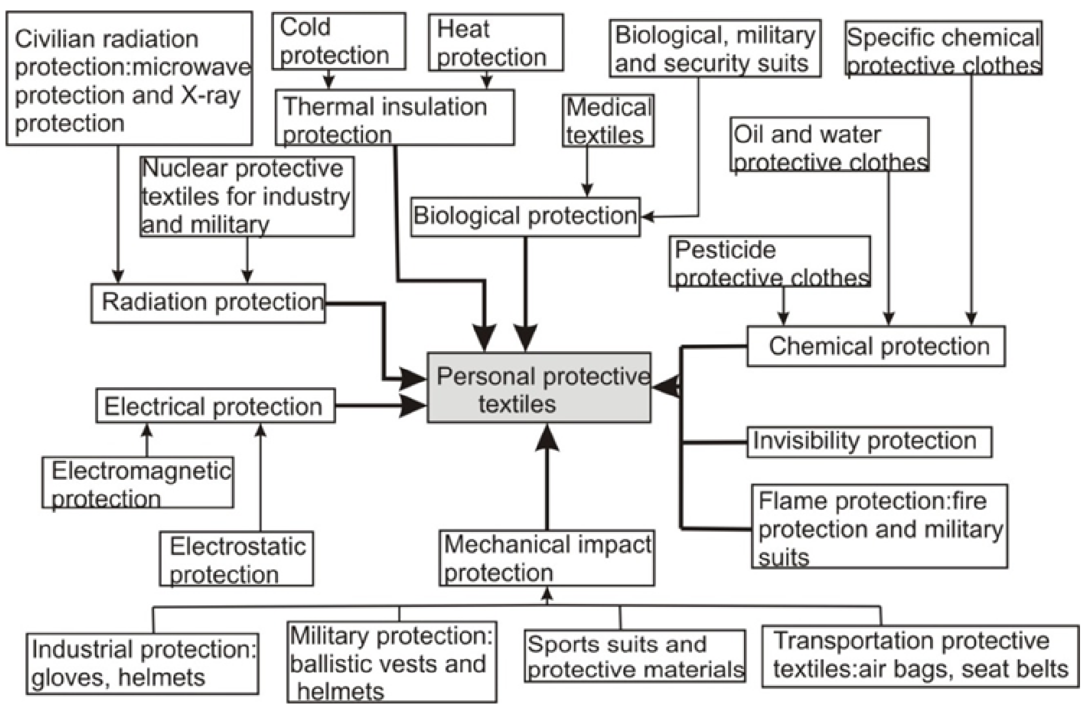


Figure 2: Protective textiles applications

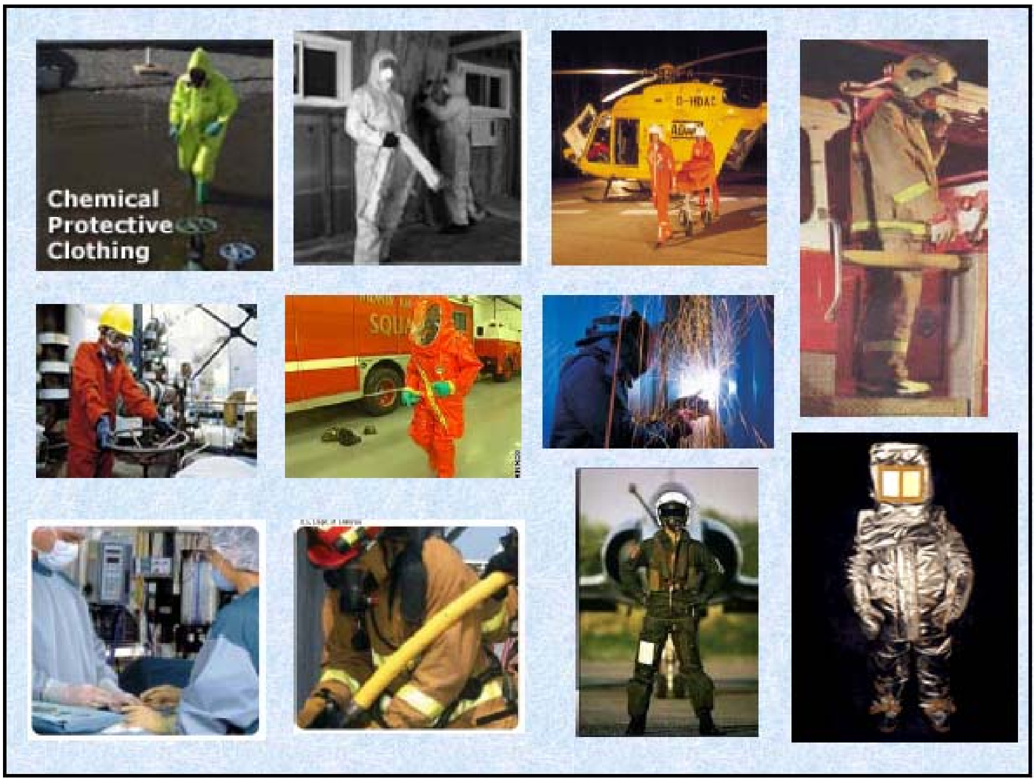


Figure 3: Protective clothes (examples)

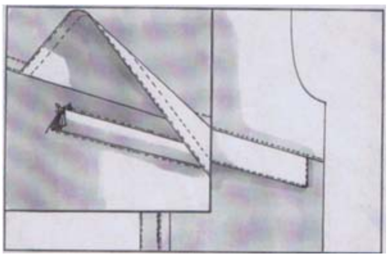
Garments that have membranes are easy to be taken care of, but it is necessary to provide them with particular treatment, as it is mentioned in their care instructions. When dry-cleaned, the presence of a membrane should be pointed out, so that no damage could be caused by the attachment of the tag. Membranes are very thin and can be combined with any fashionable outer fabric.

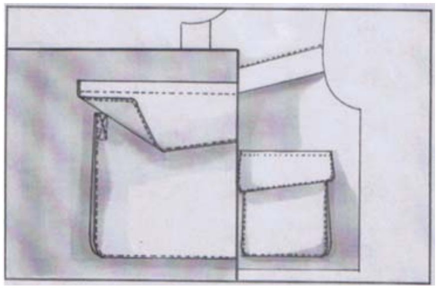
Garments made from technical fabrics require special technology for the manufacturing process. In general, these garments have several pieces or/ and several layers in their structure, depending on their destination. If the garment is designed for cold or wet weather conditions, the seam lines are sealed, in order to cover the tiny holes made by needles during the sewing process. In spite of the fact that these holes are small, they can still cause leaks. The tape type is chosen according to the membrane type in order to ensure the compatibility with the fabrics and the durability of the seam properties: waterproofness, breathability or windproofness.

Figure 4: Seam sealing

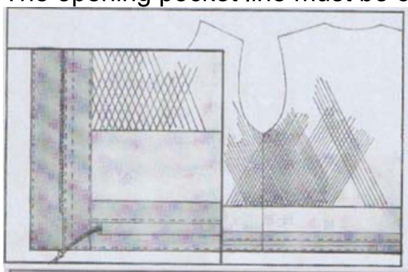
To make sure that the clothing remains wind and waterproof, the leading membranes manufacturers provide the clothing manufacturers with the most detailed instructions regarding the processing requirements: the opening line of pockets or the opening system must be covered in such a way that neither wind nor water can permeate (table 1).

Table 1: Technological indications

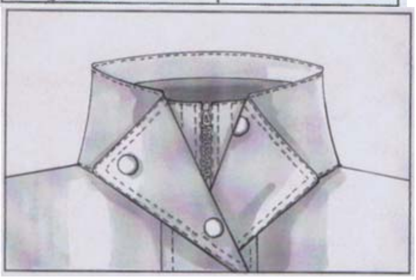


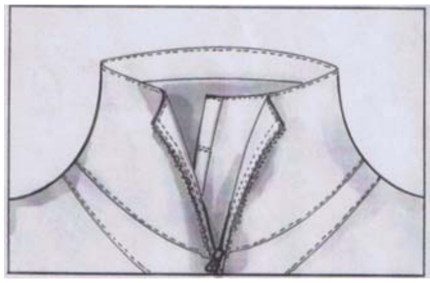


The opening pocket line must be covered



The sewing line between the lining and the outer fabric must be placed above the hem garment line.





For a closing system with zip, it is necessary to use different shapes of the vent in order to protect the body from wind or water.

Breathable fabrics represent one of the major components of individual protective clothing used under high altitude conditions. The technical excellence and comfort aspects of these fabrics have enhanced the combat efficiency of the army personnel working under extreme cold weather conditions. Fabrics having waterproof, windproof and water vapour permeable characteristics are commonly referred to as *breathable* fabrics.

When designing protective clothes for *cold weather conditions,* we must consider several important factors: hypothermia (caused by the exposure to low temperatures), rheumatism and bronchitis, cold metal injury, mechanical risk factors from the environment, the time spent in this kind of environment, etc.

The thermo- physiological comfort is a complex phenomenon which is related to the thermodynamic and moisture transfer between the human body and the clothing. The heat balance of the system depends on the skin, on the clothing and on the amount of air entrapped between them. This heat balance varies with any alteration in the wind velocity, atmospheric temperature (external factor) or in the activity of the individual (internal factor), causing changes in the heat and moisture production of the body. The individual will feel comfortable as long as the amount of heat supplied to the body-clothing system is equal to the amount of the one which is removed from it.

On these terms, for a cloth to be worn under cold weather conditions it is necessary to make some measurements: thermal insulation, evaporative resistance, wind resistance, water resistance, air permeability, etc.

This research is focused on analysing the connection between the garment thickness, the air resistance and the air permeability for clothes that protect the body in a cold environment.

This experiment was done under the following conditions:

The tested structures have similar properties under laboratory conditions as under real ones.
The values of the air resistance and of the air permeability are close one to another for the clothes which have one layer of Sympatex or Gore- Tex membrane.

Figure 5 : Protective garment for cold weather

Table 2: Experimental values for air resistance and air permeability for cold protective clothes

Type of variant	Garment thickness $\delta*10^{-3}$ [m]	Air resistance $-R_a$ [m^2h mm/kg]		Air permeability $-P_a$ [m^3/min m^2]	
		Classic	Membrane	Classic	Membrane
A	4.85	0.035	0.1441	1.9	0.456
B	5	0.037	0.1485	1.88	0.45
C	4.9	0.035	0.1456	1.91	0.461
D	4.52	0.034	0.1343	2.15	0.48
E	3.9	0.032	0.1158	2.5	0.52
F	3.5	0.03	0.104	2.6	0.55
G	5.5	0.039	0.1634	1.5	0.41
H	6	0.042	0.1788	1.2	0.38
I	6.2	0.043	0.1842	1.0	0.36
J	6.5	0.044	0.1931	0.8	0.347

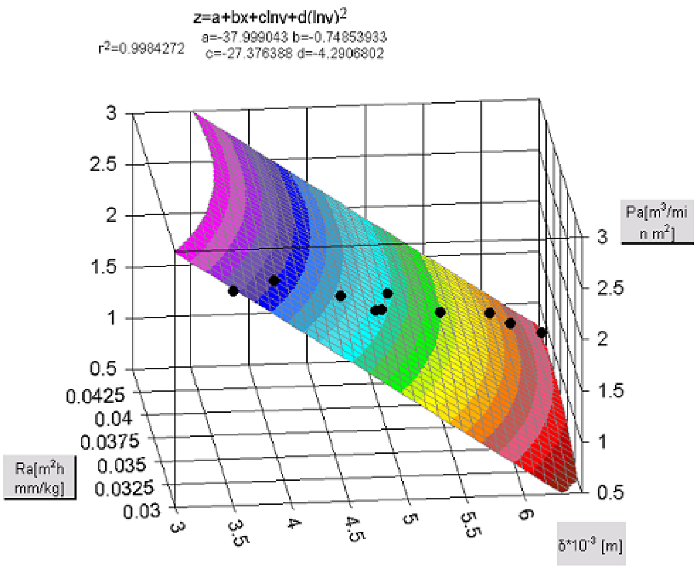


Figure 6: The dependence of the air permeability on the garment thickness and air resistance (classic variant)

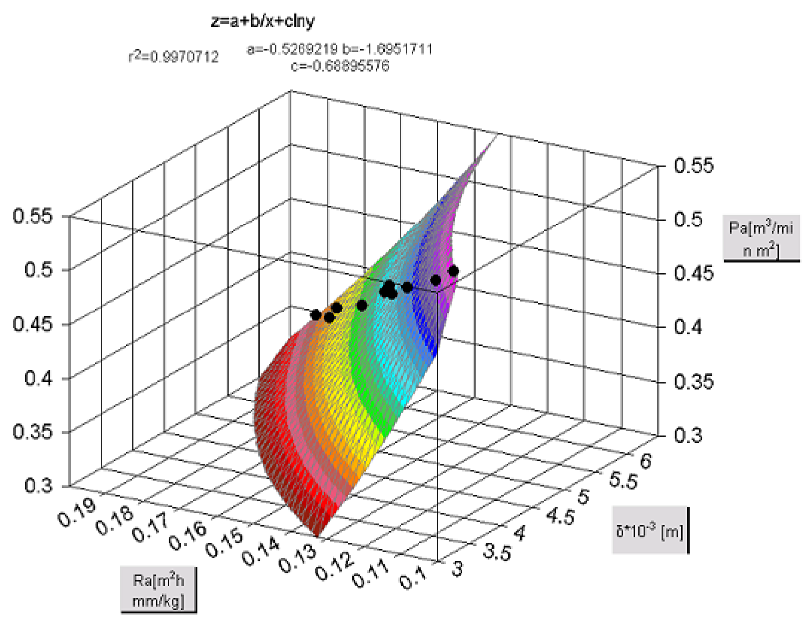


Figure 7: The dependence of the air permeability on the garment thickness and air resistance (membrane variant)

Analysing the values from the table 2, the conclusions are:

- The air permeability and air resistance are influenced by the garment structure (the type of the layers and thickness);
- When the thickness of the garment increases, so do the values of the air resistance (in the classic variant). We notice that the variation interval of the classic variant is shorter than in the case of the membrane one. The air resistance achieves higher values for a garment structure with membranes instead of a classic one;
- The values of the air permeability increase from variant A to F (variant B is an exception) and after that, the values decrease. As a matter of fact, we can say that if there are more layers in a garment structure, these layers do not have an important influence on the comfort conditions. The garment can be very heavy and it will apply more pressure on the body or it will limit its mobility and after a while a fatigue sensation and discomfort state are possible to appear;
- The values of the air permeability of the traditional variants are higher than the ones achieved in the case of the membrane ones. Under cold weather conditions it is recommended to wear clothes which do not permit the cold air from the outside to make contact with the human body;
- We can easily notice that the last case (J) has an optimal air resistance value and the lowest value of the air permeability.
- The dependence of the air permeability on the garment thickness and air resistance is negative (figures 6 and 7). When the values of the garment thickness and the air resistance increase, the values of the air permeability decrease (in both classic and membrane variants).

When we decide upon the layer structure of a garment which is meant to be worn under cold weather conditions, we must take into account that:

-The outer layer should provide adequate resistance against wind penetration and it should be water vapour permeable;

-The next-to-skin layer of the garment should wick the liquid perspiration away from the body rapidly;

-The middle layer(s) should provide the main insulation. The body heat should be reflected back by using an inner reflective layer.

CONCLUSIONS

Not only does the theoretical and experimental research conducted in this paper (on materials with membrane) underline the fact that they improve the quality of the product and ensure better comfort conditions, but it also highlights some special manufacturing stages or solutions needed to implement. This research is necessary to be continued on protective clothes manufactured with materials which have 2 or 3

membrane layers, in order to decide which combination is suitable for each kind of environmental conditions (wind, humidity and cold weather).
Among the contributing factors responsible for the successful marketing of such products we can mention the advances in polymer technology and in the sophisticated structures manufacturing techniques (of fibres, yarns and fabrics). The improved fibre spinning techniques such as the melt spinning, the wet spinning, the dry spinning and new techniques like the gel spinning, the bi-component spinning, the microfiber spinning, have made it possible to produce fibres with more suitable characteristics for use in protective clothing.
Many of the requirements of the protective clothing aim at solving a set of problems such as:

-Improved protection→ against the environment
-Maintenance of the thermo-physiological comfort → or survival in extreme conditions.
-Improved compatibility → between and within different components in the clothing ensemble.
-Reduction in weight and bulk → especially load carriage systems and ballistic protective clothing.
-Integration of the clothing items → in which the clothing items are considered parts of a multi-role system.
-Reduction of the life cycle costs → future systems may be more expensive, but more effective, durable, may consist of fewer components and could also be recyclable.

The development of new technologies and the new achievements in the protective garment field offer the possibility to diversify the products and to improve their properties.

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Scholarly communication paper

EFFECTS OF ELECTROMAGNETIC FIELDS ON HUMAN BODY

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Abstract: *The paper presents the need of the human body protection against electromagnetic fields. The biological effects and health implications of exposure to electromagnetic radiations have been under investigation for more years by various researchers in many countries. The biological effects of microwave radiation were studied and can be divided into two major categories: thermal effects where the microwave energy is converted into heat in the living organism, and non-thermal effects. The main symptoms caused by the electromagnetic radiations are cardiovascular disorders and tachycardia, visual disturbances, allergies, sleep disorders, fatigue, migraines, obesity. Therefore, the human exposure to various electromagnetic radiations can have negatives effects on health. In order to overcome the above mentioned inconveniences different textile structures are used for electromagnetic protection; some of these structures for shielding purpose are also reported in the study.*

Keywords: *electromagnetic fields, microwave radiation, biological effects, textile materials, electromagnetic shielding.*

1. INTRODUCTION

This paper presents the need of protection from electromagnetic fields (EMF) which have harmful effects on human body. Growing technology, the life style and the increasing demands of people made the electronic devices indispensable parts of our daily lives. These devices raise electromagnetic fields in different frequency bands. Electromagnetic fields can be described as a series of waves that oscillate at a particular frequency and have a certain distance between one wave and the next – the wavelength [1]. There are natural sources of EMFs such as the magnetic field of the Earth and sunlight that contains visible, infrared and ultraviolet frequencies. There are also many man-made sources such as microwave ovens, hairdryers, electric wirings in the house, remote control devices, computer screens, industrial electric furnaces, electric motors and especially wireless networks like Wi-Fi and Bluetooth [1, 2].
Today, the negative impact of the electromagnetic field on humans is a controversial, scientific, technical and often public issue. The biological effects and health implications of exposure to electromagnetic radiation have been under investigation by various researchers in many countries for years. The long-term exposure to electromagnetic waves can seriously damage a person's health. Problems may range from headache to fatigue, dizziness and memory loss to miscarriage, leukaemia and cancer [3]. Feychting and Ahlbom have performed spot measurements inside houses showing the effect of electromagnetic fields produced by the distribution lines and pointed out the proportional increase of the risk of leukaemia depending on electromagnetic field intensity [4].
Thus, the studies have begun to focus on preventing and attenuating these problems. Also, textile researchers have begun to make studies about fabrics having electromagnetic shielding properties. Therefore, shielding is important to block electromagnetic radiation that could be harmful to electronic devices, environment and especially to human body.

2. CLASSIFICATION OF ELECTROMAGNETIC WAVES

A review of the scientific literature relating to the link between electromagnetic fields and human health are presented for consideration [5]. Electromagnetic fields are characterized by their oscillation frequencies, measured in hertz. EMFs are all around us and in everyday life we are exposed to EMFs from a variety of sources.

EMFs have a very wide range of frequencies, extending from low frequency electricity supply lines with wavelengths of some hundreds of meters, through the radio and visible light frequencies, to very high-frequency medical X-rays with wavelengths measured in trillionths of a meter. This range is shown in the electromagnetic spectrum in Figure1.

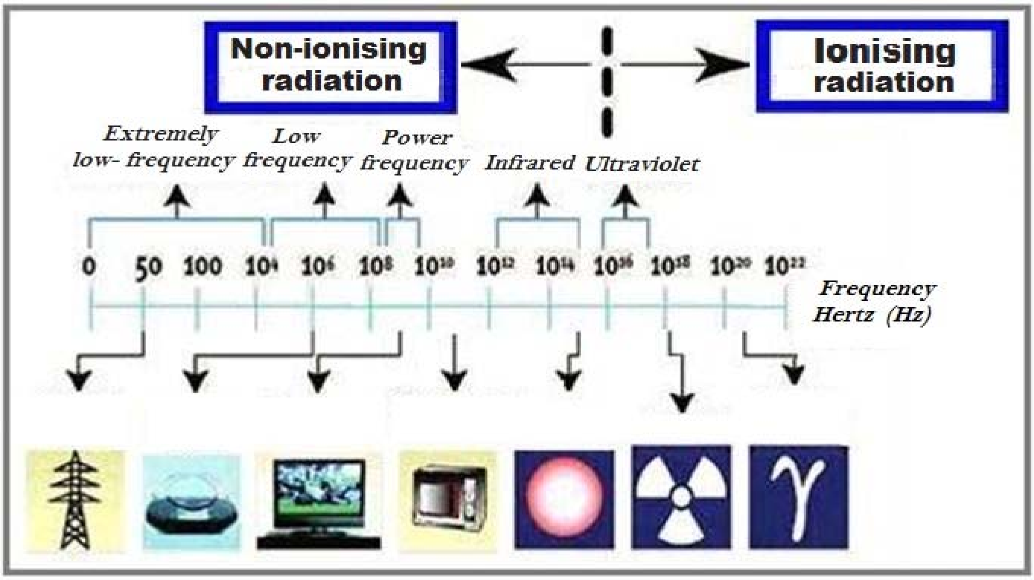

Figure 1: The electromagnetic spectrum

How these EMFs interact with biological organisms depends on their energy and frequency. The 'ionising' radiation is called so because the individual waves can break the chemical bonds between atoms to produce ions. Non-ionising radiation cannot break chemical bonds; however, it does interact in other ways and, in particular, it can create a heating effect in materials if it carries enough energy.
The fastest growing source of exposure to EMFs is communications, in particular mobile telephony. A major problem is that the effects can be cumulative and they build up in the body over time [6].
Studies at the cellular level, which uses relatively higher frequencies, demonstrate undesirable effects. In recent years there are a lot of studies about effects of EMF on cellular level; DNA, RNA molecules, some proteins, and hormones, intracellular free radicals, and ions are shown. Epidemiologic evidence compiled in the past ten years starts to indicate an increased risk, in particular for brain tumour, as a consequence of the excessive use of mobile phones [7].

2.1 Possible harmful effects of Electromagnetic Fields (EMF) on human health

When the pineal gland is stressed, melatonin levels go down, and the first thing that occurs is sleep problems. It may be an indirect consequence of EMF's because they put stress on the body and reduce the immune system's ability to deal normally with abnormal cell growth [8].
Multiple studies correlate RF exposure with diseases such as cancer, neurological disease, reproductive disorders, immune dysfunction, and electromagnetic hypersensitivity. However, the effects of non-ionizing radiation on human health have been recently noticed. Discussions and researches of non-ionizing radiation effects have focused on the thermal and non-thermal ones. However, many epidemiological studies in vitro and in vivo demonstrate that significant harmful biological effects occur from non-thermal RF exposure and satisfy Hill's criteria of causality. Genetic damage, reproductive defects, cancer, neurological degeneration and nervous system dysfunction, immune system dysfunction, cognitive effects, protein and peptide damage, kidney damage, and developmental effects have all been reported in the scientific literature [9, 10].
Much of this research is linked with the 'genotoxicity' of extremely low field and radio frequency-electromagnetic field of electricity power lines and mobile telephones respectively. A genotoxic is an agent that can damage DNA and possibly lead to cancer.
The main researches in this field are: in vitro research which is based on laboratory experiments using biological materials, for example, cell cultures; in vivo research which is performed on living organisms, such as rats or humans. These experimental approaches are completed by epidemiological research that uses surveys and statistics to investigate the occurrence of disease and its relation to environmental factors [6].
Some examples of research projects for this purpose are: Reflex, Cemfec, Interphone, Guard, and Perform-A [6].

The Reflex project studied how low-energy EMF interacts directly with biological materials in the laboratory (in vitro). The researchers showed that exposing cells to ELF and RF electromagnetic fields could cause DNA to break apart, thus affecting the way in which cells develop. According to the Reflex project electromagnetic fields from mobile phones causes DNA modification, which increases the risk of genetic mutation.
Other results show that electromagnetic fields penetrate the living tissues. Experiments made by Dr. Hans Hertel and Dr. Bernard Blanc revealed that microwaves destroy the nutritional quality of food. They also measured pathological changes in the blood of volunteers who consumed food produced in the microwave.
The results of the Cemfec project supports many of the other animal-based studies published so far and showed that exposure to the weak RF-EMF typical of mobile telephones does not have a carcinogenic effect.
The results of the Interphone project showed no increase of the incidence of brain tumours and acoustic neuromas due to mobile-phone use. The number of cases who were long-term users was, however, very small. Extensive research has been conducted regarding possible health effects of exposure to low intensity RF fields. This research has investigated a variety of possible effects and has included epidemiological, in vivo, and in vitro research. The overall epidemiologic evidence suggests that mobile phone use of less than 10 years does not pose any increased risk of brain tumour or acoustic neuroma [11, 12]. Currently available studies on neurological effects and reproductive effects have not indicated any health risks at exposure levels below guidelines.
Data on long term exposure and intracranial tumours are still sparse and in particular for acoustic neuroma some data indicate that an association with RF fields from mobile telephony is possible. For diseases other than cancer, very little epidemiologic data are available. A particular consideration is mobile phone use by children. While no specific evidence exists, there is a general concern that children or adolescents may be more sensitive to RF field exposure than adults.
Regarding ELF fields epidemiological results indicated that exposure to ELF fields might be a cause of childhood leukaemia. For some other diseases, notably breast cancer and cardiovascular diseases, the latest researches indicated that an association is unlikely. A relation between ELF fields and symptoms has not been demonstrated. Extremely low-frequency magnetic fields are possibly carcinogenic to humans and classifiable as Group 2B by International Agency for Research on Cancer (IARC). The previous conclusion that ELF magnetic fields are possibly carcinogenic, based on occurrence of childhood leukaemia, is still valid. For cardiovascular disease, recent researches indicated that an association is unlikely. For neurodegenerative diseases and brain tumours, the connection with ELF fields remains uncertain. No consistent connection between ELF fields and self-reported symptoms (sometimes referred to as electrical hypersensitivity) has been demonstrated [8, 13].

3. TEXTILE STRUCTURES FOR ELECTROMAGNETIC PROTECTION

The problem of protection against electromagnetic radiation has a very important technical aspect concerning a reduction in the level of electromagnetic interference (EMI) that occurs between electronic instruments. Furthermore, an even more important aspect of protection against EMR is the health protection of persons present in the vicinity of equipment emitting EMR and exposed to its prolonged effects. This has increased the interest in developing effective materials for EMR shielding [14].
In recent years a variety of composite structures, textile materials with shielding properties was investigated. Various approaches have been observed to prepare textile materials as electromagnetic shield. Conventionally metallic fibres were used in yarn and fabrics and afterwards metal coating was applied to textile materials. Afterwards, conductive particles such as copper, silver or even carbon particles were also applied to the textile material. Conductive polymers such as polyacetylene, polypyrrole, polyaniline etc. are applied to the textile materials and hence prepared composites structures which showed satisfactory results for electromagnetic protection [15].
The study made by R. Perumalraja et al shows that copper wires were selected as conductive filler to produce copper core yarns to make woven fabric for electromagnetic shielding. The electromagnetic shielding effectiveness of these fabrics was measured in the frequency range of 20–18,000 MHz. With an increase in the number of conductive fabric layers, finer yarn count, warp density, weft density and cover factors, an increase in shielding effectiveness was observed. With an increase in copper wire diameter, a decrease in shielding effectiveness was reported [16].
D. Soyaslana*, S. Çömlekçib & Ö. Göktepec [17] investigated the electromagnetic shielding effectiveness of some weft knitted structures. Four knitted structures (plain knitting, weft in-laid plain knitting, 1X1 rib, and weft in-laid 1X1 rib) were developed by incorporating conductive yarns (copper wire/cotton yarns). Measurements were made in the frequency range of 27 MHz–3 GHz and test results show that weft-knitted structures investigated in this study have 10–40 dB shielding effectiveness under the frequency of 500 MHz.

Another study reports the results of an electromagnetic shielding effectiveness of woven hybrid fabrics with hybrid yarns (acrylic/stainless steel/SS and cotton/acrylic/SS yarns) in the 0-3000MHz frequency domain. The plain fabrics exhibited higher EMSE values (over 20dB) in higher frequencies compared to twill fabrics [18].
Flexible electromagnetic interference shield from polyaniline-TiO2 hybrid coated cotton fabric was developed and shielding efficiency of coated fabric was calculated; it had durable electrical conductivity and strength, with good electromagnetic interference shielding in S band region [19].
Nonwoven insulation panels containing copper wires with different intensity and length were designed to provide electromagnetic wave protection by using recycled textiles. The experimental results indicated that the variation in wire length and amount affects the electromagnetic (EM) shielding property. In particular, there is a big potential for electromagnetic shielding applications in wide bandwidth, such as 1125-2925 MHz [20]. In another study (Ortlek et al) [21], eight different fabric samples were produced using hybrid yarns containing stainless steel wire. The measurements were made in the frequency range of 30 MHz-9.93 GHz. The results showed that the investigated woven fabric samples have 25-65 dB electromagnetic shielding effectiveness for incident frequency. It was also shown that the direction, density and settlement type of conductive hybrid yarn in the fabric structure are important parameters affecting electromagnetic shielding characteristics of the woven fabrics.
Electromagnetic shielding values of various knitted structures were determined [22]; the measurements were made in the frequency range of 30 MHz-1.73 GHz. Test results showed that knitted fabrics investigated have 10-20 dB shielding effectiveness for incident frequency, and the structure type have an influence on the electromagnetic shielding effectiveness of the fabrics.
The literature indicates that electromagnetic shielding effectiveness (EMSE) of the specimens is compared considering yarn components, fabric structure, number of fabric layers, and reference signal power based on frequency changes. The parameters that have an impact on the EMSE values are: structure of specimens (woven or knitted), ratio of copper wire in the content of yarn, number of fabric layers, and reference dB value of generated signals. For example, thin yarns containing copper wire have higher EMSE comparing with specimens produced using thicker copper wire yarns. Double layer samples have better EMSE then the single layer ones. The attenuation level of the samples varies depending on the different reference (dBm) levels of generated signals [23].
Based on information from the literature cited [14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27] it can be noticed a large interest for research in the frequency domain of 1kHz-2000MHz with a shielding effectiveness around 35-40 dB, as is shown in Figure 2.

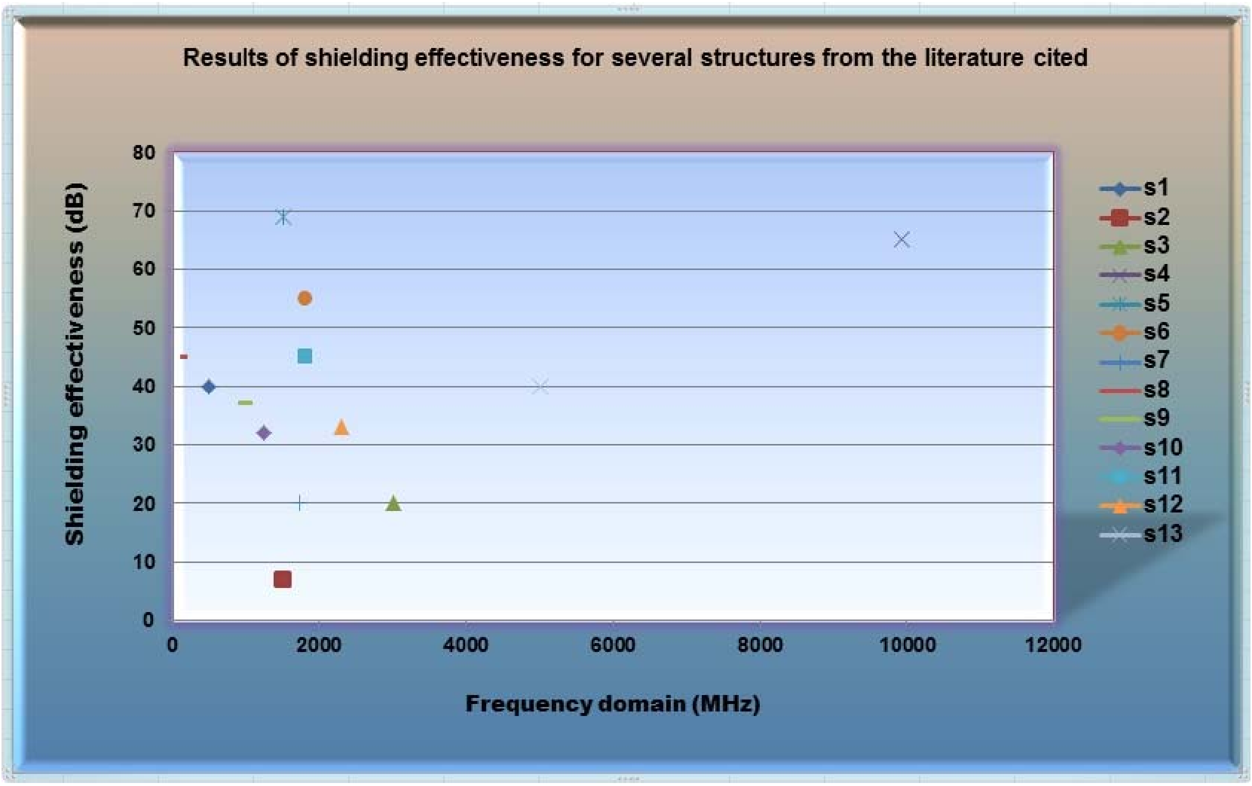

Figure 2: Results of shielding effectiveness for several structures according to the literature cited

CONCLUSIONS

The human exposure to various electromagnetic radiations can have negatives effects on health. A major problem is that the effects can be cumulative and they build up in the body over time [6]. When the pineal gland is stressed, melatonin levels go down, and the first thing that occurs is sleep problems. The studies have begun to focus on preventing and attenuating these problems. Due to the main mentioned and reported problems, textile researchers have begun to study and develop fabrics with electromagnetic shielding properties.
The main goals of their research are: to evaluate and implement different possibilities for electromagnetic shielding (new materials, composite structure, magnetic materials, other textile structures) and to develop a protective textile materials with absorbing properties, in order to protect the human body.

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Scholarly communication paper

COMPRESSIVE KNITTED FABRICS FOR SPECIAL DESTINATION

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Abstract: *Nowadays market demands are not interested so much for traditional clothes, so that there is a preoccupation for textile product development with other purposes than usual one. The specialists are interested for technical textile products parallel with the extended of their applications. It is known that knitted fabrics registered a special boom in these domains. The variety of their fields of use for knitted fabrics is in a strong correlation with the row materials, plain or spatial knitted shape, knitted structure, the type of the knitting machines, but not least its specific knitting and finishing process. The combinations of the specific weft or warp knitting technique represent a good modality for the knitted structure development correlated with the technological possibilities of the knitting machines. The domains of technical textile besides on textile for special destinations are characterised by complexity and diversity structure. The paper deals with the compressive knitted fabrics development for special destinations according with row materials and different fields of their applications.*

Keywords: *technical textiles, compressive fabrics, knitted structure, medical destination, special destination.*

1. INTRODUCTION

Market demands are not so much interested for usual clothes, but for technical textile which included different types of such kind of textile, besides on textile for special destinations, all of these being characterised by technological textile or finishing process complexity, diversity of row material type and structure and a lot of fields of their applications. In general we can say that the changes in textiles regard: consumer demands for comfort and performances, advanced technologies influencing product process innovations, compliance with eco, safety and health and aesthetics rules.
Textiles which are still growing passed through 3 development stages:

- functional textiles which are characterized through certain physical-mechanical and physical-chemical properties/characteristics as well as structure characteristics in accordance with use field;
- multifunctional textiles are characterized through a complex of characteristics/ properties which provide the ability of meeting certain multifunctional requirements to the textile support;
- smart textiles are used for creating new smart structures which can complete the following functions: detection, action and control. Innovation regarding the structure of smart textile for security and protection equipments can be stimulated through a unique set of economical, scientific, technological and human qualities based on knowledge.

The technical textiles [1] are defined as being textile products used especially for their functional characteristics, especially in high-tech purposes. In addition, the technical textiles are presented as textile structures especially designed to be used in products, processes or services from non-textile fields [2]
Although technical textiles, textile with special destination have drawn the attention in the last years, the utilization of fibres, yarns, knitted fabrics, woven fabrics for other applications than clothing, furniture, is not a new phenomenon; it is not even exclusively related to the apparition of modern man-made fibres and textiles. The evolution of industrial, technical and special textiles has a long history and generally, the production of the textiles is focused on new materials, processes and applications.

2. SMART TEXTILE

Smart textiles are defined as textiles that can sense and react to environmental conditions or stimulus, from mechanical, thermal, chemical, electrical, magnetic sources. Smart clothing is a combination of electronics and clothing textiles. New fibre and textile materials and miniaturized electronic components make it possible to create truly usable smart clothes. These intelligent clothes are worn like ordinary clothing providing help in various situations according to the designed application. Smart textiles are able to sense and respond to external stimulus in predetermined way.

According to functional activity smart textiles can be classified in three categories:

- passive smart textiles represent the first generations of smart textiles, which can only sense the environmental conditions or stimulus;
- active smart textiles are the second generation which has both actuators and sensors; active smart textiles are with shape memory chameleonic, water-resistant and vapours permeable, heat storage, thermo regulated, vapour absorbing, heat evolving fabric and electrically heated suits;
- Ultra or Very smart textiles are the third generation of smart textiles, which can sense, react and adopt themselves to environmental conditions or stimuli. A very smart or intelligent textile essentially consists of a unit, which works like the brain, with cognition, reasoning and activating capacities.

The different kind of smartness components can be incorporated in textile at during different stages of the technological process: at fibre spinning level, during row material formations (yarns or fabric textiles from different technologies), at finishing stage.
Smart or functional materials [3] usually form part of a smart system that has capability to sense its environment and respond to the external stimulus through an active control mechanism. Smart textile includes also ensembles with sensors and actuators.
Products including smart textile find their applications in many fields:

- clothing textiles, technical components of clothing and footwear;
- protective textiles, personal and property protection;
- sport textiles and textile for leisure time ;
- special textiles;
- home textiles (technical components of furniture, in/outdoor textiles and floor-coverings)
- medicine and hygiene textiles;
- technical textiles as building and construction textile, industrial textile (filtration, conveying, cleaning and other industrial uses), transportation textile, geotextiles for landscaping and civil engineering, automobiles, ships, railways and aerospace, agriculture, aquaculture, horticulture and forestry

3. KNITTED FABRICS FOR SPECIAL DESTINATIONS

Generally, textile products are: textile product for usual destination (clothes and underwear), technical textile, smart textile and textile for special destination
One of the most important special destinations, of the textile in general and particularly of the knitted fabrics, is referring to the compressive properties necessary in different applications in or out of our daily life.
Depending of their usage, there is different point of view which permitted us to present several variants of their classifications (A, B, C, D).

A. Compressive knitted product categories:
    - compressive products for generally used (special or not special destination)
    - particularly compressive product (depending on the particularly body locations)
    - compressive knitted socks
B. Compressive knitted product domains of application:
    - medical domain as non-invasive materials or knitted fabrics with different function;
    - sport activity;
    - quotidian life niches with their specific destination in use.
C. Function attributed to the compressive product allow their classification as:
    - preventive (in medical area, sport activity, leisure time, and other kind of activities)
    - prophylactic (in medical area, sport activity, leisure time, and other kind of activities)
    - protection (pregnancy or post-partum period, disability problems, post-operation, all day activities)
    - support (for person with oversize different body area, pregnancy or post-partum women, for person with different kind of disabilities, for person in all day activities, for person with healthy problem)
    - fashionable (in all situations)
    - post-operation (different healthy problem post-operation, post-partum sustainable, aesthetic operation)
    - compressive therapy (for different knitted fabric as clothes, lingerie or so called small knitted product like sock, gloves, for toes and fingers)
    - modelling of body shape (of any persons, for person with weight problems, post-partum period,)
    - thermal (post-operation, for person with peripheral blood circulation faulty, rheumatic problem, arthritis)
    - orthopaedic (in healthy aspects referring to diabetic, venous insufficiency, orthopaedic problems different body area, arthritis, rheumatic aspects, etc.)

D. Knitting machine and appropriate knitting technologies
- Weft knitting machines with specific technologies on:
  - circular knitting machines with large or small diameter
  - plain knitting machines
- Warp knitting machines and its specific technologies that permitted the realization of warp knitted structure which has a very good dimensional stability, similar with woven.

There are some important ideas to remember about compressive knitted products:

There are moments when the same type of compressive knitted product may be used for all destinations presented above: medical field, sport activity, quotidian life niches. For example sustainable belt can be used for: lumbar spine post operation or like a support for prenatal or postpartum periods or for modelling of body or people with some disabilities in lumbar spine zone or in sport for sustain lumbar zone;

in general, these compressive knitted fabrics are based on weft or warp knitted structure depending on their purpose in practical application. In these groups are also included the knitted fabric products that represent a technical, real and complex system which states modelling and optimization methods;

raw materials, the structure and the structure parameters, its characteristics and the technological parameters of the knitting process, the form obtained through knitting are elements that determine a specific behaviour of the knitted products and certain compulsory properties in connection with the destination, which has become more and more diverse;

functional design allows obtaining some fabrics with pre-established shapes, characteristics, in conformity with the destination taking into account the characteristics of the raw materials and of the approached structure;

knitting technology is especially flexible under the aspect of the fabric form, allowing obtaining the details with plan or spatial contouring, up to high degree products of assemblage through knitting and complete products

3.1 Compressive knitting garments for special destinations

Compressive products are non-invasive applications[4]. It is known a wide range of compressive knitted fabrics which has diverse purposes: preventive, prophylactic, protections, support, post-operation, compressive therapy, venous insufficiency, tired and aching leg, swollen feet, lymphatic disordes, accumulation of lactic acid in muscle etc. All these comopressive product combine therapeutic effiency, comfort, aesthetic and use rezistance.

Compressive bandages (figure 1.) are use efficiently in different part of the human body, there are consumable products, there is different kind of bandages and for them are chosen knitted structure for pressure characteristics.

Figure 1: Bandages applications

Elastic thermal underwear for women or man (Figure 2)are suitable for all those diseases where the local thermal therapy is required: arthritis, lumbago, muscle pain, colitis, inflammation of the kidneys, etc.These articles [5]are also indicated to prevent back and kidneys inflammation, resulting from long road trips, work with limited mobility and cold.The thermal effect is due to the high wool, acrylic yarn, same times angora also, elastane for compressive role and they are very comfortable for the presence of cotton in contact with skin. These articles also have the lumbar support effect due to an elastic incorporated support belt, and some products have a double fabric on the back.There are similary knitted product for both, women and man.

Figure 2: Thermal underwear for women and man

Orthopedic Wristband and Mitten (Figure 3) These articles are normally recommended for all cases where the immobilization of the hand articulation is required, after operation, in case of arthritis, after plaster bandages, during the rehabilitation period and for sport or leisure time inflammation. Deprnding on their applications there are adjustable or not orthopedic product.

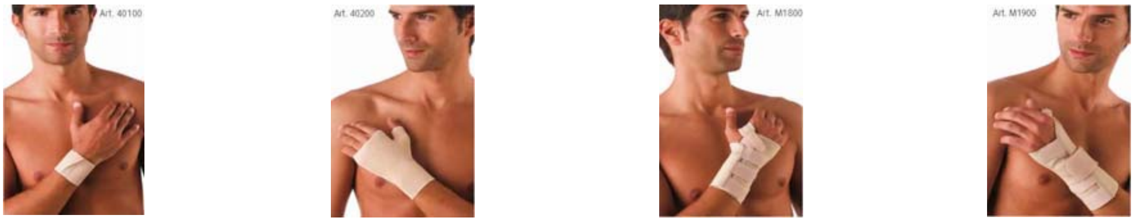

Figure 3: Orthopedic Wristband and Mitten

Tubular elastic knitted support bands for knees, ankles, calves and thighs are articles of the strong and extra strong classes of compression. These knitted products are indicated in all cases where fixation and the compression are required: after breaks, tendon and muscles tension, during rehabilitation period after plaster bandages with the immobilization of articulation, after operations.
This kind of articles use cottn yarns besides elastane (clasical compressive product), or have inside surface cotton yarns , which makes them hypoallergenic and ensures soft contact with the skin, there are very thin, (Figure 4)but also durable (besides cotton thei are knitting with nylon and elastane).

Figure 4: Tubular elastic knitted support

Elastic knitted fabric in sport field.
Compressive/Elastic knitted fabrics in sport domain are used for different purposes: preventive, protections, support in order to avoid accident at muscle, tendons or joint or in muscle, tendons or joint trauma. For this kind of purposes are used knitted fabrics similar with that medical produce (for upper limb, for legs, for dorsal or lumbar spine, compressive stocking) or knitted fabrics with special destinations (support belt for different part of the body, sports cradles) presented in Figure 1,2,3,4.
Compressive /Elastic knitted fabric for pregnancy woman or for post partum period in woman life (RelaxMaternity)or for persons with oversized abdominal area . This knitted fabrics reprresent a complete range of seamless underwear dedicated to all the pregnant women and new mothers who, in addition to looking for underwear that meets their specific needs, also demand quality, comfort and wellbeing.These

articles may have different role: aesthetical, maintenance figure, protective, sustainable, post operation. There are a voriour range of knitted product with this destinations, so there are: belts/girdle (prenatal belt, postnatal belt, post operation belt,belt for person with health problem,belt for person with oversized abdominal area, belt for modeling of body shapes, maintenance figure, aesthetic clothes belt, Belly Bend belt), panties belt (prenatal belt, postnatal belt, post operation belt, belt for person with health problem, belt for person with oversized abdominal area, belt for modeling of body shapes, maintenance figure), harness belt (prenatal harness belt, sport harness belt, post natal harness belt), maternity brief, maternity shorts, nursing bra, nursing or maternity vest top,

This kind of garments [5][7]has been specially designed to help women to face the physical changes that occur in pregnancy, and in particular to:

- help support the increasing weight of the parts of the body that are subject to increased volume;
- help contain the elongation of muscle, in order to preserve the natural elasticity of the skin;
- help prevent sagging of the skin and muscle tissue;
- distribute body weight properly in order to reduce fatigue and maintain good posture;
- regain muscle tone in the postpartum period;
- protect the skin, which becomes more sensitive and delicate in pregnancy, from friction and bacterial infections.

RelaxMaternity garments (figure 5) are made with advanced technology and offer for women maximum functionality, convenience and hygienic protection. There are known three kind of such knitted products, from row material [12] point of view: COTTON, SILVER and MILK, with a full range of briefs, bras and girdles, that models the body line, restrain and support the parts that inevitably grow during pregnancy and are overburdened by extra weight

The elasticised cotton gives each garment maximum softness, fit and stretch, gradually adapting to the changes in the size of the abdomen, breasts, and buttocks. The cotton fibres come into direct contact with skin to ensure an anti-allergic properties, breathable, sweat absorbing and sanitizing affect. The variable thickness of the fabric, along with support panels in the form of girdles, excellently perform their required function of containing and supporting, without compressing, while gently covering the different parts of the abdomen, buttocks and breasts

Antiseptic and antibacterial properties of silver have been known since ancient times and recent studies have confirmed that silver acts against most common bacteria. Thus knitted fabric with silver have the ability to protect the skin naturally from bacterial pathogens and the fermentation of sweat and milk secretions. These characteristics remain unaltered over time, even after repeated washing.

More importantly for pregnant women, it has been demonstrated that silver fibres act as a shield against the electromagnetic radiation emitted by mobile phones, radios and TVS: laboratory tests have shown that this fabrics fabric repels on average 98% of the electromagnetic waves to which we are commonly exposed.

Elasticity and seamless, extremely soft to the touch, this knitted product introduces the innovative use of a natural fibre derived from milk proteins, which, when it comes in contact with the skin, provides nourishment and hydration, making the skin smooth and soft. Its use is particularly appropriate to help minimise and reduce skin blemishes caused by the enlargement of the abdomen and breasts, which can result in the loss of tissue elasticity. Furthermore, MILK bio-fibre, thanks to its natural milk proteins, protect the skin from infections,

Figure 5: RelaxMaternity knitted garments

Orthopaedic Corsets and Belts

These [6] product (figure 6) are indicated for back and lumbar support, for hard work, for incorrect postures and after surgery. Line of belts for lumbar support, corsets and universal hernia-aids

Other products are knitted fabric for medical applications (figure 7):

- orthopaedic knitted produce/orthesis for different body zone, depending on the trauma positions: shoulder, arm, hand, finger, cervical spine, dorsal spine, lumbar spine, pelvis, hips, back, spine, knee, foot, ankle [6],[8],[9];

clothing with effects of healing diseases: special stocking against the thrombosis or for sensitive skin, antirheumatic underwear [5][11];
knitted fabrics for compressive medical burn treatment;
knitted products for post operation treatment [11] ;

Figure 6: Orthopaedic corsets and belts for man and woman

Figure 7: Knitted product for medical applications

Thermal and elastic bandages

The thermal [5] [10] and elastic bandages (belts) are used (figure 8) for all those pathologies where the local thermal therapy is required: arthritis, lumbago, muscular pains, colitis, the inflammation of back and kidneys and in cool places and in particular for the people with excess weight. The tubular bands for knee, elbow and waist in wool or wool/cotton

Figure 8: Knitted product for thermal and elastic bandage

5. CONCLUSIONS

The contents of the paper allow formulating the following ideas referring to compressive knitted garments:

- the domain of technical textiles on one side and that of textiles for special destinations on the other size, a component part of the textile sector, is characterized by complexity and diversity;
- the knitted fabrics, which are presented in the paper, are used for their compressive purpose besides other special characteristics;
- these have different role: preventive, prophylactic, protections, sustain, fashionable, modelling of body shape, post operation, compressive therapy, aesthetic, etc.;
- there are compressive knitted garments for generally used with special or usual destination, particularly compressive product depending on the particularly body locations and compressive knitted socks
- depending of their purpose, this knits are used for: non-invasive medical domain, sport activity, all day life usual activity , for special destinations (thermal underwear and orthopedic products, underwear for pregnancy, for postpartum and for baby, anticellulite products and shaping underwear for woman and man, cotton socks for man with graduated compression, diabetic and sensitive feet socks and toe socks, orthopedic and preventive elastic stockings
- compressive knitted fabrics are realized like weft or warp knitted structure depending on their purpose in practical application.

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Scholarly communication paper

TEXTILES FOR THERMOREGULATION

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Abstract: *To achieve the thermo comfort textiles must act as a humid – thermal barrier between the human body and the outside conditions, in odder to conserve a constant temperature of the body. Starting from the naturally process of production and waste of the body heat, it was created functional textiles pointed to ensure the thermoregulation. Some of these textiles act in a passive way, by storing or releasing heat, by reflecting heat, other textiles act in an active way, heating or cooling the apparel's interior, in concordance with the human body and environmental temperature. The paper deals with two groups of textiles: those that acting for warming the body, to prevent the sensation of coldness, and those that create a dynamic comfort when body is exposed both to high or low temperatures. The focus is placed on the design, principles of work and functional characteristics of some of these textiles.*

Keywords: *temperature changes, heating, cooling, dynamic comfort.*

1. INTRODUCTION

One of the main aims of the science is the systematic design of functional clothing which can to help regulate the temperature of the human body, in relation to the ambient temperature and the level of physical activity. In this direction, critical factors are the thermal insulation and the moisture management properties of textile materials (their ability to absorb perspiration and wick it away from the body).

The naturally process of production and waste of the body heat, that allows the body to conserve a constant temperature, is known as the thermoregulation mechanism. Because this phenomena is important for anyone and, is extremely important for sportsmen or for people who must facing extreme conditions, it were created functional textile for thermoregulation.
These functional textiles, which achieve improved temperature management, are designed as:

- heatable textiles – that warm the body in cold environments, and for healthcare;
- cooling textiles – that help the body to lose heat when the outside temperature is too high;
- thermo textiles with dual functionality – that heat/cool the body in concordance to environmental temperatures.

Further, discussions will be focused on some of the heatable textiles and of the textiles with dual functionality for thermal regulation, particularly on them design, principles of work and functional characteristics.

2. HEATABLE TEXTILES

2.1. Fibres for thermal insulation

Referring to the insulation of clothing against cold, it works in two ways:

- by trapping air - the more air is trapped, the more efficient is the insulation;
- by reflecting back the body's radiant heat.

It results that, thinner fibres are more efficient at trapping air, so more effective at keeping warm, and because it can be pack more fibres into the same space, they can reflect back more of the body's radiant heat.

- ❖ In this idea, a type of synthetic fibre thermal insulation is THINSULATE [1], that is about 15 micrometers (μm) in diameter, which is far finer than other fibres normally used in insulation for clothing (jackets, pants, gloves, hats and boots) used to keep warm in cold conditions (Fig.1). Due to the increased density of fibres with the decreased size of them, THINSULATE is a better insulator, the gaps between fibres not only reducing heat flow, but also allowing moisture to escape (Fig.2).

Figure 1: Thinsulate finer fibres then traditional Synthetic fibres

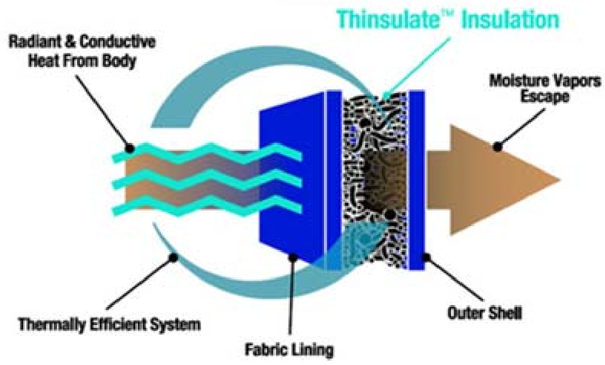


Figure 2: Work of Thinsulate™ Insulation

- THERMOLITE® is an other thermal insulation fibre [2], with a special engineered hollow-core (Fig.3). Because its structure this fibre ensure a greater insulation, by trapping more air, and because its larger surface area it allows for faster evaporation by speeding moisture away from the skin to the surface of the fabric, where it can evaporate more quickly (Fig.4). Tests prove that it dries 20% faster than other insulating fabrics, and 50% faster than cotton. This fibre provides extra warmth without the extra weight.

Figure 3: THERMOLITE hollow-core fibres

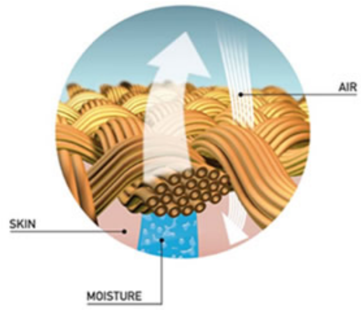


Figure 4: Work of THERMOLITE®

- An other fibre design to heat the body is CELLIANT [3], [4], that work by recycling and converting radiant body heat into infrared energy.
  Far Infrared Rays (FIR) are electromagnetic waves that are invisible to the naked eye and are characterized by low energy and penetration that does not provoke any collateral damage to biological tissue. The FIR waves are stimulated thanks to the strong interaction with the water molecules which make up 70% of the human body's mass.
  To turn the wasted energy of the body into useable energy, CELLIANT uses a new technology that load the fibre with a mix of thirteen minerals, selected for their thermo-reactive ability to most effectively convert body heat into infrared energy and reflect it back into the body (Fig.5).
  The active minerals are ground into very small particles (less than a single micron) and millions of these minerals are extruded into a resin that is loaded directly into the core of the fibres. Consequently these active minerals last as long as the life time of the material including these fibres.
  Besides regulating body temperature these fibres give the wearer other benefits as: improve circulation, increase tissue oxygen level and enhance cell vitality. These benefits may be used in different application where textiles are used, including apparel, bedding, healthcare and veterinary.

- In a similar way as CELLIANT, act EMANA [5] a combination of a polyamide 6.6 and a polymer with added bioactive crystals of bio ceramic. Because these crystals are built right into the DNA of the fibre itself, the effectiveness of the fibre remains unaltered over time despite frequent washes. The fabric with EMANA absorbs the electromagnetic waves emitted by the human body (Far Infrared Rays) and then turns these waves around towards the body based on resonance (Fig.6). This interaction with the body brings about the stimulation of tissue, offering thermo-regulation properties (thermoregulation improves by 51%) and improving blood micro-circulation.

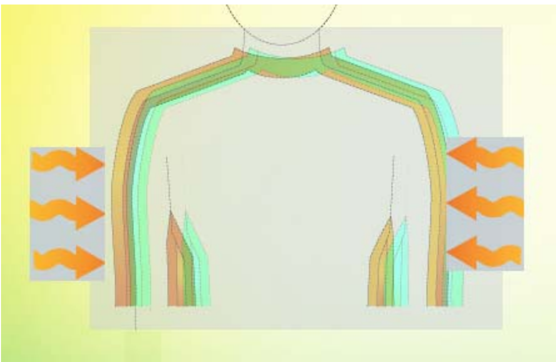


Figure 5: Work of CELLIANT

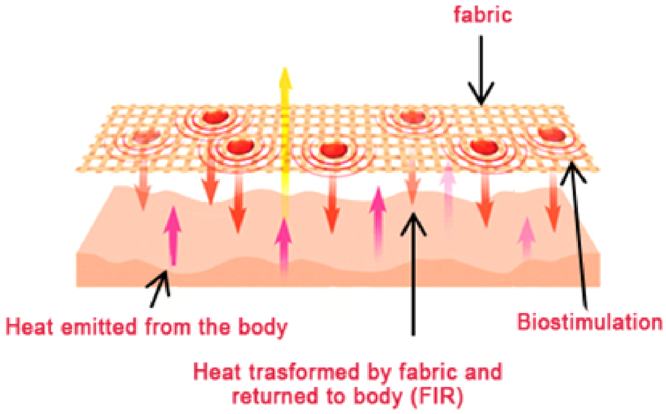


Figure 6: Work of EMANA fabric

2.2. Materials and products for thermal insulation

- An innovative material for thermal insulation is THERMOFLECT realized by a technology pioneered by NASA. It is a special composite silver material, laminated to a non-woven fabric that reflects and preserves the body's radiant heat that has proven effective in a variety of applications, including healthcare, EMS and survival gear, and in innovative functional sportwear [6]. In healthcare THERMOFLECT is used to prevent hypothermia by reflecting a patient's endogenous radiant heat, banking it in the body's core, while preventing convective heat loss (wind chill) (Fig.7).

Figure 7: THERMOFLECT blanket

THERMOFLECT can resolve too, one of the problems faced by cyclists: the dark coloured clothing tends to heat up in sunny conditions, causing discomfort and affecting performance. Manufacturing knitted fabrics treated with Thermoflect, even if they have black or dark colour, them surface behaves as it were a light colour. This means that the heat, which dark coloured textiles normally absorb, is for the most part reflected. Tests demonstrate that Thermoflect fabrics reflect 70% of the rays compared to normal fabrics that reflect around 30% of rays [7]. Consequently, part of the heat does not reach the body resulting a cooling effect, the temperature difference experienced between a black coloured conventionally manufactured fabric and the same fabric which has been treated with Thermoflect, amounting to as much as 10%.

- Using the knitting technology it were realised functional products for thermoregulation, an example being a new sock called Thermo – Twin [8]. This sock, designed to offer the wearer a high level of thermal insulation and comfort, is realised on the Twin Layer machine (from Busi), a cylinder and dial machine, with a special device, which is integrated in the dial itself, permitting to produce the double layer sock.
  This machine knits two fabrics at the same time, one inside the other: the external sock is produced in the conventional way, on the cylinder needles, while the internal sock is knitted by the dial needles. Thanks to the consistent quantity of air trapped between the two layers, such sock guarantees an extremely high thermal insulation. The knitting of two separated fabrics gives the opportunity to use completely independent yarns, with different fibre content, for the inside and outside of the sock.
  The Twin Layer machine offers the possibility to place the double layer structure in a selected part of the sock:
  - it can be extended to the complete sock, the two fabrics being joined at the welt, at the heel and at the toe, so preventing the sliding of the inner layer in relation to the outer layer;
  - it can be knit, for example, only in the sole and/or in the heel;
  - it can be knit to create pouches inside the sock.

3. THERMO TEXTILES WITH DUAL FUNCTIONALITY

- A solution to realize the temperature regulation, in concordance to environmental temperatures. is the use of phase change materials (PCMs) which have the capacity to absorb, store and release excess heat.
  Originally developed for NASA, to protect astronauts from temperature fluctuations in space, Outlast® is a heat management technology (Fig.8) that utilises such PCM's microencapsulated, to be permanently enclosed and protected in a polymer shell, resulting THERMOCULES™.

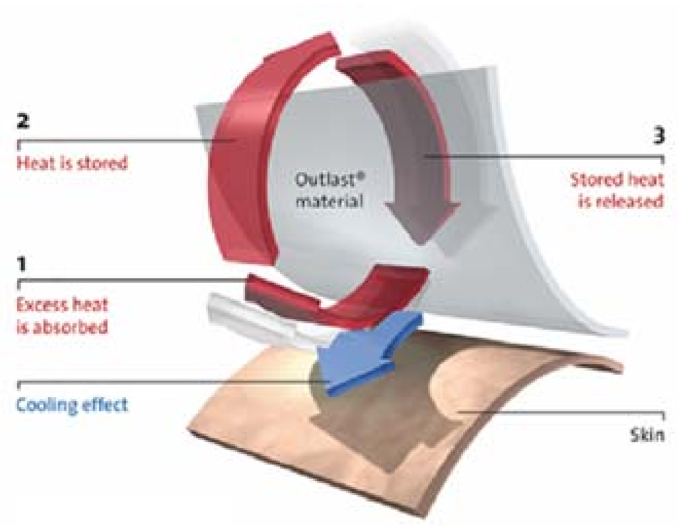
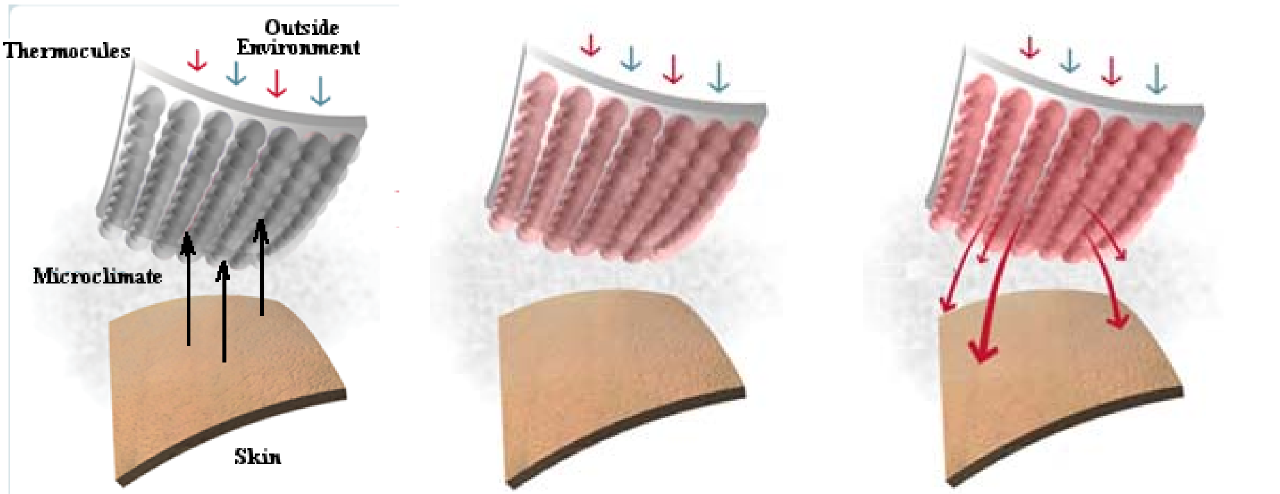


Figure 8: Principle of work of Outlast Technology

These Thermocules™ can be incorporated into fabrics and fibres, for optimal thermal comfort [9]. So, when the body is exposed to temperature changes, Thermocules™ have the following reactions:
- when overheat, the body naturally release the excess body heat and sweats to cool the skin (Fig.9.a);
- the excess heat is absorbed and stored in microcapsules (Fig.9.b);
- when the cooling process starts, the stored heat is released back to the skin (Fig.9.c).

Based on Thermocules it was created a polyester filament, used for knitted fabrics (Fig.10). This polyester features all positive characteristics of a conventional polyester fibre, like:
- low moisture absorption and a good ability to transport moisture;
- an improved wrinkle resistance;
- superior light;
- water and wind resistance;
- a high tearing and abrasion resistance.



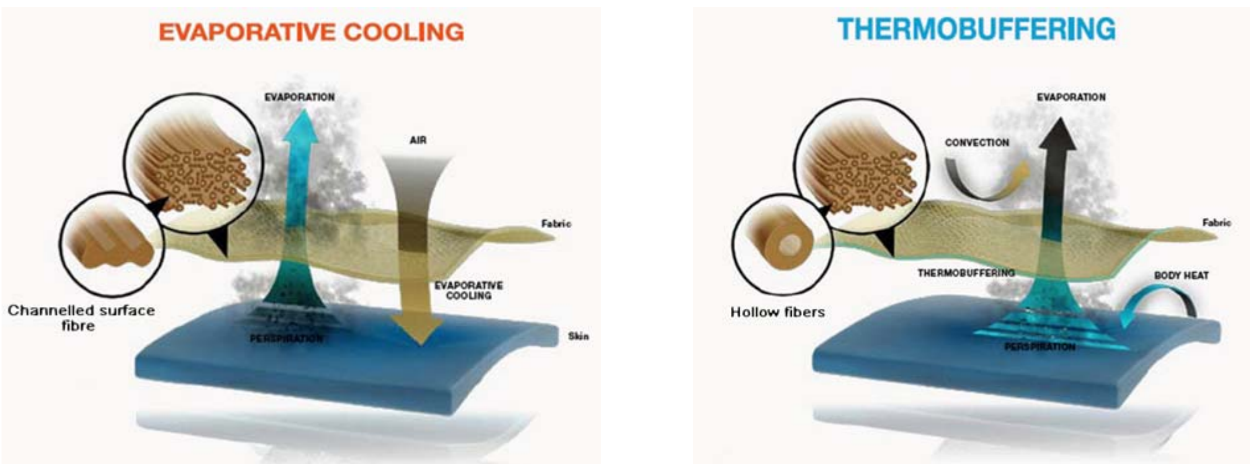
a - body release excess heat | b – microcapsules absorb and store the excess heat | c – microcapsules release to the skin the stored heat when body cools

Figure 9: Steps of thermoregulation using Thermocules™

Figure 10: Knitted fabrics based on Outlast polyester PCM

This PCM polyester can be used too, as fibre balls with application in bedy, to balance temperature in duvets or pillows, by reducing sweat production right from the beginning, leading to more comfort during sleeping.

- In odder to ensure a dual functionality (keep the body warm, respectively cold, in cold, respectively heat conditions) it was designed THERMOCOOL™ [10], a yarn including fibres with different cross sections (hollow fibres and channelled surface fibres).



a - Cooling by channelled fibres | b - Warming by hollow fibres

Figure 11: Dual functionality of THERMOCOOL™

When is too hot, the channelled fibres, thanks to them added evaporative surface, outstand moisture transport and allow enhanced air circulation, resulting in a rapidly evaporative cooling (Fig.11 a),
When is too cold, the hollow fibres, thanks to them added thermo-buffering properties, protect the user from low temperatures (Fig.11 b),

CONCLUSIONS

Functional textiles for thermoregulation can be heatable textiles, cooling textiles and textiles with dual functionality.
In the range of heatable textiles are included fibres, materials and products for thermal insulation.
Among the design solution that led to obtain fibres for thermal insulation are included:

- very thin fibres that allow to trap more air and to reflect back more of the body's radiant heat;
- fibres with a special hollow core providing extra warm at a reduce weight;
- fibres that convert body heat into infrared energy and reflect it back into the body. Such fibres are produced by new technologies that load into the core of the fibre a mix of active minerals or bioactive crystals of bio ceramic with thermo-reactive ability.

To protect the body from the temperature fluctuations it where realised textiles with dual functionality based on:

- phase change materials microencapsulated and then incorporated into fibres or fabrics;
- fibres with different cross sections - hollow fibres and channelled surface fibres – included in the same yarn.

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Scholarly communication paper

CLOTHES BECOME A REAL BODY CARE

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Abstract: *In recent years, the needs of the consumer to combine health and wellness with appearance in everyday life drive to emerge a new convergent industry – cosmetic textiles industry. The technology supporting this convergence is represented by microencapsulating where microcapsules, holding a specific amount of cosmetic substances, are incorporated into fabrics. Then by friction, or pressure, between the body and fabric the capsules are breaking into fragments and liberate the cosmetic properties. By using conventional cosmetics, in various types of apparel products, cosmetic textiles offer different benefits as: energizing and invigorating the skin, odor control, moisturizing, slimming, and cellulite reduction, but too they can act as a protective barrier against external elements. The paper presents the most used bioactive ingredients and those effects, the main methods for fixing microcapsules on apparel products, the most important cosmetic products created by global textiles and chemicals companies, and the new generation of cosmetic textiles.*

Keywords: *cosmetic textiles, microcapsules, technologies, new generation*

1. INTRODUCTION

In the modern societies the quest for well-being is a serious underlying trend, the products that improve the well-being and health offering numerous opportunities for innovative and functional textiles. Now, cosmetic textiles, which were considered as gadgets in 2000, are enjoying a strong grows (+35% per year on average) [1] because these anti-aging and beauty products meet a consumer demand, as: slimming leggings, firming tights, moisturizing body.
Based on the definition, officially established by The Office for the Standardization of Textile and Clothing Industries (BNITH), in 2006, a cosmetic textile is: "*a textile article that contains a substance or a preparation that is intended to be released sustainable on the different superficial parts of the human body, especially the skin, and which claim one (or more) particular propertie(s) such as cleansing, perfume, change of appearance, protection, maintenance in good condition, or correction of body odors*" [1], [2].
Cosmetic textiles are born from a high-performance technology, between cosmetics and textiles, resulting in effective treatments that complement traditional cosmetic treatment programs

2. COSMETIC TEXTILES TECHNOLOGY AND ITS EVOLUTION

Cosmetic textiles are created by microencapsulating substances as aloe Vera, vitamin E, various plant oils, menthol, caffeine, retinol, ceramide, or minerals from seaweed, crab shell or seawater, and attaching them to a fabric. The technology of microencapsulating cosmetic ingredients is based on the production of microcapsules, where a protective exterior membrane surrounds an active cosmetic ingredient which is suspended in a polymer matrix (Figure 1). The new generation technology uses nano capsules, (that are 1000 times smaller than microcapsules) which ensure to store in a higher quantity of active ingredients on cm^2 of textile (Figure 2) [3].

The ranges of bioactive ingredients currently included in microcapsules are very large and pointed to meet different consumer demands, by example: slimming, moisturizing, firming.

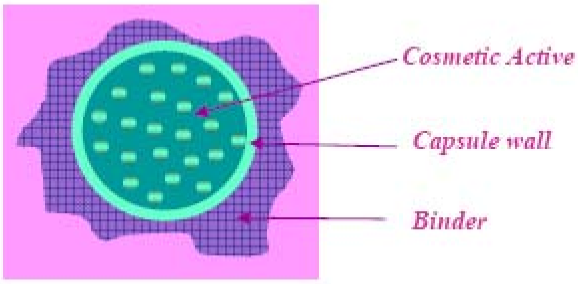

Figure 1: Microcapsules

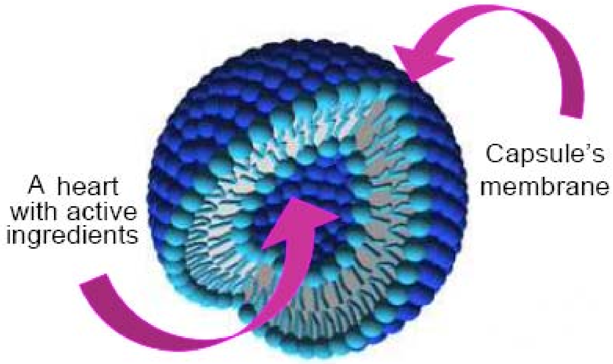

Figure 2: Nano capsules

Some of used bioactive ingredients and them effects are:

- **Caffeine:** powerful fat burning effects.
- **Forskolin:** burns fat whilst maintaining muscle mass
- **Sichuan Pepper & Buckwheat:** destocks and prevents accumulation of fats
- **Red alga:** activates fat release
- **Green Tea**: mobilizes fat and provides a stimulating effect
- **Shea Butter**: protect and nourishes the skin
- **Mango Butter**: regenerates lined and mature skin
- **Copaiba**: strengthens and regenerates the skin
- **Sweet Almond**; accelerates tissue nutrition in depth
- **Elemi resin**: tensor and moisturizer
- **Flavenger**: anti-inflammatory and anti-histamine
- **Red Vine**: provides wellness, lightness and tone

After they are manufactured, the microcapsules must be connected to the textile. Conforming to the manufacturing process of a cosmetic textile illustrated in Figure 3 [1], there are two main methods for fixing microcapsules;

Method 1 - functionalisation of fabric (process 1 to 8): microcapsules are fixed on the external surface of the fiber, on the finished product (Figure 4); this method imposed, after a different number of washes (according to the process' particularities of each company), the recharge of the cloth by using specific sprays, to increase the effective life of the cosmetic textiles.

Method 2 - functionalisation of fibers (process A to G): microcapsules are incorporated into the fiber (Figure 5).

When the cosmetic textile is worn, it progressive releases the active ingredients to the skin, where the microcapsules are opened by movement, rubbing, pressure, or because the effect of the skin's natural warmth and enzymes, throughout the duration of wearing the fabric. Then active ingredients penetrate into the skin to moisturize, nourish, firm or smooth the skin, to reduce the appearance of cellulite, or to cool or revive area where the cosmetic textile is worn.

The cosmetic textile technology [4] was first branded by Cognis in 2001 with their ***Skintex***, when them idea of »wearable skin care« has found acceptance in areas of intimate apparel and clothing for wellness. In 2003 **Invista** launches ***LYCRA Body Care***, in conjunction with a UK company specializing in microencapsulating – **Celessence**, putting together cosmetic textiles and stretch fabrics for intimates, bodywear and activewear. In the area of shapewear cosmetic textiles have seen a great success, in 2003 the French brand **Lytess** creating the first slimming tight with cosmetic textiles. Another french company, **Skin'U**p lanced in 2005 its range of slimming garments with a visual indicator (colored microcapsules) that lose color as the microcapsules are depleted (Figure 6). So, the consumer is advised to use the spray for refill the mist. Skin'Up recommends a rate of 15 sprays per day per piece of clothes to replenish the textile for up to 30 days [3].

Figure 3: Manufacturing process of a cosmetic textile

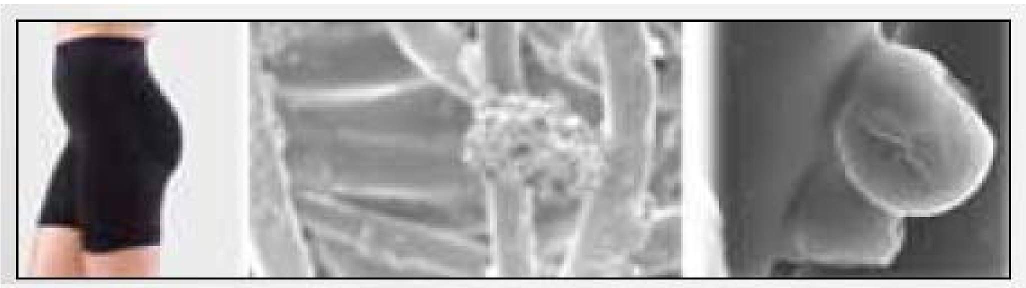

Figure 4: Method 1 - functionalisation of fabric

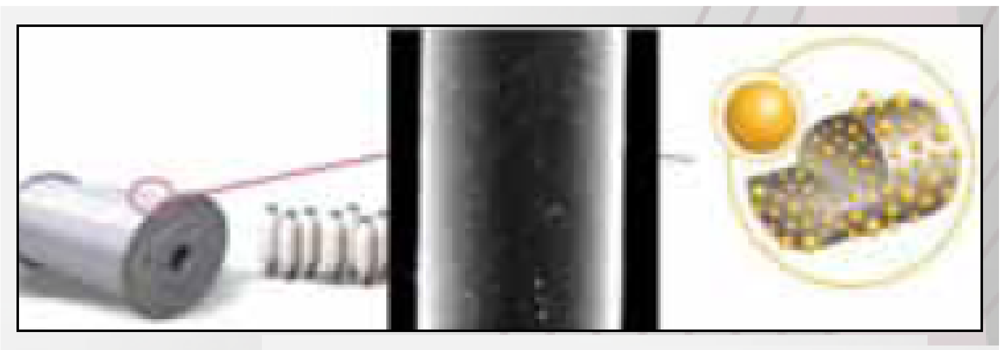

Figure 5: Method 2 - functionalisation of fibers

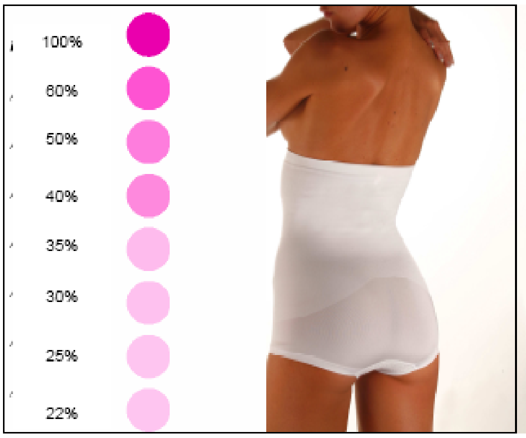

Figure 6: Percent of active ingredient after successive hand washes in 30^{0}C water

In 2006 fiber maker **Nurel** patented its ***Novorel nylon*** microfibre realized by a production process which adds the microcapsules to the polymer before extrusion. Consequently, the fabrics made with Novorel nylon, because the cosmetic benefits are maintaining for 100 washes, does not need to be recharged.
In the same idea, **Lenzing**'s ***TENCEL C*** contains microparticles of chitosan in the realm of the spun celluloses, which reinforce the skin's barrier by up to 50%, maintaining optimal moisture content and stimulating cell renewal [4].

3. THE NEXT GENERATION OF COSMETOTEXTILES AND OTHER SKIN CARE TEXTILES

Today a new generation of cosmetic textiles has appeared witch bring together the latest innovations in fiber and textile structures, as ceramic fibers, 3D knitting, shapewear, new products including scented towels, venotonic tights (which help drain and relieve heavy legs) and pulping bras.

Clariant, specialist in chemicals for the textile industry and **Lipotec**, a creator of cosmetic ingredients, developed a new technology called ***Quiospheres***. Cosmetic ingredients include a series of new peptides and biocompatible shell. Because this compatibility the capsules react with natural skin enzymes and release and deliver their ingredients.

Celessence, a division of International Flavors & Fragrances is a company focusing on aromatherapy fabrics for home and environment. Among its new products are: fragrances that keep rugs and carpets fresh or camouflage tobacco smoke, natural micro-fighting ingredients such as tea-tree oil; lavender-infused nightwear and bed linens to encourage sleep (Figure 7).

Another route to develop skin care textiles is targeted towards medical wellness, workwear and sportwear markets. **Schoeller Textile** created an ***iLoad system*** [5], a textile carrier material which can be individually loaded and regenerated with beneficial and therapeutic substances (Figure 8).

Figure 7: Lavender-infused bed linens to encourage sleep

Figure 8: Textile carrier material for medical wellness

iLoad® system include a special donor layer [6] applied and anchored to an eligible base fabric. In the subsequent loading process this donor layer, which coats every fiber of the fabric, is combined with a specific emulsion containing the required active substances (Figure 9). Like a magnet, the negatively charged donor layer attracts the positively-charged and customized active-agent emulsion and stores it like a sponge (Figure 10). The loading process takes just a few minutes, and can be accomplished using only the rinse programs in both industrial and domestic washing machines.

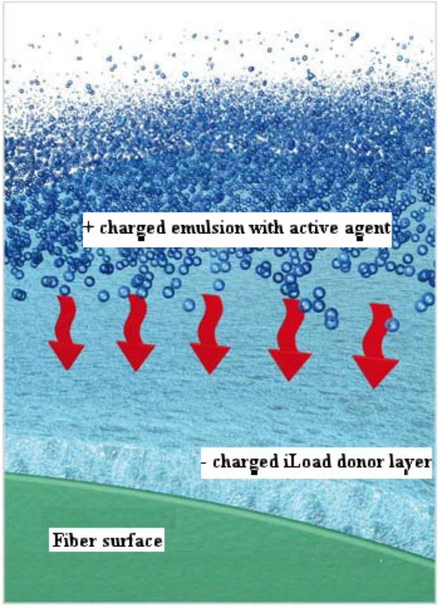

Figure 9: Attraction of emulsion with active agent by the donor layer

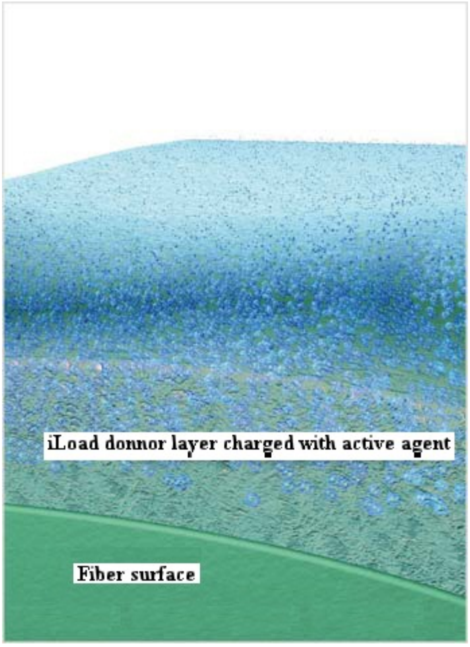

Figure 10: Charged the donor layer with active agent

Triggered by warmth, vibration, moisture and perspiration, the constant transdermal unloading process commences: the active substance in the donor layer is released onto the skin, where it can develop its full effect (Figure 11). The time desorption, i.e. the length of time for the release of the active agent, can be adapted for specific purposes.

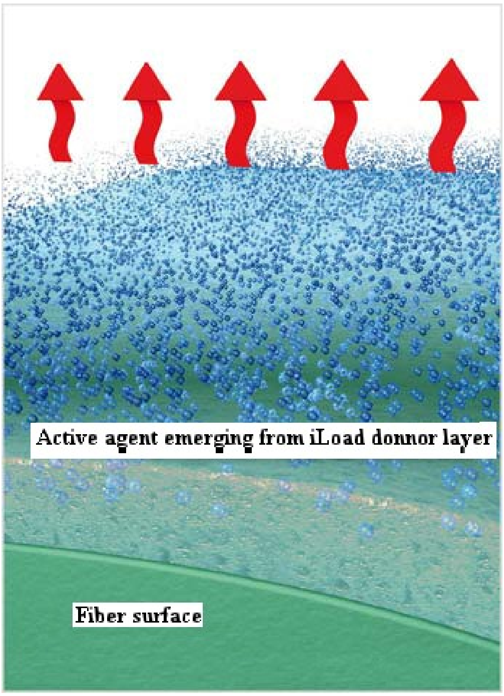

Figure 11: Active agent is release onto the skin

To load the iLoad® textile with a new active substance, the textile must be simply washed to unload any residual substances which may still be present, and then the iLoad®- textile can be directly loaded with a new active substance.
By a systematic matching of donor layer, cross-linking and active substance emulsion, Schoeller create a highly-efficacious carrier material which proved stable and permanent in tests at up to 60 °C in over 100 washing cycles [6].
On the basis of iLoad®. It was developed a hybrid two-dimensional fabric that is hydrophilic on one side, storing the desired agent and releasing it towards the skin, and hydrophobic on the opposite side, guaranteeing that the active substance is not released to any clothing.
As potential textile applications, iLoad® can be used in bedding or in pillowcases, in pajamas, underwear or hospital nightshirts, textiles that come into contact with human skin, but too, in medical Wwllness sector, for treatment of dermatitis, for sleep disorders, for patients with bedsores and even, in the future for prescription medication, in agreement with clinics and physicians.

CONCLUSIONS

Cosmetic textiles are created by microencapsulating active cosmetic ingredients.
For connecting microcapsules to the textiles are utilized mainly two methods: microcapsules are fixed on the external surface of the finished products, or are incorporated into the fibers.
Beside the classical cosmetic textiles where the microcapsules are opened by movement, rubbing or pressure, the new generation of these functional textiles includes:

- cosmetic ingredients with new peptides and biocompatible shells that are release by the reaction with the skin enzymes;
- textiles carrier materials which can be individually loaded with beneficial and therapeutic substances. A special donor textile layer can be charged, in few minutes, by a simply rinse, with the required active substance, and then it take place a constant unloading process where the active substance is released onto the skin.
- hybrid two-dimensional fabric: hydrophilic on one side, storing the desired agent and releasing it towards the skin, and hydrophobic on the opposite side, guaranteeing that the active substance is not released to any clothing.

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Scholarly communication paper

A NECESSITY OF THIS DAY AND AGE – THE CREATION OF CLOTHING PRODUCTS WITH HIGH SOLAR PROTECTION FACTOR

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Abstract: *Taking into consideration the natural changes that occurred in these last years (reduction of the ozone layer, solar flares, global warming), it was observed that solar UV radiations determine a series of negative effects on the human body, increasing the overall risk of some severe diseases. In this context the protective function of clothes worn during the torrid periods or on snowy winters has a greater importance than ever.*
Clothing products create a "barrier" between the skin and the UV solar rays and can provide the most efficient protection through design, type, structure, color and humidity level of the material.
This paper presents the different ways in which clothing products can influence the Solar Protection Factor.

Keywords: *protection, sun, clothing, radiations.*

INTRODUCTION

Solar radiation contains infrared, visible light and ultraviolet radiation. Although ultraviolet radiation (UV) represents only 5% of the solar radiation that reaches the earth's surface, it holds an important role in regard to biology because it has the greatest energy in the optical spectrum.
Taking into consideration the increase in solar activity during the last years and the reduction of the ozone layer, it is primordial to know the effects of ultraviolet radiation on the human body, as well as means of protection against them.
Solar light is electromagnetic energy that propagated through electromagnetic waves. In regards to health, the most important parts of the electromagnetic spectrum are:

- Ultraviolet radiation (UV), invisible to the human eye;
- Visible light enabling us sight;
- Infrared radiation that constitutes the main source of heat, also invisible to the human eye.

UV radiations have enough energy to cause photochemical changes that can initiate biological effects, possibly negative, sometimes referred to as "actinic effects".
Solar radiation is heavily deflected by the Earth's ozone layer, limiting terrestrial UV radiation to wavelengths of about 290 nm.

1. UV RADIATION CHARACTERISTICS AND EFFECTS

Measured UV radiation with a similar response on the human skin, are named erythemic active UV radiation (UVE) [1] and are used to calculate the UV Global Solar Index (UVI), in order to inform the large population.
Often it is necessary to monitor total UV radiation, represented by the UVA and UVB component together.
On the earth surface UVA radiation usually exceeds the UVB by 15-20 times.
Dependent on the biological effects it causes, especially on the DNA, the UV spectrum is divided in radiations: UVA, UVB and UVC. Their characteristics and possible effects on the human body are presented in table 1 and figured 1 and 2.
As to the protection against UV radiation, it can be affirmed that the most affected persons are those with the type skin 0 (white or albino skin), 1 (ginger), 2 (blond) and 3 (light brown hair), kids, or persons that spend a lot of time in nature or around reflective surfaces (water, snow). People with the skin photo type 4 (Mediterranean) and 5 (black) are more resistant, but even to them the long exposure risk can be diminished by using clothing products with solar protection.

Table 1: Correspondence between UV radiation type and the effects on human body

UV radiation types	Characteristics and effects of radiation on human body
UVA **Wavelenghts between** **315 – 400 nm**	All of them reach the earth surface. Take part in the tanning process. Can determine photosensitivity to solar rays. Can have effects in the DNA through direct or indirect mechanisms (free radicals) – figure 1. Can have detrimental effects on the skin and eyes. Increase premature skin ageing and the appearence of visible signs (lines, spots, freckles, dry skin).
UVB **Wavelenghts between** **280 – 315 nm**	Partially deflected by the ozone layer. Have detrimental effects especially during the summer months, at mid day (hours 10-16). Increase with 10% per 1000 meters altitude. Their effects are amplified by reflection on water, sand or snow. Take part in the activation of provitamin D, but can lead to skin lesions, producing burns, genetic mutations and carcinogenesis. Can determine photosensitivity to solar rays.
UVC **Wavelenghts between** **100 – 280 nm**	Absorbed entirely by the atmosphere.

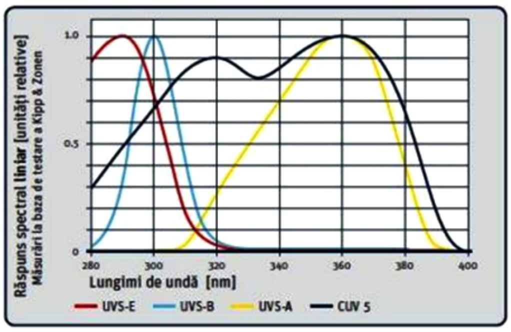

Figure 1 Radiation measurement domains

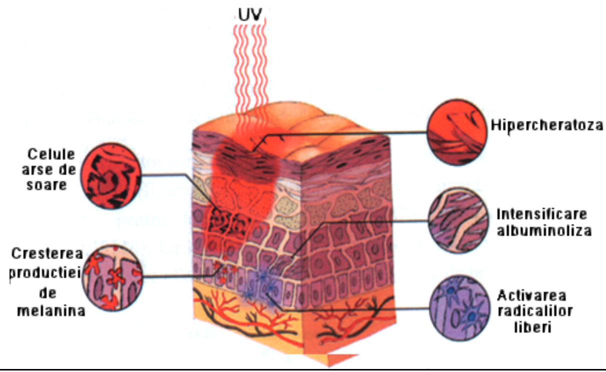

Figure 2 Radiation effects on the DNA

In figure 3 is represented the percentage variation of solar protection depending on the value of the solar protection factor (FPS) [1, 2].

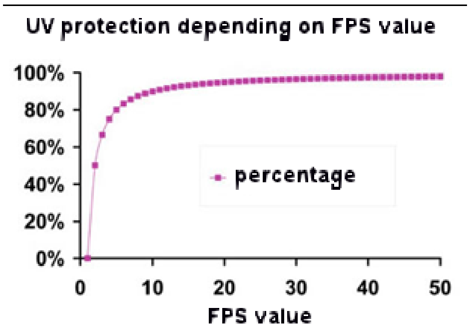

Figure 3 Solar protection depending on FPS value.

2. CLOTHING PRODUCTS PROTECTION AGAINST UV RADIATION

2.1 Evaluation of the protective function offered by clothing products

Clothing creates a barrier between the skin and the solar UV radiation and can offer the most efficient protection. While usual clothing offer a feeble protection of only 7%, "anti radiation" clothing products offer a protection up to 97% [3, 4]. In order to protect against radiation, clothing must have inscribed on their label a

protection factor of at least 15. The American foundation for skin cancer research recommend clothing with a protection factor of 30, underlining though that those with over 50 factor are the most efficient because only 2% of the ultraviolet radiations can penetrate the attire.
In order to evaluate the capacity of a clothing product to offer UV protection, researchers in different countries (Australia, USA, Spain) have established a system of reference indicators:

- UPF (UV Protection Factor) – evaluates protection against UVA and UVB;
- SPF (Sun Protection Factor) that allows evaluating the protection against UVB radiation.

SPF represents the measure of time until the apparition of solar burns on the skin treated with a protection factor.
UPF represents the efficiency of a material to block/deflect UV rays, the measurement of transmitted UV radiation being realized with a measuring instrument (Spectrum-radiometer) and an artificial source of light.
The results are translated into a mathematical equation based on "erythema active spectrum" (solar burns sustained by an unprotected skin).
The reference values of UPF [4, 5] are presented in table 2:

Table 2: Reference values of UPF

UPF Value	Protection type	Blocked radiations percentage [%]	Efficiency of penetrant radiation [%]
15 – 24	Good	93,3 – 95,8	6,7 – 4,2
25 – 39	Very Good	95,9 – 97,4	4,1 – 2,6
40 – 50	Excelent	97,5 – 99 +	2,5 – 0
50 +			

From the table above we can see that UPF values are directly proportional with the protective capacity offered by the material or textile product. The efficiency represents the percentage value of radiation that penetrates the clothing. In the case of 2% efficiency products, on the respective label will be inscribed "UPV 50 +". This number attests an almost total protection, when a maximum 2% of radiation can penetrate the clothing.

2.1 Characteristics of clothing products that influence the protection against UV radiation

Clothing products possess specific characteristics that can be managed according to usage conditions, by choosing the characteristics of raw material, structure and structural parameters and finishing processes.
Their efficiency against UV radiation is dependent upon [3, 6]:

- clothing design – through coverage degree and adjustment on the body;
- component material – though the fibrous composition and yarn count, type, structure, count, tightness, elasticity, color and humidity degree of the material;
- finishing treatments applied to the fiber, yarn or textile material.

In table 3 is presented the way in which a series of characteristics of the product can influence the protective function again UV radiation.
În tabelul 3 se prezintă modul în care o serie de caracteristici ale produsului pot influenţa funcţia de protecţie faţă de radiaţiile ultraviolete.

Table 3: Influence of textile product characteristics on the protection against UV radiation

Product characteristics	Analyzed variants	UV protection function
Type and fibrous composition of the yarn	Cotton, flax	Low protection without additional finishing treatment (optic whitening, thickening, etc.). Unbleached cotton offers a better protection (contains lignin that has the propriety to absorb ultraviolet radiation). Materials that contain mainly yarn of natural cellulosic fibers offer a lower protection against UV, compared to those of protein (silk, wool).
	Wool, silk	Moderate protection. By chemical treatment with satinizing substances the protection improves. Satin silk offers an optimal protection because it reflects the solar rays.
	Polyamide	Good protection

Product characteristics	Analyzed variants	UV protection function
	Polyester	**Very good protection** because it reflects solar rays. **The protection increases with the sheen intensity**.
	Elastomer	In materials in a relaxed state, the protection is very good because of the thickness degree. In stretched materials the protection decreases significantly because of the reduction of thickness and count.
Structural parameters of the material	Density, thickness, count, low value mass	Reduced protection, because of reduced covering capacity.
	Density, thickness, count, high value mass	**Good protection. With the increase of thickness the protection becomes very good (high covering capacity).**
Color	Light colors (white, yellow) or pastel	Low protection. *Example*: a white T-shirt has SPF = 7 – 8, a yellow one SPF = 15, and a red one SPF = 20.
	Dark colors (dark blue, black)	**Better protection with the darkness of the color or intensity.** It was observed that the best protection is offered by dark green or dark blue. Black, dark blue or green velvet has a protection factor UV 50. The type of dye used can modify the UV protection; some dyes can deviate the UV rays and others can increase their absorption. Improving the UV protection can be realized by washing with special detergents (type “Sun Guard” [7]) and by treating the material with chemical substances with screen role against UV.
Humidity	Any wet or moist material has a vulnerability increased with 50% towards UV rays. Repeated washing and wearing of clothing products can lower the thickness of the material, thus affecting the protective role.	
Tailoring line	Loose and low degree of body coverage	Low protection
	Adjusted and high degree of body coverage	**Good and very good protection**. In the case of adjusted clothing made out of polyester or polyamide materials is necessary to create models that allow the ventilation of the body (holes, flaps, openings).

3. ACCOMPLISHMENTS IN THE TEXTILE DOMAIN, REGARDING THE PROTECTION AGAINST UV RADIATIONS

In order to answer the explosive rise in demand and taking into consideration the ecological problems, research has progressed more and more. The most dynamic sectors are interdisciplinary, combining the research in medicine, textile industry, metrology, transport etc.
New generation textiles and “anti-radiation” clothing have becomes more solicited. Their market already covers 30% of textiles sold in Europe and 40% in the United States and Japan, and could well exceed 50% in the future.
Research regarding the improvement of protective functions and ecology of clothing product had as objectives:

- **using of natural fibre** (cotton, flax, silk, wool, etc.) **organically cultivated**, with the capacity to absorb and remove moisture, air penetrable, thermal regulation capacity (cooling sensation, respectively warming according to extern temperature), protection against bacteria and UV protection, contributing to the increase in environment and life quality [8];
- **using ecologic, biodegradable or recyclable fibres,** with antibacterial effects, auto-sterilizing and auto-cleaning, with high UV radiation protection;
- using a mix of natural, ecologic and synthetic fibres that will offer superior quality characteristic tu products and high UV radiation protection;
- **using yarn realized through performant technologies** to insure protection against insects, bacteria, fungi and acariens and UV protection;
- **using intelligent fibers/yarns/materials** that can influence health by adapting the temperature of the textile material according to ambient temperature fluctuations, as well as modifying the intensity of the color thus increasing the degree of UV protection;

washing the materials with special detergents or treating them with chemical substances with UV screen role, but at the same time reducing the waste of chemical treatments.

Some examples that illustrate the results of the research and improvement to ecological and protective functions are presented below.

1. **Bamboo fibres** are fabricated out of 100% **bamboo** pulp. Being completely biodegradable and sustainable, the bamboo is the most ecological material of the 21st century. Materials made out of bamboo fibres have antibacterial, anti-allergic, antiperspirant and absorptive proprieties. Articles realized from these material (example – figure 4) are light, nice to touch, natural sheen, don't cause allergic reaction, but protect the skin from UV rays perfectly (reflecting 98% of damaging rays). They have antibacterial proprieties and prevent the development of pathogenic organisms, fungi and acariens (on a bamboo fibre, 70% of bacteria is killed), and keep these proprieties even after a hundred washings.
2. **Articles realized from Cocona (derived from coconut husks).**

In figure 5 is presented as example the Power Dry blouse [10], which combines the principles of UV protection improvement and the following characteristics:

- Fabricated from Cocona and PES with Polartech Power Dry technology – a material that is part of the Next To Skin category, with absorptive capacity and humidity removal, air permissive and thermal regulation capacity;
- Anti-odorizing natural treatment, without involving any chemical antibacterial treatment;
- Offers resistance and good protection to UV rays (UPF 15);.
- Knitted structure type mesh, and the tailoring of the product is adjusted,with a high coverae degree of the body.

3. Another example are the products based on **biodegradable vegetable fibers type PLA** (contain poly-lactic acid, polymer extracted from corn) offering a very good protection by blocking the UV rays.
4. **Wear – internationally brevetted anti-radiation weave** [11] (figure 6) for articles of clothing for adults and children (is certified Oeko-Tex – Baby class), linens, covers, sleeping bags, etc.

Characteristics: - is realized from cotton and copper/silver (copper wire wrapped in silver has 0.02 mm thickness being integrated almost invisible in the weave of cotton fibres);

- is bio- compatible because of the protective polyurethane cover, hypo-allergic and antiseptic recommended especially to chemicals sensible persons;
- very good screening power, that remains unchanged even after 30 washings;
- has high density;

5. Meryl products (Rhône Poulenc France - [12]) – are made out of polyamide PA 6 and PA 6, 6 type fibres. The sheen of Meryl products can be: shiny, semi-matter and ultra- matte. From Meryl type yarn can be realized materials wind and waterproof, with goo thermal isolation, good behaviour in humidity and OV radiation protection. It is used mixed (with wool, rayon, or other types of fibre) with varied systems or yarn under the trademark Nylstar® that has loose and comfort qualities. There have been realized varied fibres Meryl®: Meryl anti UV, offers protection to UVQ and UVB; Meryl Satine, creates a light reflective effect, Meryl Tango, for weaves with a natural silk aspect etc..

6. MERINO Perform™ products (23% merinos wool and % polyester). In figure is presented a Blouse Montane Bionic that combines the principles of UV protection improvement with the capacity of thermal regulation.

In figures 8, 9, 10, 11 are presented other products with UV protection, intended for children. It is worthy to note that all of them have a **high degree of body coverage, for an efficient UV protection.**

Figure 4 Blouse - (Bambus) UPF 80

Figure 5 Blouse PowerDry - (Cocona si PES) UPF 15

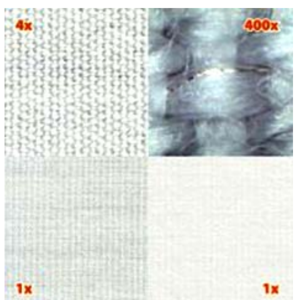

Figure 6 Wear weave

Figure 7 Blouse Montane Bionic (Merino Perform™), UPF 40+

Figure 8 Kids shirt "roto.red" – UPF 80

Figure 9 "Deep sea**"** trousers (PES 100%) – UPF 80

Figure 10 Blouse–(82% PA, 18% EL) UPF 20

Figure 11 Kids clothing product - UPF 80

CONCLUSIONS

In these conditions of climate changes and increase in solar radiation, the protective function against ultraviolet radiation and thermo-physical comfort of clothing products becomes a priority.
In order to evaluate the capacity of a clothing product to offer UV protection were established systems of reference indicators: UPF – evaluates protection against UVA and UVB representing the efficiency of a material to block/deflect UV rays and SPF (Sun Protection Factor) that represents the measure of time until the apparition of solar burns on the skin treated with a protection factor.
Anti –UV radiation protection exerted by the clothing products is determined by multiple factors presented and analyzed in this paper (fibrous composition of the yarn, compact structure, color and humidity degree of the material, product tailoring line). From this point of view, the clothing preferred must have a higher degree of body coverage, a compact structure, dark colors and not be used in excessive humid places.
This paper presents the ways in which clothing products can influence the value of Solar Protection Factor.

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Section 5: IT Applications

NEW APPROACH TO 3D PROTOTYPING IN CORSETRY

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Abstract: *In our paper we propose a new approach to 3D prototyping process in corsetry design. Proposed methodology employs the scanning process and it leads to woman chest separated from the body and parameterized, that can be adopted individually in relationship of given customer's morphology. When the curves are designated on the breast, finally we make a flattening of pattern in order to compare with traditional 2D methods of woman bra and modify the design to match with the 2D traditional method. Our results are very promising and it seems to be very interesting to develop a such data base by setting for each size in comparison with traditional methods.*

Keywords: *3d prototyping, virtual mannequin, corsetry, mass customization*

1. INTRODUCTION

Nowadays with the changes of global trade, the revolution in traditional methods of fashion design is required and necessary. The designers of new era, using the new media like Internet have to develop directly new products (garments) in a 3D virtual models. The development of adaptive models morphotypes or virtual custom models is a challenge worldwide industrial, essential accompaniment to the field "ready to wear" and mass customization, crucial to direct garment design in 3D [1, 2]. Taking into account the relationships between the heights and girths of human body, the shape and size of woman breast can varied significantly with no correlations to the others measurements [3]. The current popular system of determining bra size is inaccurate so often as to be useless. Many different styles of bras and the lack of standardization between brands cause that finding a comfortable, well-fitting bra is more a matter of guesswork, trial, and error than of precise measurements. Brassiere measurements (also called brassiere sizes, colloquially bra sizes) are labeled differently depending on the system of standards set in various countries and vary from one manufacturer to another. They usually consist of a number, indicating a band size, and one or more Latin capital letters indicating the breast cup size. These standard sizing systems are typically used to label off-the-shelf bras and are not used for made to measure bras or bras built into other garments.
The shape, size, symmetry, and spacing of women's breasts vary considerably, affecting the bra and cup size. Breasts that have been augmented and sagging breasts are shaped differently and require different kinds of bras. Even breathing can substantially alter the measurements. Obtaining the correct size is further complicated by the fact that the size and shape of a woman's breasts fluctuate with weight gain or loss. One study found that the label size was consistently different from the measured size.

2. EXPERIMENTAL

Calculating the correct bra band size is complicated by a variety of factors. Bra measurement is not an exact science. Normally a perfect fit can only be achieved by purchasing a custom-made bra, which takes into account the position of a woman's breasts on her chest and asymmetrical positioning and size of her breasts. Bra experts recommend that women, especially those whose cup sizes are D or larger, get a professional bra fitting from the lingerie department of a clothing store or a specialty lingerie store. However, even professional bra fitters produce inconsistent measurements of the same woman. A 2004 study by Consumers Reports found that 80% of department store bra fittings resulted in a poor fit.

Our approach was based on the work done in 2D-3D reality allows us to verify our assumptions on the proposed 3D design of bra.
The first step was to make a pattern of bra for a given woman body following the 2D traditional method [4].
Selected case of bra patterns for 90B size was prepared for a given table measurement presented below in table 1.

Table 1: Table measurements of 90B size

Chest round	89
Below Chest round	73
Deviation chest	20
Average height of décolleté	11
Below chest height	8

The measurements and their position on the woman body to identify which allowing to start the process of conceiving patterns in traditional method were shown on Figure 1.

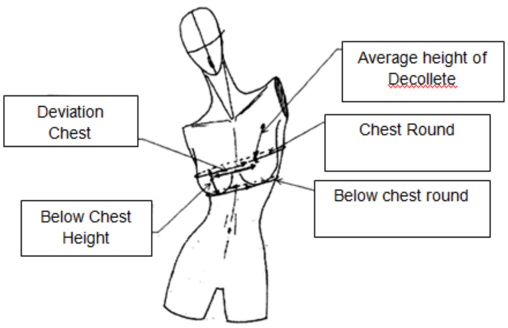

Figure 1: Woman body measurements for brasserie design

The final shape of bra pattern for 90B size is presented on the figure 2.

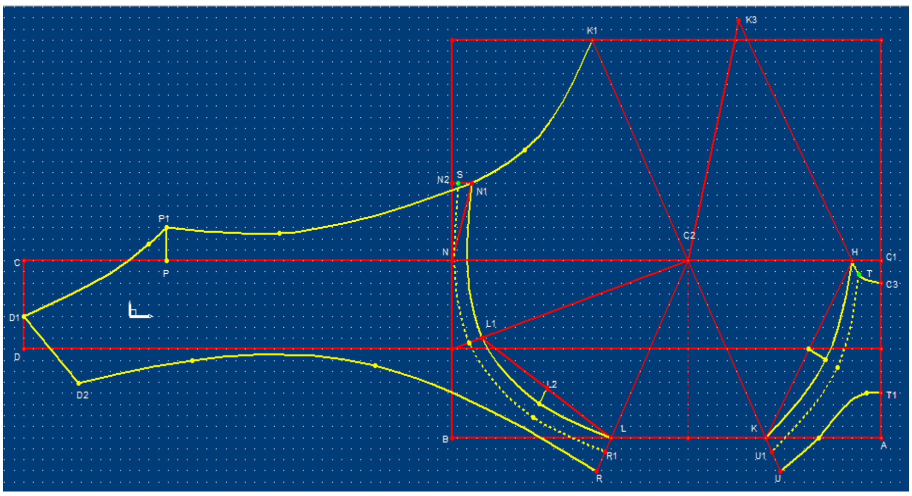

Figure 2: Bra pattern for 90B size

The next step of our work consisted on the designing of bra patterns directly in 3D employing the mannequin of woman body with 90B size of bra. The given morphology of woman mannequin issued form the 3D scanning process and transferred to the CAD software – Design Concept 3D.
The process design of bra in 3D (figure 2) starts with the points marked on the 3D bust with reference to the 2D patterns in order to define the cleavage and the other points (dart points which define the cup shape) necessary to conceive a bra. These parameterized points and correctly defined profiles allows manage the volume of the chest for a given morphology of the woman breast.

Concerning the bra design in virtual reality the most important marked point allowing the precise location of bra on the mannequin body defines the beginning of bra cup profile, validated in the 2D pattern, equal to the distance between C1 and H.

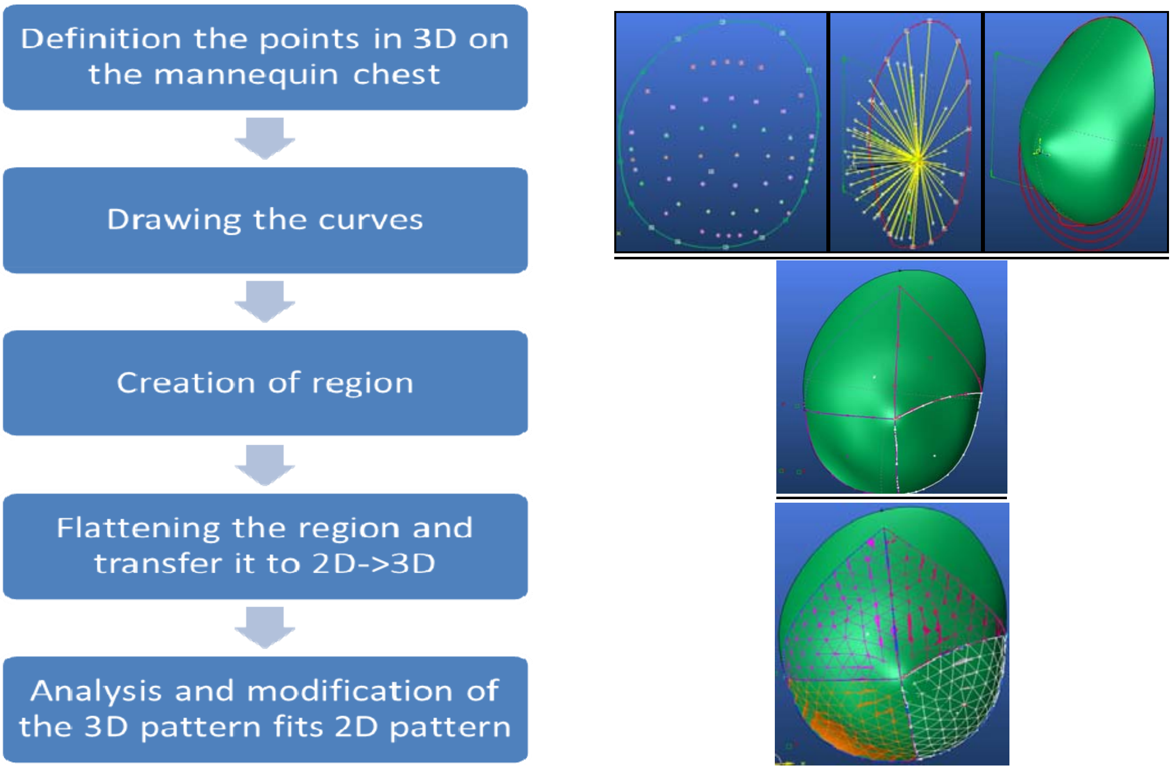

Figure 3: The process design of bra in 3D

Following step take into account the curves drawn connecting the above marked points to the centre of the chest separately. The curves are created by linking the correct points. The set of 4 curves makes a region. In order to assume the 2D shape of the bra it was necessary to create the different regions based on the these curves seen as the contours of appropriate elements of bra shape. On these regions created on the mannequin surface a mesh was built and then easily flattened into 2D to compare the 2D and 3D patterns. Improved analysis helped to introduce necessary modifications on the 3D bra pattern to fit with the outline of 2D bra, especially in upper part of bra seen as average height of decollete leading to the results shown on figure 4.

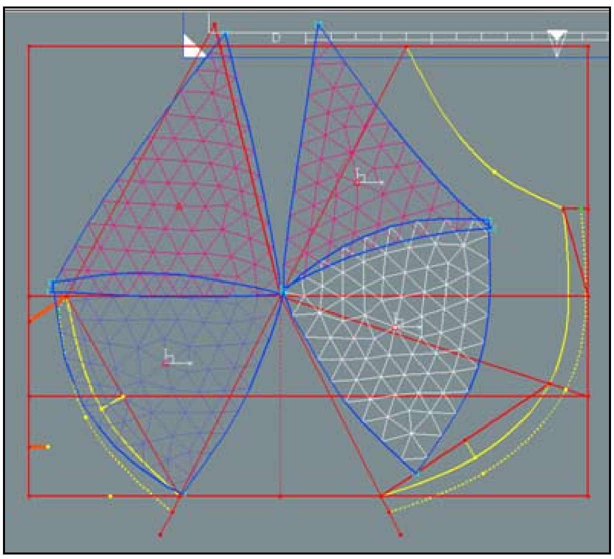

Figure 4: Flattened 2D and 3D patterns

Figure 4 shows the patterns are aligned properly, the faults in the traditional method of constructing bra was clearly visible, because of measurements not customized taking into account the position of a woman's breasts on her chest, asymmetrical positioning of breast, size of breasts, and the volume of the breast Moreover these measurements change from one model to another. Hence in order to obtain a proper fit it is required to customize the measurements as per the model.

RESULTS

Therefore, it was necessary to customize the bra as per the measurements of the mannequin which are not the same as give used size table and pattern making methodology.

Chest round	73.32
Below Chest round	57.33
Deviation chest	17.31
Average height of décolleté	11
Below chest height	8

Table 2: Mannequin measurements of 90B size

Our modified approach taken into account the appropriate measurements of mannequin with the 90B bra's size. We followed the steps mentioned previously and finally we obtained the results shown on the figure 5.

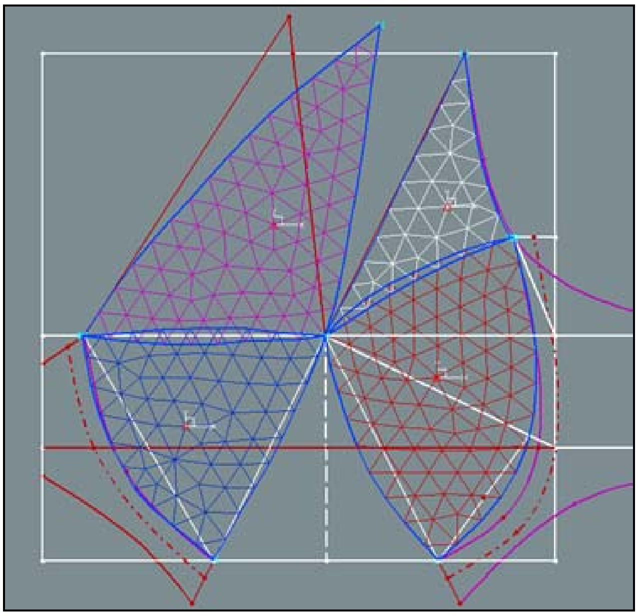

Figure 5: Flattened 2D and 3D patterns with appropriate measurement of mannequin with 90B

DISCUSSION,

Deformation in the upper dart
It was observed that the dart distance is not the same case of the upper dart. This is because the dart distance changes as per the direction and alignment of tip of the bra. In the current result the point of shifted toward right, that is towards the side seam. This shifting of the pattern depends upon the position of the tip. In order to check if the current dart position is okay, the tip was displaced to overlap with the tip in the pattern. Since the tips of both the pattern accorded the satisfactory result is obtained as shown figure 6.

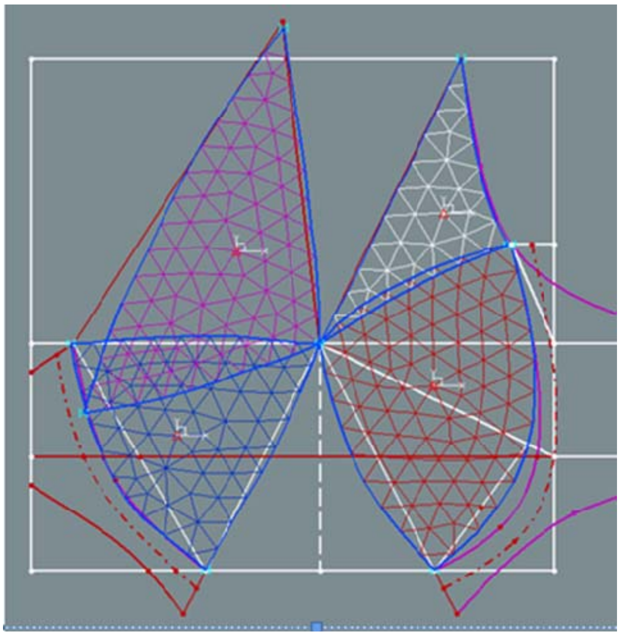

Figure 6: Position of upper dart

CONCLUSIONS.

While conceiving a bra of proper fit it is important to have customize measurement which can be obtained from the scanned mannequin. Our project identifies the faults in the traditional method for conceiving a bra with standard measurements. Besides the pre-defined measurements coming from used pattern making method was not fit to the mannequin's body. Moreover it is important to take into account that the measurements are taken in the curve whereas the 2D the pattern is defined it is on a straight line which causes the deformation of the measurement and 2D pattern do not fit do the body.
Fitting a bra on a 3D mannequin reduces the guesswork, trial and so the error is reduced. It is more precise and hence has greater scope when bra is conceived.
Our results are very promising and it seems to be very interesting to develop a such data base by setting for each size in comparison with traditional methods.

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SOFTWARE APPLICATION FOR MATHEMATICAL MODELLING AND OPTIMIZATION OF STOCHASTICALLY TEXTILE PROCESSES

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Abstract: *A software application for mathematical modelling and optimization is presented in this paper. The optimization method implies firstly to identify a regression equation able to express the relationship between the function of interest and other independent variables for which some measurements can be obtained. After a regression equation is obtained, one can determine the values of the independent variables, within a optimization area, for which the variable of interest has a maximum value or a minimum one, as applicable. Based on these results, one can make the necessary settings to improve the process. In order to obtain the regression equation, a factorial method given by Kono is implemented [1].To simplify the regression equation, some less significant coefficients can be ignored. Finally, the statistical test Fisher-Snedecor is applied to validate entirely the mathematical model given by the regression equation. In order to determine the maximum or the minimum value of the function of interest, the regression equation is transformed firstly into a canonical form. The function of interest is then represented graphically by some curves of constant level. A case study that illustrates the utility of this dedicated program is also presented in this paper.*

Keywords: regression equation, factorial methods, canonical form, optimization of textile processes.

1. INTRODUCTION

Any optimization process needs firstly a mathematical modelling. Naturally, a good model allows a better understanding of the process under consideration, and once the process of interest is better known, we must focus on identification of appropriate actions to improve it. In other words, a process optimization is strongly depended on an appropriate mathematical model. To simplify the mathematical model, in a first iteration some aspects of the real process considered less significantly can be ignored, even though we cannot be sure that what we have ignored are really insignificantly. In order to obtain appropriate results, the mathematical model of the process under study must be reconsidered in successive steps.

Generally, a technological process comprises two type of variables: independent variables and dependent ones. A mathematical model must express the relationships between a dependent variable (the function of interest) and the independent ones, for which some measurements can be obtained. This type of model is called a regression one. Note that, some functions of interest can be random variables. For this reason, in order to validate a mathematical model that reflects a regression equation, statistically methods must be used.

The correlation between the model and the measured values must be checked by using a regression analysis. Let us consider a dependent variable y (the function of interest) and an independent one *x*. Based on a set of *N* values for the independent variable *x* (x_i , i 1, 2, …, N), *N* values for the function of interest can be obtained experimentally (y_i , i 1, 2, …, N). The regression analysis must identify a function $y = f(x)$ in accordance with the set of measured values (x_i, y_i) , i 1, 2, …, N . A pair of values (x_i, y_i) reflects a point of the experimentally regression curve. Of course, it is unlikely that the continue curve $f(x)$ to go to all these points (x_i, y_i) , i 1, 2, …, N ; some of these points are closer, and other ones are further. The mathematical model obtained by a regression analysis is called regression equation.

In this paper we focus on the non-linear regression equations of 2nd degree. The coefficients for this function are obtained mostly by applying the method of the most least squares. This method minimizes the differences between the measured values and the theoretical ones. More exactly, this method implies that the sum of squares between the measured values y_i and the computed ones $f(x_i)$, i 1, 2, …, N , to be as small as possible.

2. MATHEMATICAL MODEL

For the regression analysis, the needed number of the measurements is determined statistically and it depends on the number of independent variables. The values of the independent variables x_i , i 1, 2, …, k , for which the measurements are made are determined rigorous and these values depend on the method used. In the frame of the analysis area of the independent variables, for each variable x_i , i 1, 2, …, k , a based level denoted by x_{i0} and a step of variation denoted by Δx_i are established first. The level 0 for all the independent variables reflects a reference point appreciated by the user as the most appropriate one for the function of interest *y.* For an independent variable, the mean value can also be considered as a reference level. For the variable x_i , i 1, 2, …, k , by adding or decreasing a variation step Δx_i, a superior level or a inferior one can be reached. By switching from a coordinate system in natural units to a codification one, the values for which the measurements are made are coded by +1 or -1. For example, if for each independent variable x_i , i 1, 2, …, k , only two levels are considered, a number of 2^k measurements must be made (factorial experiments).

The non-linear model most frequently used for correlation of some experimental values is a polynomial function, with the form:

$$y = b_0 + \sum_{i=1}^{k} b_i x_i + \sum_{i=1}^{k-1} \sum_{j=i+1}^{k} b_{ij} x_i x_j + \sum_{i=1}^{k} b_{ii} x_i^2 \quad (1)$$

where k is the number of the independent variables.

Thus, for two independent variables x_1 and x_2 , the following model expressed by a polynomial function of 2nd degree must be determined:

$$y = b_0 + b_1 x_1 + b_2 x_2 + b_{12} x_1 x_2 + b_{11} x_1^2 + b_{22} x_2^2 \quad (2)$$

To estimate the coefficients of this regression equation, the most effective methods are the so called “central-composed” ones [2] [3]. These methods impose an extension of the experiments made at the based level and at the factorial levels (coded by +1 and -1 as specified before) with two additional ones made at the levels coded $\sqrt{2}$ and -$\sqrt{2}$, respectively. Note that, when an independent variable x_i is set to the value $\sqrt{2}$ or -$\sqrt{2}$, all other variables $x_j , j \neq i$, must be set at the level 0. These additional experiments are called “star experiments”. For the case with two variable x_1 and x_2 , 13 measurements are necessary to apply this method: 5 distinct experiments in the central point, 4 factorial experiments and 4 star experiments. To reduce the measurements number, in our software application the method given by Kono [1] has been considered. This method allows to reduce the number of experiments up to 30%. The experimental matrix used by the method given Kono is presented in Table 1.

Table 1: Experimental matrix for *k*=2.

Experiment order number	Coded values		$y_{measured}$
	x_1	x_2	
1	0	0	
2	+1	+1	
3	-1	+1	
4	-1	-1	
5	+1	-1	
6	+1	0	
7	0	+1	
8	-1	0	
9	0	-1	

To estimate the coefficients b_0 , b_1 , b_2 , b_{12} , b_{11} and b_{22} , the equations presented in [3] and [4] have been implemented in our program. To check if a coefficient has a significant impact in the regression equation, the statistical test Student is implemented. This checking implies that the absolute value of a coefficient to be greater or equal to a confidence interval [5] [6]. Thus, if the user wants to reduce the regression equation, some coefficients marked as "less significant" after the Student test can be ignored. Finally, to validate the regression model, a statistical test Fisher-Snedecor is applied [5] [6]. To apply this test, we have used the tabulated value presented in [7].

The next step in our study is to determine the maximum or the minimum value for the function *y*, in the area of interest established before for the dependent variables x_1 and x_2. In order to determine the maximum or the minimum value of the function y, the regression equation is transformed firstly into a canonical form.

The reduction to the canonical form consists of two steps: in the first step, we operate a translation to a new central point *S* of the coordinates x_{1S} and x_{2S}, and in the second one, we operate a rotation of the system of coordinates, so as to make it to coincide with the figure's axes of symmetry. The equation, referred to the new axes X_1 and X_2, has the reduced form

$$Y - Y_S = B_{11} X_1^2 + B_{22} X_2^2 \qquad (3)$$

where Y_S is the value of the function *y* given by Eq. (2) in the new central point *S* = (x_{1S} , x_{2S}).

To calculate the coefficients B_{11} and B_{22}, we have applied the equations presented in [2]. The advantige of this canonical form is that the signs of the two coefficients B_{11} and B_{22} permit an immediate geometric interpretation, that allows to determine the maximum or the minimum point for the function of interest, into the frame of the analysis area.

To summery, the reduction to the canonical form, starting from Eq. (2), comprises three steps: searching for the new central point *S*, searching for the rotation angle of the new coordinate axes X_1 and X_2, and calculation of the new coefficients B_{11} and B_{22}. For verification, note that the old and the new coefficients must respect the condition

$$B_{11} + B_{22} = b_{11} + b_{22} . \qquad (4)$$

A geometric interpretation depending on the signs of the coefficients B_{11} and B_{22} is presented in Table 2.

Table 2: Significance of the coefficients of the canonical equation.

B_{11}	B_{22}	Type of curves of constant level	Significance of *S*
-	-	ellipse	maximum
+	+	ellipse	minimum
-	+	hyperbole	minimax
+	-		

Note that, the measure of interest is often a random variable. This mathematical model can be applied both for deterministic and random variables. In case of a random variable, function *y* given by Eq. (2) has the signification of the mean for this random variable.

3. BRIEF PROGRAM DESCRIPTION

The software application that implements the regression method given by Kono is developed in Microsoft Visio C# and is very easy to use. The interface application is composed of five tabs, one for each step necessary to solve the regression problem.

The first tab untitled "Experimental data" opens a table that allows to introduce the measured values for the function of interest *y* (the values y_i, i 1, 2, …, N). After all the nine experimental values have been entered, the coefficients for the polynomial equation given by Eq. (2) are available in the current window. For this operation, a dedicated button ("Calculus of coefficients") is available.

In order to apply the statistical tests, additional measurements are needed in the central point (the values for the experiments with the order numbers 9, 10 and 11). The user can select a coefficient with a minor impact on the dependent variable under study, to be not included in the regression equation. The tab “Model validation” is available for this step. The final form of the regression equation is generated in the current window. Figure 1 presents the first tab of this application.

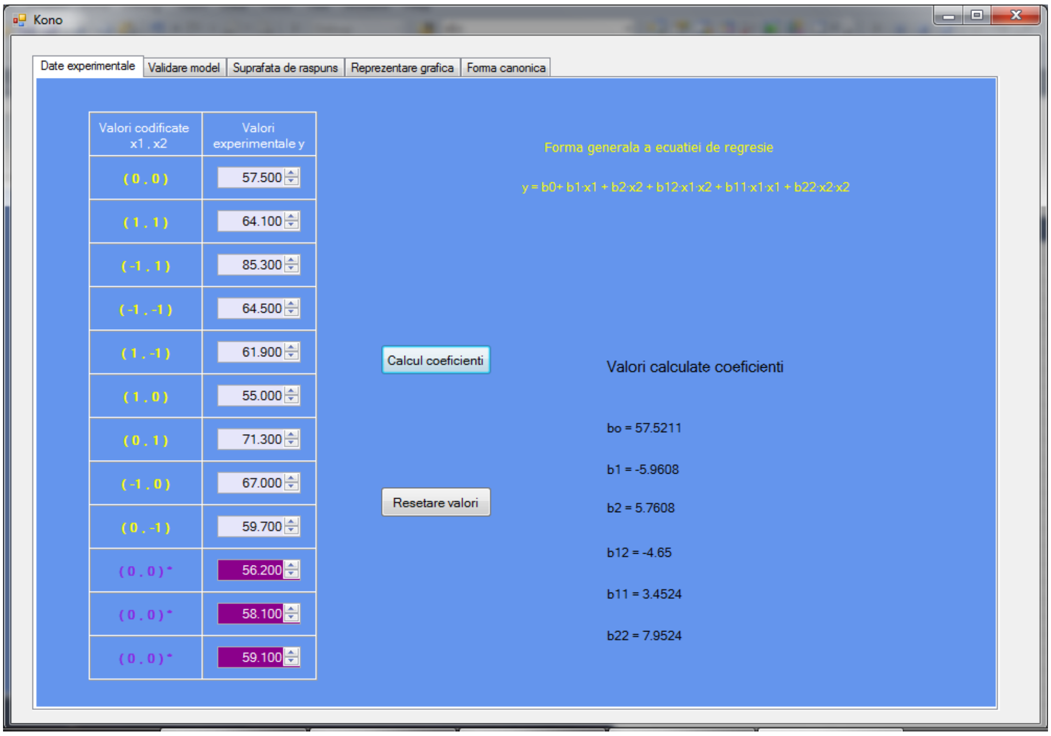

Figure 1: Introduction of the experimental data (caption from software application).

The function of interest *y* is then represented graphically by some curves of constant level. To be sure that the optimum value is determined correctly, a graphic representation for the canonical form of this function is also generated. To illustrate the optimization process for the function under study, an example is presented in the next section.

4. CASE STUDY

This example concerns a weaving process and highlights different cases of optimization we must take into account. The study is focused on two technological parameters at a weaving machine, namely: the initial tension of the warp yarns (x_1) and the advance used for shedding (x_2). We try to evaluate the influence of these two independent parameters over the weaving process, having in view the yarn breakage rate (the number of warp breakages per one fabric meter) and the tension in the warp yarns at the beating-up. Note that the both functions of interest are random variables. The yarn breakage rate is denoted by y_1, whereas the tension in the warp yarns at the beating-up is denoted by y_2. For the two independent parameters, the values we have considered are presented in Table 3. The measured values for the two functions of interest (y_1 and y_2) are presented in Table 4.

Table 3: Natural and coded values for the two independent parameters.

Independents parameters	Step of variation	Experimental area (limits of variation)		
		-1	0	+1
Initial tension of warp yarns (the spring position) [steps; 1step=15mm]	$\Delta x_1 = 1$	-1	0	1
Advance used for shedding [°]	$\Delta x_2 = 30$	305	335	5

Table 4: Measured values for the case study.

#	Parameter values (coded values)		The measured values (natural values)	
	Initial tension of warp yarns	Advance used for shedding	Yarn breakage rate [breaks per one fabric meter]	Warp yarns tension at beating-up [cN/tex]
	x_1	x_2	y_1	y_2
1	0	0	0.25	0.625
2	+1	+1	2.20	0.767
3	-1	+1	3.10	0.027
4	-1	-1	3.24	0.509
5	+1	-1	1.42	1.043
6	+1	0	1.39	0.982
7	0	+1	0.83	0.424
8	-1	0	2.75	0.328
9	0	-1	0.51	0.706

For the case in which these measurements have been made, the following equations have been obtained:

$$y_1 = 0.25 - 0.68x_1 + 0.16x_2 + 0.23x_1x_2 + 1.8195x_1^2 + 0.4195x_2^2 \qquad (5)$$

$$y_2 = 0.6286 + 0.3203x_1 - 0.179x_2 + 0.515x_1x_2 + 0.0241x_1^2 - 0.0659x_2^2 \qquad (6)$$

Both regression models are validated statistically by the Fisher-Snedecor test. A graphic representation for these two functions of interest by curves of constant level are presented in Figures 2 and 3.

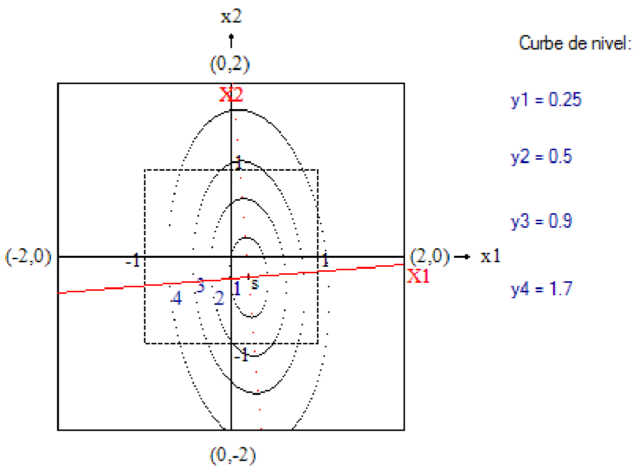

Figure 2: The variable $y_1 = f(x_1, x_2)$.

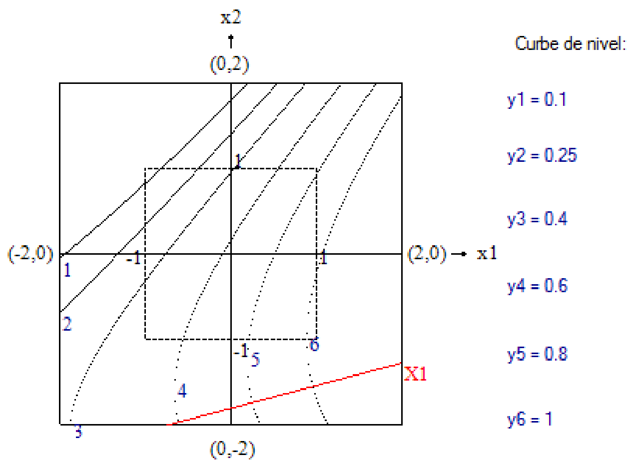

Figure 3: The variable $y_2 = f(x_1, x_2)$.

The canonical form for the two equations (5) and (d) given by our application are presented as follows:

$$Y_1 - 0.1615 = 1.8289x_1^2 + 0.4101x_2^2 \qquad (7)$$

$$Y_2 - 0.2921 = 0.031x_1^2 - 0.727x_2^2 \qquad (8)$$

Technological interpretation:

a) As regards the yarn breakage rate (variable y_1)

From Eq. (5), we can observe that the yarn breakage rate increases at the reduction of the initial tension of the warp yarns. This can be explained by the fact that the warp yarns are not tensioned properly, which favours the yarn breakages.

As illustrated in Figure 2, this variable has a minimum value $y_{1_{min}} = 0.1615$ in the new central point $S = (x_{1s}, x_{2s}) = (0.2024, -0.2462)$. Of course, the parameters x_1 and x_2 must be set as close to this point; a lower or a greater value for any parameter affects the yarn breakage rate.

b) As regards the warp yarn tension at beating-up (variable y_2)

From Eq. (6), we can conclude that the warp yarn tension at beating-up increases along with the initial warp tension. At the same time, the warp yarn tension at beating-up decreases when the advance used for shedding increases. But, this second parameter influences in a smaller extent the warp yarn tension at beating-up.

The canonical form presented in Eq. (8) indicates a minimax response surface, because $B_{11} > 0$ and $B_{22} < 0$. The central point of this surface (invisible in this graphical representation) is $S = (x_{1s}, x_{2s}) = (-3.66, -2.79)$.

On this basis and taking into account the curves of constant level presented in Figures 2 and 3, the following conclusion one can draw: to have a yarn breakage rate in acceptable limits (0.2 up to 0.4 breaks/m), it is necessary that the warp yarn tension at beating-up to have values into the interval [0.6, 0.75] cN/tex. For this purpose, the two parameters x_1 and x_2 must have coded values in the following intervals:

$$x_1 \in [-0.2, 0.5] \text{ and } x_2 \in [-0.8, 0.4].$$

5. CONCLUSION

Theoretically, one could proceed by estimating the regression equation corresponding to a model of a sufficient high degree, and then differentiating it to find the coordinates of the maximum for the function of interest. But, it is easy to realize that the number of trials becomes rapidly prohibitive. For this reason, a software application for aiding the user during the process of optimization of this non-linear functions with technological restrictions is absolutely necessary. An extension of this application dedicated to this regression model will be available soon.

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DEVELOPMENT OF TECHNOLOGY OF THREE-DIMENSIONAL SCAN OF A HUMAN FIGURE WITH THE USE OF BODYSCANNERS COMPANY «HUMANSOLUTIONS »

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Abstract: *One of the requirements to the quality of finished garments of various types and purposes is their compliance with the size and shape of the human body. Which requires information not only on size but also on the shape of the human body obtained during the study of anthropometric and body antropomorfologic signs of the human body.The current dimensional typology and classification of typical figures of women, as shown by its analysis, does not include the morphological characteristics of the body and integrated into the group, which includes people of different body shapes. According to the research institutes and the Museum of Anthropology Lomonosov Moscow State University is due to the fact that over the past 40 years since the last mass population anthropometric studies conducted in 1972, there have been significant changes in body size. This was the basis for the development of technology antropomorfologic studies, witch provides to get information about the size and shape of the body.Existing standard contact measurement methods do not allow obtaining information about the shape of the body. At the moment of greatest interest for anthropometric measurements are non-contact methods of obtaining information about the size and shape of the body using bodiskaner.*

Measurements obtained using bodiskaner, compared with measurements obtained using anthropometric instruments. It was found that when scanning figures small and medium sized groups withdrawal measurable traits in the automatic mode is correct. When removing measurable traits with figures large size group problems associated with incorrect automatic location anthropometric points on which measurements are made.

For realization of the possibility of using bodiskaner during mass anthropometric research it was developed methodical program and processing technology of avatars - three-dimensional image of a human figure.

In order to optimize the process of removing the signs dimensional avatar satisfied with the programming language in the embedded block xmlns Scan Wizard program ANTHROSCAN.

Thus, using the method of three-dimensional scanning of human figure significantly reducesOne of the requirements to the quality of finished garments of various types and purposes is their compliance with the size and shape of the human body. Which requires information not only on size but also on the shape of the human body obtained during the study of anthropometric and body antropomorfologic signs of the human body. The current dimensional typology and classification of typical figures of women, as shown by its analysis, does not include the morphological characteristics of the body and integrated into the group, which includes people of different body shapes. According to the research institutes and the Museum of Anthropology Lomonosov Moscow State University is due to the fact that over the past 40 years since the last mass population anthropometric studies conducted in 1972, there have been significant changes in body size. This was the basis for the development of technology antropomorfologic studies, witch provides to get information about the size and shape of the body.

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Measurements obtained using bodiskaner, compared with measurements obtained using anthropometric instruments. It was found that when scanning figures small and medium sized groups withdrawal measurable traits in the automatic mode is correct. When removing measurable traits with figures large size group problems associated with incorrect automatic location anthropometric points on which measurements are made. The time of measurement improves accuracy and occurs in more comfortable conditions both for researchers and for measured.

Keywords: *anthropometric studies, body size, 3D scanning, bodyscanner.*

INTRODUCTION

One of the demands to the quality of the ready-made sewing garments of different type and purpose is their accordance size and shape of the body. This requires information not only about the size, but also about the form of the body, obtained during the research of anthropometric and the anthropo-morphological characteristics of the body.

Existing dimensional typology and classification of the type of women's figures [1], as shown by analysis, does not contain morphological characteristics of the body and united in groups, including people of different body shapes. According to the research of the CR Institute and Museum of anthropology of Moscow state University named after Lomonosov this is because over the past 40 years since the last mass anthropometric studies of the population, conducted in 1972, there have been significant changes in body size.

This was the basis for the development of technologies anthropological research, which allows to get information about the size and shape of the body.

1.TECHNOLOGY OF 3D - SCANNING OF THE PERSON

Existing standard contact measurement methods do not allow to get information about the shape of the body. The measurement process of one person using anthropometric tools [2] takes 10 to 20 minutes, depending on the research program. The process figure is measurement sufficiently time consuming and tedious for both the measured person and researcher.

At present the greatest interest to conduct anthropometric studies are non-contact methods of obtaining information about the size and shape of the body with the help of bodyscanners. Bodyscanner render accurate three-dimensional virtual models of the human body. The most famous bodyscanners are developed in the USA, France, Germany, Japan.

To estimate the possibility of anthropometric data for bulk study using three-dimensional scan of a human figure is proposed to use bodyscans, developed by firm "HumanSolutions", Germany [3].

This bodyscanner has from 2 to 4 columns (figure 1). On each of which is assigned one or two cameras sensor that perform scanning quantity of cameras specifies the precision, the more cameras, the more accurate the measurement and more wide application. Are the use of bodyscanner significantly increases the speed of receiving and processing information.

Figure 1: Three-column bodyscanner VITUSSmart LC3 of the company "Human Solutions"

For 12c, it allows to get information on the figure of the man in the form:
- avatar - virtual three-dimensional model of a human figure;
- sections in a horizontal, vertical and inclined planes;
- the aggregate size signs(figure 2).

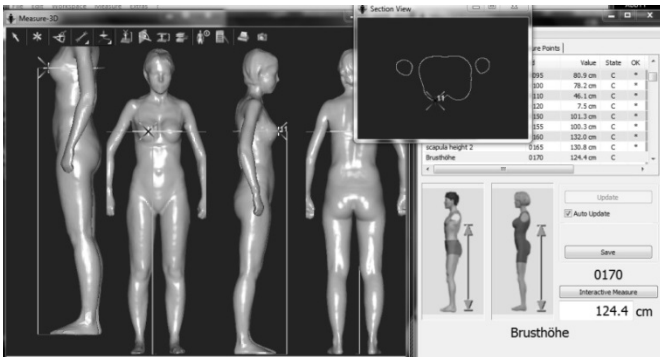


Figure 2: Information about the figure of a man, obtained through bodyscanners of the company "HumanSolutions

In addition, the software ANTHROSCAN allows to automatically process the data scanning and automatically retrieve data of figures measurement by 40 dimensional characteristics of the program. The obtained measurement data can be saved in a Protocol of measurements, and three-dimensional image to be exported to various formats for work with virtual mannequin.

Measuring specific dimensional signs, for example, to design corsetry, can be made either in manual mode using the tools of the program or to perform their programming to get in automatic mode.

2. EVALUATION OF THE POSSIBILITY OF USING BODYSCANNER OF THE FOR MASS ANTHROPOMETRIC STUDIES

2.1. Caring out of pilot research

To assess the possibility of using bodyscanners company "HumanSolutions" in the clothing industry a program anthropometric studies of 94 of body dimensions necessary to design products for various purposes and assortment has developed. During a pilot study was conducted scanning of 30 women shapes of different body type.

The measurements obtained with the help of bodyscanners were compared with measurements with using anthropometric tools.

It is established that when scanning figures of small and medium-size groups taking of body measurements in the automatic mode is done correctly. When taking the body measurements of large dimensional groups figures problems face connected with incorrect in automatic mode of the location of anthropometric points, with the help of which the measurements are taken. For example, when the demention of breast gland is large and there is a protruding belly, the point of mammary gland base is defined at the point of contact of the mammary gland with belly. Consequently, the quantities taken dimensional signs may not be correct.

Another problem of the use of bodyscanners for mass anthropometric research is the difference in methods of taken body measurements inherent in software bodyscanner and reflected in Russian state standard 31396-2009 "Classification of typical figures of women in height, size and completeness groups for planning of clothes".

2.2. Development of technology of scanning

To enable the use of bodyscanner for mass anthropometric studies methodical program and processing technology avatars - dimensional images of a human figure is developed.

Appearance of measured person must meet the following requirements:
- hair should be smoothly combed and gathered in a bunch;
- scanning is performed in underwear, located on the body, without squeezing;
- hands must be removed from the body by 15-20 cm from the hips, fingers should be closed and rectified;
- the distance between the feet should be 30-35 cm.

With the purpose of optimization of process of taken of body dimensions with avatara programming language xmlns inline block ScanWizard program ANTHROSCAN is made. The program contains 94 dimensional characteristic removed in an automated mode.

Measures need in manual mode to place on the surface of the avatar anthropometric points between which are performed measurements (figure 3). After placing of all anthropometric points from the list, the program removes meanings of the body dimension (figure 4).

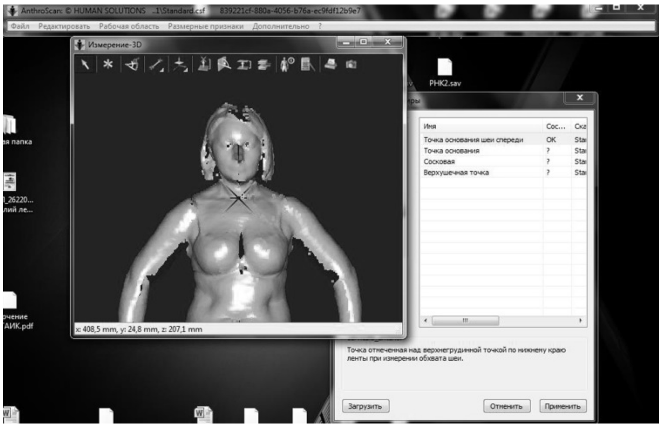


Figure 3: Placement of anthropometric points on avatar in the program ANTHROSCAN

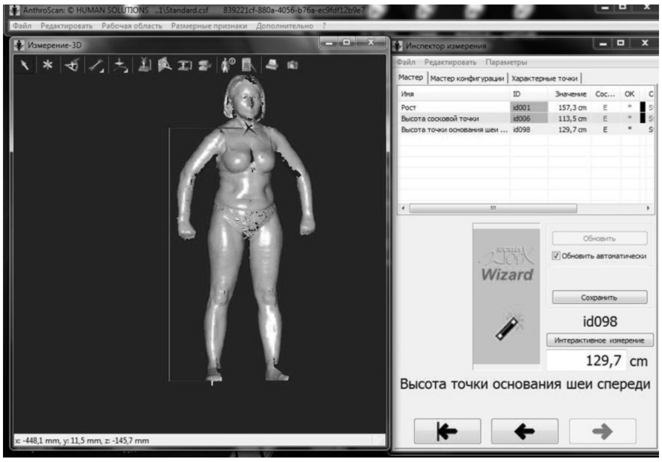


Figure 4: Taking of body dimensions in the program ANTHROSCAN

Because scanning figures occurs when a person is not closed legs, the distortion of body dimensions characterizing height occurs. For their correction it is necessary to use the Cv factor. The value of the coefficient we derived from the length of the legs and the distance that's legs (figure 5):

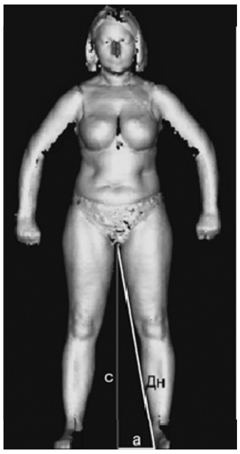
$$Кв = Дн/с$$, where

Дн - leg length on the inner surface (distance from the floor to the groin in the position of the feet together),
с - the distance from the floor to the groin during scanning.

Therefore,

$$Кв = \frac{Дн}{\sqrt{Дн^2 - а^2}}$$, where

а - the value of feet tap from the vertical when scanning.



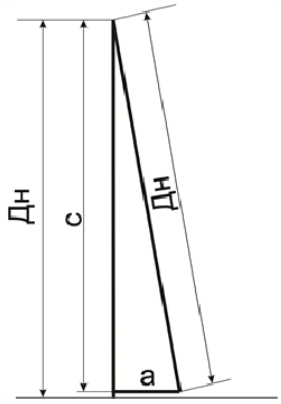


Figure 5: Scheme for calculation of the coefficient Кв.

The resulting coefficient should be used for the correction of all the altitude of body dimensions.

CONCLUSION

Thus, using the method of three-dimensional scan of a human figure time of measurement considerably reduces, accurate and occurs in more comfortable conditions both for the researcher and for measured person. Measurement protocols immediately are received electronically and they are ready for statistical processing, which significantly reduces the time to prepare data for processing.

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USING OF MAMAGI SYSTEM FOR THREE-DIMENSIONAL REPRESENTATION OF THE CLOTHES MODELS

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Abstract: *Modern design and manufacture of clothing is a complex system, which is characterized by a large dynamic production processes that combines the solution of artistic, technical and social problems. Before manufacturers acute problem reducing the time the start of production of new clothes and search for the optimal design and technological solutions garments depending on antropomorfologic signs consumer.*
The lack of opportunity quickly to correct the process of development of project solutions in terms of outsourcing, leads to the increase of terms of introduction of new models, to lower the quality of the designed products.
The development of visualization tools for remote work with primary samples of garments, quality control, planting and advertising finished products contributes to the solution of this problem.
Any sewing product is covered not by itself, but a relationship with a human figure, which represents a three-dimensional object. For quality assessment of cloth accordance, power silhouette, the degree of fit is very important to be able to view sewing product, put on the person's body from all sides. Use standard photo does not give such result.
To solve this task, the company Gerber Technology Solutions developed system MAMAGI - technology of three-dimensional images of 3D objects (gerbertechnology). MAMAGI can be applied at different stages of the product life cycle.
And this cycle can be repeated until you reach the desired result. This process extends the production cycle, is complex and expensive.
The system MAMAGI gives the opportunity to the contractor company in real time to sent to the office of the customer company accurate three-dimensional image of the sample models, put on a mannequin or a human figure. The customer can look at the sample from any side, increase in details and browse its components and apply to the image necessary comments.
Currently growing popularity of buying ready-made clothes through Internet shops grows. The main reason of refusal from making such purchases is the fear that the actual appearance of the product will differ from the images in Internet-shop. This is because a typical photograph does not give a full idea of the external appearance of a product, its proportions, and the peculiarities of the fitting on the figure of a man.
Only a three-dimensional image of the product, put on the man, gives full details and trusts by customers.
The buyer has the opportunity to examine all sides in the zoom mode separate parts of a model.
The result of 3D pictures can be easily viewed in any web browser without installation of additional software.
Using the method of three-dimensional image reduces the development time and control of primary samples increases the success of advertising and sale of products.
The conversion rate (the number of purchases of the goods in relation to the number of views) is on 60% higher in the case of presentation of goods in the Internet-shop in bulk full form.

Keywords: *3D-picture, virtual try-on sample, quality control, remote viewing, antropomorfologic signs, advertising.*

INTRODUCTION

Modern sewing production is a complex system, which is characterized by high dynamics of production processes. Before producers acute the problem of reduction of start terms in manufacture of new models of clothes and search for optimal constructive-technological decisions of garments.

The lack of opportunity quickly to correct the process of development of project solutions in terms of outsourcing, leads to the increase of terms of new models introduction, to lower the quality of the designed garments.

As F. Kotler [1] underlines, elimination of shortcomings is possible, if carefully consider such marketing functions, as the identification of customer needs, the development of targeted goods and establishment of the relevant rates, the establishment of goods distribution system, effective of sales promotion. Using the results of marketing analysis in project activities will help to produce such products, which, for sure, will find sales in the consumer market.

Social-economic changes of the beginning of XXI became the reasons of formation of the new concept in the manufacture of clothing – «address design», radically revising the means, methods and values of design.

Consumer research is devoted to a large number of studies, not only in the design of clothing, but also in the adjacent fields of knowledge. It should be noted the works of M.I. Kiloshenko and A.B. Hoffmann, revealing the psychological aspects in the design of clothing and system of artistic design of a suit.

A number of authors: G.S. Gorina, T.V. Kozlova, A.I. Cheremnykh discusses forming technologies in clothes. L.P. Shershneva and E.B. Koblyakova deep enough investigated issues relating anthropological characteristics of a person.

However, consumers resolved sufficiently the problem of complex development of clothes with regard to appearance, and social aspects of a person and situation purpose of the suit, as well as the mechanism of choice of clothes.

The experience of sewing industry enterprises showed that the efficiency of work in the conditions of market economy and high goods competition is largely determined by the availability of technology and information - technical tools to ensure production flexibility, automation of artistic-projecting works and the targeting item of designing cloth.

Developing tools visualization system of design objects for remote work with the primary samples of garments, quality control, compliance garments size and shape of a human figure, as well as for advertising finished products helps to the solution of this problem.

1 USING OF MAMAGI SYSTEM FOR THREE-DIMENSIONAL REPRESENTATION OF CLOTHES MODELS

A holistic approach regarding the system "environment-people-costume-production", proposed by Volkova E.K. and considered in the works of other scientists (Shershneva L.P., Koblyakova E.B.) is a rational route of production development, connected all elements of the system. However, in modern conditions of social-economic transformation approach "man - environment - production - society" more appropriates. Components of this approach are as complex systems, which are in constant interaction. In the region of intersection of these systems there is the clothes choice (figure 1).

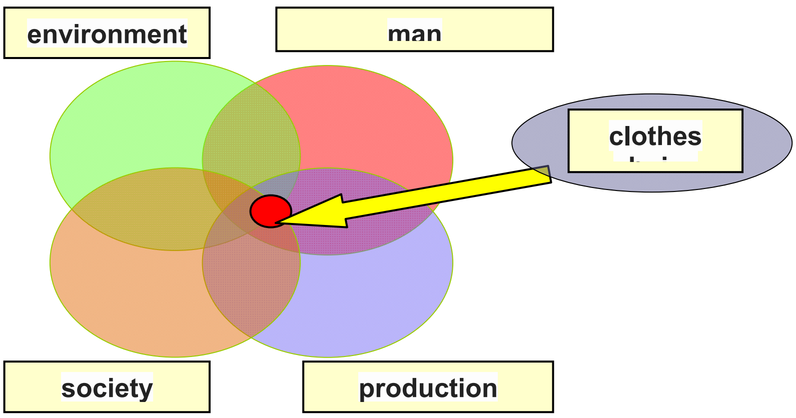

Figure 1: System of clothes choice

Any sewing product is covered not by itself, but in the context of the human body, which is a three-dimensional object. To assess product quality and its compliance with the figure, the fashioning of the silhouette, the degree of fit it is very important to be able to view sewing product, put on the person's body from all sides. Use standard photo does not give such result.

To solve this problem the company Gerber Technology Solutions developed system MAMAGI - technology of three-dimensional representation of voluminous objects [2]. MAMAGI can be applied at different stages of the product life cycle.

1.1 Remote control of primary samples of models

The classical scheme of work in terms of outsourcing is as follows:
- the client company forms a package of primary documents on the collection;
- the contractor produces primary samples of models and sends them to the client company;
- the client company evaluates aesthetics, quality, compliance of sample models to figure, formulate comments, changes in the documentation and sent to the contractor company.

This cycle may be repeated several times, until you reach the desired result. The above process of interaction between the customer and contractor extends production cycle, is complex and expensive.

The system MAMAGI gives the opportunity to the contractor company in real time to pass to the office of the customer company accurate three-dimensional image of the sample model put on the dummy, or a human figure. The customer can look at the sample from any side, to increase and to see a region of interest of product model and to apply to the image comments (figure 2).

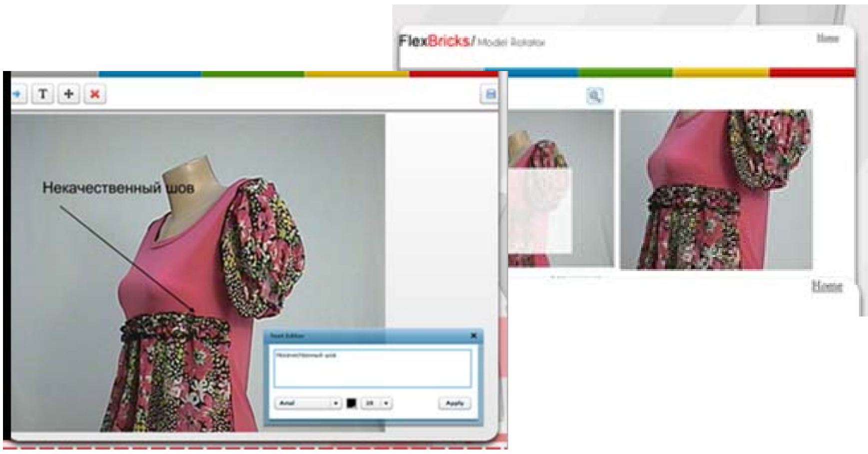

Figure 2: View sample garments online in three-dimensional format

1.2. Presentation of models of clothes on web-sites of Internet-shops

Now the popularity of buying ready-made clothes through Internet-shops is growing. The main reason of refusal from making such purchases is the fear that the actual appearance of the product will be different from the images in Internet-shop. This is because of a typical photograph does not give a full idea of the appearance of the product, its relative proportions of the figures, the peculiarities of appearance models, put on a human figure.

Only a three-dimensional image of the product, put on a human figure, gives full information and trusted by customers.

The customer has the opportunity to examine the model on all sides, in the mode of increasing of individual sites.

2. TECHNOLOGIES OF CREATION OF VOLUMINOUS REPRESENTATION OF THREE-DIMENSIONAL OBJECT

The system for work with three-dimensional object MAMAGI includes a special platform, camera and personal computer (figure 3).

Figure 3. The appearance of the system MAMAGI

The platform is a stand witch rotates at a certain speed. This platform is connected with the camera and your computer. The camera must be mounted on a tripod to avoid errors from the lens shift in the time of shooting.

The computer runs a program Mamagi Static Studio, the parameters of which we can set the number of frames to join in the three-dimensional representation. When program is launched platform starts smoothly rotate. At the moment of rotation of the platform, the camera performs the specified number of images.

The result of 3D pictures can simply be viewed in any web browser without having to install additional program security.

2.1. Using the system MAMAGI for the analysis of anthropological characteristics

Man is a complex object, not only in form but in content, so the existing classification does not cover the entire range of features of the human body and their variations, but it is the individual human characteristics are often the cause of dissatisfaction of consumers by clothes. It is established, that at present, when designing clothes it is accounted only a small number of characteristics of the consumer, namely-growth, size and weight.

A great variety of group segments and not the full amount of information about potential consumers adversely affect the quality of the design - finished product: it is difficulty to choice of preferred models of clothes, there may be problems of a good fit products in the figure.

Currently, the man is not seen as an abstract entity with a perfectly calculated and verified proportions, and as a living being, manifesting itself in the diversity of types and classes System MAMAGI extends the analysis of anthropological characteristics of man, greatly influencing the choice of composition-constructive solutions in design of clothes.

CONCLUSION

Based on the above, we come to the following conclusions:
- only three-dimensional image of the product, put on a human figure, gives full information and trust of buyers;
- the buyer has the opportunity to examine the model on all sides, in the mode of increasing its individual sections;
- using the method of three-dimensional image the development time and control of primary samples

reduces, the success of advertising and sales of products increases;
- the conversion rate (the number of purchases of the goods in relation to the number of views) is 60% higher in case of submission of goods in the Internet-shop in full volume.

Using the method of three-dimensional image reduces the development time and control of primary samples increases the success of advertising and sale of products.

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Режим доступа: свободный, яз. русс.

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PARAMETRIC DESIGN OF KNITTED GARMENTS BY USING CAD SYSTEMS AND BASIC APPLICATIONS

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Abstract: *This paper presents parameterized product design for a knit sweater for men, using specialized graphics programs (demo application module Gemini Pattern Editor and Gemini Tailoring Assistant - Made to Measure) and non-specialized programs (Excel, AutoCAD) . Parametric design system is proposed to merge all the advantages of general-purpose programs in its field (Excel, AutoCAD) using the programming language Visual Basic for Applications. This allows to integrate applications in Microsoft Office and other usual applications. The possibilities of parametric design allow construction and patterns design for the entire size range for a product. As basic parameters were taken absolute values of the dimensional characteristics for the typical body and main additions required to build patterns for a sweater for men, according to the methodology of constructing VDMTI.*

Keywords: *Parametric design, knitted products, general purpose programs, Gemini CAD.*

1. INTRODUCTION

The use of automated systems in the constructive design of clothing has a number of advantages compared to manual methods. They consist in increasing the precision of patterns and elimination of repetitive tasks, reduce the amount of manual calculations specific to the construction of apparel patterns [1].
Possibilities, offered by parameterized design, allow to design patterns for the entire range of needed cloth sizes for both products from fabric and knits [2]. As basic parameters were taken absolute values of the dimensional characteristics for the body types and main additions needed for basic pattern construction. This work presents construction of sweater pattern for men and this is made according to the methodology of constructing VDMTI [3], being applied both constructive parametric design methods.
As representative for CAD systems with parametric design was used Gemini CAD, which is an integrated system consisting of both software and the specialized equipment designed to support the whole design activity and cutting in textile factories. Gemini ensure both technological process for those working in Lohn system and those who design their collections being made computerized following: design, digitizing, grading, patterns measurement and verification, cut planning, optimization and plotting. Gemini Systems also include equipment for digitization and 1:1 patterns and nesting plotting.
With the Gemini Tailoring Assistant - Made to Measure, the system is perfectly adapted to automatically process the individualized products, unique or particular dimensions of each client. The focus is on the design and the rapid development of new products, automatic grading and grading for the size of each client. The system also can be provided with optional electronic communication between the stores network and the production department for making of new orders. This module is designed specifically for fashion houses, shops and haute couture networks, creative workshops.
To automate the calculation of constructive segments for basic patterns using general purpose programs as an example was taken Microsoft Excel program, which is used as a database manager and as automated spreadsheet for construction sequence for patterns. Because a workbook can contain multiple spreadsheets, it can hold various types of information in the same file. To simplify the work on the first sheet is created a database, containing anthropometric measurements of typical bodies needed for clothing design and the next worksheet calculates the sequence of basic pattern design of the product for one size from measurement table (fig. 3.), the original data being used from the measurements database.
Entering new values in measurements tables, spreadsheet is calculated automatically and a new constructing sequence is provided for the product. Also you can calculate sequences for products construction designed for one body type using different addition values, which can contribute to more rapid resolution of specific design problems and research in the field of Textile, especially when working with large amounts of data, complex computations and repetitive work and complex graphics.

2. PARAMETRIC DESIGN OF KNITTED PRODUCTS USING CAD SYSTEMS

Currently in production on an industrial scale of knitted products assortment for men a higher weight of product types are: sweaters, vests, jackets. Products, parts or knit from which they can be made are obtained on various types of knitting machines (straight, circular or warp) from various types of raw materials and various forms (contured, semi-contured, panels or line). For this reason it is necessary to use some methods for basic patterns design which include all the particularities to obtain the final product (proper selection of margins depending on the machine on which parts or knit are manufactured, additional margins for knit extensions or contractions in the longitudinal direction and the cross-cutting of the fabric) [2].
According to the methodology of knitted products design developed by VDMTI (Home of unional modelling of knitted products) [3] one should follow these steps:

1. Construction of basic patterns of the product.
2. Construction of product model patterns by considering the deformation of knitted fabrics and model features.
3. Grading of marks for the range of sizes and weights.

By working method offered by Gemini Tailoring Assistant - Made to Measure, called by producer "geometric design" at first step positions of the major points are defined which will define the shape of the pattern, then the designer will draw the outline pattern in drawing mode, which will anchor the points defined geometrically.

The workflow in Gemini Tailoring Assistant is highlighted through the following main steps:

- the preparation of sizes set with necessary allowances;
- estiblishing the position of geometric points that define the pattern contour (geometric layer development);
- anchoring of the nodes of pattern contour to the geometrical points from previous step.

The following paragraph presents the steps in developing workflow for a men sweater pattern sizes 44-58, waist I [4], in the Gemini system.

2.1. Entering initial data set for basic pattern construction for the sizes set

The first step in parameterized design of patterns consists in initial construction data set preparation and definition of the sizes set. Very important is that additionaly to establishing and setting the set of sizes in this table (Figure 1.) is to establish and edit all initial data accurately (dimensional characteristics and margins additions which vary according to size, type of machine, the elasticity and type of fabric), because from them will be made automatical grading of designed model.
Sizes set reprezents a list of conventional symbolization that can be associated with different sizes from one country to another and from one manufacturer to another (eg. S, M, L, XL, XXL or 40, 42, 44 ... , and so on).
Designer in Gemini Tailoring Assistant may use saved sets of sizes, which are delivered with the program, or can define their own sets of sizes as either simple lists of names, or more elaborate, adding specified size quotas for each size of the set, which can be useful later in the design phase. Created sizes sets can be saved to your computer then reused in other projects, as one needs rarely to create a new set. To edit the sizes set for a model one have to enter in the mode "RATING" and click the button 'Edit set size' in the top left of the screen:

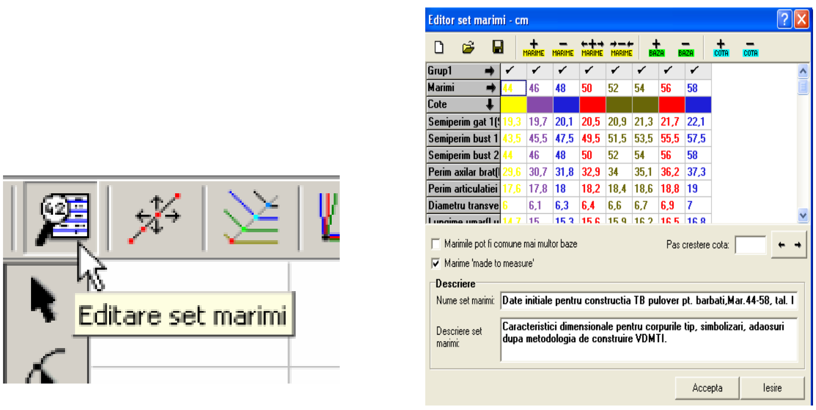

Figure 1: Editing sizes set and entering initial data for pattern base construction.

Figure 4 shows the result of parameterized construction and automatic grading for a product designed in GeminiCAD according to saved values from sizes set.
Grading is performed simultaneously with the construction process of details and requires no other documentation or quotas for this. With the "show / hide gradations" button, grading can be viewed or hidden at any stage of product design.

2.2. Drawing the basic pattern of the product using the module Gemini Tailoring Assistant Made to Measure

After determining the sizes set and initial data for basic pattern, in the work area shall be established the main points of the construction using the special tools.
The work area is the area that displays geometric constructions made using design functions. In the work area can be viewed either geometric layer (Figure 2) or shape layer (Figure 3), or both layers simultaneously.

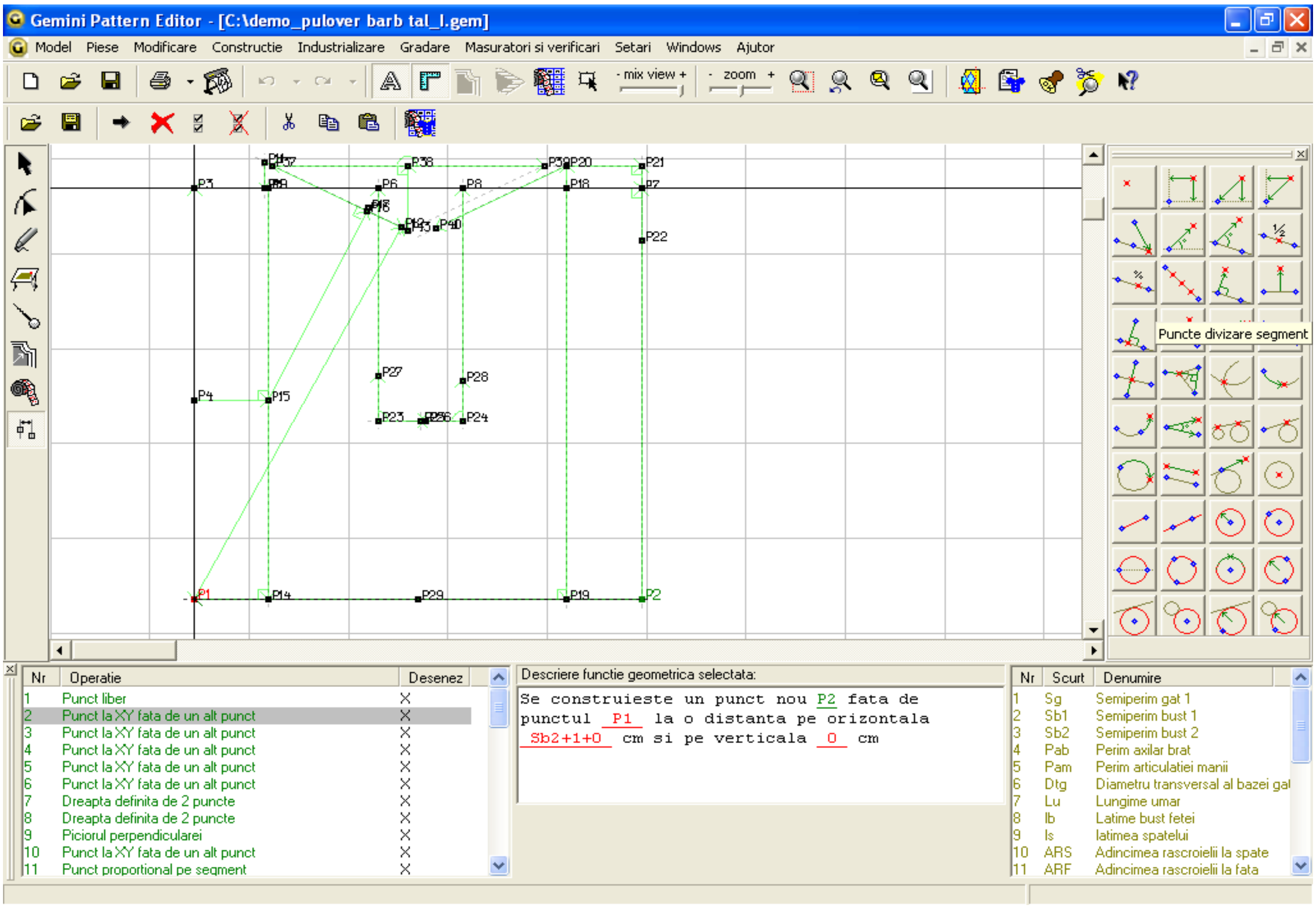

Figure 2: Construction of geometric layer in Gemini Pattern Editor.

Mixing between geometric layer and shape layer can be done interactively using the "mixed view" tool located in the front of Gemini Pattern Editor [3]. By simply dragging it with the mouse will make the transition from one layer to another.

Advantages arising from parametric design of patterns with Gemini:

- anchored patterns on a geometric layer can be graded fully automatic using dimensions from the sizes set and initial data for design;
- anchored patterns on a geometric layer can be automatically adjusted to meet each client's personal dimensional characteristics for individual products design.

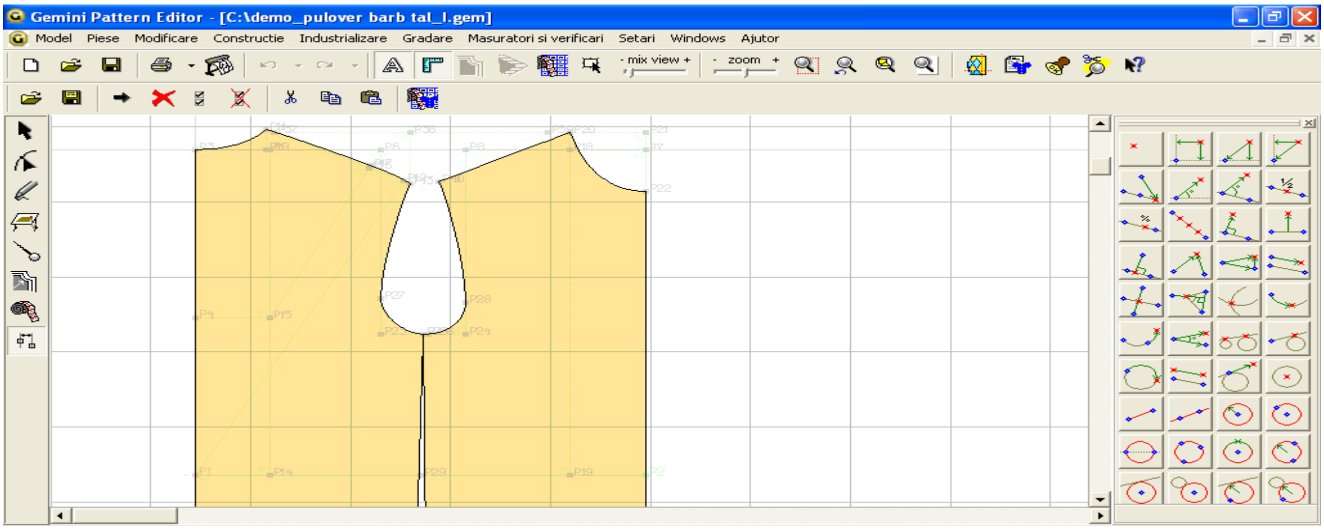

Figure 3: Construction of shape layer in Gemini Pattern Editor.

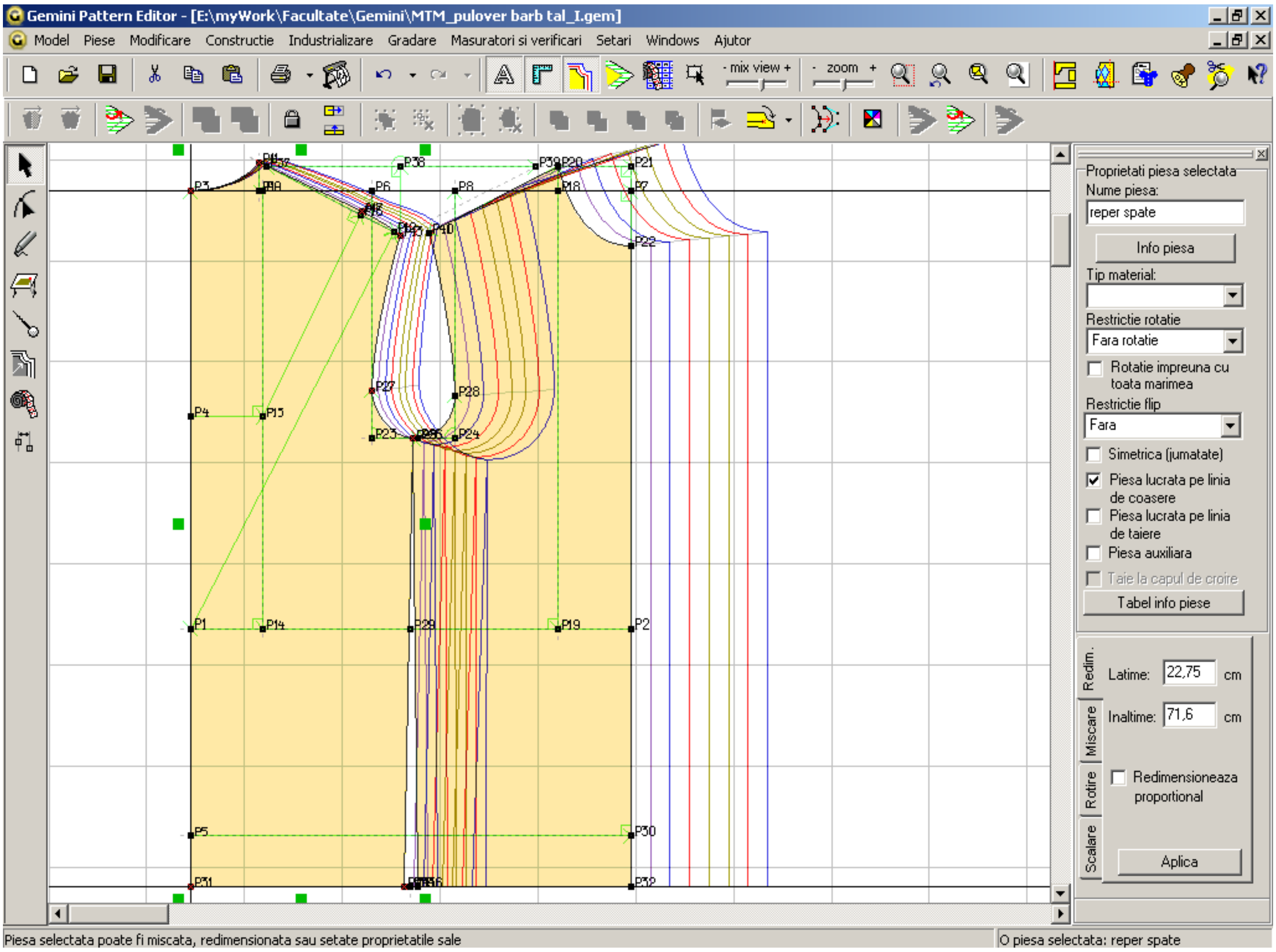

Figure 4. Automatic grading for a product in GeminiCAD.

These the two major advantages are able to compensate the extra time and effort required for constructing geometric anchor layer because grading operation disappears altogether. Modifying some initial data and margin additions in the sizes set editor can get a variety of new forms of pattern of knitted sweater that can be executed on different machines with different structures and materials. Also, databases can be created with different patterns, ready graded, knitted on existing machines in a given enterprise.

3. CONTRIBUTIONS TO THE PARAMETERIZED DESIGN OF PATTERNS OF KNITTED GARMENTS USING NON-SPECIALIZED PROGRAMS

A parametric design system is characterized by the fact that the graphic objects are represented separately in two modes - the graphical objects and textual instructions. Textual instructions are programming graphical objects using the functions developed in the programming language Visual Basic for Applications [32]. Graphical representation is a result of description of objects in textual form. Next is presented a parametric design system developed by authors and steps which can be been taken to obtain the basic pattern for a sweater for men [2].

3.1. Presentation of the proposed parametric design system

For the development of parametric design system it is proposed to join all the advantages of general-purpose programs in its field (Excel, AutoCAD) using the programming language Visual Basic for Applications. This allows to create an integrated solution for Microsoft Office and other applications [2].
Thus, to facilitate the work on the first sheet is created a database containing anthropometric measurements of typical bodies required for product design. In the next sheet is calculated the construction sequence of the basic pattern of the product for all of the sizes from the sizes table (Figure 5.), with initial data from the created database.

	A	B	C	D	E	F
1	Marimea	58				
2		9				
3						
4	Nr. d/o	Segmentul	Formula	Adaos	Valoarea	
5				[cm]	[cm]	
6	1	T1T2	Sbll+Ab+Agm	1,00	59,00	
7	2	T1A1	Lts+ALs	2,30	43,30	
8	3	A1D	ARS+ALs	2,30	24,40	
9	4	A1Б	Lfes+Als	0,40	63,80	
10	5	A1A3	Is+AsAb+0,4*Agm	0,12	23,12	
11	6	A2A4	Is+(Sbll-Sbl)+AsAb+0,4*Agm	0,12	23,62	
12	7	A3A4	T1T2-A1A3-A2A4		12,26	
13	8	A1A5	0,4*A1A3		9,25	
14	18	A1a	Dtg+Alg	1,30	8,30	
15	19	aa1	0,4*A1a		3,32	
16	20	a1П	lu+Atu	1,00	17,80	
17	21	T1П	lous+Alou	0,30	47,20	
18	22	a1П1	lu+Atu+Alu	1,70	18,50	
19	23	a3	0,3-0,5	0,50	0,50	
20	24	A2A6	A1a+0,5		8,80	
21	25	T3A7	Lts-A1a+Atf	0,10	48,60	
22	26	A8B1	tabelar		9,30	
23	27	A7П2	lu+Alu	0,70	17,50	
24	28	П2П3	tabelar		1,40	
25	29	A3P	ARS+Als+Acr	2,60	24,70	
26	30	PP2	PP1/2		6,13	
27	31	PP3	PP1/2+0,5		6,63	
28	32	P2M1	P2P1		6,13	
29	33	P3M2	PP3		6,63	
30	34	T1T4	T1T2/2		29,50	
31	35	H2H3	1			
32	36	H2H4	1		1,00	
33	37	БН	7 cm		7,00	
34						
35						

Figure 5: The sequence of the basic pattern constructing in Excel

The author has been developed a library of functions (Table 1.) which are used to achieve several parameterized design elements for clothing products with minimal effort. This library is open, which permits changing the data, adding new features, offering diversification opportunities. It provides further development of parametric design library with new functions to increase the number of tools used in the design and modeling process of clothing products.

Table 1: Library functions for the parametric design (excerpt)

Nr	Functions	Param 1	Param 2	Param 3	Param 4	Input data
1	**2**	**3**	**4**	**5**	**6**	**7**
1.	**point_xy**	nr. p1	Coord. X	Coord. Y	-	coordinates (x,y)
2.	**point_med**	nr. p3	nr. p1	nr. p2	0,5	point p3 will be in the middle of segment made by points p1 and p2
3.	**line_2p**	nr. l1	nr. p1(x1,y1)	nr. p2(x2,y2)	-	nr. p1, nr. p2
4.	**line_rotate**	nr. l2	nr. l1	nr. p1	angle	nr. l1 – number of reference line, nr. p1 – number of reference point for rotation, rotation angle
5.	**delete_line**	nr. l1	-	-	-	nr. of line to delete
6.	**circle_op**	nr. c2	nr. p1	nr. p2	-	Make a circle c2 with center point p1 through the point p2
7.	**arc_center**	nr. c1	nr. p1	nr. p2	nr. p3	p1-center, p2 and p3 – points on arc
8.	**arc_3p**	nr. c1	nr. p1	nr. p2	nr. p3	arc c1 through points p1, p2 and p3

3.2. Development of construction sequence for basic pattern

To write a sequence for automated construction in parametric form (figure 5) one shall set a origin point, which is considered as the point with coordinates (0, 0).

sg_start				
set_layer	baza			
point_xy	1	0	0	
point_xy	2	59,00	0	
point_xy	3	0,00	43,30	
point_xy	4	0,00	18,90	
point_xy	5	0,00	-20,50	
point_xy	6	23,12	43,30	
point_xy	7	59,00	43,30	
point_xy	8	59,00	-20,50	
line_2p	1	3	5	
line_2p	2	1	2	
line_2p	3	3	7	
line_2p	4	7	8	
line_2p	5	5	8	
point_xy	9	59,00	18,90	
line_2p	6	4	9	
point_xy	10	35,38	43,30	
point_xy	11	9,25	43,30	
point_xy	12	8,30	43,30	
point_xy	13	8,30	46,62	
line_2p	7	12	13	
circle_or	1	13	17,80	
circle_or	2	1	47,20	
point_int_AA	14	1	2	0
line_2p	8	1	14	
circle_or	3	13	18,50	
point_%	15	13	14	3
line_2p	9	13	15	
point_xy	16	9,25	18,90	
point_xy	17	9,25	-20,50	
line_2p	10	11	17	
line_move	11	9	13	16

Figure 5: A sequence of basic pattern construction in parametric form (fragment)

Coordinates of the other points are calculated according to origin point. In sequence any new point can be used as reference points for next sequence. To define lines in parametric form point numbers are used in sequence lines. Using Excel functions we can perform many operations with objects "line", "circle", such as copying, moving, rotating, mirroring them. Auxiliary objects that were created during the writing sequence can be easily erased.

By using the proposed parametric design system we obtain a combination of features specific to Excel calculation and graphical facilities of AutoCAD.

Setting up a database for dimensional characteristics of typical bodies, it can be used in many construction sequences for different clothing products and can be used in construction of industrial collections of patterns (Figure 6). In this way there is no need for grading schemes and calculations for new models (Figure 6.b).

(***a***) (***b***)

Figure 6: Basic construction for a sweater for men realized by parametric design system (a) and automatic grading (b).

4. CONCLUSIONS

Using automated design of clothing has a number of advantages compared to manual methods. They consist in increasing the precision of the results and eliminating repetitive tasks in design process, reducing the amount of manual calculations specific to the pattern construction. Modern automation systems in design are based on parameterized pattern construction.

Benefits resulting from parametric design of patterns in Gemini CAD:

- anchored on a geometric layer, patterns can be graded fully automatic, using dimensions from a set of initial data with required sizes;
- anchored on a geometric layer, patterns can be automatically changed to meet each client's personal dimensions and can be used for individual products design.

The two major advantages are able to compensate the additional time and effort required for building geometric layer because grading operation disappears altogether.

Modifying some initial data and margin additions in sizes set editor we can get a variety of new forms of patterns for a sweater that can be knitted on different machines with different structures and materials.

The major advantage of the proposed system with parameterized design using usual programs is the ability to modify both the dimensional characteristics and values for margin additions used in the patterns construction, which contributes to a faster resolution of specific problems in textile clothing design.

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A STUDY REGARDING DATA COLLECTION METHODS FOR 3D FOOTWEAR ORTHOTICS MODELLING

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Abstract: *The use of in-shoe pressure measuring systems have significantly increased lately, since their application has expanded considerably. As each field of use requires different specifications, different types of sensor have been developed. We have analysed the constructive and functional characteristics of the most common types of sensor, capacitive and resistive, to evaluate each one's efficiency for in-shoe measurement applications. Systems based on in-shoe sensors must provide specific degrees of accuracy in both static and dynamic measurements, along with force and timing information for a precise analysis of foot functionality and gait. We performed the analysis on the most used sensors on the market. In conclusion we determined that the resistive sensor, is suitable for application where the pressure distribution mapping is necessary but the precise values are not critical. On the other hand, the capacitive sensor is appropriate for high precision determinations of the force on each mapped point.*

Keywords: *data collection, pressure measuring, footwear, orthotics*

INTRODUCTION

The gait analysis by foot pressure distribution determination is one of the main tools for the assessment of patients with knee arthritis and other lower limbs associated disorders. [1] To accomplish this, one of the methods consist in using a mat embedded with pressure sensors [2] for measurements that don't involve the use of footwear products, and in-shoe sensor system [3] for footwear related measurements.
Force sensing devices are found in a wide constructional variety. However, each variant uses the same principles. For measuring forces on the plantar surface of the foot, flexible sensors are needed. The flexible sensors are produced by various technics [4] depending on the required features. The sensors flexibility improves the measurement accuracy and the sensor durability. Another factor that influences the result is the sensor size [5]. For the particular case of plantar pressure determination, a sensor surface of 25 mm^2 is optimal, but it can vary in large limits as the measurement range is mainly defined by the interfacing circuitry.
The accuracy needs for the sensing devices are depending mainly on the field of use. Even if low cost sensors are not too accurate, there are a few methods of increasing the accuracy especially when the pressure mapping is dynamic and the centre of pressure needs to be tracked [6].
In this paper, we present the constructive and functional aspects of both capacitive and resistive sensors as well as an analysis of the main characteristics of this type of sensors. A comparison chart of the analysed characteristics is presented at the end of this paper.

STRUCTURE OF THE MEASURING UNIT

The measuring units, commonly named sensors, are converters that measure a physical quantity and converts it into a signal that can be read directly or by means of specialized instruments. Most sensors convert physical measurements into electronic signal which can be read by electronic instruments. The sensors used for in-shoe force measurements are manufactured in the form of flexible films that fits the insole contour, films that contain a bi-dimensional array of sensors disposed as a matrix. The matrix resolution depends on the field of use. Even if the cost of the sensor is not significantly influenced by the matrix resolution, the overall system price depends in a linear way on it. The electronic instruments reading the sensor signal is as complex as the resolution of the sensor. Even if different sensor configurations can be developed for in-shoe measurements, the most used type of configuration is the classical matrix configuration which is illustrated in Figure 1.

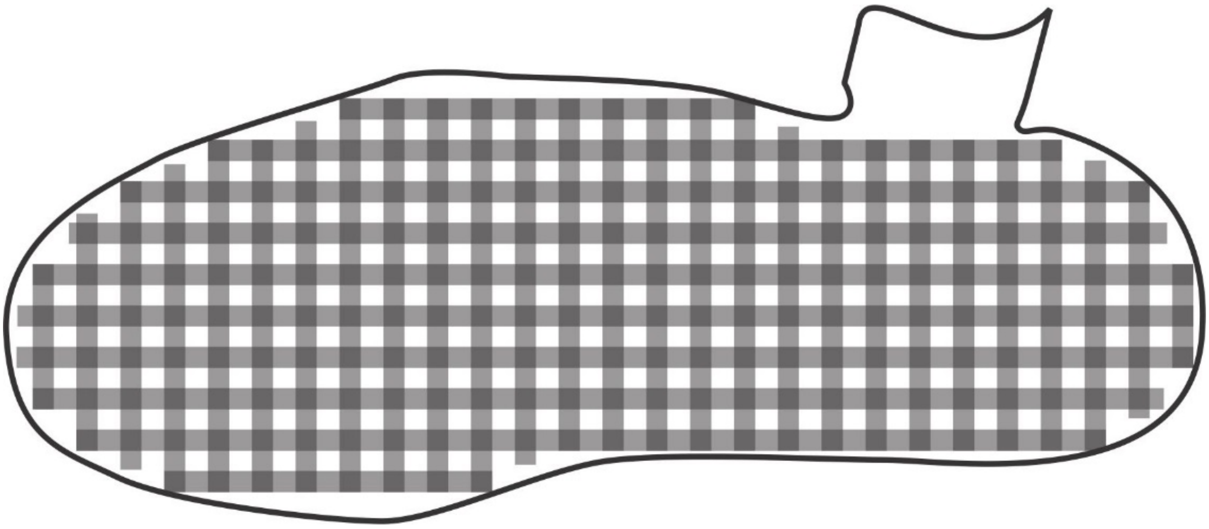


Figure 1: Sensor matrix configuration

Each sensor consists of two electrodes shaped to maintain the flexibility. The schematic diagram of the sensor is illustrated in Figure 2.

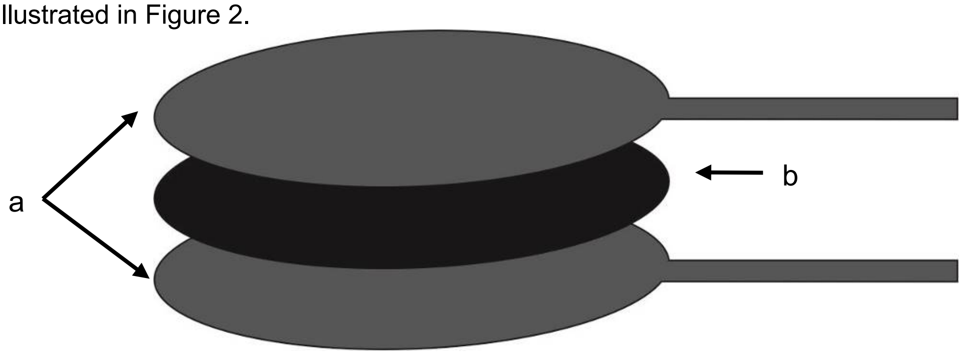


Figure 2: Sensor schematic diagram (a – electrodes, b – dielectric/resistive material)

The same configuration is used for both capacitive and resistive sensors. The difference consists in the material used between the two electrodes [7]. In the case of capacitive sensor, a dielectric material is used to separate the electrodes. In the case of resistive sensor, an electrical resistive material is used. The entire sensor is usually packed between two layers of polymer foil. Special properties for the sensor assembly can be obtained by using different support materials. A good flexibility and tear resistance is obtained by using textile fabrics instead of polymer foils, joined by adhesive and/or sewing.

INTERFACING THE MEASURING UNIT

Resistive sensors are usually interfaced through operational amplifiers (OA) as signal conditioners and multiplexers to analogue to digital converters (ADC) [8]. There are two available configurations for this interfacing type, depending on the amplifiers and multiplexers positions. The first configuration, presented in Figure 3, first amplifies the analogic signals from the sensors and then multiplexes and converts to digital.

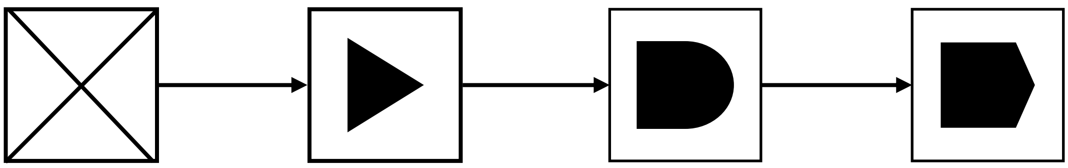


Figure 3: Sensor – Signal conditioner – Multiplexer – Converter configuration

The second configuration, presented in Figure 4, multiplexes the analogic signals from the sensor, then amplifies the multiplexed signal and converts to digital.
The first configuration is more expensive, as it uses an amplifier for each sensor, but its precision degree is higher. However, the second configuration is typically used as there are fewer components needed around the sensor and it's easier and less expensive to implement.

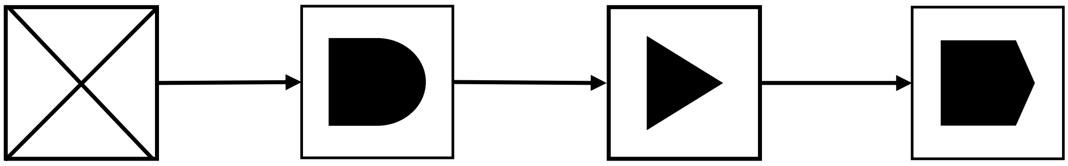


Figure 4: Sensor - Multiplexer – Signal conditioner – Converter configuration

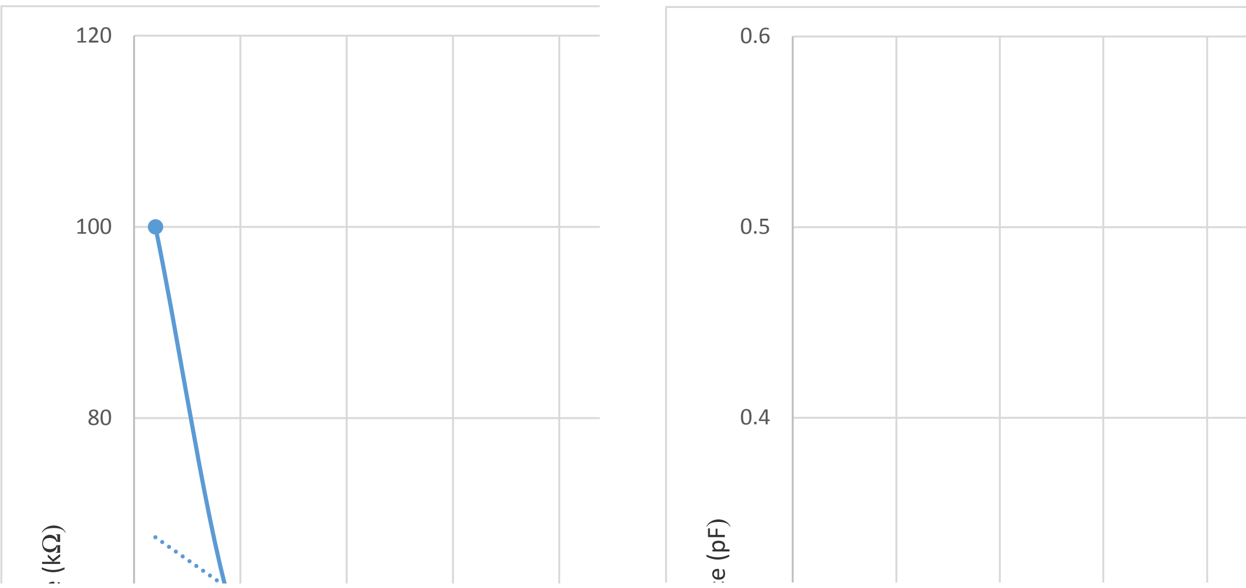
Capacitive sensors are interfaced through a more complex circuitry. The capacitance variation is converted into a voltage, frequency or pulse width modulation. Even if simple circuits can be used, a simple circuit is affected by leakage or stray capacitance, rendering useless these circuits for small capacitance sensors. Because the precision of the capacitive sensor measurements depends on the signal conditioning, the multiplexing is performed after the conditioning, as in the configuration presented in Figure 3.

MEASURING UNIT ANALYSIS

We have analysed the functional characteristics for both sensors under different conditions to determine the stability and precision of each one.

4.1. Analysis of linearity

By applying force on the sensor, a linear variation of the sensor value is expected, those the returned value of the sensor can be expressed as S = F*a + b, where "a" and "b" are constants.
The purpose of linearity analysis is to identify to what degree the measured value of the sensor deviates from the expected linear dependency on the applied force.
In Figure 5 is illustrated the response for both resistive and capacitive sensors. The determinations ware made at 20 ºC, starting with a 200g weight and then using weights from 1 to 10kg with 1kg step. Because the sensors are sealed, the humidity is not interfering in the determinations.

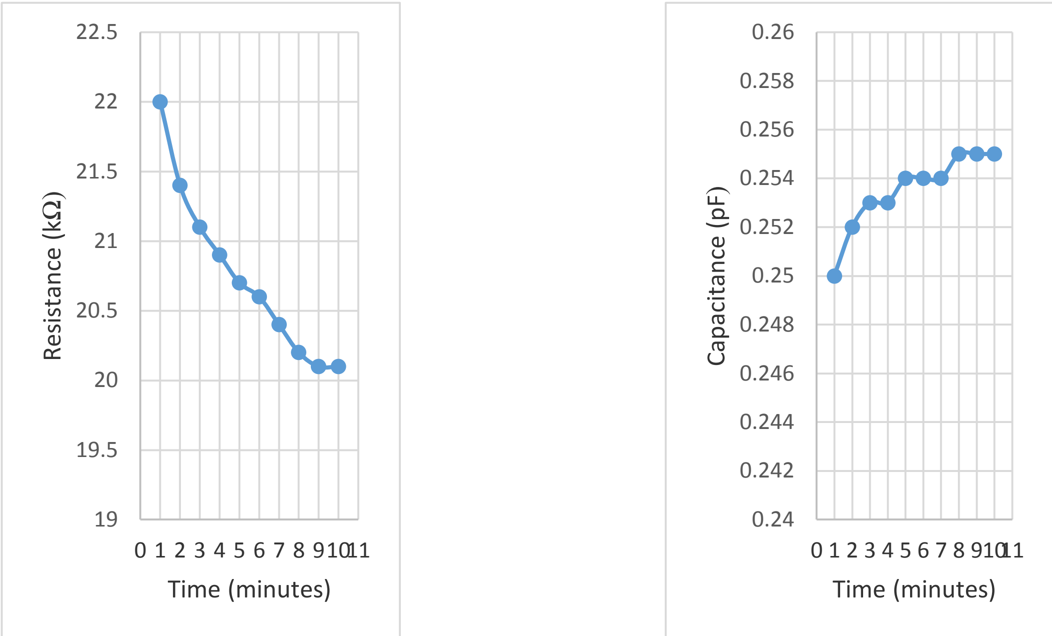


a. Resistive sensor b. Capacitive sensor

Figure 5: Sensor linearity analysis

4.2. Analysis of drift

Sensor value drift is an important parameter in force measuring sensors because their values vary with time for a constant load applied to the sensor. This situation appears in the calibration phase, when various weights are placed on the sensor to determine the constants in the value variation function. A long time drift is an indicator of the sensor properties degradation over a relatively long period of time.
The sensor value variation in time, at a constant weight of 5kg, is illustrated in Figure 6 for both resistive and capacitive sensors.

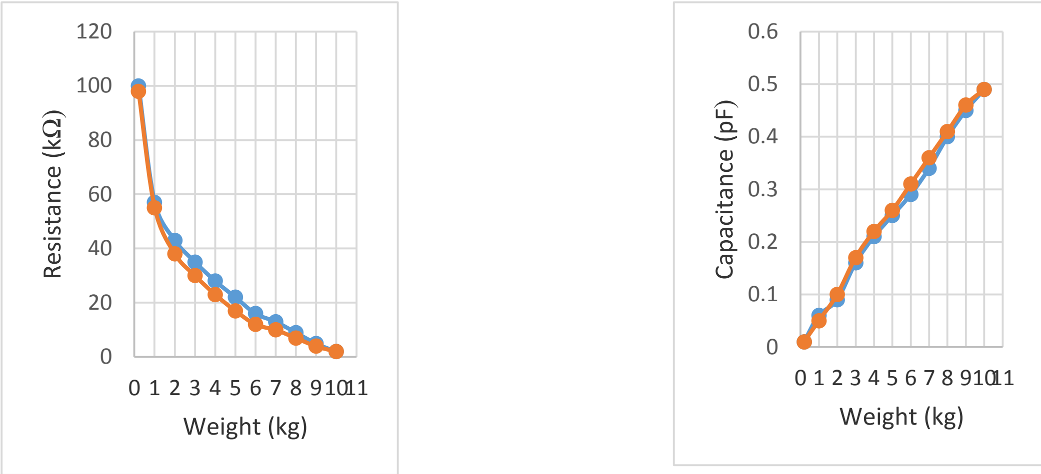


a. Resistive sensor b. Capacitive sensor

Figure 6: Drift analysis

4.3. Analysis of hysteresis

The hysteresis is an error that appears when the sensor value is measured in reverse direction (unloading). Usually the hysteresis is caused by a time lag for the sensor to respond, causing a different offset in the loading than unloading directions.
In Figure 7 is illustrated the hysteresis for both resistive and capacitive sensors.
Even if the capacitive sensor has a hysteresis magnitude that influences to some extent the measured value, the resistive sensor hysteresis magnitude is up to three times higher and its hysteretic behaviour may even prevent it to return to the initial stand-by state fast enough to perform repetitive dynamic measurements. This characteristic of the resistive sensors demands recalibration before each use and even intermediate recalibrations, when used in dynamic data gathering.



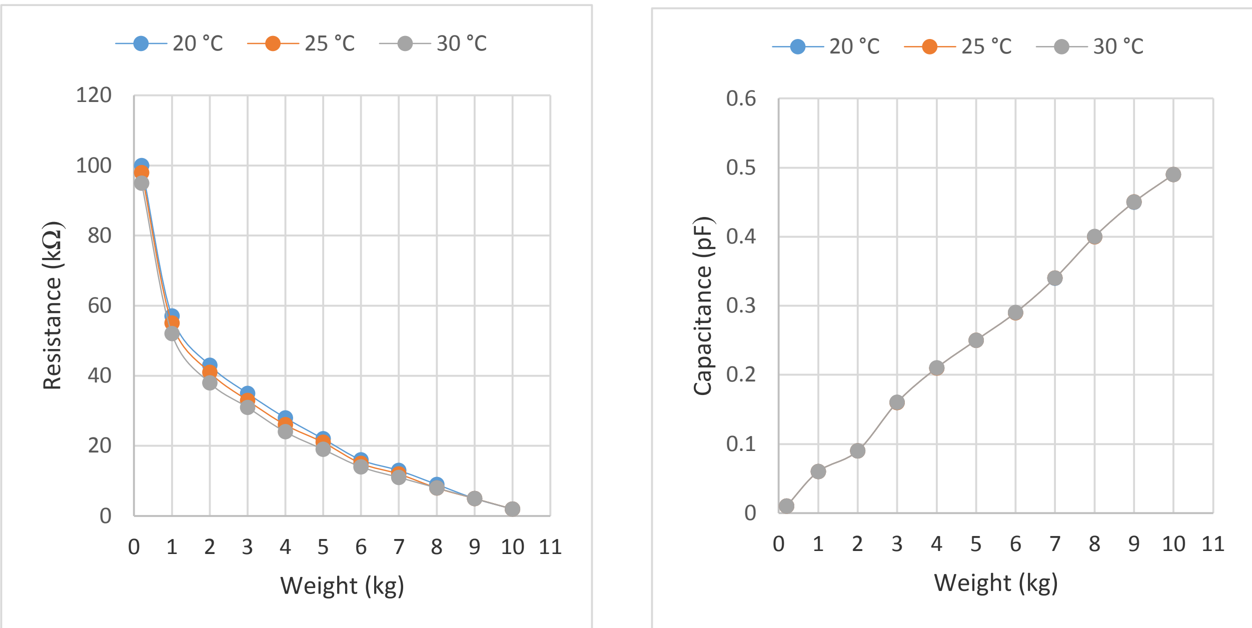
a. Resistive sensor b. Capacitive sensor

Figure 7: Hysteresis analysis

4.4. Analysis of temperature influence

To some extent, the sensors are sensitive to properties other than the measured one. The environment temperature is the most common factor that influences the sensor response.

In Figure 8 is illustrated how the sensor response varies with the environmental temperature. In contrast to the resistive sensor which is significantly influenced by the temperature, the capacitive sensor response is insignificantly changed.



a. Resistive sensor b. Capacitive sensor

Figure 8: Temperature stability analysis

CONCLUSIONS

In Table 1 are summarised the analysed aspects for the resistive and capacitive sensor. Except the production price and interfacing, the overall performance is evaluated on a five point scale (Poor, Fair, Good, Very Good and Excellent).

Table 1: Results summary

Parameter \ Sensor type	Resistive	Capacitive
Production price	Medium	Low
Interfacing	Simple/Cheap	Complex/Expensive
Linearity (R^2)	Good (0.79)	Excellent (0.99)
Drift	Good	Very Good
Hysteresis	Good	Very Good
Temperature influence	Fair	Very Good

The resistive based data acquisition systems are recommended for the cases where the acquired data is used in comparison or distribution mathematical models. Even if the accuracy of the resistive systems is influenced by the environmental factors in a high degree, with the right calibration algorithms the accuracy can be significantly improved. The calibration should be run as often as possible, at least before each data acquisition session. Intra-session calibration is a good practice to obtain data with a higher degree of accuracy. Simple and low priced systems are built for reading data provided by resistive sensors arrays [9].
In comparison with the resistive systems the capacitive based data acquisition system have a high accuracy, the influence of the environmental factors over the accuracy is low and the calibration process is not needed too often. The higher accuracy comes at a higher production price and the investment is justified only for the cases where the exact data values are required.

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A STUDY REGARDING DATA PROCESSING FOR 3D FOOTWEAR ORTHOTICS MODELLING

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Abstract: *In this paper is described a complete data processing method developed by the authors in order to automate the design and the production of 3D footwear orthotics using as input data collected by measuring pressures at the foot-footwear interface. In the specific case of data collected for 3D footwear orthotics modelling, the qualitative data collection method is used. After the collected data is available for processing, a set of steps is used in order to obtain usable data: validation, summarization and aggregation. The validation ensures that the supplied data is clean and correct. The summarization reduces the detail data to main values. The aggregation combines multiple sets of data. The processed data is then added to a cloud based database.The final shape of the 3D orthotics is constructed by a non-uniform rational basis spline mathematical model for the top side and by replicating the existing support surface for the bottom side.*

Keywords: *data processing, pressure measuring, footwear, orthotics*

INTRODUCTION

Collecting foot pressure distribution data has evolved from impression moulds to digital data collecting devices. Regardless the method used to measure the foot pressure distribution, the scope was always the same: using the collected data to produce three dimensional footwear orthotics. From the methods mostly based on observations, by using foot moulds, up to using digital data processing capable of analysing and proposing orthotics solutions, the final product is usually manually manufactured. This leads to a final quality of the orthoses strongly related to the experience of the workman manufacturing the product.
As precision prototyping and processing machinery have been developed, the workmen have specialized in 3D CAD and CAM. By using these technologies, the orthosis are built by using a variety of materials using 3D printers and/or CNC milling machines. The precision increased significantly and the production time was reduced.
Even if the technology and methodology evolved dramatically in the recent time, a crucial step in the process experiences a significant lag. The conversion of the collected data into a 3D mathematical model of the orthoses is still mostly manually done.
In this paper is presented a method developed by the authors to fully automate the data processing and 3D orthesis model generation. Once the data is collected [1], the first step in processing consists in data validation. The main method used for data validation consists in establishing the limits of the measured values and eliminating the determined values that fall outside the limits. As the normal (or Gaussian) distribution is a very commonly occurring continuous probability distribution, this function is used to tell whatever the collected values are falling between the limits [2].
The next step in processing the collected data consists in summarization. Thus, the arrays of data are further reduced to its main values [3]. Since the data in the database is of very high volume, there needs to be a mechanism in order to get only the relevant and meaningful information in a less messy format [4]. Data summarization provides the capacity to accomplish this.
The final step in data processing is the data aggregation [5]. In this step, data obtained in several measurements is combined. In the classic method of data aggregation, groups of observation are replaced by summary statistics [6]. In the particular case of 3D orthosis, both summarized data and aggregated data is stored in a cloud based database storage. The aggregated data is used as corrective parameter while the summarized data is used both for updating the aggregated data and define categories of orthosis.
The cloud data storage [7] is used in order to obtain high quality parameters by computing collected data obtained by measurements performed in different situations on different groups of subjects. By using this

method the subjects can be grouped by different criteria (job, age, ethnicity, etc.) to obtain relevant data for each group.

DATA COLLECTION

Data collecting is performed mainly using in-shoe foot pressure measurement sensors. The data collection component of the development process emphasis on ensuring accurate data. The accuracy of the collected data is mainly determined by the measuring equipment. In Figure 1 is illustrated the classical sensor type for in-shoe data collection.

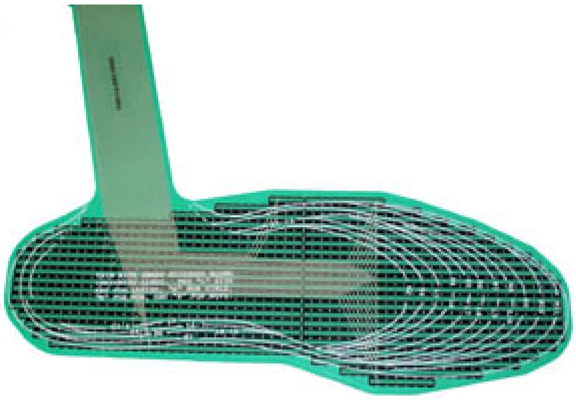

Figure 1: In-shoe pressure measurement senor

The sensor is the pressure sensing element but the full data collection system includes the processing unit. The full system is illustrated in Figure 2.

.
Figure 2: In-shoe pressure data collecting system

Collected data provides both dynamic and static pressure, force and timing information for foot function and gait analysis. Each type of data, of dynamic and static measurements, is used for specific application [8]. For the specific case of generating 3D orthotics, the static pressure measurements are used.
Depending on the structure of each footwear product, the results of the measurements will be significantly different. This highlights the fact that the orthotics inserts are specific for each particular case of foot – footwear combination. In Figure 3 is presented the graphical result of the measurement of the same foot using two different types for footwear.
Consequently, the orthotics insertion for each footwear product will have its unique shape defined by a mathematical model based on two factors: the measured value and the correction factor.
The measured value is easily obtained directly from the measuring system. Contrary, the correction factor is obtained through a complex algorithm of data processing [9]. The precision of the correction factor is proportional with the amount of data available for analysis. A community based data sharing will lead to better results. This is feasible by using a cloud based database storage for both raw and processed data.

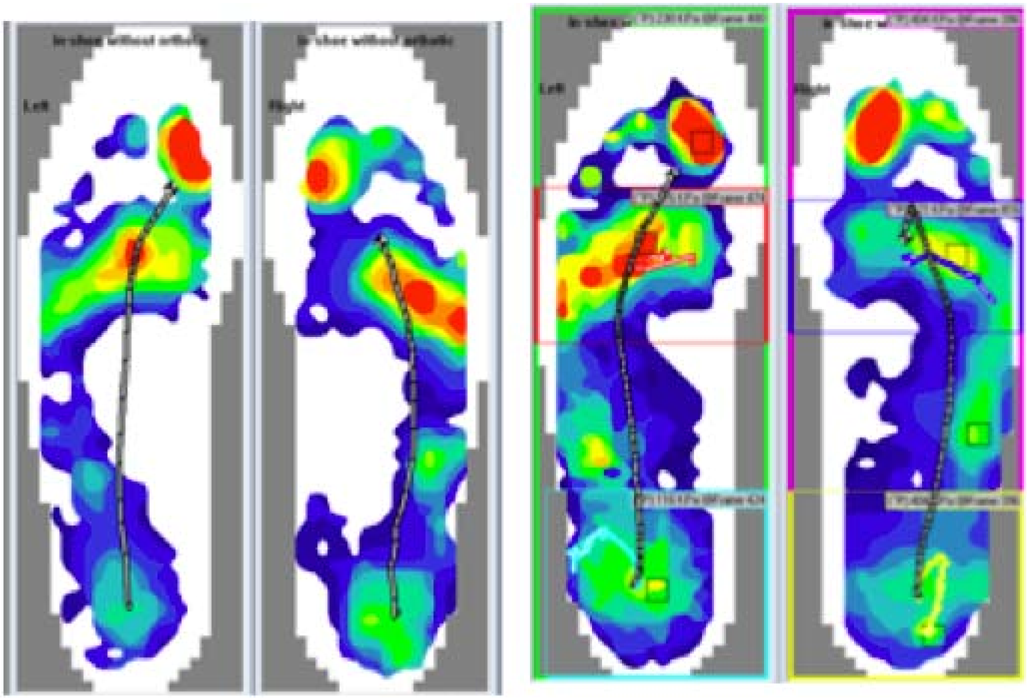

Figure 3: In-shoe measurement using different types of footwear

DATA VALIDATION

The purpose of data validation is to provide certain well-defined guarantees for accuracy, and consistency for the input into an application or automated system. Data validation rules can be defined and designed using various methodologies.

In evaluating the basics of data validation, generalizations can be made taking in account the different types of validation, according to the scope, the complexity, and the purpose of the validation operations to be performed. For example: data type validation, range and constraint validation, code and cross-reference validation, and structured validation.

Input data from sensors is usually validated by simple range and constrains method. Simple range and constraint validation may examine the input data for consistency with a minimum and maximum range, or consistency tests against regular expressions.

The normal distribution mathematical model is used for sensor data validation [10]. The normal distribution is based on the central limit theorem, which states that, under normal conditions, the mean of many random variables independently collected from the same distribution is distributed approximately normally, irrespective of the form of the original distribution. The normal distribution mathematical model is presented in equation 1.

$$f(x,\mu,\sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \quad (1)$$

The parameter μ in the equation represents the median value or the expectation of the distribution. The parameter σ is the standard deviation and its variance is therefore σ^2. A random variable with a Gaussian distribution is said to be normally distributed and is called a normal deviate. The bell curve obtained by the graphical representation of the collected data is similar to the graphic presented in Figure 4.

As the process data can be used in various processes, the validation algorithm must be flexible enough to allow validations with different degrees of accuracy. A single validation type implementation, based on strict rules, can be performed by a relatively simple algorithm. As the validation must include different methods and the need for flexibility of the rules increases, the complexity of the validation algorithm increases significantly. If a simple validation algorithm include only one validation type and the rules are defined by constant values, a complex validation algorithm includes multiple validation methods as: range and constrain validation, cross reference validation, structured validation, etc. The rules used in complex validation algorithms can be almost completely defined by the user, the only applying restriction being the mathematical restrictions.

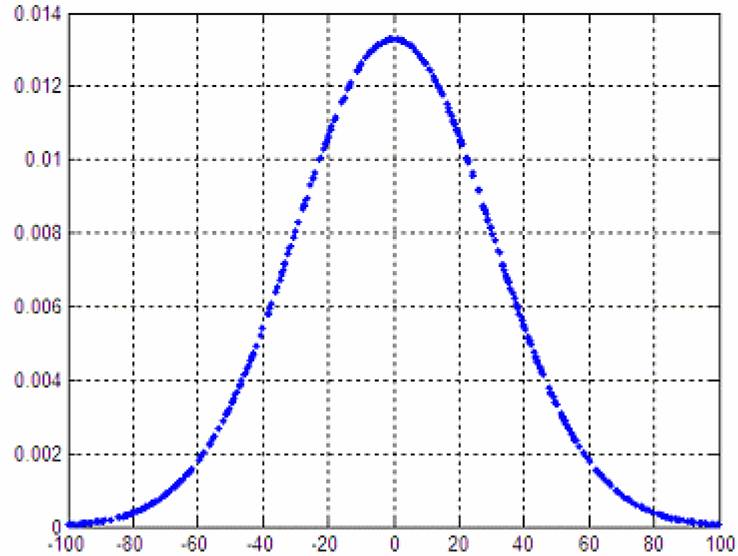

Figure 4: Graphical representation of the collected data distribution

DATA SUMMARIZATION

The data summarization provides an overview of the data that serves to identify trends and irregularities. In practice, the data is not usually stored in summarized form because the summarization consist itself in a set of steps that prepare the data for visualization and usage. This process is repeated each time the data is needed, as raw data is constantly added [11].
The data summarization process consists in three different operations: summarization, correlation and visualization. The raw data used in summarization is data obtained for specific cases. For example, the summarization can be applied to all measurements made on diabetic foot but should not combine data from diabetic foot with data from flat foot measurements.
A graphical representation of data summarization is presented in Figure 5.

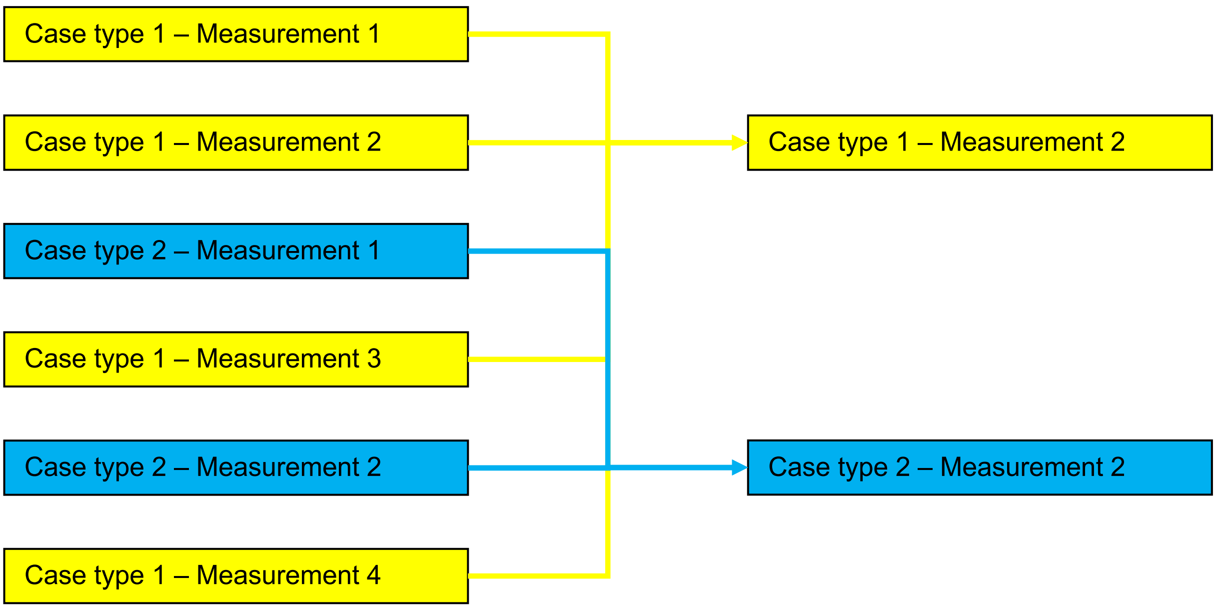

Figure 5: Data summarization – graphical representation

DATA AGGREGATION

If data summarization processes data collected at one collection point, the data aggregation processes data from different collection points. In order for this processing to be effective, the database should be stored in a cloud based storage system [11]. The data aggregation model is graphically represented in Figure 6.

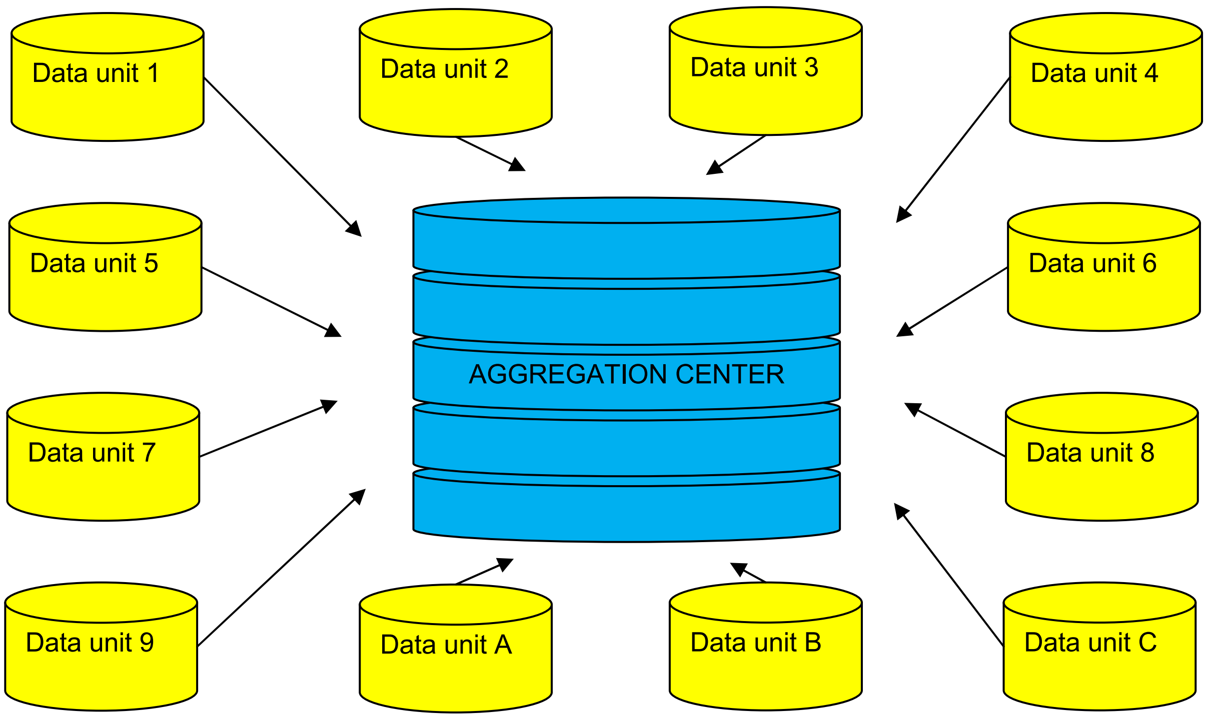

Figure 6: Graphical representation of the data aggregation model

The data aggregation service implements its own data collection [6], validation and processing. From a functional point of view, the aggregation process includes the following sub-processes:

- Data collection – the data is gathering from the data units using dedicated methods, for example WSDL (Web Service Description Language).
- Data and format validation – once the data has been collected, the integrity of data's structure and syntax is validated.
- Data transformation – validated data is converted and translated from the external format to the internal storage format.
- Data normalization – is the process that converts special data values to data storage compatible values.
- Data enrichment – additional identification data is appended to the processed data to allow data gathering processing.
- Data mapping – formats the data structure between its source and target systems according to certain transformation rules and business logic.
- Data extraction – algorithms to select relevant data using specific parameters.

As different data collection methods and system coexist, the aggregation service should be able to interpret and map the collected data to a unified system [9]. This process is required even for the same data collection system between its versions.
To ensure a smooth transaction process, the aggregator must provide a set of functions:

- Convert and translate data automatically
- Monitor data at every stage of aggregation
- Avoid remedial data quality efforts by spotting specific discrepancies, errors, failures, and exceptions in data events and resolving them mid-cycle
- Facilitate partner and data source customized data aggregation templates and profiles
- Pinpoint the location of all records on a particular data unit

As the data is converted into a specific format for transfer, the aggregation system ensures data compatibility between all the external units.

CONCLUSIONS

Currently, the existing systems collect data and store it locally in a proprietary format. This data is used mostly to display in different formats, information about the foot pressure distribution.
The method presented in this paper for data processing fully automates the data processing and 3D orthesis model generation. In Figure 7 is presented a 3D orthosis model built on a CNC milling machine.

Figure 7: 3D orthoses model built on a CNC milling machine

By collecting data in the aggregation centre, the highest precision is obtained. The main element in assuring the precision is the sheer amount of available data. The cloud data storage is the optimal solution for data aggregation that allows to obtain high quality parameters by computing collected data obtained by measurements performed in different situations on different groups of subjects.

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Section 6: Machinery Developments

COMPUTER-ASSISTED WRAPPING OF FABRICS WITH CONSTANT OUTPUT SPEED ON ROLLS WITH VARIABLE ROTATION SPEED

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Abstract *This paper presents a series of programming relations of the wrapping rotation speed variation of rolls of fabrics that have a constant speed output in textile machines. Programming relations use the length of the "on-line" output fabric as a control element for rolls revolution variation. Furthermore, we focus on the presentation of variation relations of rolls rotation speed, specific to the principles of continuous and cyclical fabric wrapping on wrapping rolls.*

Keywords: *wrapping speed, relations of programming fabric wrapping, automated system of wrapping*

1. INTRODUCTION

Tangential wrapping of fabric for weaving machines, measuring machines, fabric winder machines, etc., requires operating the rolls of wrapping with variable speed. According to the diagram in figure 1, depending on the speed of the fabric, the wrapping roll may be operated with variable speed, continuously or cyclically, from an motor 4. The speed of the motor no. 4 is controlled "on-line" from the machine computer programmed to intervene in accordance with the technology principles presented in this paper.

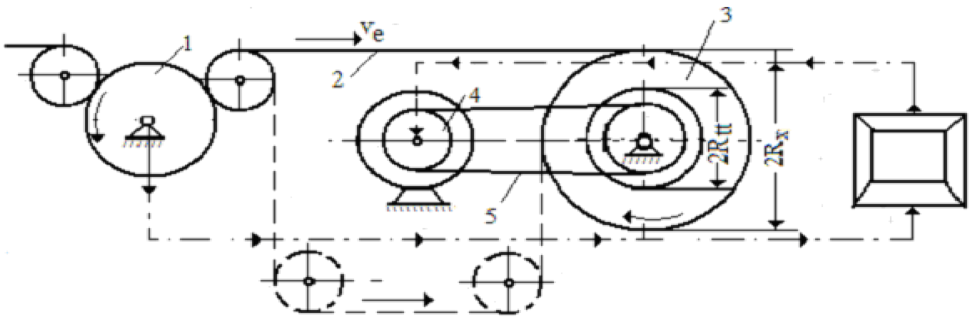


Figure 1.

Where:

- 1 - measuring (drag) cylinder or flow cylinder;
- 2 - fabric;
- 3 - fabric wrapping roll;
- 4 – operational electric motor with variable speed;
- 5 - roll operating system;
- 6 - computer control unit.

2. RELATIONS OF PROGRAMMING THE ROLL ROTATION SPEED DEPENDING ON THE LENGTH OF THE FABRIC ROLL WOUND CONTINUOUSLY

Wrapping fabric on rolls, according to the continuous principle, is encountered when the wrapping speed is relatively high. In this case, the speed of the fabric roll is dependent on the roll wrapping diameter and is determined by the following relationship:

$$n_x = \frac{v_t}{2 \cdot \pi \cdot R_x} \qquad (1)$$

Replacing the technological characteristics of the fabric, in the above relation, it results the following equation for calculating the speed of the roll:

$$n_x = \frac{v_t}{2 \cdot \pi \cdot \sqrt{R_{tt}^2 + \frac{\delta \cdot L_x}{100 \cdot \pi}}} \qquad (2)$$

Where:

n_x – rotation speed of fabric wrapping roll;
v_t - the speed of wrapping the fabric on roll, m / min;
R_x - wrapping radius of the roll at a given time "x" in m
R_{tt} - tube radius of fabric wrapping, in m
 - thickness of fabric wrapped on roll, in cm
L_x - length of fabric wound on roll, in m

The speed of wrapping the fabric according to the principle of continuous wrapping, v_t, is determined by the following relationship:

$$v_t = \frac{n_{ap}}{100\, P_{bt}} \qquad (3)$$

Where:

n_{ap} - rotation speed of the main spindle of the weaving machine, in rev / min;
P_{bt} - weft density of the fabric, in yarn / cm;

When the speed of the fabric roll is controlled, "on-line", from the computer of the machine, it must vary according to the following relation:

$$n_x = \frac{n_{ap}}{200 \cdot \pi \cdot P_{bt} \sqrt{R_{tt}^2 + \frac{\delta \cdot L_x}{100 \cdot \pi}}} \qquad (4)$$

Limit speeds of the fabric roll for weaving machines is determined by the following relations:

$$n_{x0} = \frac{n_{ap}}{200 \cdot \pi \cdot P_{bt} \cdot R_{tt}}; \qquad (5)$$

$$n_{xf} = \frac{n_{ap}}{200 \cdot \pi \cdot P_{bt} \sqrt{\cdot R_{tt}^2 + \frac{\delta \cdot L_{xf}}{100 \cdot \pi}}} \qquad (6)$$

3. RELATIONS OF PROGRAMMING FABRIC WRAPPING WITH CYCLICAL VARIABLE SPEED OF THE ROLL

At low speeds of fabric wrapping on roll, the principle of cyclic operating the roll during wrapping is met. In an actuation cycle, the fabric roll is in a stationary phase, in which the length of the fabric produced by the machine drag roller is put aside in reserve. The wrapping phase proper follows the stationary phase. It represents the moment when both fabric length put aside during the stationary phase, and length of fabric produced during this stage are wrapped on the roll of fabric.

In order to maintain a constant speed of wrapping the fabric, from the first to the last wrapping cycle and, respectively, during both phases mentioned above, it is necessary to decrease the roll rotation speed by computer control, with a certain value after each wrapping cycle, according to an operational program of the machine. Through the operational program the computer of the wrapping machine will intervene to cyclically decrease the speed of the roll operating motor, so that the speed of fabric wrapping remains constant during the increase of the roll wrapping radius (R_{xn}), regardless of the wrapping cycle (n).

For a proper functioning of the roll actuation system it is initially necessary to program the warp length (L_o) which is supplied into the weaving machine. During weaving, the computer records "on-line" the produced length of the fabric (L_{dx}) via the machine drag roller.
Based on the length of produced fabric (L_{dx}), the machine computer can establish "on-line" the wrapping radius of the roll of fabric (R_x), and, thus, the rotation speed of the roll of fabric (n_x), as well as the motor speed of roll actuation (n_m). When a wrapping phase begins the actuation motor speed will be determined by

the computer of the machine, based on the algorithm that modifies the speed of the fabric roll, relative to the wrapping radius of the roll.

The wrapping radius of the fabric roll (R_x) is determined by the following relationship:

$$R_x = \sqrt{R_t^2 + \frac{\delta \cdot L_x}{\pi}} \qquad (7)$$

Where:

$R_t = R_{x0}$ - is the radius of the support cylinder, i.e. the initial radius of the roll wrapping (R_{x0});
 - thickness of fabric wound on the roll;
L_x - length of fabric wrapped on roll corresponding to the wrapping radius (R_x) of the roll.

At the beginning of the wrapping cycle (n) the machine computer records the length of produced fabric (L_{dxn}) related to the cycle (n). This length of fabric produced during the cycle (n) will be wrapped around the roll and therefore this amount will be used as a control parameter for changing the rotation speed of the wrapping roll operating motor. Consequently, it is necessary to establish the relationship between the length of produced fabric (L_{dxn}) and the length of fabric wound on roll (L_{txn}) within the cycle (n).

The total length of the fabric produced by the machine drag roller (L_{Td}), corresponding to the warp length (L_u), from the warp roll at its setting on the weaving machine, can be determined by the following relationship:

$$L_{Td} = L_u \cdot \frac{100 - C_u}{100} \qquad (8)$$

Where:

L_u - initial length of warp from roll (stored in the computer);
C_u - the weaving warp shrinkage, in%.

The length of fabric wound on the roll for each operating cycle of the roll (L_{ik}**)** is determined by the following relationship:

$$L_{ik} = \frac{L_k \cdot P_b + n_{ap} \cdot t_{ik}}{P_b} \qquad (9)$$

Where:

L_{ik} - length of wrapped fabric in an actuation cycle;
L_k - (constant) length of fabric put in reserve, and which is to be wound on roll during the next actuation cycle of the roll;
t_{ik} - length of a wrapping phase for a roll actuation cycle;
n_{ap} - rotation speed of the weaving machine main spindle;
P_b – weft density of the fabric.

The speed of wrapping of the fabric (v_i) is determined by the following relation:

$$v_i = \frac{n_{ap} \cdot t_{ik} + L_k \cdot P_b}{P_b \cdot t_{ik}} \qquad (10)$$

Where:

v_i - speed of fabric wrapping on roll;

The total number of fabric wrapping cycles (N_k) corresponding to the initial warp length (L_u) is determined with the following relationship:

$$N_k = \frac{L_{Td}}{L_{ik}} \qquad (11)$$

Where:

N_k - the total number of fabric wrapping cycles.

The length of fabric produced by the drag roller (L_{dx}), which is put aside in reserve, is the length of fabric that is not wrapped on roll until the beginning of the first wrapping phase. This length of fabric can be defined as the fabric length measured between the flow point on the drag roller and the point of fabric wrapping on the roll (L_{d0}), and is established at the beginning of the first wrapping phase of fabric on the roll (n=0). The following equality appears:

$$L_{dx} = L_{dx0} = L_{d0} \tag{12}$$

The total length of fabric produced by the drag roller (L_{dxn}) till the (n) cycle is established by the following relationship:

$$L_{dxn} = L_{dx0} + n \cdot L_{ik} \tag{13}$$

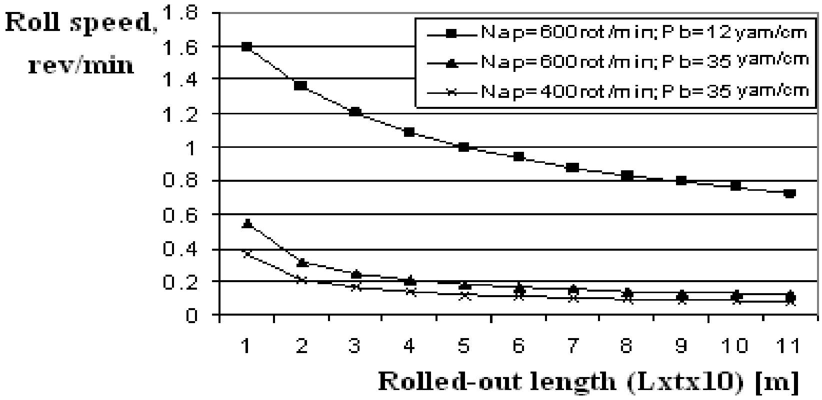


Figure 2. Speed variation of the roll of fabric for a weaving machine

The length of fabric existing on the fabric roll at the beginning of the wrapping cycle (n) is determined with one of the relations 14 or 15, depending on the length of the produced fabric (L_{dxn}) or on the number of wrapping cycles (n).

$$L_{txn} = L_{dxn} - L_{d0} \tag{14}$$

$$L_{txn} = n \cdot L_{ik} \tag{15}$$

The wrapping radius of the roll at the beginning of the cycle (n) is determined by the following relation:

$$R_{xn} = \sqrt{R_{x0}^2 + \frac{n\,\delta\left(L_k\,P_b + n_{ap}\,t_k\right)}{\pi\,P_b}} \tag{16}$$

The value of the cycle (n) is always an integer which can be determined as follows:

$$n = \left|\frac{L_{dx} - L_{d0}}{L_{ik}}\right|^{*} \tag{17}$$

If the output length of fabric (L_{dxn}) is counted up, the wrapping radius of the fabric roll at the beginning of the cycle (n) is determined by the following relationship:

$$R_{xn} = \sqrt{R_{xo}^2 + \frac{\delta}{\pi} \cdot (L_{dxn} - L_{d0})} \tag{18}$$

The rotation speed of the fabric roll is determined by the following relationship:

$$n_{xn} = \frac{n_{ap} \cdot t_k + L_k \cdot P_b}{2 \cdot \pi \cdot P_b \cdot t_k \sqrt{R_{x0}^2 + \frac{\delta \cdot (L_{dxn} - L_{do})}{\pi}}} \tag{19}$$

If the length of the fabric (L_{txn}) wrapped at the beginning of the cycle (n), is: $L_{txn} = L_{dxn} - L_{d0}$, it results the following formula for calculating the speed of the fabric roll:

$$n_{xn} = \frac{n_{ap}\,t_k + L_k\,P_b}{2\,\pi\,P_b\,t_k \sqrt{R_{x0}^2 + \frac{\delta\,L_{txn}}{\pi}}} \tag{20}$$

If the number of operating cycles, "n", is counted up, the roll speed is determined as follows:

$$n_{xn} = \frac{n_{ap} \cdot t_k + L_k \cdot P_b}{2 \cdot \pi \cdot P_b \cdot t_k \sqrt{R_{x0}^2 + \frac{\delta \cdot n \cdot (L_k \cdot P_b + n_{ap} \cdot t_k)}{\pi \cdot P_b}}} \tag{21}$$

The wrapping roll speed is transmitted from the actuation motor:

$$n_{mn} = n_{xn} \cdot i_{sm} \qquad (22)$$

Where:

n_{mn} - speed of the actuation motor, in "n" cycle;
n_{xn} - speed of the roll wrapping, in "n" cycle;
i_{sm} - the transmission ratio of the movement between roll and actuator.

4. EXPERIMENTAL STUDIES ON SPEED VARIATION OF THE WRAPPING ROLL OF FABRIC FOR TEXTILE MACHINES

4.1. Variation of roll speed for machines with continuous wrapping of the fabric

Figures 2 and 3 show a series of variation curves of the speed of the fabric wrapping roll for both a weaving machine and a measuring-and-batching machine. The speed variation of the roll is determined by the fabric wrapping speed and by the thickness of the fabric ( ) that is wound on the roll.

The following observations result from analyzing the graphs presented in Figures 2 and 3:

- for the weaving machine it is found that the roll speed of fabric wrapping depends on the speed of the main spindle of the weaving machine and on the weft density of the fabric, and the roll speed is relatively low for the area to be tested;
- fabric-roll speed continuously decreases once with the increasing of the length wound on roll, while the speed values become lower and lower;
- at the same speed of the main spindle of the weaving machine, once with the increasing of the weft density there is a significant reduction in the speed of the fabric wrapping roll;
- irrespective of the length of fabric wrapped around the fabric roll, the roll speed increases once with the increase of the fabric wrapping speed;
- at the same speed of fabric wrapping it is found that the drop in the speed of the fabric wrapping roll is greater when the thickness of the fabric increases;

According to the above observations, it appears that operating large rolls of fabric at a weaving machine with variable speed motors, programmed by computer, is achieved with relatively difficult technical solutions

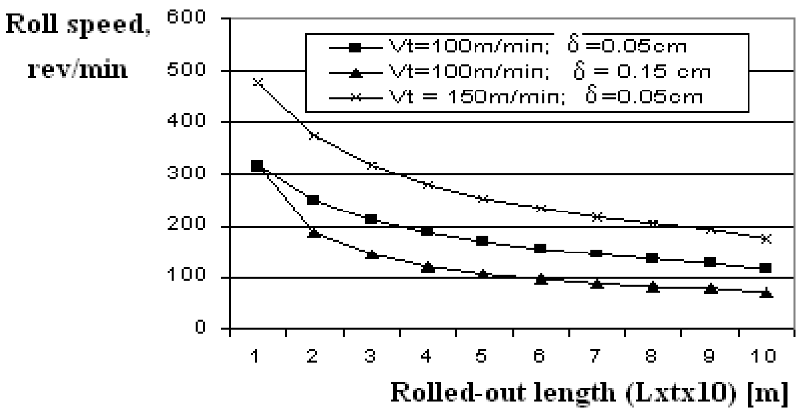


Figure 3. Roll speed variation for a measuring-and-batching machine

due to relatively low speeds of the wrapping rolls.

Therefore to prevent problems during fabric wrapping on roll it is proposed that fabric wrapping on rolls should be made with motors of variable speed, based on the principle of cyclic wrapping of the fabric. Cyclic wrapping is achieved by alternating a stationary phase with a proper wrap stage of the fabric produced by the weaving machines.

4.2. Wrapping fabric with roll speed cyclical variation

Designing the mechanism of fabric wrapping on the fabric roll for the weaving machine should be based on both constructive features of weaving machines and on fabric characteristics. These depend on the constructive version of the weaving machine.

During weaving, weaving machine computer records "on-line" the length of fabric produced by the drag roller (L_{dxn}) and establishes the following values: radius of the roll wrapping, R_{xn}, roll speed, $n_{xn,}$ and motor speed of roll actuation, n_{mn}.

During the wrapping cycle "n", the machine computer controls the set point for the speed of the machine actuation motor (n_{mn}) obtained using an algorithm which is based on the actual values of the wrapping radius, $R_{xn,}$ of the roll speed, n_{xn}. Thus, the roll wrapping speed will be linked at any time of wrapping with the wrapping radius of the roll, order received through the fabric produced length (L_{dx}), which will ensure that the condition of maintaining constant fabric wrapping speed on roll is respected, regardless of the wrapping radius of the fabric roll.

Chart 1 presents some numerical data, specific to a particular textile machine and to a certain fabric, and figure 4 shows the concrete values of speed variation of the fabric roll depending on the wrapping cycle.
Productive and technological data adopted in the examples below are as follows:
initial length of the warp, L_u=2000 m;
warp shrinkage during weaving, C_u=3%;
constant length L_k=4 m;
duration of an actuation cycle, t_{ik}=0,5 minutes;
initial radius of the fabric roll, R_{x0}=0,06m ;
length of fabric that flows during an actuation cycle in a drive cycle L_{do}=7 m ;
speed of the weaving machine main spindle, n_{ap}=400 rev/min;;
fabric weft density, P_b=2000 threads / m;
thickness of the fabric, = 0.0008 m

To determine the influence of the speed of the weaving machine main spindle (n_{ap}) on the speed variation of the fabric roll a number of technological items have been adopted, such as: L_k= 5 m; t_{ik} = 0.5min; P_b=2000 threads /m; R_{x0}=0.06m; L_{d0}=7m.

Speed of the wrapping roll (n_{xn}) during different operating cycles (n) Chart 1

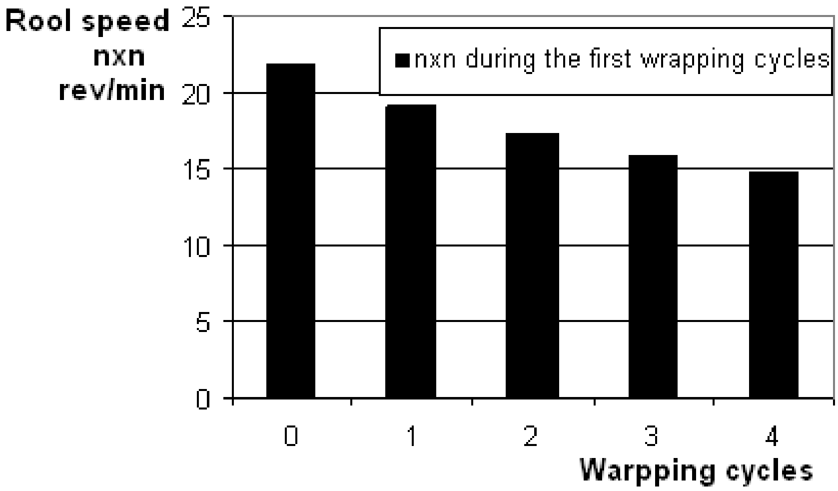
No. operat. cycl. (n)	0	1	2	3	4	…	469	470	471	472	473
n_{xn}, rev/min	21,76	19,16	17,31	15,91	14,80	…	1,858	1,856	1,854	1,852	1,850

In this paper, the speed of the fabric wrapping roll (n_x) was determined by the computer program following data: length of fabric wrapped at a certain time, (L_{tx}), speed of the weaving machine main spindle (n_{ap}=400 rev/min; n_{ap}=600 rev/min, n_{ap}=400 rev/min) and thickness of the fabric (=0.0005m; =0.0008m and =0.001m) wound on roll. The speed variation of the fabric roll was determined with the relations presented in this paper, for the first 50 m of fabric wrapped on roll, and the results are shown in Chart 2.

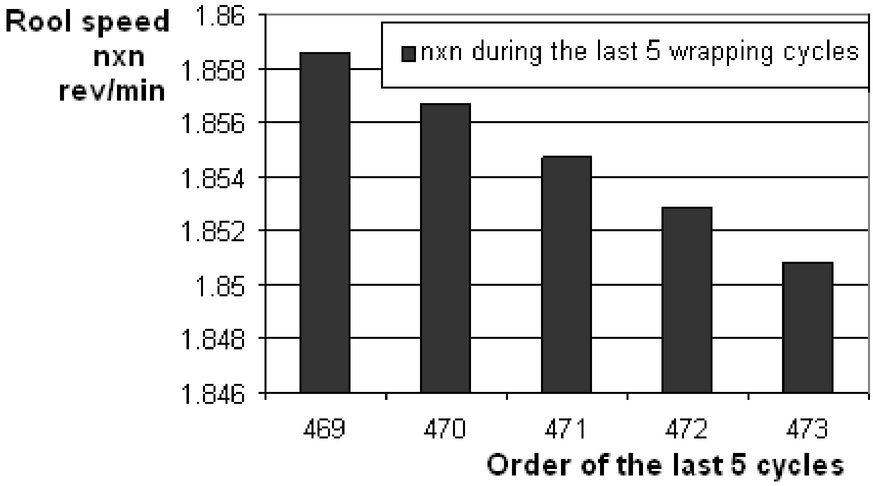
Wrapping roll speed variation based on technical data Chart 2

The length of fabric wound on roll, Ltx, in m	Speed of the weaving machine main spindle, n_{ap}, in rev/min		
	n_{ap}=400rev/min/ =0,0005 m	n_{ap}=600rev/min/ =0,0008 m	n_{ap}=800rev/min/ =0,001 m
0	27.07	27.335	27.6
10	22.54	20.917	20.105
20	19.71	17.588	16.585
30	17.74	15.467	14.439
40	16.26	13.966	12.955
50	15.11	12.831	11.852

Based on the data in Chart 2, the variation curves of the fabric roll speed are drawn in Figure 5, according to the length of fabric wound on roll.



a. First 5 operating



b. Last 5 operating cycles

Figure 4. Cyclic variation of roll wrapping speed

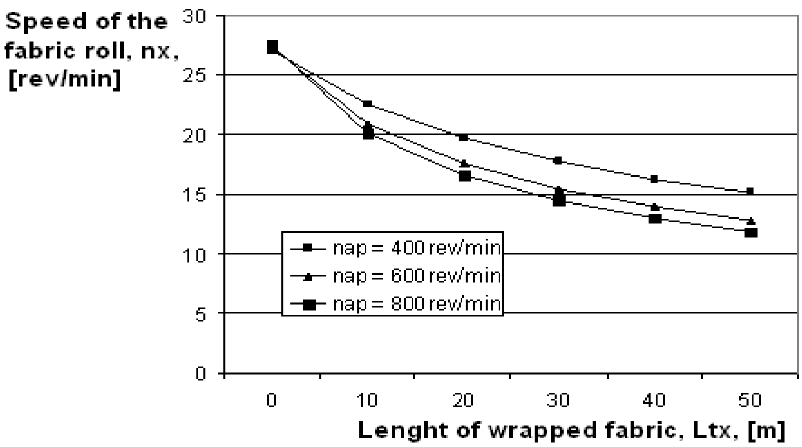


Figure 5. Speed variation of fabric roll according to fabric length

Analyzing the graphs presented in Figures 4 and 5, the following conclusions are drawn:

to maintain a constant speed of wrapping of the fabric, during each cycle (n) of wrapping the fabric, roll speeds must decrease;

cyclic decrease of fabric roll speed has higher values during the first cycles (the roll speed n_x decreases from n_{x0}=21,76 to n_{x1}=19,16 rev/min as shown in figure 4 and it becomes smaller towards the end of wrapping (n_{x473} decreases to 1.85 only from n_{x472}=1,852 rev/min) which means a decrease of the speed with a percentage of 91.5%;

cyclic lowering of the speed of fabric wrapping roll becomes more pronounced with the increasing speed of the weaving machine main spindle (n_{ap}) and increases the thickness of the wrapped fabric, as seen in chart 2 and in figure 5;

during the wrapping of the first 50 m of a fabric with a thickness of = 0.5 mm, at a weaving machine speed $n_{ap=}$400 rev/min, the speed of the roll of fabric should decrease by 44.18% and for a fabric with a thickness =1 mm and a main spindle speed n_{ap}=800rev/min, the fabric roll speed must decrease by 57.06%.

5. CONCLUSIONS

1. The use of an automated system of wrapping of the fabric on a single large-sized roll, outside the actual gauge of the weaving machine, and that may ensure the cyclic wrapping of fabric resulted of a warp roll, prevents the fabric sectioning and shortens the preparation technological flow of the lots of fabrics for the fabric finishing process;
2. The relations used in the technical calculation of the cyclical revolutions of the fabric roll, presented in this paper, allow the determination of the variability of the fabric roll speed, according to the characteristics of the fabric and to the structural and operational features of the weaving machine;
3. The kinematic adjustment command of technological speeds of the roll according to the roll diameter is transmitted from the computer of the weaving machine, depending on the "on-line" recorded values of the length of fabric produced by the weaving machine drag roller (L_{dxn}), using a program suitable for this purpose.

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Scholarly communication paper

TECHNOLOGICAL RELATIONS FOR AUTOMATIC CONTROL OF PRELIMINARY BEAMS BRAKING FOR WARPING MACHINE STOPPING AT YARN BREAKAGE, AFTER A WARP CONSTANT LENGTH WRAPPED

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Abstract: *On the direct warping machine the stopping take place at a broken yarn, by braking the preliminary beam. As preliminary warp are winding on beam its mass and wrapping radius is changed. Also, the working speed can be higher or lower, depending on the yarn quality. Technologically, it is recommended that the length of the warp wrapped in the phases of the beam stop when a yarn break, be constant. The value of this length must be set so that the broken end of the yarn to no wrap of the beam. In this paper presents the relations for determining the friction forces depending on the length of the warp wound on beam, may be used to develop software for self–regulation of these forces, which ensure the same displacement of the broken end of the yarn to stopping the machine regardless of mass warp on the beam or warping speed.*

Keywords: *preliminary beams, direct warping, braking.*

1. INTRODUCTION

On all direct warping machines the stopping to a broken yarn is realized by braking preliminary beam. As the preliminary warp winding on beam, increase their mass and winding radius. Also, the work speeds may be higher or lower, depending on the yarn quality.

From the technological point of view, it is recommended that the length of the warp wound onto the phases of the beam off a yarn break, be constant, regardless of the winding rays or speed. The value of this length should be set so that the end of the yarn has broken do not wrap the on beam, even when the yarn breaks would have done the bobbins closest to the warping machine. The cinematic point of view, this condition means imposing a certain space admitted (S_a) for the movement of the end of broken yarn from the breakage moment of the yarn to stop the machine.

The stopping of warping machines in such technological conditions can be achieved through auto regulation braking force computer controlled based on software which use specific relations for the calculation of braking forces.

2. SPECIFIC RELATIONS FOR CALCULATION OF BEAM BRAKING FORCES, ADAPTED FOR STOPPING THE MACHINE AFTER BY CONSTANT LENGTH WRAPPED

The control unit of the braking force of the preliminary beam to stop after a constant length wound in the off phase onto the yarn breakage can be wound radius (R_x) or length of warp (L_x) wrapped and recorded online on counter machine, figure 1.

The braking force of a preliminary beam for the yarn breakage stopped could be calculated with relation 1, [1]:

$$F_{fx} = \frac{\left[J_{s0} + \frac{\pi \, H \, \rho \, (R_x^4 - R_t^4)}{2} \right] \frac{v}{R_x \, t_o}}{R_{fs}} - \frac{T \, F_p \, R_x}{R_{fs}} \qquad (1)$$

where: F_{fx} is the braking force of preliminary beam, in N;
J_{so} – inertia moment of empty beam, in kg.m^2;
H – width of preliminary warp, in m;
R_x – radius of the winding at any given time, in m;
R_t –radius of empty beam tube support, in m;
v – warping speed, in m/s;
t_o – recommended stop time in breakage of a yarn, to ensure a constant length of warp during wound stop, regardless of the warping speed and the winding radius, in s;
T – yarn tension at warping, in N;
F_p – yarn numbers on preliminary beam.

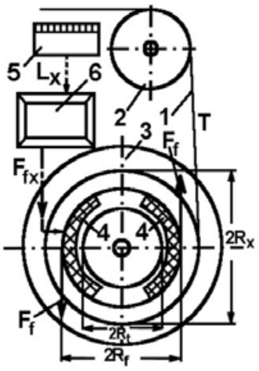

Figure 1: Brake control principle: *1 – preliminary warp, 2 – ruler cylinder (measurer), 3 – preliminary beam, 4 – brake blocks, 5 – counter, 6 – computer*.

The winding radius (R_x) is determined depending on the length of the warp wound on the on beam, with relation 2, [3]:

$$R_x = \sqrt{R_t^2 + \frac{T_t\, F_p\, L_x}{10^6 \pi\, H\, \rho}} \quad \text{or} \quad R_x = \sqrt{R_t^2 + \frac{T_t\, F_p\, (L_p - L_{rx})}{10^6 \pi\, H\, \rho}} \qquad (2)$$

where: T_t represents the length density of the yarn, in tex;
L_x – length of wound warp on beam, in m;
– winding density on preliminary beam, in kg/m^3;
L_p – programmed length of the warp on the preliminary beam, is constant introduced in counter, in m;
L_{rx} – remaining length is also wrapped on beam until the end of the warp, displayed online on the counter, and used as control for beam braking force.

The stop time (t_0) is established technological, based on the relationship:

$$t_o = \frac{2\, S_a}{v} \qquad (3)$$

where:
S_a – allowed space to be covered by the end of the yarn has broken during braking beam until it stops in m (the value adopted for this space is equal to the distance from bobbins creel to preliminary beam);
v – warping speed at run regime, in m/s.

After these clarifications, it follows a relationship for braking force of the preliminary beam having as variable online element the warp length on beam (L_x), as:

$$F_{fx} = \frac{v^2}{2\, R_{fs}\, S_a \sqrt{R_t^2 + \frac{T_t\, F_p}{10^6\, \pi\, H\, \rho} L_x}} \left(J_{so} + \frac{F_p\, T_t\, R_t^2}{10^6} L_x + \frac{F_p^2\, T_t^2}{2\, 10^{12}\, \pi\, H\, \rho} L_x^2 \right) - \frac{T\, F_p}{R_{fs}} \sqrt{R_t^2 + \frac{T_t\, F_p}{10^6\, \pi\, H\, \rho} L_x} \qquad (4)$$

All elements of the formula are known numerical. Density shall be adopted depending on other technological parameters of warping. Its value will be correct after winding a sample length (L_0) and measuring the resulting wound radius (R_{x0}) using the relation:

$$\rho_e = \frac{T_t\ F_p\ L_0}{\pi\ H\left(R_{x0}^2 - R_t^2\right)} \qquad (5)$$

The effective density value (ρ_e), so corrected, will replace the value (ρ) in eventual software used for warping machine.

3. THE VARIATION OF BRAKING FORCE DEPENDING ON THE LENGTH OF THE WOUND

In the variant of stopping the warping machine, after winding of a constant length of warp from the moment of yarn breakage, it can be used for the length of the warp wound (L_x) as a control for the self-adjustment of the preliminary beam braking force according to the relation (4). Constructive data of the beam (R_{fs}, R, H, J_{so}, Sa) are introduced as constant data into the computer, and constant technological data warp (v, Tt, F_p, ρ, L_p in the case $L_p = L_p - L_{rx}$) are introduced in a computer to the start of a new warp.

During the warping, the counter of machine records online, either directly L_x or L_{rx}. The computer takes over directly the value L_x or determines as $L_x = L_p - L_{rx}$. Based on the values of Lx and the relation (4), the computer will determine on-line the values of braking force F_{fx}. Through the automation system of the machine, any yarn breakage will apply another braking force on the beam, so that stopped after the same S_a, regardless of warping speed or distance winding.

In figure 2 are presented the variation curves of the braking preliminary beam with increasing length of the warp wound at different warping speeds. Constructive data taken into consideration were the following: R_t = 0.125 m; J_o = 2,5 kg.m^2 ; R_f = 0.15 m ; H = 1,8 m; S_a = 3 m. Preliminary warp had F_p = 500 fire; T_t = 25 tex; L_p = 20000 m; T = 0.15 N/fir and ρ = 480 kg/m^3.

Based on the numerical values of table 1 and the curves in figure 2 can make more observations.

Table 1: Braking forces of beam

Lx, (m)	Braking forces Ffx , (N), at warping speed:			
	v=5m/s	v=7m/s	v=10m/s	v=15m/s
0	378.78	912.11	2045.45	4823.22
1000	352.01	862.74	1948.04	4608.09
2000	346.63	855.24	1936.05	4585.07
3000	355.23	875.10	1979.81	4687.43
4000	373.95	914.72	2063.86	4880.38
6000	433.46	1037.11	2319.87	5463.88
8000	514.91	1202.32	2663.06	6243.33
10000	613.22	1400.44	3073.26	7173.33
15000	916.06	2006.94	4325.05	10006.70
20000	1283.56	2739.42	5833.14	13415.78

As you increase the length Lx of wrapped warp, at small values of its, braking force of the beam decreases slightly. For example, at v= 5 m/s, F_{fx} decreased from 378.78 N to 346.63 N, with an increase of the wrapped length of 0-2000 m. At a speed of 15 m/s, decrease of the braking force is achieved at 4823.22 to 4585.07 N for an increase of length from 0 to 2000 m.

A further increase in the length of 2,000 m to 20,000 m, requiring an increase in the braking force of the beam of 346.63 to 1283.56 N at the speed of 5 m/s, and from 4585.07 to 13415.78 N, at a speed of 15 m/s Order to be able achieve the same space (Sa) come the end of the yarn broke, regardless of warp the mass on beam requires a significant increase in braking force to breaking the yarn, as you increase warping speed. The increase braking forces of the beam to a broken warp yarn are more pronounced, as the wound warp length and speed warping are higher (figure 2).

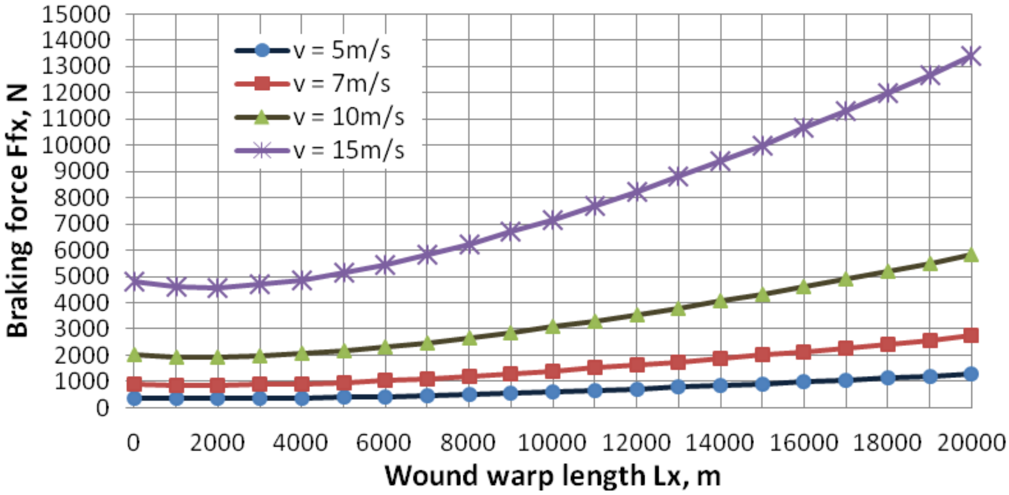

Figure 2: The variation of the braking force of the beam, at yarn breakage

In order to provide of the beam stopping after the same length of warp wrapped on beam at any breakage of the yarn and the broken yarn end is not wrapped on beam should braking systems, beams to self-adjust the braking forces after the type of curve in figure 2. Changing the speed of work should entail and the automatic change of the brake force, which then regulate it according to the length of the warp L_x deposited on beam.

CONCLUSIONS

1. Operating conditions of direct warping machines and warp quality can improve by automated braking systems of beams to stop warping at yarn breakage.

2. The relations for determining of the friction forces depending on the length (L_x) of the warp wound onto the beam will be used to develop online software for self regulation of these forces, which provide the same displacement of the broken end of the yarn at the machine stopping regardless of warp mass on beam or speed warping.

3. Using the length (Lx), as a control for self-regulation braking has the advantage of its online registration during warping.

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Scholarly communication paper

TECHNOLOGICAL RELATIONS FOR AUTOMATIC CONTROL OF SECTIONAL WARPING DRUM BRAKING FOR MACHINE STOPPING AT YARN BREAKAGE, AFTER A SECTION CONSTANT LENGTH WRAPPED

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Abstract: *The sectional warping machines stopping to a broken yarn is made by brake of warping drum. On the measure of section are wrapped, is changed a number of parameters that influence the behaviour in dynamic of the drum. It is recommended that the length of the section wound by the drum stop phases, at breaking a yarn, to be constant regardless of the wrapping radius or the working speed and the value of the length should be set so that the broken end of the yarn to no wrap on the drum regardless bobbin position in the creel. Technological relations presented in this paper can be used for control software's of the brake force of warping drum break a yarn, that having as on–line command elements length of the sections wrapped and the number of sections wrapped on drums, considering the conditions of wrapping the sections on the drum.*

Keywords: *section, sectional warping, braking.*

1. INTRODUCTION

On all sectional warping machines take place the stopping of the machine at a broken yarn through braking of warping drum. On measure of the winding sections, increase the mass of the drum and winding radius. Also, the working speeds can be higher or lower, depending on the yarn quality. From the technological point of view, it is recommended that the length of the section wrapped in drum stop phases, on the breaking of yarn to be constant, regardless of the winding radius or speed. The value of this length must be set so that the end of the broken yarn is not wrapped on drum, even when the yarn breaks would have done at the bobbins closest to the machine. Cinematic point of view, this condition means imposing a certain space allowed (S_a) for the moving end of the broken thread, since breakage the yarn to stopping the machine.

The stopping of the warping machines in such technological conditions can be achieved through auto regulation of computer controlled braking force on the basis of software's which use specific relations for calculating braking forces.

2. CALCULATION OF THE BRAKING FORCES FOR DRUM STOPPING AT BREAKING A YARN AFTER A CONSTANT LENGTH SECTION WRAP IN STOPPING PHASE

Taking account of the winding sections on the warping drum, the brake force of drum warping (figure 1), to stop at the yarn breakage shall be determined by the relation 1:

$$F_{ft} = \frac{\left[J_{t0} + \frac{\pi\, H_b\, \rho \left(R_F^4 - R_T^4\right) N_b}{2} + \frac{\pi\, H_b\, \rho \left(R_x^4 - R_T^4\right)}{2}\right] \frac{v}{R_x\, t_o}}{R_{ft}} - \frac{T\, F_b\, R_x}{R_{ft}} \tag{1}$$

where: F_{ft} represents the braking force of warping drum, in N;
J_{to} – inertia momentum of empty drum, in kg*m^2;
H_b – section width, in m;
ρ – warp wrapping density on drum, in kg/m^3;
R_F – final wrapping radius at section end, in m;
R_T – empty drum radius, in m;

N_b – number of sections finished, existing at the some point on warping drum; N_b can count on a machine computer, and may in sequence the values: 0; 1; 2; . . . until the penultimate section;
R_x – wrapping radius, at some moment, of some section, in m;
t_0 – technological recommended stopping time, în s;
T – yarn tension at warping, in N;
F_b – the number of yarns in a section;
R_{ft} – braking radius of warping drum, in m.

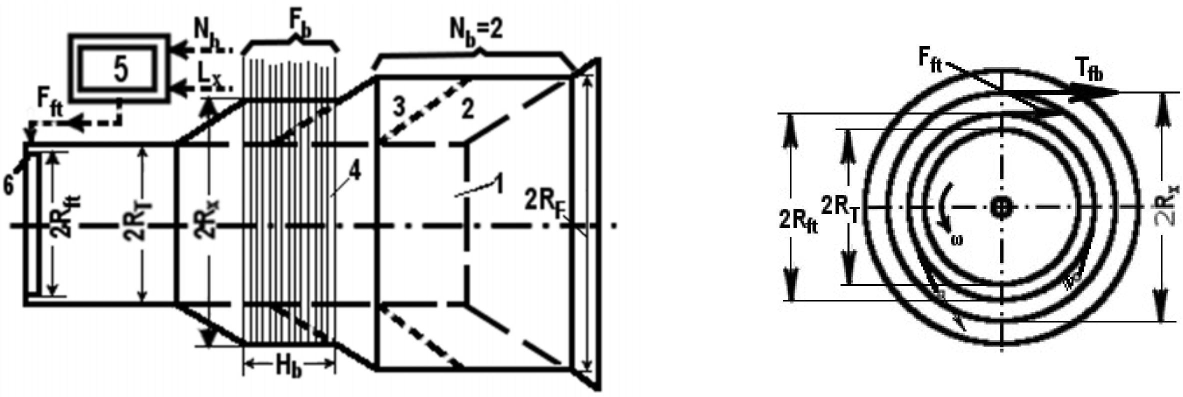


Figure 1: The specifics of section warping and the principle of drum brake

The relation between the radius of wrap (R_x) and the length of the wrapped (L_x) is the same as the beams used, namely:

$$R_x = \sqrt{R_T^2 + \frac{T_t\, F_b\, L_x}{10^6 \pi\, H_b\, \rho}} \qquad (2)$$

In the same mode for stopping time:

$$t_o = \frac{2\, S_a}{v} \qquad (3)$$

In these conditions, the specific relationship of the variation of the brake force of the warping drum (F_{ft}) for the stopping in breakage yarn, depending on the length (L_x) of the sections wound on the drum, will be:

$$F_{ft} = \frac{v^2}{2\, R_{ft}\, S_a \sqrt{R_T^2 + \frac{T_t\, F_b}{10^6\, \pi H_b\, \rho} L_x}} \left(J_{to} + \frac{T_t^2\, F_b^2\, L_b^2}{2 \cdot 10^{12} \cdot \pi\, H_b \rho} N_b + \frac{T_t\, F_b\, R_T^2}{10^6} \cdot \left(L_x + L_b \cdot N_b\right) + \right.$$
$$\left. + \frac{T_t^2\, F_b^2}{2 \cdot 10^{12} \cdot \pi\, H_b\, \rho} \cdot \left(L_x^2 + L_b \cdot N_b^2\right) - \frac{T\, F_b \sqrt{R_T^2 + \frac{T_t\, F_b}{10^6 \cdot \pi\, H_b\, \rho} L_x}}{R_{ft}} \right) \qquad (4)$$

All the constants constructive and technological parameters are numerical known and depending on the machine and warping article. In this case, the density (ρ) can be corrected at the beginning of the first section, after the wrapping of a sample length (L_0), and measuring the winding radius on the drum (R_{xo}) resulting to this length. It uses the formula:

$$\rho_e = \frac{T_t\, F_b\, L_0}{\pi\, H_b \left(R_{x0}^2 - R_T^2\right)} \qquad (5)$$

The effective value of correcting density (ρ_e) will introduce into the computer, instead of the value initially adopted ρ. The correction of density (ρ) value can be made automatically by suitable software.

The software of the section warping machine computer requires, in this case, the automatic counter an N_b values (at the beginning of the first section, N_b=0; at the beginning of the second section, N_b=1; etc.). Generally, the value of N_b, registered in the computer will be the number of records values of the length counter, corresponding to the end of each section.

3. THE VARIATION OF BRAKING FORCES DEPENDING ON THE LENGTH WRAPPED

To the sectional warping machine, warping drum dimensions and mass are significantly higher than those of the empty preliminary beam in direct warping. For the study the variations of the braking force warping drum, to a break yarn, have adopted constructive values corresponding to a relatively small drum: J_{to} = 100 kg*m^2; R_T = 0.4 m; R_{ft} = 0.4 m; S_a = 4 m. The warp was characterized by: F_b = 500 yarns; T_t = 50 tex; H_b = 0.25 m; T = 0.2 N/yarn; ρ = 380 kg/m^3 and the final length of the section L_b = 3000 m.

On the basis of these adopted characteristics have been calculated the braking forces of the warping drum based on the current length of wound section. The technological condition has imposed that stopping the drum in the breakage of a yarn, to carry after a forward to the end of broken yarn on a constant distance S_a=4 m, regardless of charging with sections or the length of the wrapped section on drum.

The results obtained are shown in tables 1 and 2 and in figure 2. Have been exemplified values for two warping speed (v=5 m/s and v=10 m/s) and three loads with current sections (N_b=0, N_b=3 and N_b=7).

Table 1: Braking forces for v=5 m/s

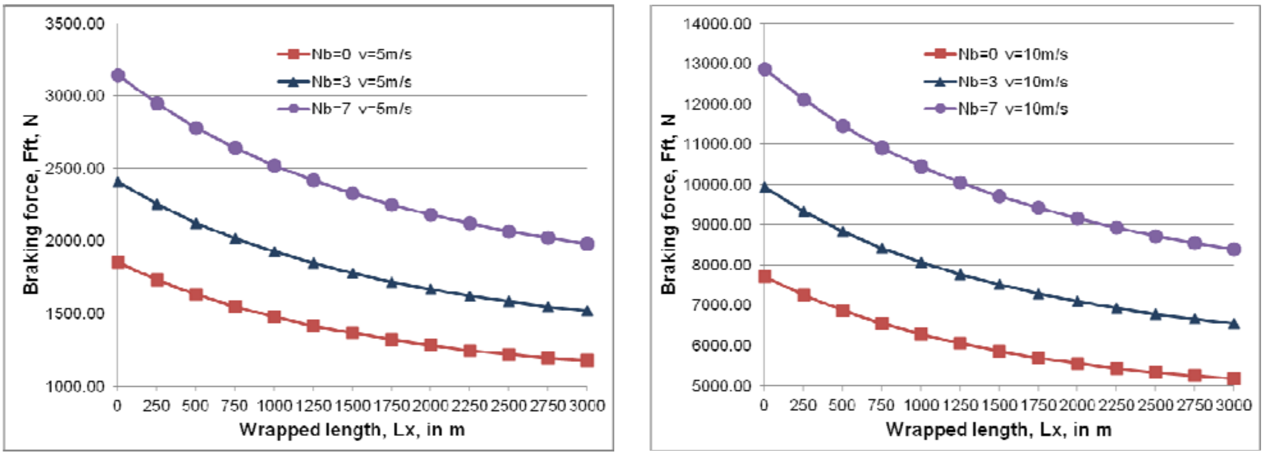
Lx, (m)	Braking force, Fft, (N)		
	v=5 m/s Nb=0	v=5 m/s Nb=3	v=5 m/s Nb=7
0	1853.20	2405.37	3141.59
500	1631.06	2122.62	2778.04
1000	1475.55	1922.90	2519.36
1500	1362.63	1775.88	2326.89
2000	1279.25	1665.18	2179.74
2500	1217.61	1581.00	2065.52
3000	1172.70	1517.09	1976.28

Table 2: Braking forces for v=10 m/s

Lx, (m)	Braking force, Fft, (N)		
	v=10 m/s Nb=0	v=10 m/s Nb=3	v=10 m/s Nb=7
0	7712.81	9921.48	12866.37
500	6861.21	8827.46	11449.14
1000	6272.51	8061.90	10447.75
1500	5851.38	7504.39	9708.39
2000	5546.23	7089.93	9148.20
2500	5326.27	6779.83	8717.91
3000	5171.78	6549.35	8386.10

Based on these tables and graphs can highlight several technological observations. The braking force of warping drum, in a yarn breakage should significantly increase with increasing of speed warping. For example, a drum loaded with 7 sections of 500 yarns and a length of 3,000 m must increase the braking force from 3141.59 N to 12866.37 N, as a result of the increase speed of 5 to 10 m/s. The braking force of the warping drum must increase with increasing with the loading sections of the drum to ensure S_a=constant condition, regardless of the speed (v) and the length (L_x). For example, when v=10 m/s at the beginning of the first section (N_b=0 and L_x=0) is 7712.81 N and is increased to 112866.37 N at the beginning of section 8 (N_b=7 and L_x=0).

The braking force of warping drum continuously decreases with increasing length (Lx), regardless of speed or load factor of the drum warping with sections (figure 2). For example, to ensure the condition S_a=constant at v=10 m/s and N_b=0, the braking force (F_{ft}) decreases from 7712.81 N to 5171.78 N, while (L_x) increases from 0 to 3,000 m. For the fulfillment of technological condition S_a=constant, regardless of sections load on the drum, of warping speed or wound length of the current section, requires an order brake force variation through appropriate software that have online controls like: the current wound length L_x and N_b value of the number of sections wrapped around the drum. Other constructive and technological data from a relation (4) are constants, depending on the machine used or warping article.



a) v = 5 m/s b) v = 10 m/s

Figure 2: The variation of braking force depending on the length L_x

4. CONCLUSIONS

1. The operating conditions of sectional warping machines and warps quality can be improved and compliance requirements to stop the machines on yarn breakage.

2. Stopping the warping in the breakage of a yarn, under a constant length of the warp wound on the drum, regardless of wound warp mass or speed warping requires specific technological relations, possible to use in the software.

3. The technological relations of the type presented in this paper can be used to software's of the warping drum brake force to a yarn break, which have the on-line control element length (L_x) of section wrapped and the number of sections already wrapped on the drum (N_b).

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Section 7: Fashion Design and Product Development

MATHEMATICAL CORRELATION BETWEEN SECTION LINES IN 3D SHAPES AND FASHIONING LINES IN 3D KNITTED FABRICS

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Abstract: *3D shaped knitted fabrics present a very good potential for complex technical applications and have known a significant development in the last two decades. In order to design a 3D-shaped knitted fabric, the first step to be followed is represented by the transition from the 2D solid evolutes of the geometric shape to the fabric plan. Mathematically, the section lines for each type of 3D shapes are continuous and they can be accurately defined. However, knitted fabrics are made of stitches of certain dimensions that must be taken into consideration when defining the mathematical models of the straight or curved fashioning line segments.*
The paper presents a method to define the vertical and horizontal increment of a fashioning line, based on the error approximation between the continuous section lines and the segmented lines in the fabric plan.

Keywords: *mathematical model, section lines, fashioning lines, error approximation*

INTRODUCTION

A 3D shaped knitted fabric is produced using the spatial fashioning technique. This kind of fabrics are characterised by a 3D geometry that is based on a 3D solid with regular or irregular shape. Until now, the researchers focused more on the shape modelling than on the modelling of the section and fashioning lines [1]. To ensure a proper definition of the 3D knitted fabrics, both section lines of the 3D body and the fashioning lines of the 3D shaped knitted fabric must be defined [2, 3]. Fashioning lines has usually two components: one with a decreasing direction and one with increasing direction. The final 3D shape is obtained through the union of these lines according to their specific parameters (line increment and stitch dimension). Taking into account the particularities of the knitted fabrics, the fashioning lines are formed by varying the number of stitches knitted in each row.

Section lines, given by the 2D develop of the 3D solid are represented by continuous lines: straight (with constant increment) or curved (with variable increment). A fashioning line, given by the 2D develop of the fabric plan is segmented, being compounded by multiple line segments [1].

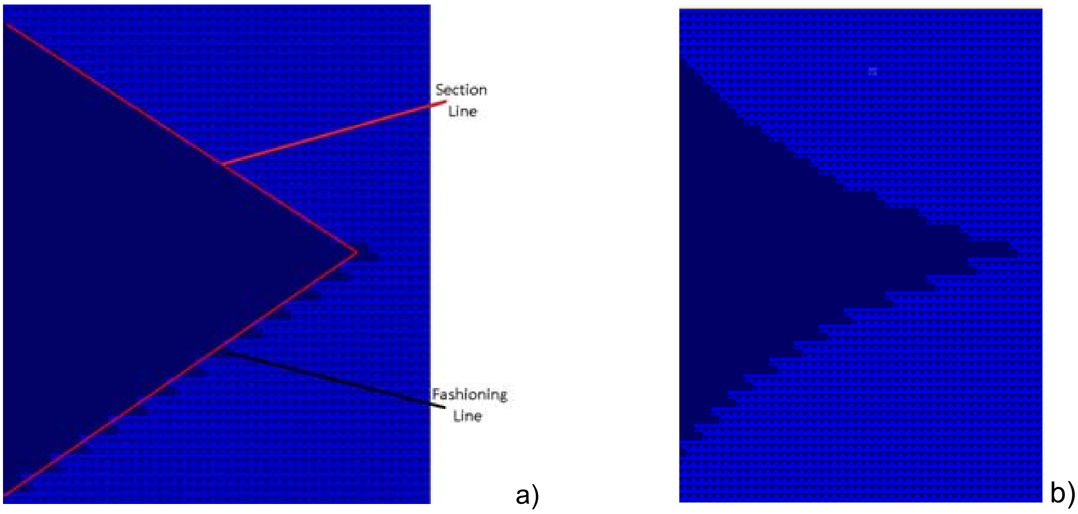

Figure 1. Aspect of fashioning lines - a) straight and b) curved

Because the fashioning lines are not continuous lines, as it is the case with the section lines, they are quantified using the line increment Δr and Δa, representing the number of rows, respectively needles by which the line varies at each step. The basic element is the knitted stitch and its dimensions – the stitch pitch and height. The fashioning line can be therefore considered as a polygonal line that follows the stitches in the knitted fabric. Due to the nature of these lines (the section line is continuous while the fashioning line is segmented) the equations that define them will differ.

In order to ensure a correct definition of the narrowing and widening steps, which are given by the line increment Δr and Δa, a strictly correlation between section lines in 3D shapes and fashioning lines in 3D knitted fabrics must be made. When this correlation is made, between these lines appear differences that influence the number of stitches that must be produced in a row in order to obtain a certain dimension. To solve this problem the surface of the 3D shape develops bordered by the fashioning line must be determined.

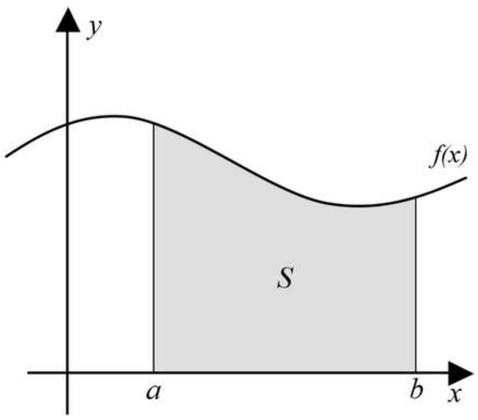

Figure 2. Numerical integration

For rectangular knitted panels (when the length and width of the panel are known) the surface and the necessary number of stitches can be easily determined. For knitted fabrics with irregular shape that are defined by a curved fashioning line (as illustrated in figure 1.b) between fashioning and section lines will appear a difference, or error. Initially this error can be practically approximated but if an exactly shape is required rigorous solutions, represented by the integral calculus and approximation, must be applied. The integral calculus consists in finding the numerical approximation for the surface S [4].

If the y = f(x) section line curve is consider on [0,1] interval the integral surface of the f(x) function on the given interval is represented by the integral area of f and is noted $\int_0^1 \sqrt{x}dx$. The error approximation has been carried out using 5 and 12 steps, as illustrated in figure 3. It can be remarked that if a higher number of approximation steps is used the error between the section and fashioning line is smaller.

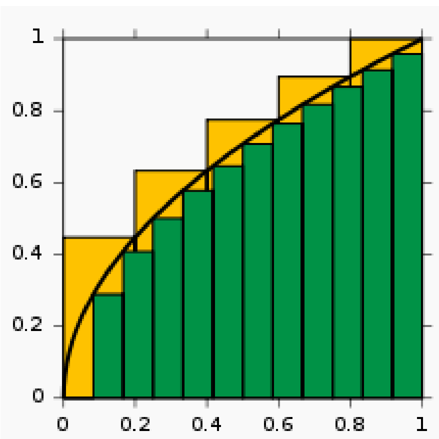

Figure 3. Error approximation for y = f(x) function with 5 and 12 steps

ERROR APROXIMATION METHODS

Several technique for approximating the definite integral can be used [4] to approximate the error that appears between the fashioning and section lines, so that the surface of the knitted fabric, the number of stitches, the narrowing and widening steps are accurately determined:

Rectangle rule (also called midpoint rule)
Trapezoidal rule
Simpson`s rule

2.1 Rectangle rule

The rectangle method (also called the *midpoint* or *mid-ordinate rule*) computes an approximation to a definite integral, made by finding the area of a collection of rectangles whose heights are determined by the values of the function. The rectangle rule offers three possible solutions, as illustrated in figure 4:

The left rule uses the left endpoint of each subinterval;
The right rule uses the right endpoint of each subinterval;
The midpoint rule uses the midpoint of each subinterval.

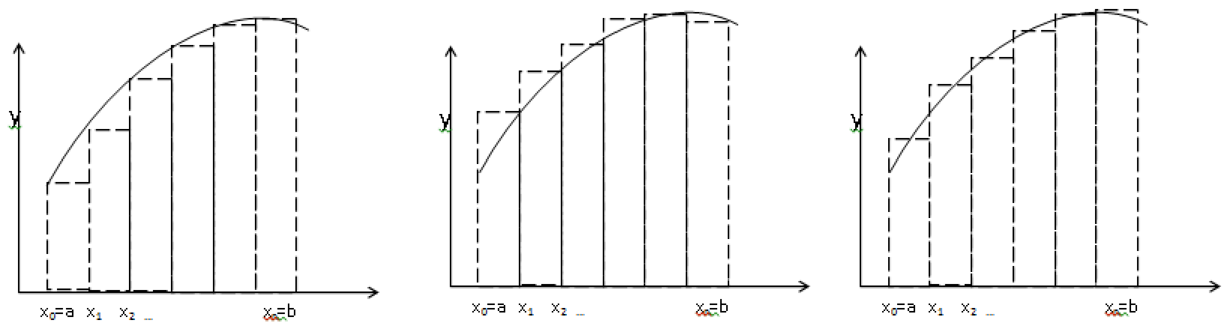

Figure 4. Error approximation using the rectangle rule

For the error approximation of a knitted fabric fashioning line specific geometry the best suitable method is represented by the right rule, which use the endpoint of each interval. For the $y_i=f(x_i)$ function, with $x_i=h_i=\ a_i$, the error approximation is given by the following relations:

Left rule

$$\int_a^b f(x)dx = \Delta a_1 h_1 y_0 + \Delta a_2 y_1 + ... + \Delta a_n y_{n-1} + \mathrm{Rn} \tag{1}$$

Right rule

$$\int_a^b f(x)dx = \Delta a_1 y_1 + \Delta a_2 y_2 + ... + \Delta a_n y_n + Rn \tag{2}$$

Midpoint rule

$$\int_a^b f(x)dx = \sum_{i=1}^{n} \Delta a_i f(\frac{\Delta a_{i-1} + \Delta a_i}{2}) + Rn \tag{3}$$

Where: Δa is the horizontal increment, h is the horizontal step and R_n error approximation.

The vertical increment Δr must be defined in order to complete the calculus of the fashioning line. Generally, the vertical increment can be 1, 2 or 3 courses. When the vertical increment is set up the technical limitations of the knitting process should be considered.

2.2 Trapezoidal rule

The trapezoidal rule works by approximating the region under the graph of the function f(x) as a trapezoid and calculating its area, as illustrated in figure 5.

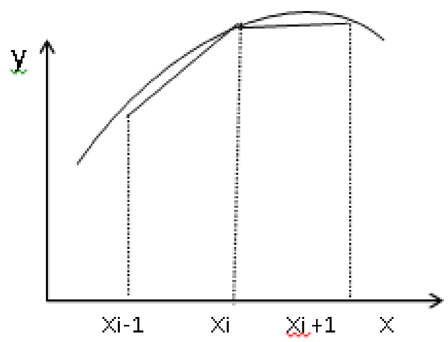

Figure 5. Error approximation using the trapezoidal rule

On $[x_i, x_{i+1}]=[a_i, a_{i+1}]$ segment the trapeze is determined by the $(a_i,0)$ $(a_{i+1},0)$ extremities of the segment on OX axis and by the $(a_i,f(a_i))$ $(a_{i+1},f(a_{i+1}))$ f(x) function values in the extremities. The error approximation is given by the following relations:

$$\int_a^b f(x)dx = \sum_{i=1}^{n} h_i \frac{f(\Delta a_{i-1}) + f(\Delta a_i)}{2} + R_n \tag{4}$$

$$h = \frac{b-a}{n} = \Delta a, x_i = a + ih, i = 0...n \tag{5}$$

Where: Δa is the horizontal increment, h is the horizontal step and R_n error approximation.

2.3 Simpson`s rule

In contrast to the trapezoidal rule, which uses the linear interpolation method (the approximation is made using straight), the Simpson`s rule use quadratic polynomial parabolic interpolation. One derivation replaces the integrand f(x) by the quadratic polynomial P(x) which takes the same values as f(x) at the end points *a* and *b* and the midpoint *m* = (*a* + *b*) / 2. Due to this reason the precision of this method is superior to rectangle or trapezoidal rule.

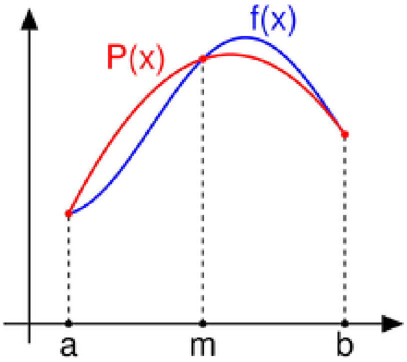

Figure 6. Error approximation using the Simpson`s rule

The error approximation is given by the following relations:

$$\int_a^b f(x)dx \approx \frac{\Delta a}{3}[f(\Delta a_0) + 4f(\Delta a_1) + 2f(\Delta a_2) + ... + 2f(\Delta a_{n-2}) + 4f(\Delta a_{n-1}) + f(\Delta a_n)] + Rn \tag{6}$$

Where: Δa is the horizontal increment and R_n error approximation

ERROR APROXIMATION UNSING SIMPSON`S RULE

The most suitable method that can be used to determine the error between the section and fashioning lines is represented by the Simpson`s rule.

An application has been developed using different browser – supported programming languages. The interface and computations was carried out in PHP and JavaScript combined with a mark-up language (HTML). The designed application allow the users to determine the errors using the Simpson`s method and based on the bordering function the line increment Δr and Δa.

Two cases that have been illustrated are for two different functions. In figures 7 and 8 the bordering function is f(x)=sin(x)+1.5 and in figures 9 and 10 f(x)=cos(x)+1.5.

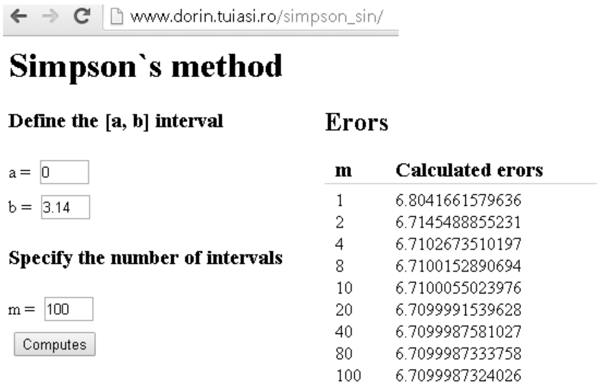

Figure 7. Error determination for f(x)=sin(x)+1.5

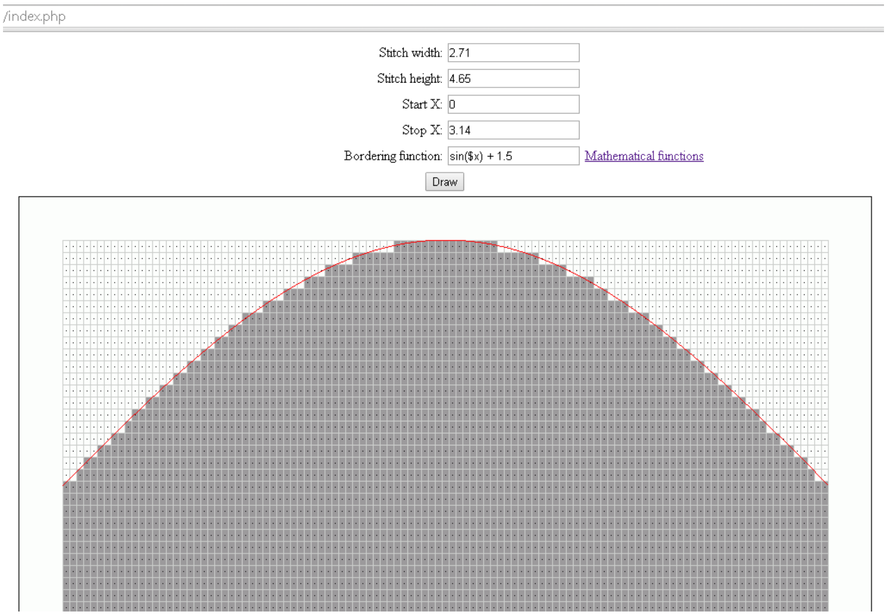

Figure 8. Narrowing and widening steps for f(x)=sin(x)+1.5

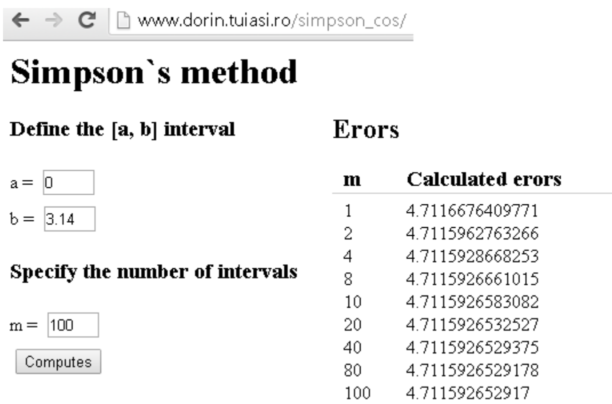

Figure 9. Error determination for f(x)=cos(x)+1.5

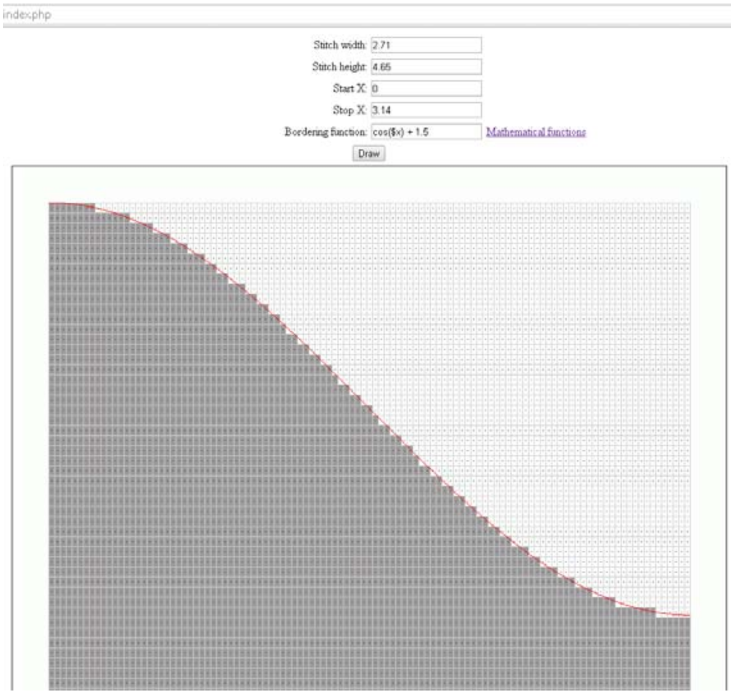

Figure 10. Narrowing and widening steps for $f(x)=cos(x)+1.5$

CONCLUSIONS

The 3D shaped knitted fabrics that are produced using the spatial fashioning technique have a good potential for technical applications. In order to produce such a fabric it is necessary to ensure the correlation between the 3D shape of the solid and the 2D develop of the knitted fabric. Also the errors that appear between the section and fashioning lines must be determined in order to define the widening and narrowing steps specific for the fashioning technique.
The most suitable method that can be used for error determination is represented by Simpson`s rule because it allows a smooth approximation between section and fashioning lines.
In both cases that were presented ($f(x)=cos(x)+1.5$ and $f(x)=sin(x)+1.5$) it can be remarked that the errors decrease with the increase of the interval number considered.

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IMPROVED METHOD FOR THE CONSTRUCTION OF CORSETRY BODY SCAN

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Abstract: *sidered a method for constructing drawings of clothing that exactly follows the contours of the body. To construct the garment drawings to use the dimensional features of the human body that are characterized not only by its size but also the shape. In the papers was reported that the chest circumference of the third (OгIII) form of the shoulder girdle depends on the aspect ratio of different chest measurements according to:*
Кг.к=dп-з.гIII/dп.гIII, где
Кг.к - Aspect ratio of the chest;
dп-з.гIII – antero-posterior diameter of the chest;
dп.гIII - transverse diameter of the chest.
The basis of the method of constructing a complete scan of the body decided to use the methodology for constructing Russian correspondence Institute of textile and light industry, as it provides a good fit to the shape of human design and contains the construction of the sweep hand. To introduce additional enhancements to the dimensional characteristics, allowing a more accurate and reliable information about the nature of a woman's body surface.
This method of constructing a body scan can be used to design tight and correctingyour body shape and range of different purposes – residential corsetry, lingerie, andmedical compression products.

Keywords: *shape of the chest, scan the surface of the body*

INTRODUCTION

Analysis of demand for corsetry, worn directly on the body for the formation and correction of its separate parts for aesthetic or therapeutic purposes has shown that they are needed by the consumer.

It is established that it is a multifunctional product, parameters, and whose properties (physical, mechanical, aesthetic, constructive and others) are very diverse and depend on the purpose of a particular product.

It is established, that the greatest number of corsetry shape body in the area of chest and hip sections. However, there was a need for the products, including in its function and a sounder girdle.

1. ANALYSIS OF METHODS OF CONSTRUCTING SCAN OF A FEMALE FIGURE SURFACE

A significant contribution to the solution of tasks of designing corsetry was made by the scientific schools of Moscow University of design and technology, Russian correspondence Institute of textile and light industry, Saint-Petersburg state University of technology and design, Central research Institute for garment industry, Ivanovo state textile Academy [1-4] and others. In their investigations methods of their design and production, and identified criteria for evaluation of functional and were proposed ergonomic parameters were determined.

Their proposed ways of construction drawings of parts of corsetry can be divided into two groups. In the first group it was included the ways of construction drawings calculation and graphic ways in which measure of standard shapes, rarely individual were used. In papers there are no recommendations on the shoulder part of the corset.

In the second group of drawings of the parts are built as the sweep surface of the body by model or by other geometric means. This group of methods is sufficient by consuming and may not be used for the design of medical devices when working with surgical patients.

Disadvantages of the above methods have necessitated the development of calculation and graphic way of building drawings of parts of corsetry type "Romper" for the standard and individual figures.

2. DEVELOPMENT OF A METHOD OF A SCAN TORSO FEMALE FIGURE CONSTRUCTION

2.1. The analysis of the proportions of torso female figure

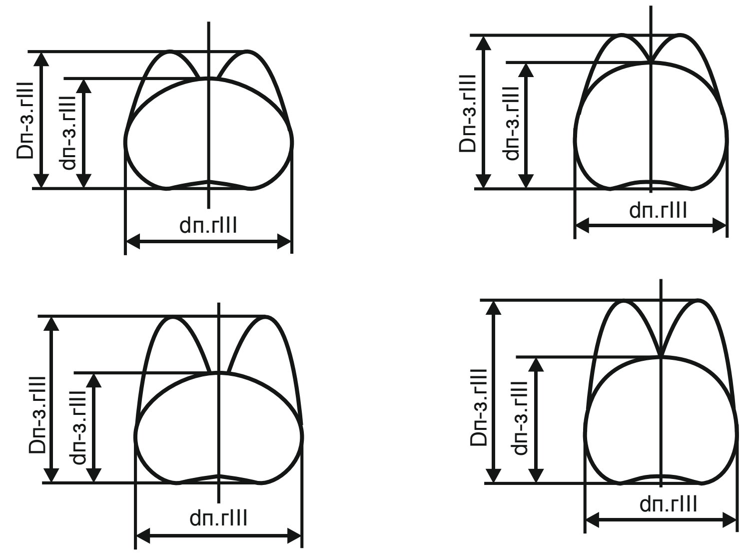
For the construction drawings of parts of the corset calculation and graphic way, you should select the dimensions of the human body, which is characterized not only by its size, but also the form of a parcel.

In the works of Russian correspondence Institute of textile and light industry [5] it was proved that at equal values of the chest third (OrIII), the shape of the shoulder girdle depends on the ratio of diameters at the level of the chest third, i.e. to have a different aspect ratio of the chest:

$$\text{Кг.к} = \frac{\text{dп–з.гIII}}{\text{dп.гIII}}, \quad \text{where}$$

Кг.к - the aspect ratio of the chest;
dп-з.гIII - anterior-posterior diameter of the chest;
dп.гIII - transverse diameter of the chest.

As a result it was set three options of the shape of the chest - standard, septicemia and round. This leads to the fact that the slope of the shoulders, the level of situations of the base and the centre of the breast and the distance between them are changed (Fig 1).



elliptic chest rounded chest

Figure 1. The form of a thoracal section

In the Ivkin M.P. work [2] it was proved that if the dimension of the anterior-posterior diameter breast DA-pb III considering hanging breast gland, it is possible to determine the size of the development of the breast at equal values of the anterior-posterior diameter of the chest DA-pb III (Fig.1, 2).

In addition, it is established that with the increase of the size of the breast gland is changing its form, when, instead of the spherical form, it hangs down. So we believe that measurement of breast gland should be performed in lingerie.

Figure 2. A computer model of the figure with different degree of development chest of breast glands

In addition, in [2] the work is proved that the distance between the front points of the chest glands varies depending on the weight of the breast and body type.

2.2. Initial data for scan construction

For a basis of a method of constructing a full body scanner decided to use the method of constructing Russian correspondence Institute of textile and light industry, as it provides a good fit design on the human figure and includes building a sweep of the hand. For its improvement it is necessary to introduce additional dimensions to allow a more accurate and reliable information on the nature of the body surface woman (figure 3):
P – growth;
Влт - the height of the waist;
Втос - the height of the point of the front base of the neck;
BorVI - the height of the base of the breast;
dпа - transverse diameter of the shoulder acromion;
OrVI – volume of the chest the fourth;
ШгI - the width of the breast first;
Дв - vertical arc of the breast;
Дп - transverse arch breast cancer;
dв – the vertical diameter of the breast;
dп – transverse diameter of the breast;
Дгж - the distance between the front points of the breast.

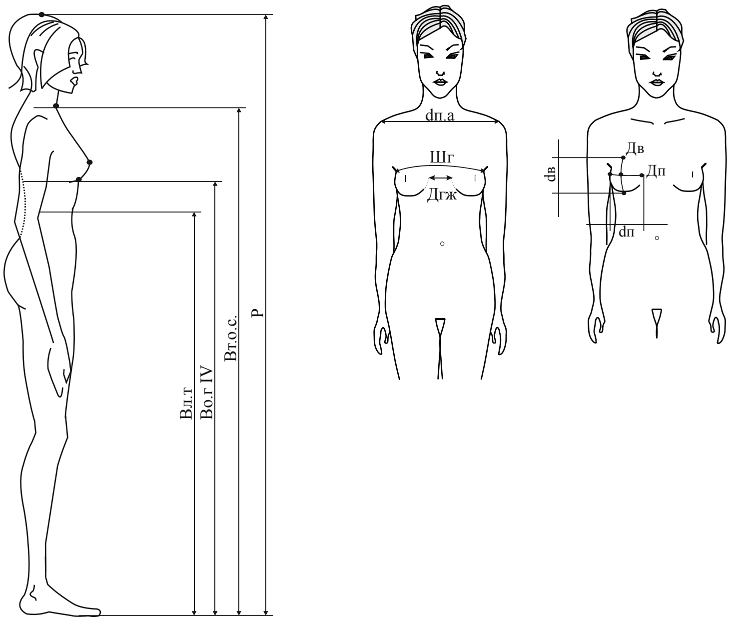


Figure 3. Anthropometric measurements of the shape for a body scan designing

Methodology developed by Central research Institute for garment industry is accepted for the basis for designing of cup breast gland sweep.

2.3. Steps scan of design

Construction drawings body scan in accordance with and the developed technique is carried out in several stages:
- calculation and construction of the basic grid of drawing;
- calculation and construction of the shoulder girdle of the back sweep;
- calculation and construction of the shoulder girdle of the front sweep;
- calculation and construction of the sweep of a Cup;
- calculation and construction of the hip of the body girdle

In the method of constructing a body scan following changes:
1. The width of the base mesh A0A5 determined by the sum of measurable traits, half the width of the spine (0.5*Шс), the anteroposterior diameter of the arm (dп-з.р) and halfthe width of the breast (0.5 * ШгI).
2. The point of the front base of the neck is defined as the difference between the A6sized signs point the height of the front base of the neck (Втос) and the height of the waist line (Влт).
3. Position of the shoulder point before the П3 level determined by the intersection of the cross-shoulder acromial diameter dпa and width of the shoulder Шп.
4. The position of the base of the breast is defined as the difference of measurable traits of the height of the base of the breast (ВогVI) and the height of the waist line (Влт).
5. The position of the cup is determined by the stitching distance between the front points of the mammary gland (Дгж), vertical (da) and transverse (dп) diameters of the breast.
6. The total solution of darts at the chest circumference of the fourth is calculated as the difference between the width of the base mesh A0A5 and volume of the chest the fourth OrIV.

Stages of building a sweep cup, hand and hip belt are the same (Fig. 4).

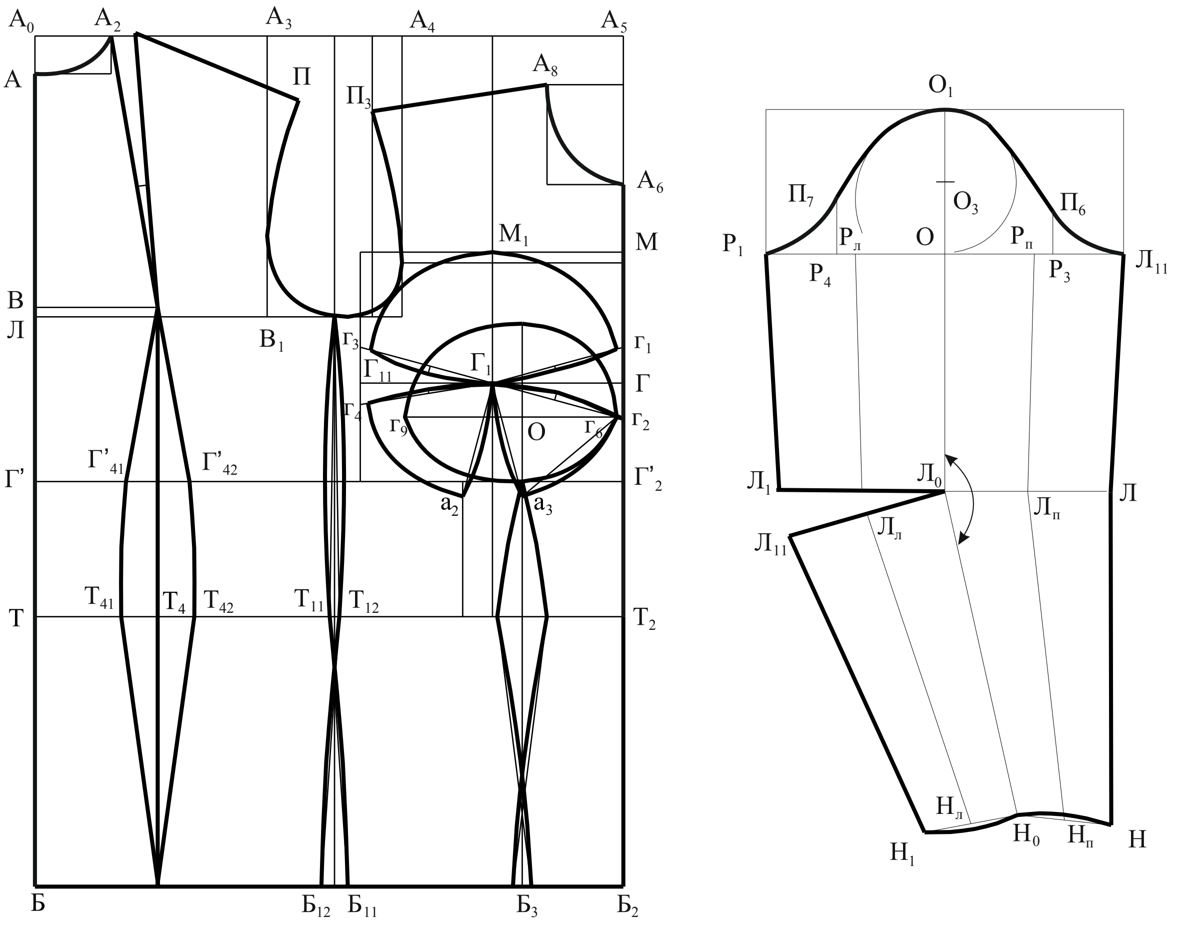


Figure 4. Drawing of the body scan of standart type figure D-D 164-88-92, Cup A

CONCLUSION

For approbation of a method of a body scan construction drawings for individual figures are designed. The models showed their compliance with the shape of the body.

This method of constructing the body scan can be used for designing tight and corrective body shape products of various purpose and range domestic corsetry, medical corsets and stockings as for the standart figure, and for the individual.

When working with individual figure, the method allows for its shape and proportions.
You can create drawings for clothes with two cups, one or no cups. Such clothing is required after resection of the breast.

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CONSIDERATIONS REGARDING THE DESIGN AND MANUFACTURING PROCESS OF CUSTOM-MADE DIVING SUITS

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Abstract: *Diving suits are manufactured either for the persons who have hobbies, or for the researchers. These suits are used in deep, warm or cold waters, but no matter what the environmental conditions are like, the wearer must feel safe, comfortable and free to move. The main material from which these suits are manufactured is neoprene, coated with different other materials to become resistant and to maintain stretchable characteristics, according to its destinations. The properties of the material, the environmental conditions or threats determine special requirements regarding the designing and manufacturing process, which are presented in this paper.*

Keywords: *diving suit, custom patterns, stretch, glued and taped stitches.*

INTRODUCTION

Nowadays, many people choose to practice water sports. Scuba diving is a form of underwater diving in which a diver uses a self-contained underwater breathing apparatus (scuba) to breathe underwater.

Figure 1: Scuba diver

The scuba divers carry their own source of breathing gas, (usually compressed air) in order to allow a greater freedom of movement. The scuba equipment may be an open circuit, in which the exhaled gas is expelled in the surroundings, a closed or semi-closed circuit re-breather, in which the breathing gas is purified by removing carbon dioxide, and the oxygen used is replenished from a supply of feed gas before being re-breathed (figure 1). In water, a scuba diver moves around by using fins attached to the feet.

In this sport, the equipment consists of the following parts [6, 7, 8, 9]:
- breathing apparatus;
-diver mobility equipment;
-underwater vision equipment (masks and lights);
-diving suit (dry and wetsuits);
-monitoring and navigation system;
-safety equipment;
-accessories.

A wetsuit is made of foamed neoprene, because it provides thermal insulation, abrasion resistance and buoyancy. The material contains enclosed bubbles of gas which reduce the heat waste. Also, these bubbles give the wetsuit a low density, providing buoyancy in water.
The suit is equipped with a few zips which reduce flushing and maintain its waterproof properties.

A dry suit protects the whole body while immersed in water except the head, hands, and sometimes the feet. These types of suits must be well designed and sewn to prevent water from entering.

The main difference between dry suits and wetsuits is that the dry suits are designed to prevent the water from getting through it. This generally allows a better insulation making them more suitable for use in cold water. Dry suits can be uncomfortably hot in warm or hot air, and are usually more expensive and more difficult to manufacture. For divers, they are also more difficult to use as the suit must be inflated or deflated depending on the depth changes in order to avoid "squeezing" during the descent or an uncontrolled rapid ascent due to the over-buoyancy.

Wet suit

Dry suit

Figure 2: Scuba diver suits

These suits are made from neoprene, which is manufactured by foaming the polymers with nitrogen gas, in order to obtain the specific insulation properties of the tiny enclosed and separated gas bubbles (nitrogen is used for chemical convenience). The foam cells created in this way make the material quite buoyant, and the diver must compensate for this by wearing weights.
For diving in deep cold water it is indicated to use a 7 mm-thick suit, because the material will compress in deep water, will become thinner and it will offer the needed protection and safety for the wearer.
The designing and manufacturing process of scuba diving suits has some particularities which are determined by the characteristics of the material and by the wearing conditions.

CONTENT

This paper presents some considerations regarding the designing and manufacturing process of scuba diving suits [1, 2, 8, 9].
The main stages are:

A. Obtaining the physical stage of neoprene material. The initial liquid form of neoprene is mixed with different additives and baked in a large oven in order to obtain a big and large rubber loaf of bread. After that, it is necessary to relax until it becomes cool.
B. The rubber loaf of bread runs through a slicing machine in order to obtain different thickness values of the material (3, 5 or 7 mm). After that, these sheets of rubber are laminated with different materials to become stretchy, thermally insulated and resistant against abrasion (figure 3). After that, these sheets are controlled and sorted into groups.
C. Cutting the sheets into pattern pieces.

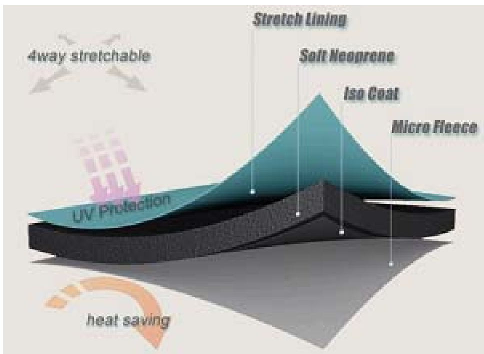
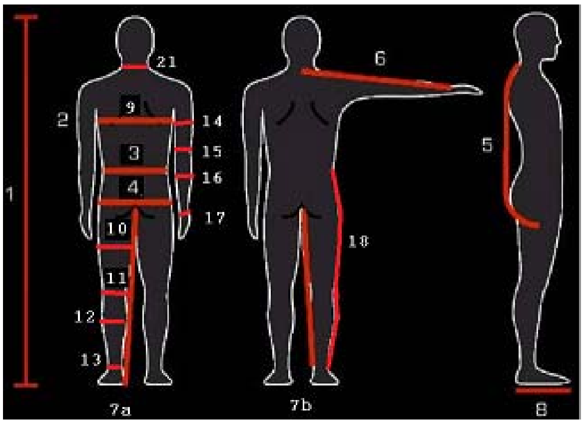


Figure 3: Laminated rubber

The designing process of scuba diving suits must take into account the properties of the material, the environmental conditions, the comfort requirements and the mobility of the body.
It is recommended to wear a custom- made suit, because it is tailored more closely to the body shape ("anatomically designed patterns"). On these terms, the suit will have a minimal internal volume and little air and it will provide more mobility.
For example, a wet diving suit must be a "second skin" in which the wearer feels both comfortable and safe.
The shape of the patterns is drawn using CAD system functions. The sizing of the patterns is performed according to the mathematical relations of proportionality in which the body dimensions and allowances are used [3, 4].
When designing patterns for neoprene suits it is necessary to take into account some of its characteristics (thickness and stretching properties) and water influence. Neoprene is considered a very "stretchable" material, but in time it gets "older" and less stretchable. A 7 mm thick neoprene sheet is less stretchable than one which is only 2 or 3 mm thick.

For a good use and comfort, the patterns of these suits are designed in a custom-made manner. In this case, it is necessary to know different body dimensions, as it is shown in figure 4.



1-Body height
2-Maximal chest perimeter
3-Maximal waist perimeter (at belly point)
4-Maximal horizontal hip perimeter
5-Neck- crotch (length from the 7th cervical vertebra to the crotch point)
6-Neck –wrist (length from the 7th cervical vertebra to the wrist)
7a- Crotch to floor (for dry suits)
7b- Crotch to ankle (for wet suits)
8- Foot size
9- Back width (for the backside of the body) and front width (for the front side of the body). These dimensions are measured horizontally, between the armpit points
10- Thigh perimeter (where the muscles are very well developed)
11- Knee perimeter
12- Calf perimeter (where the muscles are very well developed)
13- Ankle perimeter
· Arm perimeter (where the muscles are very well developed)
15- Elbow perimeter
16- Forearm perimeter (where the muscles are very well developed)
17- Wrist perimeter
18- Lateral length from the waist line to the level of malleola

Figure 4: Body dimensions

The patterns are designed in the Gemini CAD System *Made -to- Measure* environment. In the *MTM* module all the mathematical relations used for dimensioning the shape of the main patterns of the suit are written. In this way, the main points of the pattern (named as P1, P2, P3,…., P_i) are positioned in a geometric layer. In this way, if something changes in the structure of the mathematical relations or in the values of the initial data, the positions of these points will change automatically.

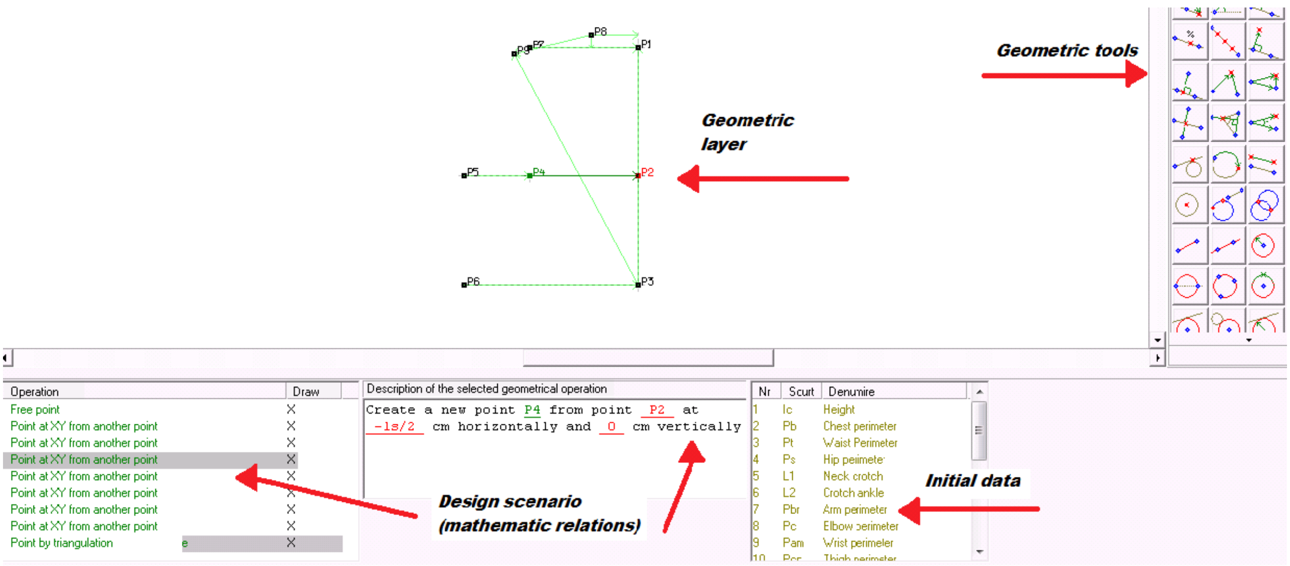


Figure 5: Design scenario

The general structure of the mathematical relations is:

$$Y = X' + A_x \qquad (1)$$

Where: Y= the constructive segment of the pattern
X'=the dimension of the body "adjusted" according to the stretching value of the material. X is the body dimension that directly has an influence on the segment of the pattern.
A_x= the value of the constructive allowance

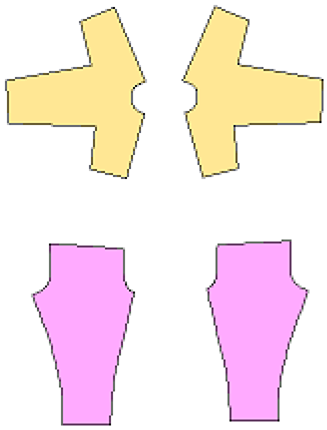
This type of allowance has two components:

$$A_x = A_g + A_\ell \qquad (2)$$

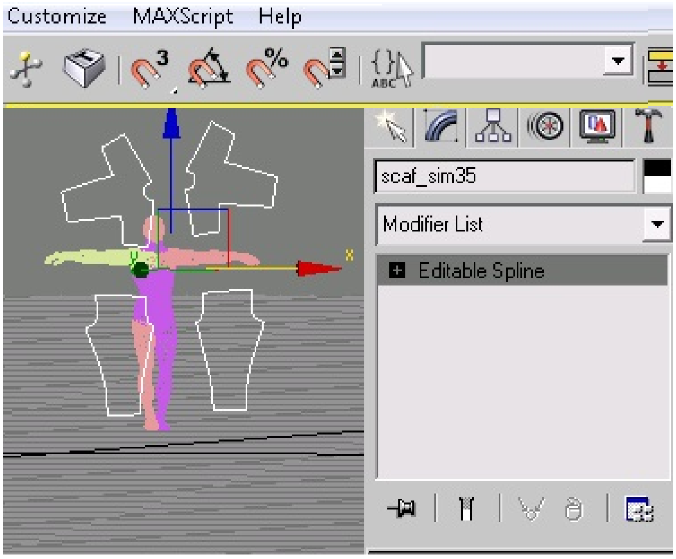
Where:
A_x =the constructive allowance
A_g=the thickness allowances
A_ℓ= the freedom allowance

In general, all the layers used to obtain the material for the manufacturing process of diving suits will be called *"base material"* in this paper. The suit is made of a stretchable material and for this reason the stretching property of the material plays the role of the freedom allowance.
A material, as the one presented in figure 3, can be 3, 5 or 7 mm thick. In determining A_g, half of this thickness is taken into account, because these materials interact with the environment and the body.
If the whole thickness of the material is taken into account, the resulting value of the constructive allowance will be higher, it will lead to bigger areas of the patterns and much bigger weights, which will apply a higher pressure on the human body while the diver is under water.

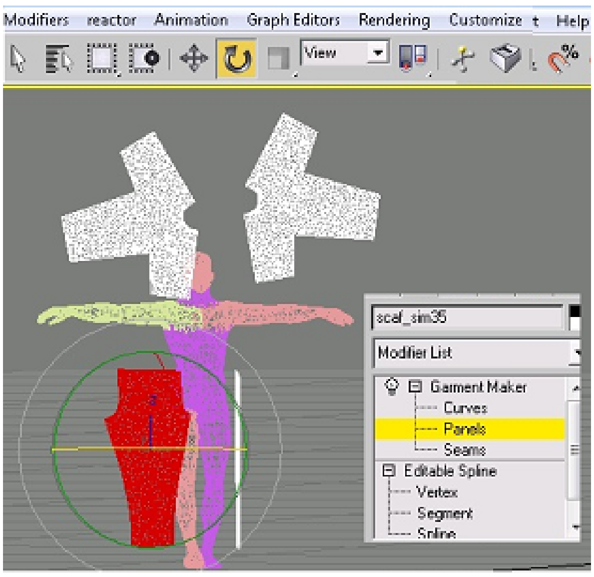
The stretching properties of the base material determines some reductions in the body dimensions used in the mathematical relations. Under water, neoprene will compress, will become thinner and better-shaped on the body and so it will provide good protection for the diver. Usually, the reduction percentage of the perimeters is about 40 % and for the lengths or widths, the reduction percentage is around 20%.
Taking into account all this information, the main parts of the diving suit (the blouse with sleeves for the upper part and the trousers for the lower part of the body) are designed in a 2D environment.
Before going further to divide these parts into pieces, it is necessary to simulate how they will fit on the body, by taking into account the properties of the material.



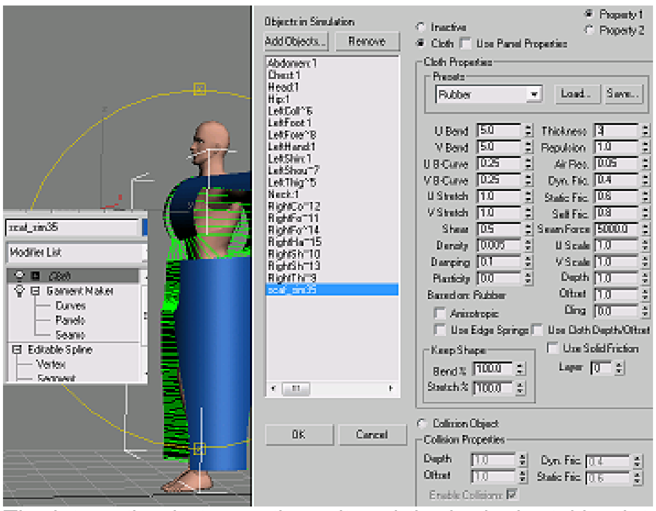
Flat patterns



Importing the flat patterns in the 3D environment for the simulation



Arranging the pattens around the body (moving and curving them)



The interaction between the suit and the body, by taking into account the properties of the material.

Figure 6. The patterns are verified in a 3D environment (in several stages)

After that, the flat patterns are split according to the shape and size of the needed pieces (or panels). If some values of the initial data are changed or the structure of the mathematical relations is changed, the shape and size of the pieces are automatically changed, because these pieces are linked to the geometrical layer of the main patterns from which they have been obtained. In this environment, the patterns are designed by using the technical values of the allowances needed for the manufacturing process.

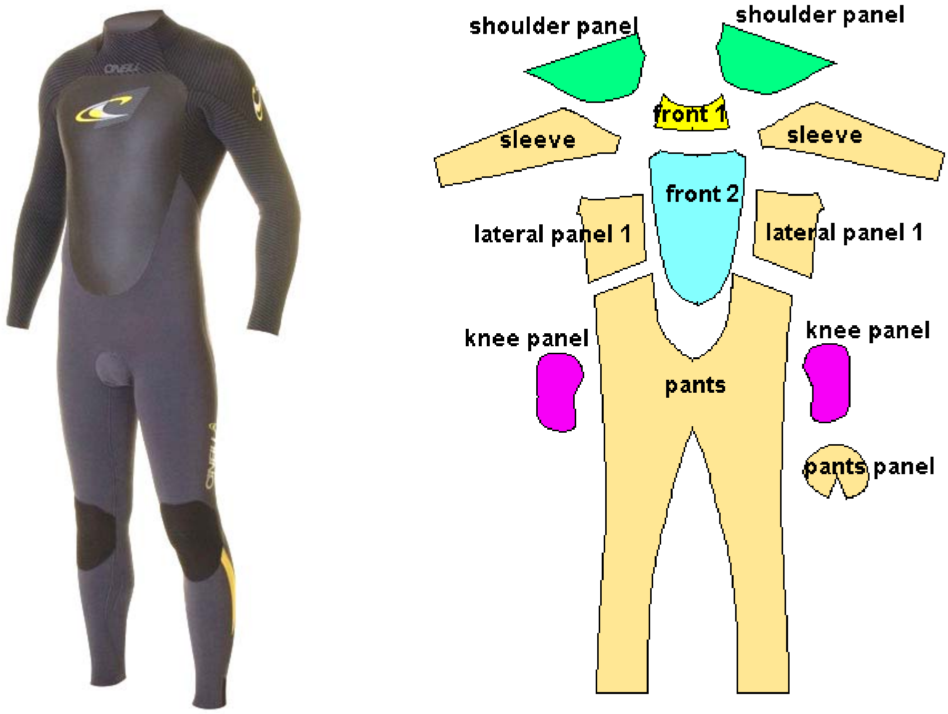


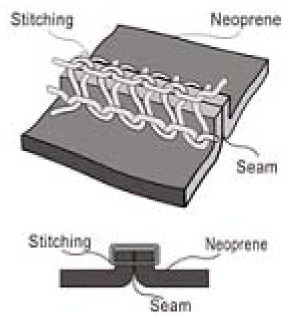
Figure 7: The pieces of the diving suit

D. The pieces of the suit are put on the sorted layers of neoprene and the outline contour is traced with a white crayon. After that, the pieces are cut, sorted and sent to the next stage of the manufacturing process.

E. The sewing process.
A well-fit wetsuit is essential for protection against the low temperatures, and this goal is achieved by using separately-tailored panels. These panels are joined one to each other by stitching them along the seams. The seams are less flexible than the neoprene sheets. In a high quality wetsuit, seams are kept away from the areas where a high flexibility is important. Seams should not run along the shoulders or under the arms, where they could intrude in the paddling areas. In a low quality wetsuit, water will enter through the seams [1, 2, 6, 8] .
The indicated types of stitches for sewing neoprene are:

- ✓ Glued and blind stitched seams eliminate water because the needle doesn't go through the fabric. Flat-seam or flat-lock stitching is softer but allows water in, making it better-suited for warm-water suits.

Table 1: Types of stitches used for sewing neoprene materials

	Overlock Stitch- this type is uncomfortable and it is used on cheap wetsuits (it is rarely used nowadays)

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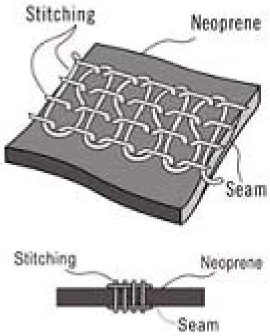
<td>

Flatlock Stitch- is comfortable, flexible, but leaks. This type of seam allows the water to move in and out of the seam and keeping the body at an average temperature.</td>
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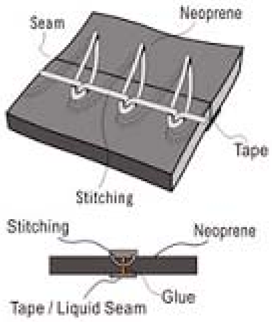
<td>

Glued & Blindstitched- it is used in manufacturing wetsuits for the warm season. The needle never penetrates the neoprene completely, so there are no holes. This seam has glue on its inner side. After glue, a stitch is applied over the top to enforce the neopren layers.</td>
<td>
Blind stitch on the outside

Taped seams and taped stress points

Glued & Blindstitched and fully taped</td>
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- ✓ A high-quality zipper backed by a smooth-skin sealing system creates a water- blocking barrier that can't be beaten. Some suits employ zippers with overlapping teeth designed to reduce the quantity of water which enters the suit.


Figure 8: Diving suit zippers

A back zip suit is the traditional entry system, with a long zipper along the back of the suit. This zipper has an attached cord which allows it to be fasten/unfasten in the wetsuit. The advantage of this type of entry system is that it is easy to be put on.
A zipper on the chest area allows the wearer to get in and out of the wetsuit. When unzipped, the person gets in through the neck area of the suit. It is much easier to get in this kind of suit than in a back zip one, due to the advances in technology and because of the greater neoprene flexibility. It usually takes just a little amount of time to get used to it and the advantages of a chest zip suit are major.

- ✓ The flexible kneepads provide substantial coverage for the knee and leg area but don't hinder swimming. Anti-abrasion patches on the shoulders and rear protect the wetsuit.

Figure 9: Diving suit kneepads

Figure 10: The seal on the area of wrist

- ✓ The seals at the neck, wrists and ankles keep water from entering the wetsuit

F. The suits are cleaned and inspected for quality and tags are attached by using stitching or a hot press.

In this stage the following are verified:
- ✓ the aspect of the seams,
- ✓ how the kneepads are stacked,
- ✓ how the zippers are sewn,
- ✓ if there are any holes in the material,
- ✓ the structure of the reinforced areas and their resistance;
- ✓ how they fit on the neck, wrist and ankle areas;
- ✓ the values of the product measurements are checked to be the same or almost the same with the values written on the technical sheets (on different sizes).

CONCLUSIONS

The design and manufacturing stages influence the quality of the garment. For the diving suits, the comfort properties, the mobility and the safety are very important requirements which must be fulfilled. This goal is achieved when:
- ✓ the quality of the material is the best and it is chosen according to its destination. It is important to choose the type of the layers and the technology by which these layers are stuck together very carefully, according to the conditions in which the final product is meant to be used (warm or cold water, season, etc.)
- ✓ the patterns must be very well-fit on the body, as the diver must feel comfortable in the water. If the suit is not shaped properly, it will work against the desired movements of the diver, causing additional fatigue and chafing. A properly-fit diving suit will help maintaining a regular body temperature by allowing a small amount of water to get between the surface of the diver's skin and the inside of the suit (this thin layer of water reaches the body temperature in a small amount of time). If the suit doesn't fit properly, there is a constant exchange between the colder water from the outside and the warm water from the inside of the suit. The secret of manufacturing a warm suit is to trap the warm water inside and to keep the colder water from getting in.
- ✓ the stitches must be perfect (the needles have a curved shape and they are chosen according to the thickness of the material). For sewing, the worker must be very well-qualified to make good seams, well-glued or taped, as necessary.

A very good diving suit must be made of materials with a high level of quality and it must be manufactured by using the adequate technology, equipment and well-qualified workers.

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METHODS FOR ASSESSING THE MODEL FAMILY ECONOMICS

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Abstract: *The clothing manufacturers, usually for testing the market in the phase of assessing the model families, create models which are similar by their constructive - aesthetic particularities, technological and structural layers but the differences from one model to another are due new elements attachments at the base model. Before the market launch of the model families, it is necessary to test how the proposed models respond in terms of raw material costs. As is known, to achieve a clothing product, raw material costs represent approximately 85%, which explains the constant concern of manufacturers to find cost-effective solutions.*
In this context, the paper aims to exemplify, for "jacket for women" garment a testing methodology of the economics for the models family in order to propose to further user cost-effective solutions.
To solve the paper's aims was elaborate a family of 10 models for "jacket for women." These models have as common features: modified cuts, straight silhouette, constant length, sharp dividing of the basics parts.

Keywords: *clothing, family models, economics, markers*

INTRODUCTION

It is known that in the apparel industry, the raw material costs represent 80 to 85% of the cost for a clothing item. In this context, companies developing their collections of clothing are constantly preoccupied with rationalizing the use of raw materials to produce profitable clothing [2]
The use of CAD systems for technical documentation development activities, allow specialists to conduct a preliminary analysis of the costs of families of models developed by performing automatic markers.
The literature presents researches assessing the efficiency of use of raw materials based on evaluation of assignment made by CAD systems [4].
The paper presents a method for assessing the use of raw materials belonging to a family of models for "jacket for women."
To address the objectives of the research the following steps were made:

- designing a family of models;
- constructive designing the patterns;
- elaborating the working patters;
- elaborating markers for each model, for the same width of fabric;
- evaluating the use of raw materials, for the markers performed by calculating the specific consumption, use indicators of the of raw material and indices of loss;
- applying the assessment method of models economy by calculating a dimensionless parameter $\varepsilon_{(p,q)}$, which by its values allow the grouping of models in economic models, wasteful models and questionable models.

The economy assessment for the family of models under study, based on economy indicator $\varepsilon_{(p,q)}$ requires the introduction of dimensionless standardized variables, like [1]:

$$q_i = \frac{Q_i}{Q_{\max}}\ ;\ q_{\min} = \frac{Q_{\min}}{Q_{\max}} \quad (1)$$

$$p_i = \frac{P_i}{P_{\max}}\ ;\ p_{\min} = \frac{P_{\min}}{P_{\max}} \quad (2)$$

where:

Q_i is the specific consumption model "i"
P_i – rate of loss model "i"

Q_{max} – maximum specific consumption for a model of the family of models studied
Q_{min} – minimum specific consumption for a model of the family of models studied
P_{min} – minimal loss index for for a model of the family of models studied
P_{max} – maximum loss index for for a model of the family of models studied

For $\varepsilon_{(p,q)}$, the following relation is used:

$$\varepsilon_{(p,q)} = \frac{1}{2}\left(\frac{1-p_i}{1-p_{min}} + \frac{1-q_i}{1-q_{min}}\right) \quad (3)$$

From this relation, results:

$\varepsilon_{(p = pmin, q = qmin)} = 1$
$\varepsilon_{(p = pmax, q = qmax)} = 0$

Because $0 \le \varepsilon_{(p,q)} \le 1$, results according to the ecuations "golden section" that for:

$0 \le \varepsilon_{(p,q)} \le 0{,}32$ model is uneconomical
$0{,}32 \le \varepsilon_{(p,q)} \le 0{,}62$ the model is questionable in terms of economic
$0{,}62 \le \varepsilon_{(p,q)} \le 1$ is the economic model.

For the product under study, the modified cut is constant and the closing, the collar, the sleeve endings, the further dividing of front back and sleeve elements are changed [3].
Figure 1 shows the reference model of the collection, and Figure 2 a), b), c), d) present the model elements in the first processing step.

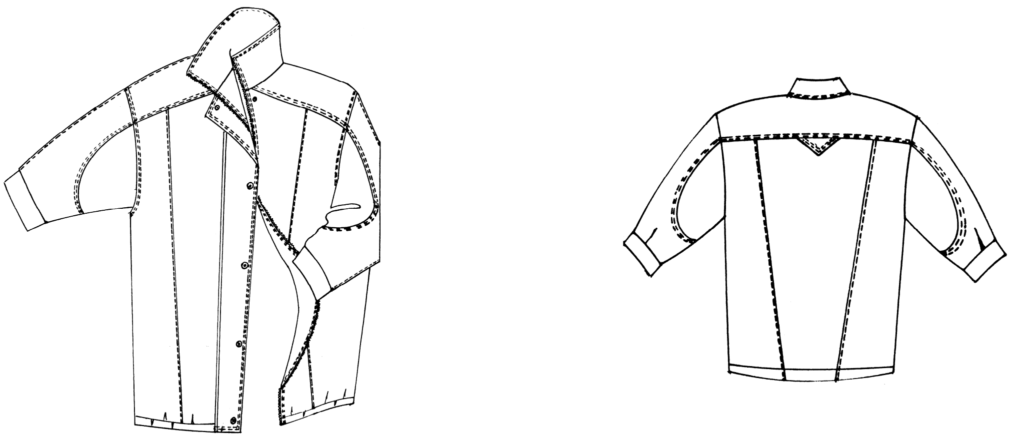
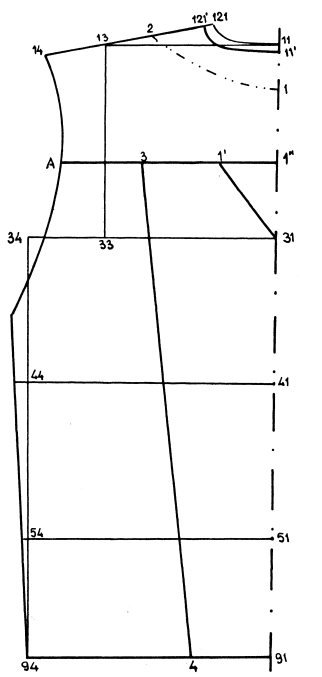
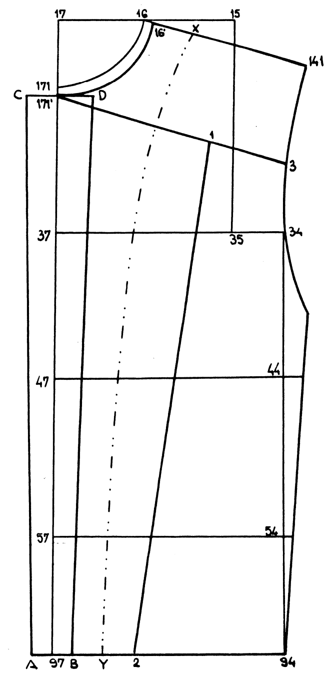


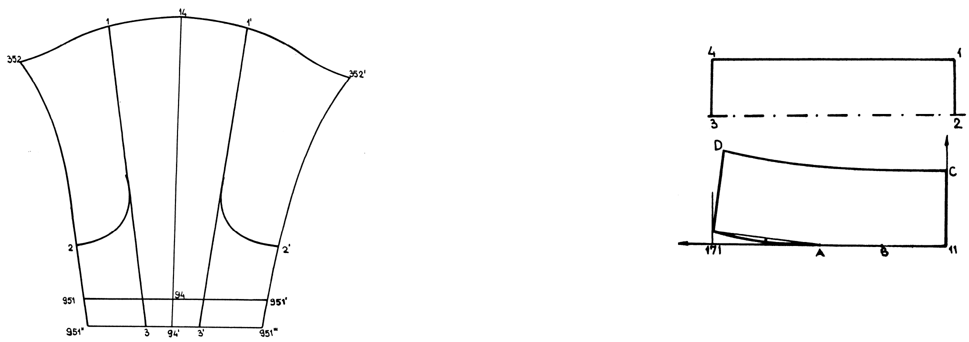
Figure 1: Reference model



a)



b)



c) d)

Figure 2. Model elements in the first processing step

EXPERIMENTAL PART

For all models, the patterns were developed to model patterns, preliminary stage in the construction of main working patterns.

Since in the markers, the shape, the geometry and the number of items used to build the model are significant, in Table 1 the number of items for each item was centralized for the family of models.

Table 1: Items of the product elements

No. of model	Product elements									Total no. of items	No. of big items	No. of little items
	Front	Back	Sleeves	Collar	Pocket	Closing	Aplac	Bizet	Ending			
1	6	6	5x2=10	2	0	2	1	2	0	29	17	12
2	8	6	4x2=8	4	4	2	0	2	0	35	14	21
3	8	7	8x2=16	4	4	4	1	2	0	46	15	31
4	8	4	4x2=8	2	8	2	1	2	0	35	17	18
5	8	8	5x2=10	2	2	0	1	2	1	34	19	15
6	2	1	2x2=4	2	4	2	1	2	0	18	7	11
7	4	3	2x2=4	2	4	2	1	2	0	22	12	10
8	4	4	2x2=4	2	6	0	1	2	0	25	12	13
9	2	2	3x2=6	0	6	0	1	2	0	17	8	9
10	4	3	3x2=6	2	6	0	1	2	0	24	15	9

From Table 1, it is found that the proposed models have a variable number of items, which will lead to different values of indicators to asses the use of raw materials, to the developments of markers.

For the ten models of the collection, the main patterns were built and the markers were developed for the base material with a width of 152 cm (all markers were performed on the doubled material, size 46).

From the markers performed in GEMINI CAD system, the specific consumption in m and m^2, the using index Iu and the loss index Ip in % were resulting (Table 2).

Tabelul 2: Indicators for evaluating the use of raw material i

No. model	Cs m	Cs m^2	Iu %	Ip %
1	1,74	2,65	75,63	24,36
2	1,72	2,61	83,38	16,61
3	1,56	2,37	86,30	13,60
4	1,64	2,50	89,84	10,15
5	1,72	2,62	79,24	20,75
6	1,75	2,66	78,14	21,85
7	1,70	2,59	73,21	17,3
8	1,78	2,59	73,21	26,79
9	1,68	2,70	75,61	24,30
10	1,68	2,55	77,64	22,36

From Table 2, it is found that:

- Cs(m^2) varies widely; from 2,37 m^2 obtained from model 3 to 2,7 m^2 for model 9;

- biggest loss index Ip was obtained for the model 8 and the lowest for model 4;
- there are models that have similar values for Cs, but the values are different Ip.

Based on calculations made using the relations 1.2, 3, and information compiled in Table 2, are presented in Table 3 dimensionless index values $\varepsilon_{(p,q)}$ and distribution of models in economic models (E), questionable (D) and non-economic (NE).

Table 3: Evaluation of economy models

No. model	p_i	q_i	$\varepsilon_{(p,q)}$	E, D, NE
1	0,909	0,980	0,155	NE
2	0,620	0,964	0,452	D
3	0,507	0,878	0,896	E
4	0,378	0,924	0,811	E
5	0,774	0,969	0,360	D
6	0,815	0,985	0,210	NE
7	0,645	0,959	0,453	D
8	1,000	0,956	0,180	NE
9	0,907	1,000	0,074	NE
10	0,834	0,942	0,371	D

From Table 3, we can draw the following conclusions:
- from the family of models studied, two models are economic (model 3 and 4), models characterized by the balance between small and large items with surfaces which resulted in a loss index with values lower than the mean recorded for this indicator the entire family of models;
- for the two economic models, also the specific consumption values are below the mean values recorded on the family of models;
- the family of models studied have resulted in a total of four models questionable, are models that can easily modified to minimize loss index without distorting the original appearance of the model, by reducing large areas of the elements through the lines of division up to a threshold that can not be perceived by the user;
- Non-economic models (4 models) is characterized by having a smaller number of items (such as model 8), compared to the other models of the family of models, and shows design elements that do not allow a judicious location of patterns in marker (such as model 9 has a shawl collar with back collar indivisible element face).

CONCLUSIONS

- LaunchING into production of families of models must be preceded by a study to examine the use of raw material in the marker in order to avoid inefficient models in terms of material costs;
- Use of CAD systems in developing technical documentation enables rapid implementation of the study presented in the paper with important repercussions on knowledge utilization efficiency of raw materials each model family of models developed for market launch;
- The study demonstrates that the creative activity of models design is necessary to know the technical aspects of how to divide the surface of the basis, structure parts elements, directing the shape and geometry of decorative elements, in order to reduce losses in patterns markers on material but without diminishing the aesthetic requirements imposed by fashion;
- The study can be extended to all kinds of clothing, the stage of formation of families of models, as is a preliminary analysis of return of developed models.

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METHODS FOR CONSTRUCTIVE AND AESTHETIC DIVERSIFICATION OF SHAPES OF THE KNITTED PRODUCTS

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Abstract: *The paper presents results of a forms systematization and structures of knitted products that fully characterize their diversity, followed by an example to demonstrate the influence of product characteristics on the form of knitted fabric, also being elaborated some examples of product design for a sweater for women made by various methods. Systematization criteria were selected to characterize the shape and construction of knitted products underlying to most effective diversification of assortment of knitted garments. The paper presents some ways to create new forms for a product using the method of decomposition to presentation elements.*

Keywords: *knitted products, diversification, shape and construction of knitted products*

1. INTRODUCTION

Knits have some features that permit the production of products that fully meet all the imposed requirements for functional clothing. Knitted fabrics are characterized by virtually limitless possibilities for aesthetical diversification, offering a large work area for creators to meet the most demanding preferences of the wearer.

Since knitted products have relatively simple forms, consisting mainly of three elements: back, front, sleeve; can be carried out a systematization of form and knitted products construction. In the work is presented a describtion and a systematization by diagram (Figure 1.) the most important factors underlying the shape characteristics and of knitted garment product [1].

The reduced number of shapes and cuts will always be an important feature of knitted garment. On this aspect, it is noted that aesthetics diversification of these products will be made especially by implicit methods [2], expressed through the fabric surface effects (structure, color, ornaments applied, etc..).

The creation of knitted products requires a systematic approach to meet the following objectives:

- manufacturing of products according to fashion trends in a timely manner;
- obtaining the same type of item or product of a large number of variants;
- solving optimal value for both the product and the buyer.

Achieving these objectives is determined by solving methodologies of the creative process and the construction of models, respectively by the approach of the two stages of the process such as: artistic design stage of the new model (compositional solution) and constructive design stage.

2. INFLUENCE OF THE SHAPE CHARACTERISTICS ON THE SHAPE OF KNITTED PRODUCT

The shape is one way of showing the diversity of all the clothing patterns representing the outline of the object given by the silhouette and cut [2].

In terms of aesthetics, product form depends on the functionality of the materials used to build the product and the forces acting upon them. It is closely related to its content and in a certain order to the distribution of the constituent elements of the product, highlighting the link between its internal and external structure.

In the current technology for manufacturing clothing product, flat components after processing in the product become spatial nonlinear surfaces.

Components of a product are characterized by a very high diversity and change by:

- size and shape of the human body;
- type and destination;
- functional, aesthetic and ergonomic requirements;
- row materials properties.

In this context, the form of clothing is a spatial surface in which it is "organized" when located on the human body or mannequin.

Clothing form has a number of characteristics:

- objective characteristics, referring in particular to the shape geometry (structure, type of geometric figure, surface relief, plastic character);
- subjective characteristics that require psychological effects, enabling the perception of the elements of aesthetic creation and notification of new forms (visual impression, static character).

The main features of the shape are: structure, configuration, surface and type of surface. Structure determines the physical complexity of the product structure and form composition characterized by the type and number of components, so that they differ by: simple and complex forms. The simple ones have one structural part, while complex forms consist of several elements organized as a whole.

Shape configuration represents the outer contour, the type of geometric shape. Type of the shape surface is a feature arising from the drafting method of form. After this indicator surfaces can be simple (no issues of diversification outside) and complex (those that are developed in two or three directions, called spatial character forms).

The shapes of the knit product can be smooth or embossed, according to the type of structure, the manner of production and manner of finishing. The complexity of the shape surface is achieved by means of more decorative, decorative - constructive and functional technics .

Sketch of the model is underlying the shape and silhouette of knitted product, this also establishes product dividing in components and structural additions. In the dividing of the product is taking into account the negative properties of the fabric (running at the edges, dividing lines aimed at reduction of these properties). Constructive additions must ensure obtaining the desired shape and comfort conditions during operation [3].

Knits type and properties, determines the size and shape of the surface of the product or of parts of components.

3. CONTRIBUTIONS ON METHODS AND PROCEDURES OF DIVERSIFICATION OF FORMS OF KNITTED GARMENTS

The knitted product forms are not so varied and complex and can be resolved in a few variants of the cut. For example, product type sweater often create the right silhouette or semi adjusted, the main product parts (back, front and sleeves) being constituted of one single marker.

The reduced number of shapes and cuts will always be an important feature of knitted garment. On this aspect, it is noted that aesthetic diversification of these products will be made especially by implicit methods [2], expressed through the fabric surface effects (structure, color, applied ornaments, etc..). In most cases the form of knitted products is determined not by way of dividing the surface into its constituent elements and markers but use one and the same marker of various knit structures with varying degrees of scalability and elasticity.

Knitted products have relatively simple forms, consisting mainly of three main elements: back, front sleeve, which allows a systematization of forms and knitted products.

The shape characteristic of the exterior knitted garment product depends on many factors, the most important being described and proposed in the following systematizion diagram (Figure 1.).

Starting from the concept that a model for a type of product represents a variant of a particular case (determined compositional, constructive and technological), which are considered a diversification and are classified as [2]:

2. **Implicit methods,** that exploit the decorative effects due solely to appearance and quality of material used in manufacturing of these products. For knitted products primarily are valued decorative effects due to their structure, structure drawings and color, running at the margins as well as the same model obtained by combining different colored knits or structures and colors.

3. **Explicit processes,** that use decorative effects which can be applied and obtained by product cutting. Applied decorative effects are realized by ornamental seams (usually embroideries made in different styles and techniques arranged in different areas), gaskets (knitted ribbons, laces, trimmings, etc.) placed at the termination or within product elements, of functional-decorative elements (pockets, flaps, etc..) and non-textile accessories (buttons,zippers, buckles, etc)

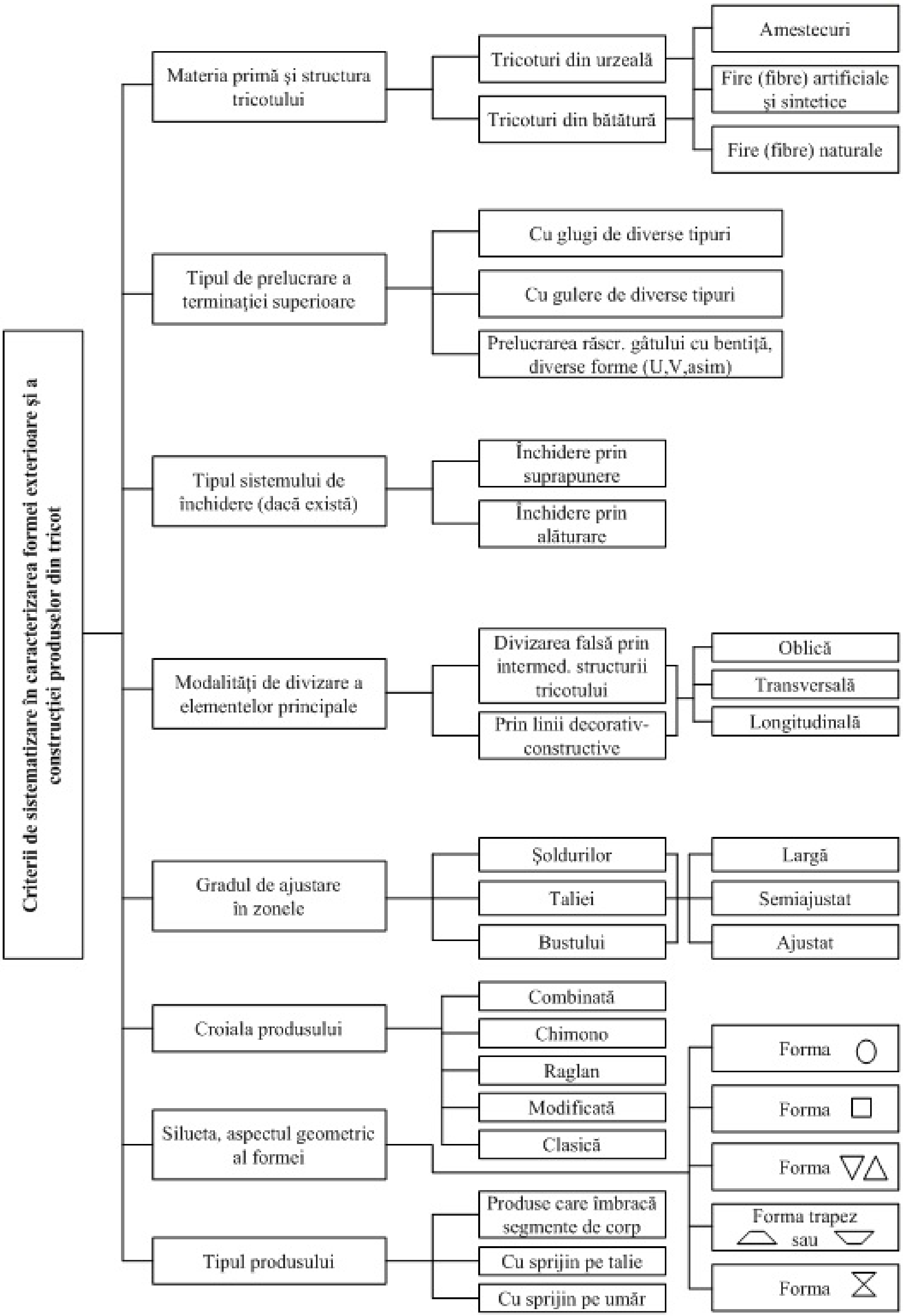

Figure 1. The scheme of criterias for construction features of exterior knitted garment products [1]

Resulting decorative effects by cuts are reflected either by changing the shape and size of various elements with margin finishing elements (hems, collars, cuffs) or by introducing different sectioning lines (different by way of guidance through their shape), which allow the introduction of creases, or folds.
Most commonly, these two ways of ornamentation (implicit and explicit) are used in combination, thus multiplying unlimited possibilities for patterns diversification for the same product.
To illustrate the use of these procedures, has been developed six patterns of the knit products for women for which was developed base and model patterns [1].
In Figure 2, models 3 and 5 contain in product body different modules of the structure and model 4 is decorated with embroidery, being diversified by implicit procedures. Models 1, 2, 3 from Figure 2 are diversified by explicit methods and are designed based on the changed cutting, and the patterns 4,5 and 6 – based on the raglan cutting varying lengths at the product ends, the sleeves, such as the neck cutting, changing the proportions of products by changing the waistline position.
Decorative effects mentioned above can be applied on any part of the product or completely, in a specific shape of product.
General methods for aesthetic diversification work will be chosen based on the objective as follows [2]:

- reinterpretation for optimization of known products by investigating of some decorative elements and functions of components;
- development of totally new products, of avantgarde with role of awareness and forecasting.

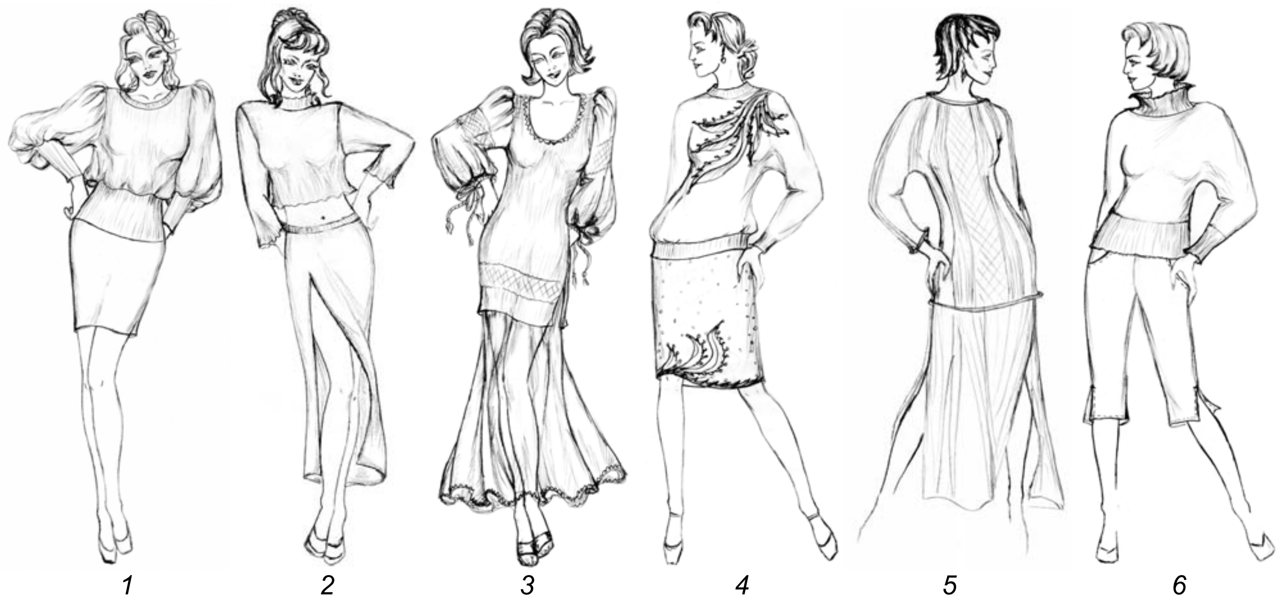

Figure. 2. Examples of creating form of knitted sweater for women made by explicit and implicit methods [1].

The first group of methods aims to diversify in terms of reduced costs related to the preparation stage of manufacture and shortening the duration of this activity being specific to serial production.
The second group of methods requires manufacturing of unique products, the individual production, as well as in the case of major changes in the required style line of fashion.
To highlight the opportunities for knitted garment diversification and for the implications of their construction, it is considered that the most rational approach is the decomposition of product in specific varieties of elements (Figure 3).
The association of a particular model variant for its elements will be based on compliance with the laws of the composition so that the final result show unity, harmony and balance.
Diversification of subdivisions for "body" elements can be provided by various methods, the most used are:

- Simple division of the initial surface by decorative-constructive lines;
- Dividing and rearrangement of the original surface to produce creases, folds;
- False dividing of initial surface for shaping of some applied marks or to remove portions of the pattern;
- Transfer of forceps (if any).

For knitted garment products (especially sweaters), one of the most important elements for product diversification is changing the higher termination. Along with the classical and original solutions are used which gives personality and expressiveness of relatively simple garments.
In terms of construction, finalizing of higher termination requires solving the following two aspects:

change the neck line cut;

construction of patterns for items or parts applied on neckline.

By the position of the collar to the cervical spine, according to the sealing, form and method of neck collars cutting for knitted goods can be [1, 3]:

- **A. Stationary collars**: for products without closing or closing to the neck applied to the neck cut separate from the product element (type collar tunic with stei and cape, shirts collar)
- **B. Flattened collars**: Products with or without applied closure in normal cutting or in décolleté neckline that is tailored separately.
- **C. Closure with lapel collar**: lapel corner may be normal or high.
- **D. Indivisible collars**: the whole cut with face and (or) behind.
- **E. Fancy collars** - ruffles, lace.

Most often on the process of neck cutting for sweaters hair bands are used (seals) flattened or molded neck (Figure 2. Models 1, 2, 4, 6,) rolled collars, rarely stei collars indivisible with the front and the back of product. In Figure 3.6. and Figure 3.7. processing methods are presented for neck cutting: types of collar and necklines commonly used in product sweater.

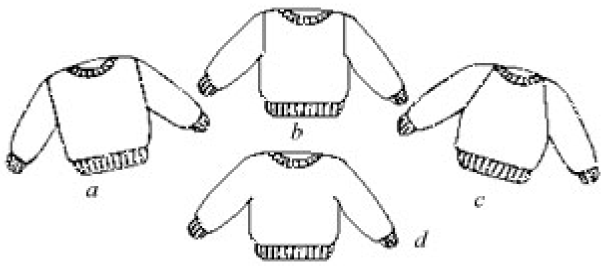

Figure 3.1. Types of cuts

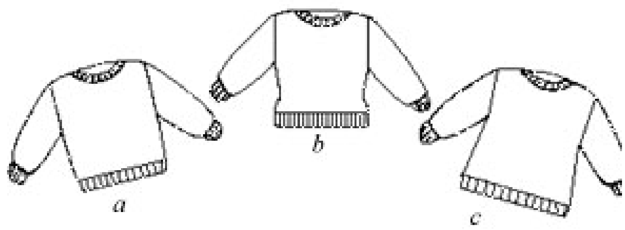

Figure 3.2. Types of used silhouettes

Figure 3.3. Product types (a - sweater, b- jacket)

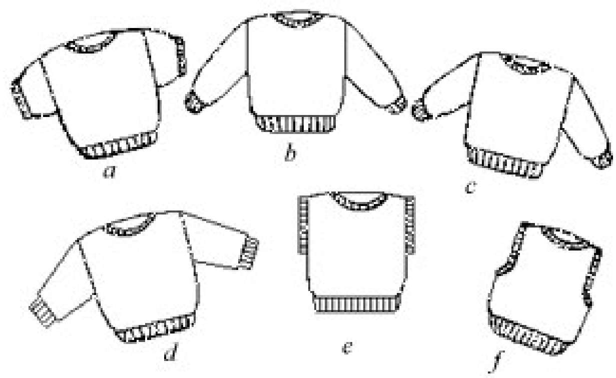

Figure 3.4. Changing of the sleeve length or depth of cutting

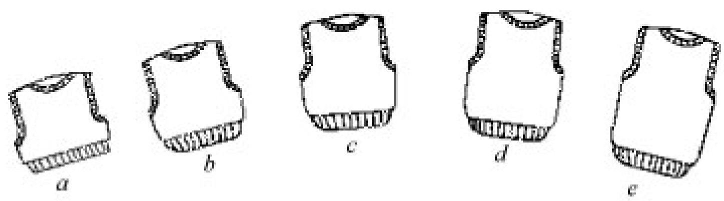

Figure 3.5. Changing of shape by varying the length of the product

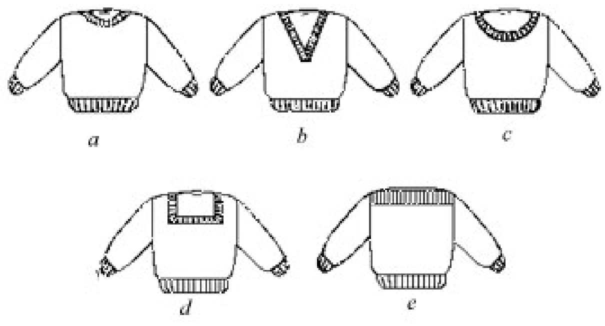

Figure 3.6. Types of décolleté

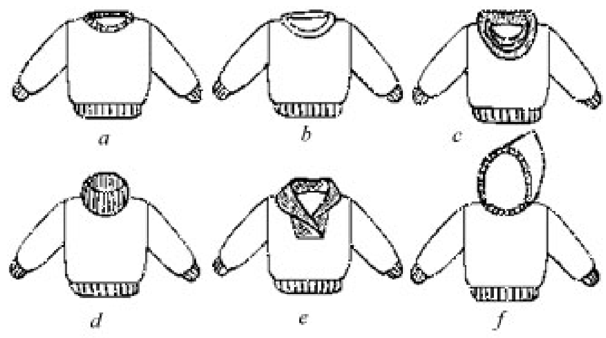

Figure 3.7. Processing variations for neck cutting

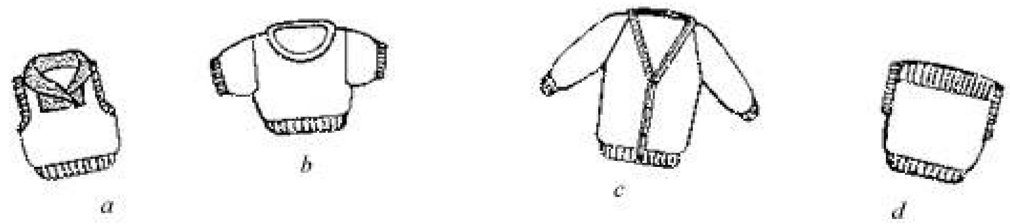

Figure 3.8. Examples of products obtained by combining shape elements.

Figure 3. Creating new forms of a product using the product decomposition method and presentation of specific variations for each element [1].

Fastenings have a functional role of fixing a certain amount on the surface of the aesthetic part of the body by shape and dimensions. Knitted garment products may have various solutions to fastening system. Fastenings for knitted products can be classified:

1. Locking by side (zipper, cord clamps).
2. Locking by overlapping a row or two rows of buttons, symmetrical or asymmetrical:
   - Partly, from the neckline down the bust line (products with feint and without);
   - Partly, from termination to the top (products with lapels);
   - Locking the entire length (products with cutted feint from whole, without feint, separate tailored feint or sublaist).

Various models of knitted products can be created by using different cuts for clothing with shoulder support (figure 3.). The cut of the sleeve is a constructive - aesthetic feature with a major importance, both for appearance (image) of clothed product and material consumption.
By customizing the structural elements (relative to classic cut) knitted garment products are distinguished by following types of cuts of sleeve:

- classic cut (Figure 3.1. *a)*;
- kimono cut (Figure 3.2. *models* 4, 5, 6), (Figure 3.1. *d)*;
- raglan cut (Figure 3.1. *c)*;
- modified cut (Figure 3.2. models 1, 2, 3), (Figure 3.1. *b)*
- combined cut.

In developing of patterns with such cuttings should be considered the correlation between the shape and form sleeve head cutting. Because of the tendency of the geometrization of parts in case of modified cut, the correspondence of the two lines will be easily made, further causing some facilities on product manufacturing.
An important objective critera which allows the comparison of forms of clothing products is the product silhouette given by compositional additions on bust line, waist and hips. The silhouette is a generalized expression of the shape of the graphic image of the product and determine to a certain extent the shape of the product, but does not reflect its construction. Most commonly used shapes of knitted products (sweaters): right (Figure 3.2.a), adjusted semi-adjusted (Figure 3.2. b) and flared (A) (Figure 3.2. c).
Based on the same basic pattern can be obtained different types of products:

1. adding decorative elements - constructive or decorative-functional (fastenings (Figure3.3)*;*

2. changing the sleeve length and neckline sleeve (Figure3.4);
3. changing the product length (Figure 3.5).

Products and forms obtained by decomposition method and combining of shape elements are present in the collection of sweaters for women (Figure 2.), this is achieved by combining explicit and implicit methods. The models are using two types of cuts: modified (models 1, 2 and 3) kimono (models 4, 5 and 6), diversity being obtained by solving different cuts for neck, sleeve endings and product using structural changes and decoration with embroidery.

Further, as a totalizing, are presented possibilities of constructive-technological diversification and broadening product assortment weft knitted, summarized in Table 3.1., showing an example of the possible variants of solving constructive parts of the main and supplementary knitted outerwear products for women, the combination of which can form various patterns. The same way parts and other knitted products can be decomposed by type and destination (sweater, jacket, vest, skirt, etc..).

Table1. Decomposition in parts of a conventional knitted clothing for women in order to obtain new models.

Name of the product component	Variants of solving constructive form parts of knitted garments
1	2
Marks of the upper parts with support on shoulders (front and back bodice)	1. The variation of the shape of the neck cuts: round, oval, in the form of a "V", "U", square, asymmetric, etc. .. 2. The variation of sleeve cuts: classic raglan, kimono, modified, type shirt, square, combined; 3. Yokes of different forms: corners, rounded, symmetrical, asymmetrical, etc.
Marks of bottom parts with support on waist (front and back skirt or pants)	4. Various alternatives for endings solving: straight, flared, slim, with additional details, etc.; 5. With gussets, folds, creases, plissee, waffles 6. Corselet of different forms: corners, curved, symmetrical, asymmetrical, etc..
Marker sleeve	7. According to the type of cut 8. Different variants for solving endings: straight, flared, narrow cuff; 9. With gussets, folds, creases, plissee, waffles, etc. 10. Cuffs of different forms: knitted or other material, with corners, rounded, symmetrical, asymmetrical, knitted together with the sleeve as a curb, etc.
Marker collar	11. Rolled (sharpened, with stright corner, rounded) 12. The lapels, press, type shawl 13. Rolled neck, turtleneck type 14. Stei Type: in whole, cut separately. 15. Collar convertible into hood, etc.
Pockets	16. Applied, cut, with seams, flaps etc.
Flaps	17. Rectangular, parallelepiped 18. With straight corners, sharp, rounded
Elements and decorative details for processing endings parts and open cuts.	19. Knitted decorative elements: ribbons, ruffles, vents, cuffs 20. Other parts and accessories: laces, trimmings, lace, etc.

In the process of knitting of contoured or semi-contoured shapes, not only structures and the effects of drawing are created, but also the construction of the product, which is determined by the number of parts and their shape, the type of processing and assembly technology of component parts.

Whatever the methods are used to constructive-aesthetic diversification, they must conform to fashion trends, destination of products and compositional particularities of knitted surface of products.

3. CONCLUSIONS

Diversity of knited products construction depends on the model, structure, shape of the basic details and decorative elements and methods for their production.
Using the method of decomposition and recombination of parts and components of various knitted products can be obtained new constructve solutions.
Contributions presented in this paper:

- There was shown the influence of the knits characteristics on the shape of product being developed sample models for creating new forms for knitted sweater for women by using explicit and implicit methods.
- Has been developed a totalizing scheme with systematization criteria for exterior shapes characterization which permits an optimal diversification of knited products.
- Creating of new product forms using the method of product decomposition in elements and presentation of specific variations for each item.

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SURGICAL GOWNS AND DRAPES – RESTRICTIONS FOR THE DESIGNER

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Abstract: *The risk of getting infected is greater for the doctor than for the patient, considering that dentists come in contact with saliva (scattered by the dental drill), which often contains blood. Protective clothing should be able to meet a wide range of requirements. Therefore, the manufacturers of dentist gowns should focus on two main aspects: achieving an adequate protection from infections by hindering the penetration of blood and saliva, and assuring the needed comfort (freedom of movement, the creation of an antiseptic barrier and the prevention of heat build-up) [1]. The list of the restrictions imposed on the designer becomes complete when we add the consumer demands [2] too. In order to create a new pattern, the designer should take into consideration the fabrics that are most suitable for manufacturing such gowns, the comfort that can be provided through the shape of the gown, and the general aspect of the gown. One of the goals of this research will be to create a fun and nice gown that will not frighten the child patient. A second aim would be to create a professional and at the same time fashionable gown for the women (but not exclusively) who work in this area.*

Keywords: *dentist, gowns, restrictions, design.*

INTRODUCTION

In order to create a new pattern, the designer should take into consideration the fabrics that are most suitable for manufacturing such gowns, the comfort that can be provided through the shape of the gown, and the general aspect of the gown. The gown should be representative of the wearer's personality and its professional activity because, after all, its main purpose is to protect without necessarily being street fashionable.

By using European Standards EN 13795 [3], we can carry out the necessary tests in order to determinate the best configuration of the fabric we use and its properties in order to create the final product – the dentist gown. The European Standard also provides us with the two main critical areas that need protection: the chest area and the sleeves (as shown in Fig. 1).

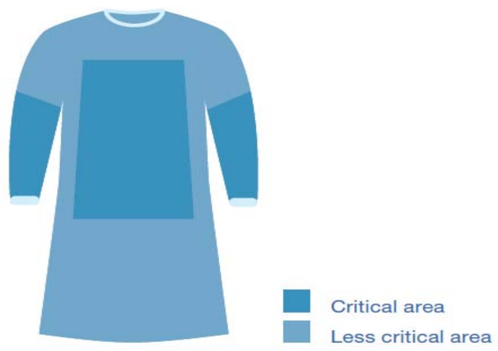

Figure 1 – Critical areas according to EN 13795 (European Standards for Surgical Drapes and Gowns)

In order to provide adequate protection/filtration, one should focus on the chest area, according to the study conducted in France (by Matthieu Arnold in his thesis of state diploma of doctor of dental surgery), which shows us that the short-sleeved gowns are the most suitable for daily use. So far, experts conducting studies have been using waterproof fabrics [4], disposable drapes, or gowns made entirely of non-woven in order to protect the chest area.

In order to guarantee the same comfort provided by the commonly used fabric (a mixture of cotton with polyester) and, at the same time, to increase protection against the external contamination factors, we attached a nanofibre layer to it through the electrospinning process [5]. The process uses an electric field which helps create a charged polymer solution jet. As the jet travels through the air, the solvent, in our case formic acid, evaporates and the only thing left on the collector is the charged fibre, in our case a PA 6/6 fibre.

EXPERIMENTAL

The layer of nanofibres was electrospun directly on the fabric by using the ELMARCO NS 1WS500U machine which simulates a semi-industrial scale deposition on the fabric. As requested by the medical staff, we chose a mixture of cotton and polyester (Table 1 – Fabric parameters and wave structure) because this particular type of fabric is more resistant to maintenance, unlike the 100% cotton fabric which is more comfortable but its »washing life« is relatively small, or the 100% polyester one that can become uncomfortable enough to distract the medic from their job.

Table 1 – Fabric parameters and wave structure

Properties	60% cotton and 40% PES fabric
Fabric structure	Plain wave (Basket wave) Cotton weft – 2 treads PES warp – 2 treads
Fabric weight	210 g/m^2
Fabric thickness	0,48 ± 0,10mm
Colour	Black (chose only in order to see the nanofibres deposition better)

The machine ELMARCO NS 1WS500U (Figure 2) also imposes some restrictions on the designer because of the limited dimensions of the collector (the maximum width is 65 cm, no limitation on the length), which will force him to operate a lot of cuts on the front pattern (area where we will use the nanofibres – figure 3). However, there are no limitations for machines that use an industrial scale deposition.

Figure 2 – ELMARCO NS 1WS500U


Figure 3 – Deposition of nanofibres on fabric

The designer has to take into consideration that so far the dentist gowns have been defined by short sleeves, a V opening line, no closing system and at least 2 pockets. The length of the blouse usually reaches the hips and the colours are usually white, blue and green. This is why we suggest some new designs for the female gowns in particular because female doctors are the ones who have to give up their fashion style at work most of the times. We used the following designs (as shown in Figure 4 – Study designs for female dentist gowns) in order to find out the preferred length, number of pockets, collar and closing system.

The designs we chose present a range of collars and opening systems in order to see if the dentists will respond well to the change we want to make. We suggested a tighter blouse but not too tight because we do not want to hinder the doctor's freedom of movement. We did not attach any pockets because we want to find out from the doctors where it is best to position them.

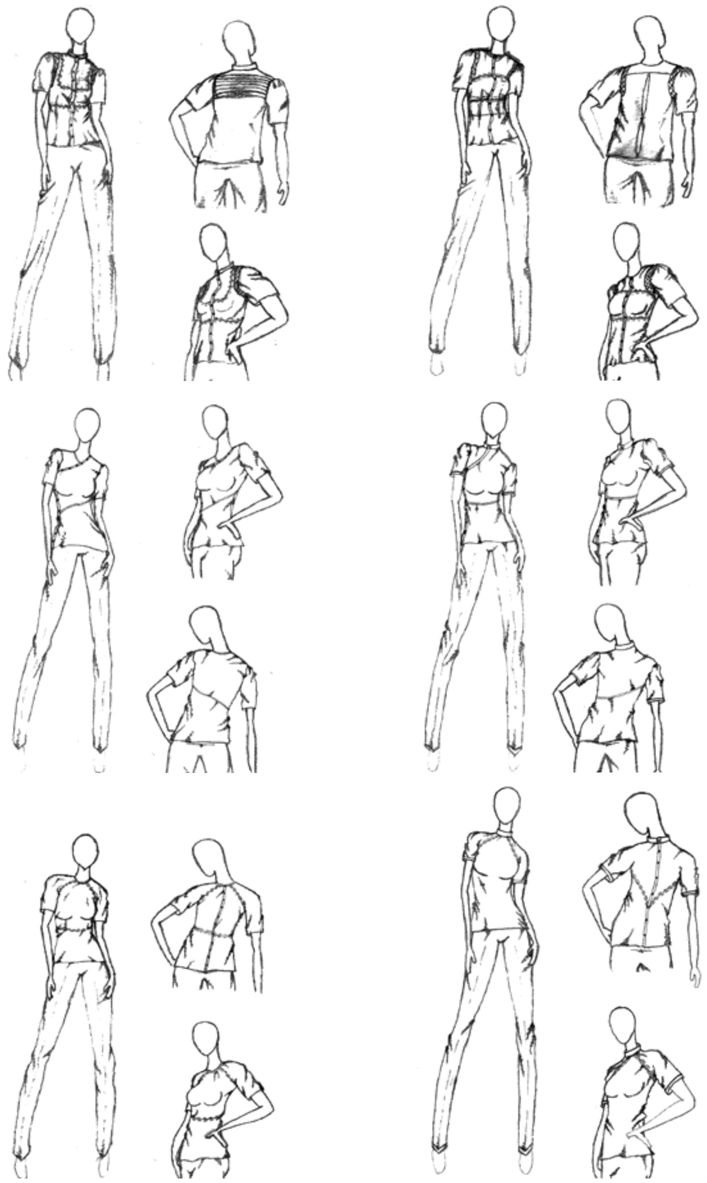

Figure 4 – Study designs for female dentist gowns

RESULTS

Although the modification of technical gowns so as to make them more fashionable is usually not well received, especially in the dental field, we got a concrete response from the female subjects. The collar they preferred was mainly the one in V shape, followed by the one at neck base. For our prototype, we chose the V-shaped one which closely follows the neck line in order to provide more protection with nanofibres on the chest area. The system of closure was positioned sideways or at the back; the one in the front had a lot of shortcomings, especially since the blouse is being worn directly on the skin (the risk of body exposure is higher, therefore making the doctor more uncomfortable and unable to focus on the job).

The wearer considered that the most suitable length is the one that reaches the hip line because it provides an additional psychological comfort. We learned that two pockets are needed in general; however, the doctors who work with children prefer having one pocket in the chest area because they will be able to place something colourful in it, thus diverting the patient's attention.

Regarding the colour we have two main directions: the ones who work with child patients and want colourful clothes in order to keep the patient calm and unafraid, and the ones who work with adult patients that might prefer a single colour other than white, green and blue, without making the uniform look unprofessional.

DISCUSSION AND CONCLUSIONS

In the future, we will try to improve all the aspects of the dentist gown: protection and design. As far as protection is concerned, we will try to obtain a better adhesion between the nanofibre layer and the fabric. At this point, this aspect is still being studied. Concerning the design, we will conduct a survey at the level of the Romanian dental medical subjects because the results discussed so far come from French assessments. The final data will allow us to compare these two European countries, although the requirements for protection and comfort should be the same. The styles approached at work will offer us different ideas for designing improved dentist gowns.

The aim would be to create a blouse for the female subjects and a different one for the male subjects since their body shapes are distinct. This is not the only aspect that will be taken into consideration. The female and male subjects have different requests depending on their work style and body posture while at work. A secondary aim would be to create the blouses depending on the patient's type: one for the child patient and another one for the adult patient. These two have different criteria to take into consideration, the essential one being the colour of the blouse.

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INTERFERENCE OF TRADITIONAL MOLDAVIAN SUIT WITH THE CONTEMPORARY WOMEN'S SUIT

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Abstract: *Presently the traditional clothing attracts the attention of various specialists: historians, ethnographers, painters, designers etc. The complexity of studying this important element of spiritual culture consists in the diversity of appearances reflected in the traditional suit.*
The traditional Moldavian clothing is a sculptural one, it is a simple and clear composition, its cutting underlines the body shape without any artificial inclusions. It is the only suit worn exactly in the same composition both at work and during holidays, being actual for all ages, as its shape and structure are adequate for all ages. The object of study were the blouse and the skirt (catrinta) for women.
The results of performed study may be useful for the contemporary designers in the actual circumstances where the globalization and the consumption criteria result in the dilution of the way the objects of primary importance interact with people at the existential level.

Keywords: *traditional Moldavian suit, skirt, catrinta.*

INTRODUCTION

Presently the traditional clothing attracts the attention of various specialists: historians, ethnographers, painters, designers etc. The complexity of studying this important element of spiritual culture consists in the diversity of appearances reflected in the traditional suit For these considerations the study examined the multitude of aspects of the popular Moldavian suit, as well as its influence over the contemporary urban suit. The performed research resulted in the study of characteristic aspects of national women's suit.
The work systematizes the components of traditional cut of women's suit in the light of cutting techniques and structure.

THE STRUCTURE OF POPULAR MOLDAVIAN SUIT

The popular Moldavian suit is a sculptural one, it has a simple and clear composition and by its cut it underlines the body shape without any artificial distortions. It is the only suit worn in this composition both at work and in festive occasions and at all ages [1]. In line with its practical function, the popular suit has some other specific functions (see figure 1).

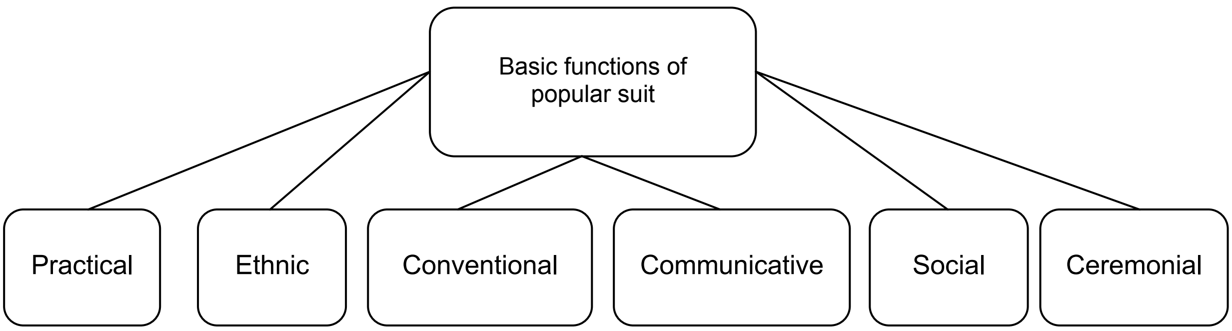


Figure 1: Functions of popular suit

The main legalities observed in the process of creating a popular suit are the equilibrium and harmony, optimum relationship between rational and beautiful, tradition and innovation, collective opinion and proper aesthetic taste. This is why the popular suit represents the harmonic and balanced ensemble of elements impregnated with the sense of measure and proportion [2].

The basic suit comprises three distinctive components: the blouse, the catrinta (fotă) and belt, each representing a separate class of products cut in vertical contours, developed by each creator in separate. The wearer's image is supplemented with accessories (figure 2).

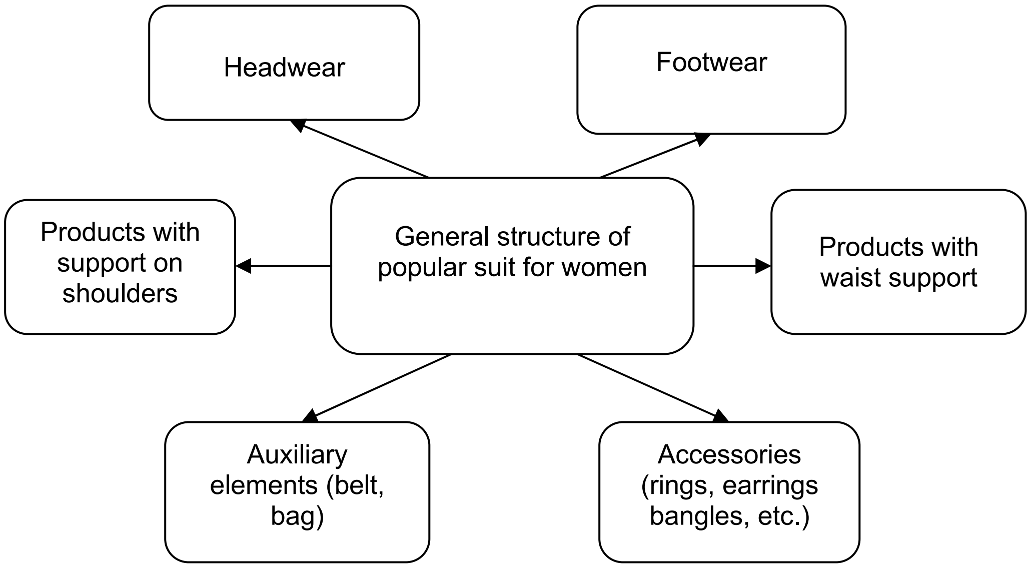


Figure 2: General structure of popular suit for women

The blouse represents the main product, it covers the most of the body, has the richest décor, it determines the structure and shape of other components.
The product covering the inferior part of body is named catrintă or fotă. The most widely spread are the ones that follow the Moldavian tradition on both banks of Prut river and are similar to the models from other Romanian ethnographic zones [3].
According to the old traditions, women used to wear several variants of belts having practical, magic and symbolic roles [4].
The most remarkable among the belts is the woolen belt, 18-20 cm wide, woven on four corner racks, worn over the blouse. It is of natural wool color, blue or dark green, decorated on its entire length with woven ornaments of alternating colors. It is used, as a rule, for decorative purposes, being wound for several times around the waist in order to accentuate that level.
The second belt is light and narrow or very narrow piece, used for fixing the catrinta around the body.

ANALYSIS OF CUT OF POPULAR MOLDAVIAN SUIT FOR WOMEN FOR THE IDENTIFICATION OF STRUCTURAL ELEMENTS FOUND IN THE CONTEMPORARY SUIT

The typology of blouses is based on the cut accepted by the researches as an essential tool for the formation of product shape. The cut of old blouses was determined by the width of woven fabric. Each component of blouse: facade, back, sleeves, flaps could be made of several pieces of fabric joined together with expressive techniques in order to accentuate or supplement the décor [5]. During the following two centuries the women of our cultural space used to wear three major types of blouses (figures 3, 4):

- ✓ Blouse for elderly (tunic-type blouse) (figure 3, a);
- ✓ Blouse with patch or upper blouse (figure 3, b);
- ✓ Blouse with frills at neck or embroidery, in the flapless version – i.e. (figure 4, a, b).

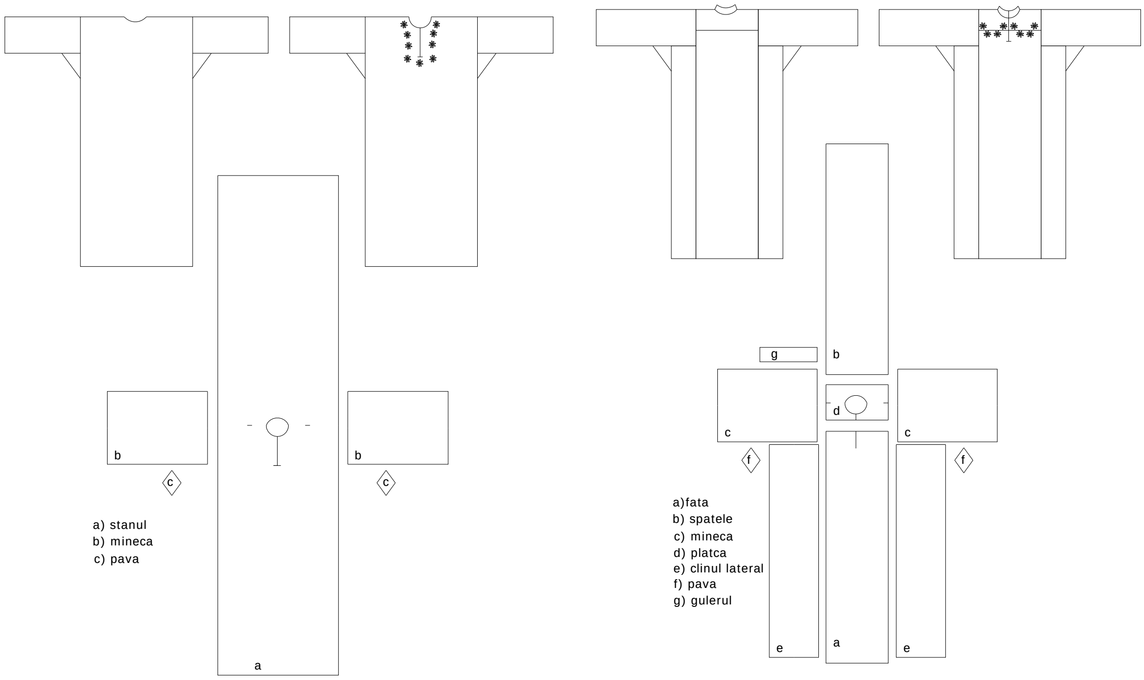
Notwithstanding the destination of blouse, it was composed of two distinct components:

Upper part – body panel;

Lower part – flaps.

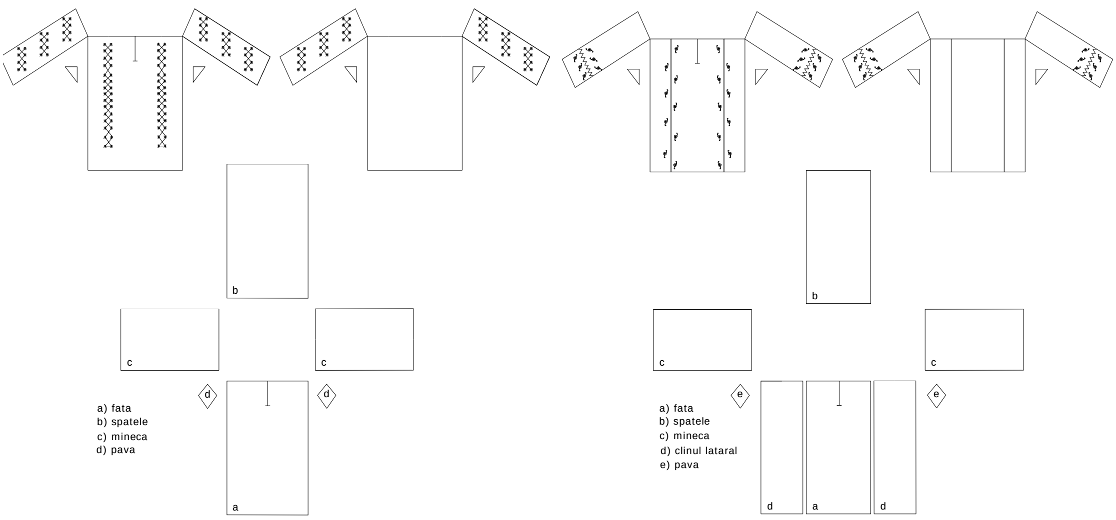
In order to systematize the blouse cuts their upper parts were taken as presentation variants.
The first and the oldest type of blouse is the blouse for the elderly or the tunic-type blouse. The flaps of this blouse are covered by skirt. The cut of this blouse includes three rectangular reference figures: the façade cut integrally with the back and the two smaller reference figures – the sleeves. These blouses are differentiated by the collar shape. The sleeve is wide at ends. Embroidery is done both on the façade and on the back of body panel.

In the XIXth century under the influence of urban fashion, Russian and Ukrainian style appears the blouse with additional reference figures in the shoulder zone that in the second half of XIXth century transformed into a „upper blouse".
This type of blouse is characterized by a small collar; round neck cut, sleeves cut from a single reference figure and frills at shoulders.
The last type of blouse, and the most representative one – is the blouse with frills at neck (ia). The cut is relatively simple: one rectangle of fabric, cut round around the neck and frilled with a torn lace. The sleeves are usually frilled both at shoulders and at ends. It is a flapless blouse, unlike the ones described above [6].



a) b)

Figure 3: Types of Moldavian blouse cuts: a) blouse for the elderly (of tunic type);
b) blouse with patch [1]



a) b)

Figure 4: Cut of blouse frilled at neck: a) simple; b) with lateral reference figures [1]

The performed analysis allows us to affirm that the popular blouse consists of three of more reference figures of rectangular shape fitting into the definition of unified reference figures. This cutting variant allows to save fabric and time and this is why even nowadays it is of great interest and used as a basis for the elaboration of new and contemporary models.

There are basic types elaborated for the manufacturing of women's blouses (figure 5), they are implemented in accordance with the dimensional characteristics of the common-type bodies. Their contours are much more sophisticated compared to the traditional cut. Constructive modeling techniques are applied in order to obtain a certain shape and volume.

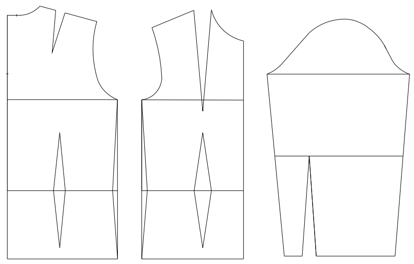
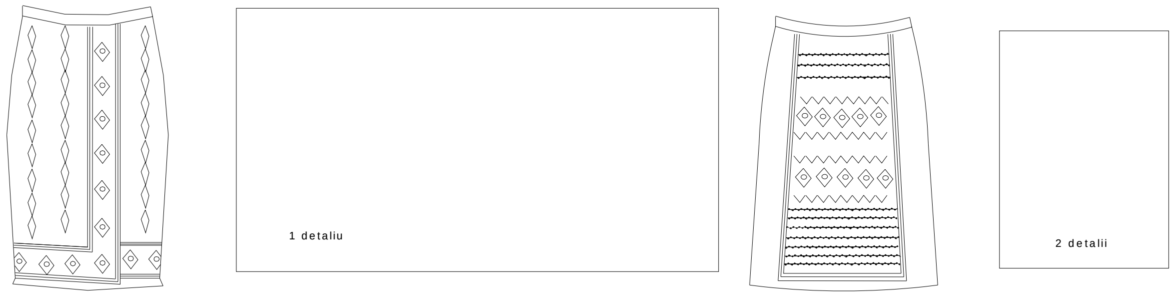


Figure 5: The contour of basic reference cut for the contemporary blouse

The products with waist support are the skirts obtained from integrally woven reference figures and sewed together. There are two types of skirts obtained from integrally woven reference figures: catrinta and fota. *Catrinta (figure 6, a)* is a piece of fabric of rectangular shape wound around the body, from waist down and fixed with a wide belt. The most widely spread is the catrinta in vertical colored strips obtained in the process of weaving.



a) b)

Figure 6: External appearance and cut: a) catrinta; b) fota

The Fota (figure 6, b) is also a type of catrinta. It is made of two identical reference figures of rectangular shape: one in the front and another on the back. It is ornamented with colored horizontal strips obtained in the weaving process.

The skirt sewed with cut reference figures (figure 7), ending at ankle level, it is wide and ondulatedat the level of upper contour. Usually it is made of 2-3 rectangular reference shapes or of 4-6 trapezoid wedges cut from fabric. Most often the termination of skirt is decorated with color strips, embroidery, flounce, small embroidery elements, beads.

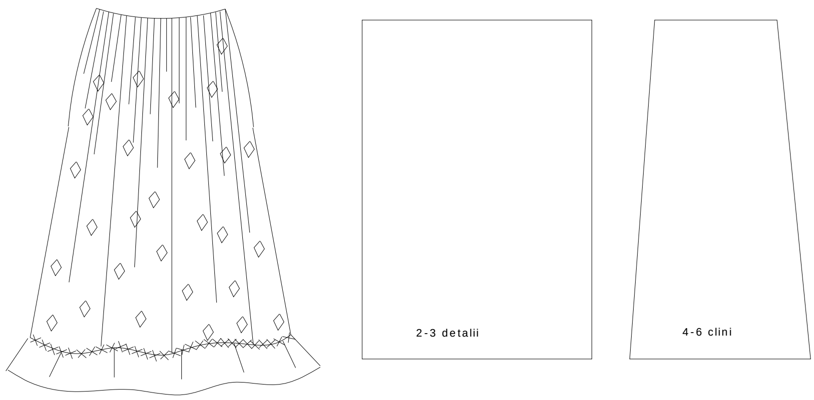
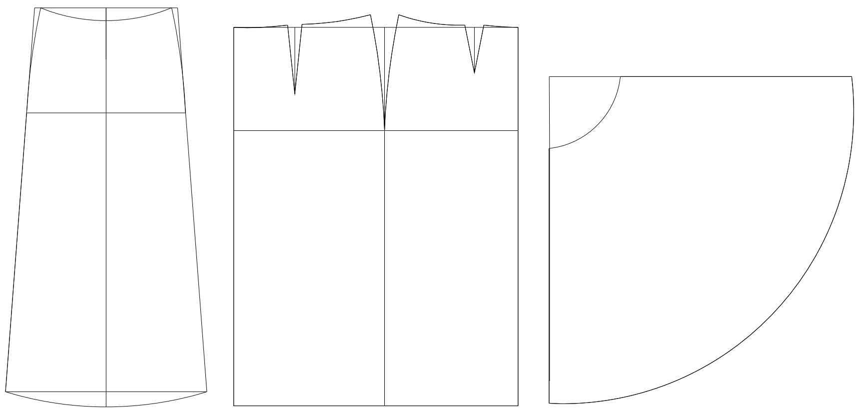


Figure 7: External appearance and cut of seamed skirt

Actually, for the execution of a certain type of skirt there is a wide variety of basic templates (figure 8). These do not differ much from the contours of popular skirts. Depending on the shape and volume of future product one may choose a template and then apply the constructive modeling techniques in order to diversify the models.



a) b) c)

Figure 8: Main contours for contemporary skirts. a) wedged; b) straight line skirt; c) conic skirt.

CONCLUSIONS

The modern cut is influenced by the quite large width of woven fabric. The secular experience of making garments of locally available primary materials, in accordance with the accepted traditions, has accumulated and perpetuated a rich set of techniques and abilities that are integral parts of immaterial cultural patrimony. The modernization process resulted in the simplification of techniques of manufacturing garments.
The harmony of elements, the motifs, the ornamental compositions of the popular Moldavian suit are objects of interest for the contemporary fashion designers. The suit represents a unitary vision of the world where the elements, components and ensembles mutually supplement themselves. The basic elements of the popular suit nowadays appear in the modern garments in that or another form. New models with an added spiritual, aesthetic and semantic value may be obtained by maintaining the connection between traditions and modern fashion.

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USE OF SPECIFIC ELEMENTS OF MOLDAVIAN FOLKS GARMENTS IN THE ELABORATION OF NEW MODELS OF PRODUCTS FOR WOMEN

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Abstract: *The study was centered on the traditional Moldavian suit for women and the possibility of using its specific elements for the elaboration of new models of garments. In this context, the method of morphological analysis was applied, implying the decomposition of products into component elements with subsequent combination in different manners.*
The experimental research resulted in the elaboration of suits composed of two main elements: one with waist support – skirt (trousers) and one with support on shoulders – blouse, as well as dresses fixed around the waist with belts and tapes. The system of models has a flexible shape made of single-color materials, thin and easy, providing for the maximum wearer's comfort. Also there persists a series of characteristic decorating elements: embroidery, laces, flounces, defining accessories, such as belts etc. These types of products can be worn both at special occasions and in daily life, being intended for the women of young and middle age.

Keywords: *product elements, traditional Moldavian wear.*

INTRODUCTION

Owing to its originality and beauty, the traditions of popular Moldavian suit deserve to become a basis for the inspiration in creating new models of products: for festive occasions or ceremonies, for daily wearing or for holidays.
For centuries the popular suit has been a symbolic spokesman of wearer: from where, who is he, how old is he, of what nation and social status, and for what event he is prepared or is getting prepared. These symbols and messages very clear in the past became riddles for the contemporary man [1]. The researchers and specialists dedicated to the design and development of styles and lines of fashion consider with great attention the cut, the décor, the motif and chromaticity of popular suit in attempts to recover the values of this treasure.

INTEGRATION OF POPULAR SUIT INTO CONTEMPORARY FASHION

Clothing is not only a protection element but also a creative factor in each person's life. The more chiseled are the ideas of creative designer the more interesting and diverse are the shapes proposed by him/her. The designer gives impulses for the development of an idea or new line of products and must intuitively feel the disposition of „brand consumer". At the incipient stage the new idea is accepted by a narrow circle of wearers, with time it appears on the front stage and attracts everybody's attention. Fashion follows this rule. Contemporary fashion is distinguished by the wide diversity of ideas and freedom of choice. Nowadays numerous creators resort to the traditional suits in the search for inspiration in the shapes, chromaticity, and décor – balanced and tested by centuries.
The Republic of Moldova has a vast ethnographic heritage capable of attracting the designers to use this cultural, original and extremely valuable patrimony. Inspiration may originate not only from the popular fabric and suits, but also from the diverse objects created by archaic techniques.
The performed study of traditional Moldavian suit and blouse in special allows to attest their prolonged existence in the ensemble of traditional clothing. Owing to its laconic shapes, environmental characteristics of materials and not in the latest turn aesthetic aspect, the Moldavian blouses deserve to be studied and preserved. This is why their cut templates are found in the models of contemporary garments. The Moldavian suit is an element of nation itself, processed and chiseled for hundreds of years it has fascinated the fashion creators.

The character of folks arts can be transmitted by the ornaments and perpetuation of symbolic images or other aspects taken from nature, from surrounding life that by stylization and adaptation to technical possibilities of sewing and weaving followed the straight line contours, the motifs being schematized in geometric shapes. Each ornamental portion has its own kind of ornaments, is adapted to the place and value it represents in the composition.
The suit must correspond with the man's personality, be harmonic with the posture, color of eyes, age and place in society.
If we refer to the women's blouse, one may observe that by its organization and décor – with far and unknown origins – the sleeves may be divided into three categories of distinct ornaments, namely: „altiţă" on shoulder, „încreţul" under „altiţă", „râuri" on the arm (in vertical direction).

COMPONENT-BASED MORPHOLOGICAL ANALYSIS OF POPULAR AND CONTEMPORARY SUIT

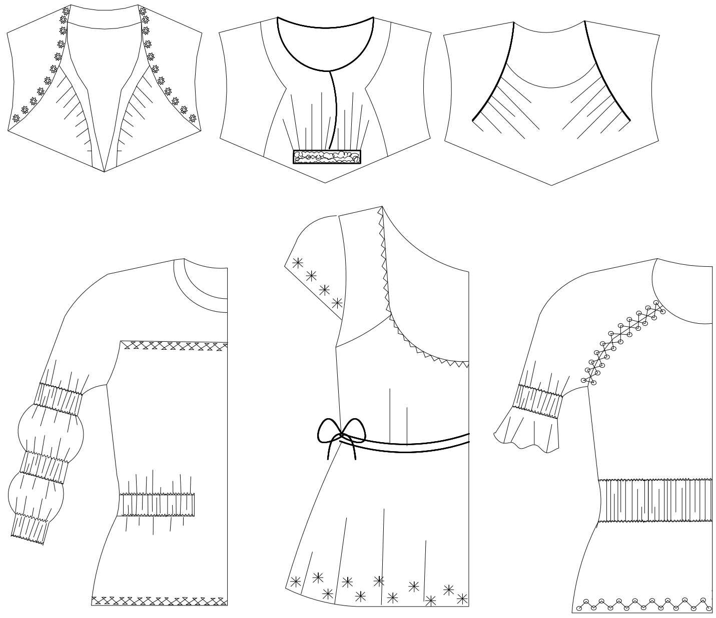
The popular suit includes various types of products worn in a specific manner. The products were associated in aesthetically harmonic sets capable of complying with certain requirements: age, season, destination, etc. According to the performed study, the most functional components of popular women's suit used most often are the blouse or „ia" and the „catrinţa" or skirt.
The scope of this work is confined to obtaining new models of products with characteristic elements of popular suit. In this context, in order to obtain new solutions we applied the morphological analysis method. This method consists in the decomposition of the object of study into representative elements with subsequent combination in various variants resulting in new ideas and solutions. Both the popular and the contemporary blouse have been subjected to the morphological analysis, as well as the traditional sewed and contemporary skirt.

Table 1: Morphological analysis of national and contemporary women's blouse

Product element	**Popular blouse**	**Contemporary blouse**
1	**2**	**3**
Silhouette	✓ straight ✓ trapezoid ✓ freeform	• straight • trapezoid • freeform • semi-adjusted • adjusted
Product cut	✓ one reference shape ✓ 3 rectangular reference shapes ✓ 4 rectangular reference shapes ✓ 6 and more rectangular reference shapes	• classical • raglan • kimono • shirt-type • combined
Neck cut shape	✓ round ✓ square ✓ configured	• round • square • V-shape • configured
Sleeve length	✓ long ✓ short ✓ 3/4	• long • short • ¾
Sleeve termination	✓ laced ✓ with elastic insert ✓ with flounces ✓ with cuff ✓ tapered	• laced • with elastic insert • with flounces • with cuff • tapered • biased
Number of reference shapes of sleeve	✓ cut integrally with the product body ✓ from one rectangular piece ✓ from 2 reference shapes (inferior and „embroidery at armholes")	• cut from one reference shape • cut from 2 reference shapes: superior and inferior • cut from 2 reference shapes: anterior and posterior • cut from several reference shapes obtained from the modeling process

1	2	2
Additional reference shapes	✓ wedge ✓ lateral wedges ✓ inferior parts (flaps) ✓ straight inserts	✓ wedge ✓ lateral wedges ✓ inferior parts (flaps) • straight inserts, configured pockets
Neck cut processing	✓ laced with flounce ✓ with straight collar ✓ bias cut	• laced with flounce • with collars of various types • bias cut • with frill
Closing system	✓ opening on the front side ✓ laced	• opening on the front side • laced • with buttons in one row • with zipper • with clips
Processing of lower edge of product	✓ simply tapered ✓ with flounce	• simply tapered • with flounce • with betel • elastically tapered • overlock + elastic thread
Elements of décor	✓ with embroidery ornament on armhole element ✓ with embroidery ornament on sleeve ✓ with embroidery ornament on neck cut ✓ with embroidery ornament at termination	• embroidery ornament • flounces • artificial flowers • bands • small belts • decorative buttons • beads
Used materials	✓ cotton ✓ flax ✓ natural wool	• cotton • flax • natural silk • artificial silk • synthetic silk • tricot

By combining the characteristics of popular garments with the contemporary products, one may obtain new and original decorative-constructive solutions stemming from the old popular suit of our nation. The most successful are shown on the figure 1.



a)

b)

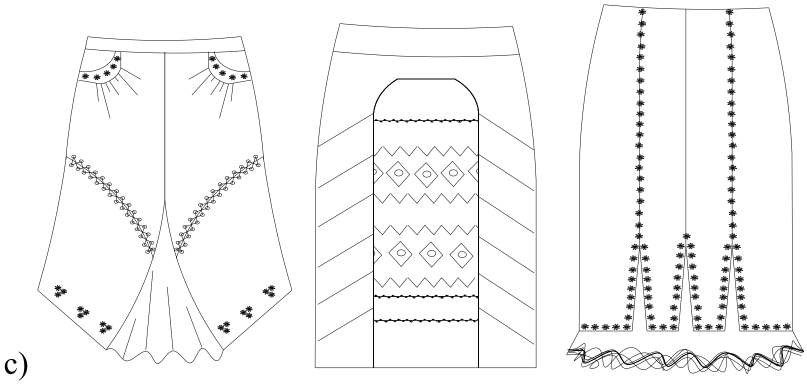


Figure 1: Variants of product elements obtained by combination: a) – neck cut; b) – sleeve and termination; c) - skirt.

ELABORATION OF NEW MODELS OF GARMENTS WITH CHARACTERISTIC ELEMENTS OF POPULAR MOLDAVIAN SUIT

Nowadays the garments integrate into various styles and the popular suit is a permanent source of inspiration for designers. The characteristic style of this fashion trend – the folk style implies the creation of shapes associated with the popular suit and formation of products with new constructive solutions, characteristic trimming and decorative elements for traditional suit.

The silhouette of folks style is the trapezoid, straight or oval one and the volume is moderate. The sleeve cut is free and functional. The models will have flexible shapes and will be manufactured of lightweight and thin fabric of the same color capable of providing comfort while wearing. The elements of décor characteristic for popular suit are not neglected either: embroidery, lace, flounces, belts, etc.

The collection of models to the greatest extent is represented by suits consisting of two products: one with waist support – skirt (trousers) and one with shoulder support – blouse, there also being some dresses with the waist line accentuated by a belt (figure 2).

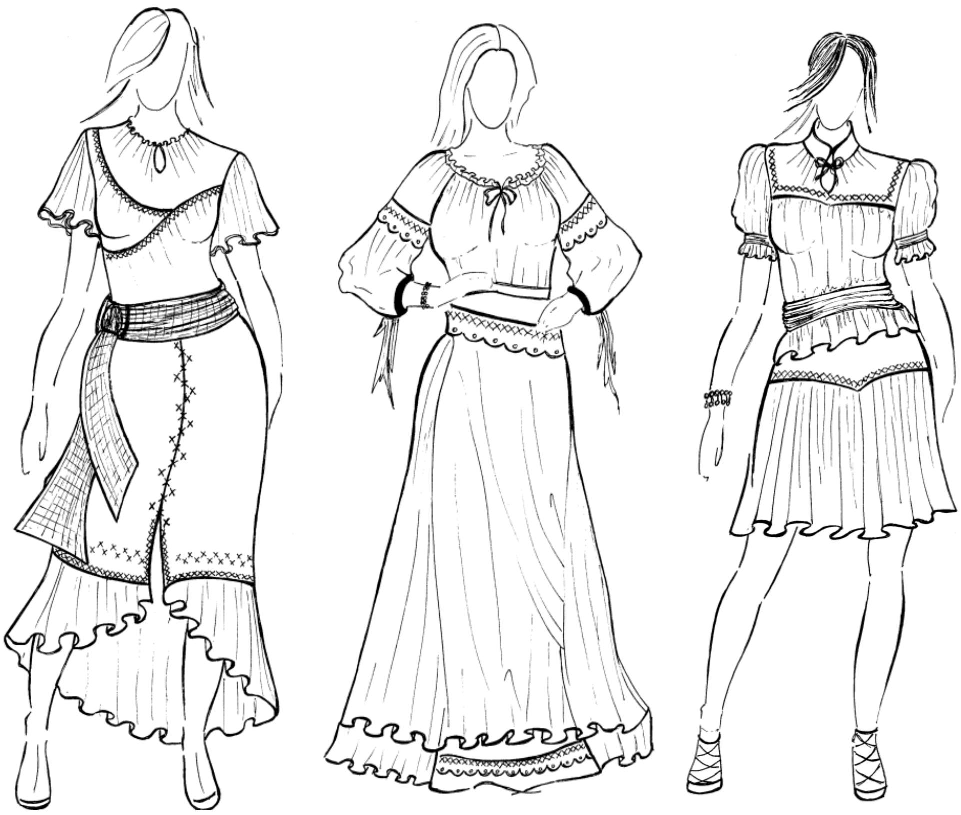


Figure 2: Sequence from the collection of new models inspired by the Moldavian popular suit

CONCLUSIONS

Like the all phenomena of material culture, the popular suit is subject to continuous evolution. The tight connection with social life makes it appear as a phenomenon of continuous transformation, adapting to the changing conditions of life.
The study considered the aspects of structure of traditional Moldavian suit and its impact over the contemporary fashion. The contemporary suit must provide for the spiritual and social-aesthetic equilibrium of product shapes specific to traditional wear. This is why the contemporary products are elaborated based on the characteristic elements of folks wear, always appreciated by the wearers.
The system of models may be characterized as a romantic and contemporary one, reflecting the entire variety of specific elements of traditional folk wear, starting from product elements and décor and ending with materials. The results of theoretical research and the system of elaborated models contribute to the preservation and implementation of the elements of traditional wear, talking into account the requirements of contemporary fashion.

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Scholarly communication paper

DIVERSIFICATION OF ASSORTMENT OF JACKET-TYPE PRODUCTS FOR MEN

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Abstract: *The work considers the problem of developing the assortment of products for men by applying the principles of modular design. Theoretical studies were aimed at determining the methodology of modular design and principles of its application in diversifying the assortments of products for men. The researchers have defined a system of coefficients for the evaluation of systems of models of products elaborated with the use of modular design principles. The experimental researches included the formation of a nomenclature of constructive modules for jacket-type products, creation of a database called SB-GIOVANI in the automated design system Investronica and elaboration of series of new models and series of jackets for men by using the nomenclature and the mentioned database. Owing to the implemented SB-GIOVANI database and the nomenclature of constructive modules, it became possible to elaborate a wide series of new proposals and the basic model was used for the subsequent manufacturing of products in a wide gamma of sizes, waistlines and conformance groups at experimental stage.*

Keywords: *products for men, principles of modular design, jackets for men, constructive modules.*

INTRODUCTION

This work represents the applicative results of a study of diversification of assortment of jacket-type products for men implemented in the conditions of an enterprise specialized in garments for men. The actuality of this study results from the development and diversification of the assortment of models of products for men manufactured in quality assurance conditions, optimization of production costs and efficient use of technical facilities owing to the application of modular design principles.

THEORETICAL ASPECTS

The principle of modular design implies the elaboration of finite products using a set of unified component elements with observation of their mutual correspondence, functional, constructive and aesthetic parameters. Modulation and aggregation offers the possibility to structure a product from a small number of common-type elements totally or partially meeting some common geometrical and functional requirements. Modular design is based on the elementary structural entity of *constructive module* with the following definition: „common-type element of a structure, functionally independent, unified by the implementation principle" [1].

The modular design methodology is based on the legalities of model constructions and structuring the product into interchangeable component elements. The application of modular design principles implies the implementation of the following categories of works:
1) Analysis of basic constructions and their legalities by types of products.
2) Identification of constructive modules – general and variant constructive modules.
3) Elaboration of the nomenclature of constructive elements and encoding of the nomenclature elements.
4) Diversification of assortment and elaboration of new models by aggregation.
5) Evaluation of efficiency of modular design activity.

The application of modular design system for elaborating product structures is a direction of unifying and standardization thereof, providing also the following specific advantages in addition to the general ones:

It allows to implement the basic structure (BS), the basic common-type structure (BCTS) and the model structure (CM) using the aggregation methods from among the following unified structural elements;

Implementation of a multitude of basic common-type structures (BCTS) by changing initial data;

Raising the efficiency of design process by getting rid of repetition of some works and reduction of design timings.

If the constructive module is adopted as an elementary structural entity of product, then it is proposed [2] to assess the degree of unification using the following quality unit indicators that may be included into the hierarchical scheme of quality indicators of the group of constructive unification coefficients K_{212}:

1) *The unification coefficient of a model construction* expressing the degree of unification of constructive modules of a model construction of a new product

$$K^{MC}_{ui} = n^{MC}_{ui} / n^{MC}_{u} ,\ K^{MC}_{ui} < 1 \qquad (1)$$

where: n^{MC}_{ui} – number of common-type constructive modules for the type of design product used in the model structure; n^{MC}_{u} – total number of constructive models of the analyzed model structure.

2) *Coefficient of reuse of constructive modules* in a series of products expressing the degree of unification of model structures in a series of products

$$K^{MC}_{rs} = n^{MC}_{us} / n^{MC}_{s} ,\ K^{MC}_{rs} < 1 \qquad (2)$$

where: n^{MC}_{us} – number of unified common-type constructive modules characteristic for all the model structures of a series of products; n^{MC}_{s} –total number of constructive modules for the products of series.

EXPERIMENTAL STUDY

The experimental study considered the application of modular design methodology for the diversification of assortment of jacket-type products for men, a stable assortment allowing to apply efficiently the principles of constructive unification.

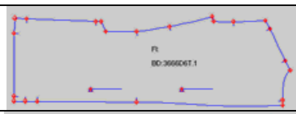
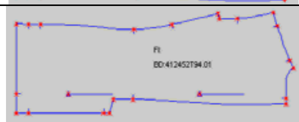
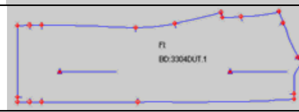
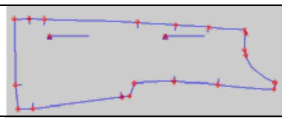
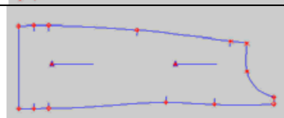
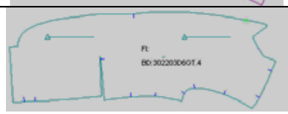
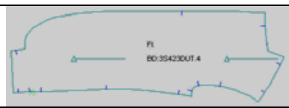
In order to establish the nomenclature of constructive modules for a men's jacket we considered the optimum division of product into component elements. The structuring of jacket into component elements is done based on the principle of interchangeability in a modular system, defining the properties of an element of product that may be found in the same constructive-technological variant in different models of jackets. 16 constructive modules have been identified. The Model structures of series will be established based on the general constructive modules: façade, wedge, back and sleeve and the variant constructive modules: collar, closing system, trimming, flaps, pockets. The constructive models elaborated in the nomenclature determine more variants of basic common-type constructions depending on the used initial data: values of anthropometric indicators; values of legerity additions depending on the trends of fashion; constructive particularities of product. The elaboration of nomenclature allowed to visualize clearly all the general constructive modules and the variant modules, as well as to automate the process of design and elaboration of technical documentation.

The modular design of products is a perspective direction of unification and elaboration of common-types, since the formation of nomenclature and databases of constructive modules allows to automate efficiently the design principles.

The experimental studies included the formation of a nomenclature of constructive modules for the assortment of jacket-type products for men and the creation of a database SB-GIOVANI in the automated design system "Investronica", the GENMA software that included the nomenclature of constructive modules elaborated in the PGS-MODELLING design software, as well as a component of gradation norms for the jacket-type product for men. The GENMA software is tightly connected with the PGS-MODELLING design menu and the framework fit menu MARK, the framework drawing menu PLOTWIN. The major functions of this software are: creation of a library of titles and types of reference shapes, models, sketches, firms; search for reference shape data based on the specified parameters; printing of various reports; model creation (based on specified reference shapes); administration of fitting process based on the types of fabric, cutting methods and other parameters, fitting of images into fabric and framework application rules. The SB-GIOVANI database implemented in the INVESTRONICA Automatic Design System and the nomenclature of constructive modules are used as a basis for the manufacturing of serial products for all sizes, waists and conformance groups allowed by the implemented database. Following the implementation of the created database it became possible to elaborate a wide series of models of jackets starting from a basic model, subsequently models of jackets have been elaborated that are now at the experimental stage.

In continuation one may consider a fragment from the matrix of constructive solutions for the identified modules – the table 1 and the models resulting from its application – figure 1.

Table 1: Nomenclature of constructive models (fragment). Men’s jacket.

Module code	Element code	Module name	Schematic presentation
KM1	1	Back	
	1.1	With two cutouts	
	1.2	With one cutout	
	1.3	Without cutout	
KM2	2	Lateral wedge	
	2.1	With cutout	
	2.2	Without cutout	
KM3	3	Façade	
	3.5	With tapered cut pockets	
	3.6	With straight cut pockets	
	3.7	With applied pockets	

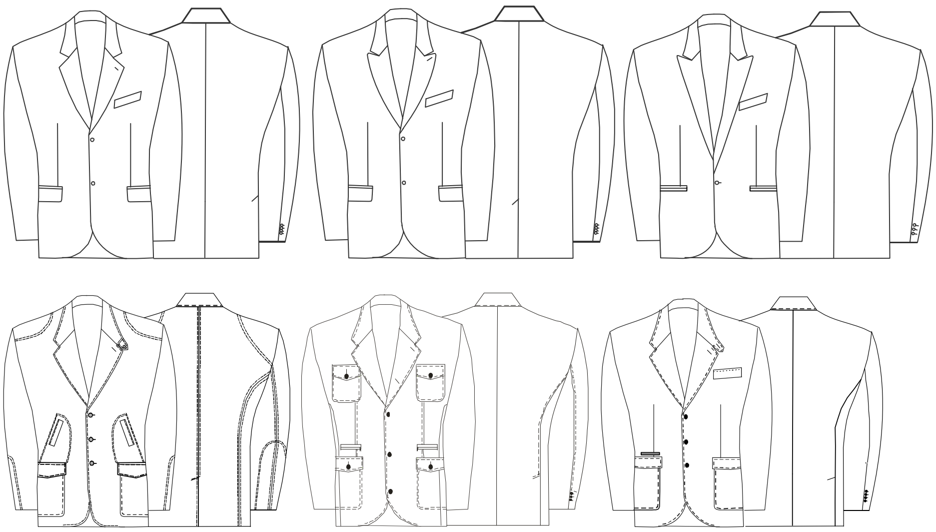


Figure 1: Series of jacket models (fragment)

In order to evaluate the series of models elaborated using the modular method we have calculated the coefficient of unification and the coefficient of reuse of constructive modules for the newly elaborated models (relationships 1 and 2):

1) *Coefficient of unification of a model structure:* $K^{MC}_{ui} = n^{MC}_{ui} / n^{MC}_{u} = 4 / 16 = 0,25$

2) Coefficient of reuse of constructive models elaborated in a series: $K^{MC}_{rs}=n^{MC}_{us}/n^{MC}_{s} = 10/16 = 0,625$

According to the obtained results each model may contain at least 4 common-type elements reusable in a series of jacket-type products for men.

In continuation one may consider several newly elaborated models in the result of diversification of modules, in lining view. The combination of models of basic fabric with the lining models results in the creation of new lined products, semi-lined products and only back-lined products. The variants of combining fabric and lining models characterize the interior processing of product. Diversification of products with lining occurs following the combination of constructive lining modules with small interior elements (tucks, flaps) and diversified trimming modules. Diversification may also be obtained by the play of colors in the models of basic fabric and lining increasing the number of models – see figure 2.

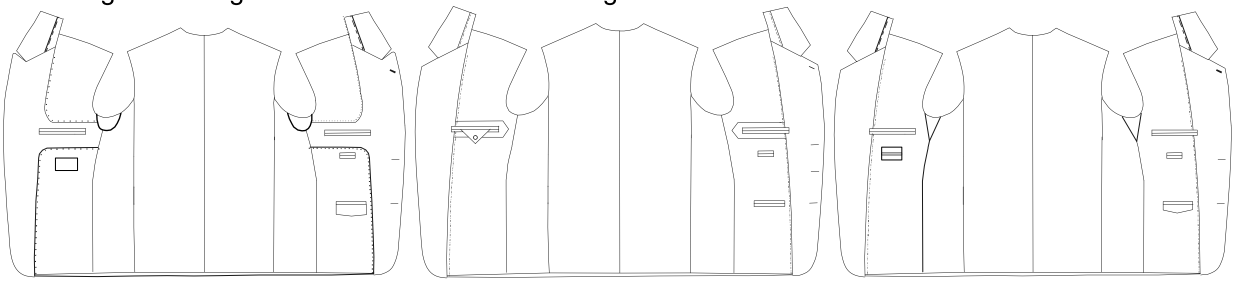


Figure 2: Proposals to diversify the jacket-type product for men

CONCLUSIONS

The work proposes constructive-unified series of models of jackets for men in a wide range of sizes, waists and conformance groups specific to the wearers of the 18 … 40 years age group. These series represent a set of modified constructive variants of similar or diverse destinations, their major characteristics being referred to the common-type basic structures (silhouette, cut of major reference shapes, processing methods) and the secondary ones – the closing system, collar, pockets – modified variants of series, i.e. the derived constructions of basic model.
The results of the studies have been proposed for implementation in a company specialized in the manufacturing of garments for men.
The formation of nomenclatures and databases of constructive modules by types and categories of products allow to apply efficiently the principles of automated design.
The use of modular principles in the process of designing garments allows to raise the degree of constructive and technological homogeneity of products with a positive impact over the efficiency pf design process and labor productivity that are imperative for the textile industry in the actual economic conditions.

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Scholarly communication paper

METHODOLOGICAL ASPECTS OF RATIONAL WARDROBE

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Abstract: *This work considers the problem of elaborating assortments of products in the context of rational consumption. The methodology of collecting a wardrobe and assortments of garments is based on the principles of satisfying the material and spiritual needs of consumers. The volume and the structure of rational wardrobe have been identified as determining indicators of the population's life level and cultural development level, these being important factors for development and design of new assortments of products. The methodology of formation of rational wardrobe may be applied in the elaboration of wearer group-targeted design, depending on the social indicators and behavior characteristics in relation with the consumption of garments. The experiments were aimed at applying the methodology of establishing a rational wardrobe for a definite group of wearers. The work determined the rational consumption norms for garments by assortment groups based in their usage term. A rational wardrobe has been proposed for women for the group of dresses and suits, containing 23 units of products for the wearer group of women aged 18-29.*

Keywords: *assortments of garments, rational wardrobe, the rational consumption norms for garments*

INTRODUCTION

Elaboration of technologies of developing assortments of garments in the context of design of garments intended for target groups of wearers represents an important problem for the specialists of light industry. The use of rational wardrobe concept in the design of new assortment collections may constitute a possible solution of the problem of rational consumption of products, including the garments, and rational use of material, power and other resources. The scope of study consists in the structuring of the methodology of establishing a rational wardrobe and applying it in the design of products intended for groups of wearers. The actuality of this study results fro the modern modality of applying the available technologies of developing garments.

THEORETICAL ASPECTS

The wardrobe is a complex of interdependent functional products capable of satisfying certain needs in a certain period of time. The rational wardrobe is a collection of products to be owned by a person in order to satisfy his/her real needs for garments. The real needs represent the maximum demands of the person supported by the possibilities of national economy in the given time span. The volume and structure of rational wardrobe are important indicators since they characterize the level of life, cultural development, aesthetic preferences of population and play the role of main drivers of development and manufacturing of assortments of garments.

The assortment represents the multitude of products and the relationships between the various types of products in serial production of an enterprise, branch or a group of products. Pursuant to the constructive-typological approach, already at planning stage the assortment may be represented as an ensemble of consumption goods created based on the multilateral market analysis, study of certain consumer groups and manufacturers. The basic principles of this approach are reflected in the process of formation of assortment collections.

The process of elaborating the rational wardrobe and assortment is associated with the solution of problem –

determination of structure and optimum volume of products in the wardrobe bearing in mind the life environment, technical-scientific development and the level of people's requirements.

One may consider the process of formation of rational wardrobe as a hierarchical structure with four levels (figure 1):

- OP (object of design in ensemble) – the wardrobe or the assortment;
- GS (assortment groups) – outer wear, intermediary products, lingerie, headwear, etc;
- US (assortment units) – topcoats, dresses, trousers, etc. characterized by the quality indicators of products;
- ICPÎ – quality indicators of products.

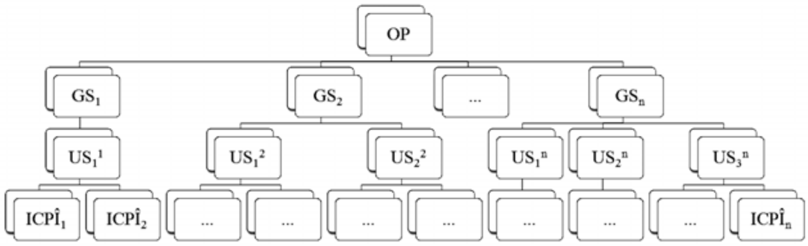

Figure 1: Hierarchical structure of the object of design: structure of wardrobe and assortment of products

Thus, the mathematical model of a rational wardrobe may be represented by the relationship (1):

$$OP \in GS_{1 \ldots k} \in US^{m}_{1 \ldots n} \in ICPV_{1 \ldots l}, \quad (1)$$

The structure of the assortment is established successively at all structural levels taking into consideration the trends of fashion, the preferences of various consumer groups and the technological capacities of manufacturers.

The solution of the problem of rational wardrobe has to take into account the fact that it will not be the same for the various groups of wearers obtained from their classification by income, age, etc. and consumer behavior (volume and structure of wardrobe, attitude to fashion, etc.).
The complex object for the formation of the assortment of products is the assorted collection of products. The collection of assortment appears as an ensemble of products of various types from the same assortment group, each element in particular representing an assortment entity. This concept is widely spread in case of optimization of industrial collections. For this purpose at the initial design stages of a new collection the manufacturers have to collect the information on consumer demands and their own technological possibilities.

One of the most representative indicators that may be used for assessing the costs of population are the consumption norms for various goods. In the process of analysis it is important to mark that the minimum consumption norms may deviate from the structure and real consumption volume of goods. Since the society of the Republic of Moldova is strongly differentiated from the income point of view, this fact directly affects the consumption of garments and depends on the well-being of each individual in particular. Also, consumption depends on the average per capita income and social-economic situation in the country.

The degree of satisfaction of people's needs for garments depends on the ensemble of factors, the most important being the development of industrial production (especially light industry); income growth; cultural development of population; number and structure of population (age, sex, occupation); anthropomorphological and psychological characteristics of individuals; climatic conditions, etc.

The improvement of life levels and cultural development imposes the diversification and growing quality of garments, increased consumption, extension and saturation of individual wardrobe. So, the personal wardrobe must comprise a sufficient number of products with various functional roles, with pleasant appearance, improved ergonomics and corresponding lifetime. For the better satisfaction of needs of various consumer groups a correct analysis of requirements to the products is necessary at all stages of manufacturing process (design, manufacturing, sales).

The population size and its demographic composition affect the volume and the assortment structure of garments. The men-to-women-to-children ratio directly affects the volume and the assortment of garments necessary for the market. The age is another important aspect for the analysis of consumption of products. The persons of different ages may change their wardrobes in different ways.

According to the facts stated above, it is insufficient to aim at only one direction, say, the fashion trends in the respective season, but a complex analysis of preferences and needs of specific categories of wearers for whom the products are being conceived. This will require a study of anthropomorphological and psychological particularities of the considered social group.

The consumption of garments is in direct dependence with the wearer's preferences and habitudes. Also, another significant factor is the development of science and industry, in addition to the trends of fashion. So, cultural, social, personal and technical-scientific developments impose increased demands for garments. Therefore, appears a continuous and unlimited need for garments. At the same time, the permanently growing demands must never affect the reasonable limits of wardrobe and there appears the notion of rational consumption norms that in its turn results in the formation of rational wardrobe.

The rational consumption norms are in permanent modification and development process. This dynamic results from the action of numerous factors, including technical-scientific progress and innovation in various domains, social-economic and cultural factors. Namely the permanent changes in the rational consumption norms have a direct impact over the manufacturing process and determine its development directions.

The consumption of garments, like any other consumer durables, has a distinct particularity, and namely: use of product over a certain period, for example, one year, does not coincide with the acquisition in a particular period, in other words, over a particular period of time any person wears both the recently purchased products and the products purchased some time ago. The annual consumption of garments represents a part of its price that is attributed to wear and tear caused by its wearing during the year. Should the annual consumption of garments be smaller than the purchasing incidence, there will be an accumulation of products and a formation of wardrobe. In the contrary case, should the products be consumed faster than the new ones are purchased, the wardrobe volume will decrease.

The rational consumption norms represent the number of products that have to be purchased annually by each person in order to compensate the worn-out ones. For the rational consumption norms to be scientifically justified one must establish the rational wardrobe, in other words, determine the set of essential products necessary for an individual. In addition one shall consider the useful lifetime of products in the rational wardrobe.

The rational wardrobes and the norms of consumption of garments vary depending on the wearer's sex and age. These calculations are based on the per capita average. So, the wardrobe of a person has to contain the following number of products: topcoats – 4,5 units; suit-dresses – 23,34 units; lingerie group – 19,9 units; headgears – 3,4 units; scarves, headscarves – 3,49 units; ties– 2,2 units; gloves– 3,01 units; socks – 12 pairs.

In order to compensate the worn part of wardrobe each person has to purchase annually the following number of garments: topcoats – 1,2 units; suit-dresses – 9,24 units; lingerie group – 11,56 units; headgears – 1,33 units; scarves, headscarves – 1,32 units; gloves– 1,37 units; ties – 0,83 units; socks– 11 pairs.
The rational consumption norms are obtained based on the following economic lifetime of garments: topcoats – 3,75 years; suit-dresses – 2,53 years; lingerie – 1,72 years; headgears – 2,56 years; scarves, headscarves – 2,64 years; gloves– 2,2 years; ties– 2,65 years; socks– 1,09 years.
The rational consumption norms and the rational wardrobe are reconsidered and systematically updated due to instability.

EXPERIMENTAL STUDIES

The experimental studies included the application of methodology of forming a rational wardrobe for a definite group of wearers. The group of young wearers, women aged 18-29 years, adepts of casual style that may be referred to the category of "rational" consumers has been chosen, (approximately 25 % of young generation is part of this group). The consumers of this type formulate exactly their requirements to the products. In order to satisfy the preferences of this category of persons one needs a complete range of products at reasonable prices. The major aspects in the formation of wardrobe of a young person is the growing number of product units, replenishment of wardrobe depending on the trends of fashion and the personal external appearance, growing share of products for active rest, sports, options of interchangeably products of universal destination. For this group of wearers the resistance to wearing and durability of product are not important characteristics.

The rational consumption norms for garments by assortment groups have been adjusted based on the product lifetimes.

A rational wardrobe has been proposed for women with division into dress-suits including 23 units of basic products –blouses, dresses, skirts, trousers, jackets intended for the group of wearers – women aged 18-29 years (figure 2).

The proposed compositional - constructive solutions for the types of component products – blouses, dresses, skirts, trousers and jackets allow to combine products and establish a large number of combination variants and sets of products of various destinations.

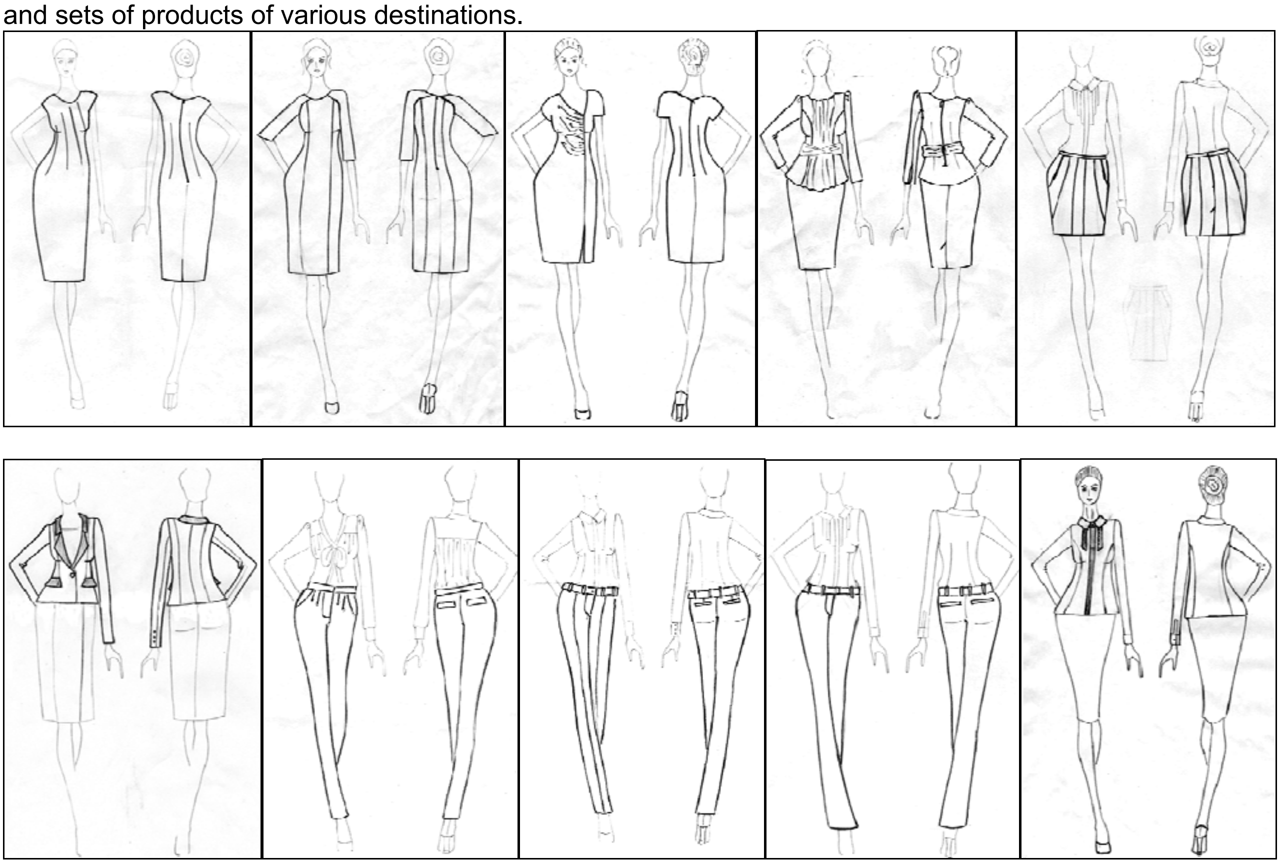

Figure 2: Sketches of product models elaborated in the rational wardrobe (fragment)

CONCLUSIONS

In the result of theoretical and experimental studies it was determined that the formation of a rational wardrobe of actual, quality, ergonomic and solicited products by the domestic manufacturers is possible. The elaboration of rational sets does not require additional costs for the constructive, technological or technical preparation, only a different approach to the conception and selection of new models is necessary. The launching of products on internal market that may be purchased in separate units or several units, at the same time compatible and interchangeable will attract many more customers tending to minimize their costs for the formation of individual wardrobes.

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DETERMINATION OF ANTHROPOMORPHOLOGICAL HOMOGENEITY OF GIRLS' BODIES OF PRESCHOOL AGE GROUP

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Abstract: *Designing products for children, compliant with the modern requirements of education process must comply with the modern anthropometric standardization, psychophysiological development of children and improved design techniques.*
The particularities of children's silhouettes are determined, first of all, by differences in the proportions of main elements. It is known that namely the proportions of silhouette represent the biggest age-related variability and affect the perception of silhouette in general.
The study considered the proportions of common type silhouettes of girls determined by a series of anthropomorphological indicators of projections. As an object of research was chosen a preschool age group, as the children aged 3 … 6,5 years have specific particularities of silhouette that must be taken into account when elaborating new models of products.

Keywords: *type body, anthropometric indicators, girls, age group 3 … 6,5 years.*

INTRODUCTION

The group of preschool age children as one with the highest degree of silhouette changeability and specific functioning of organism compared to the organism of an adult person complicates the task of designing adequate clothing.
Comfort is of special importance for the child, but fashionable clothing is not always comfortable. Clothing must not impede the physical development of children and must be convenient both from the ergonomic and utility point of view. Therefore, when designing clothing for children one should take into consideration the mutual location of functional elements (joints and constructive-decorative elements) in accordance with the particularities of body structure and silhouettes of children.

PARTICULARITIES OF PHYSICAL DEVELOPMENT OF PRESCHOOL AGE CHILDREN

In order to study the physical development of man a series of usual quantifiable important indicators is used: body height, circumference of chest, body weight, determining the structural-mechanical properties of organism. Physical development goes through a series of successive periods and depends on the age of person [1].
During the first neutral childhood (3…7 years) boys and girls have a few differences in the external body shape and many physiological and biochemical parameters. From the first year of life and until the age of 4…5 years the body growth rate decreases. All body dimensions increase at relatively stable rates. The speed of growth processes increases on the sixth year of life.
During the first period of childhood (4…7 years) an intensive growth of skeleton bones and body height is noticed (especially in the age of 5 to 7 years). In this period the dimensions and shapes of bodies of boys and girls have almost no differences. Their movements in this age are characterized by diversity, higher complexity and coordination.
The body proportions change. Changes occur mostly due to the reduction of relative dimensions of head and body and growing relative length of extremities. The height of head attains 1/6 of body length. The growth speed of upper part of body decreases uniformly, while the length of arms (shoulders and fingers) and body diameters increases. The proportions of different body parts in the process of growth change unevenly.
With time the children's posture changes due to the displacement of weight center downwards.
Changes in the adipose tissues and musculature result in changes of other components: shape of thorax and abdomen, trunk and back [2].

COMPARATIVE ANALYSIS OF COMMON-TYPE BODIES OF GIRLS, AGE GROUP 3…6,5 YEARS

In order to analyze the external shape and morphological particularities of body structures of girls of preschool age group the dimensional projection signs provided in the GOST 17916-86 were used (Common-type silhouettes of girls. Dimension signs 98-56-51, 110-56-51, 122-56-51) that is applicable on the territory of the Republic of Moldova. In this document the common-type silhouettes of girls are provided in two corpulence groups with heights of 98…122 cm and dimensions of 56…64 cm.

Since GOST 17916-86 offers a quite large variety of common-type silhouettes in the examined age group, a decision was made to produce a comparative characteristic of three common-type silhouettes by choosing one with the minimum values of main dimensional signs, the second intermediary and the third with maximum values of main dimensional characteristics, all three silhouettes being included into one corpulence group. Based on the projection dimensional signs the guide images of common type silhouettes 98-56-51, 110-56-51 and 122-56-51 have been produced.

The scheme shows the external contour of child's silhouette in three projections – backside view, profile, front view – with application of major constructive levels in the form of horizontals: neck and shoulder, scapular, thoracic-axillary, waistline, hips, subfemoral fold, knees and support surface, as well as the verticals: mid rear, neck basis in side view, armholes on back, armholes on front, chest center, средней front midline. The main anthropometric levels are marked in accordance with the UMCD CMEA methodology [3].

The graphic models of corresponding common-type silhouettes have been elaborated using the proportional-modular method, the posterior and anterior dimensions and silhouette width values.

For a more complete analysis of external silhouette shapes of girls of preschool age the comparative anthropometric analysis of graphic models of common-type silhouettes has been performed based on the constructive levels. For this scope the deviations of projection-dimensional signs in each pair of common-type silhouettes have been calculated– with height 98 and 110 and accordingly, 110 and 122 cm.

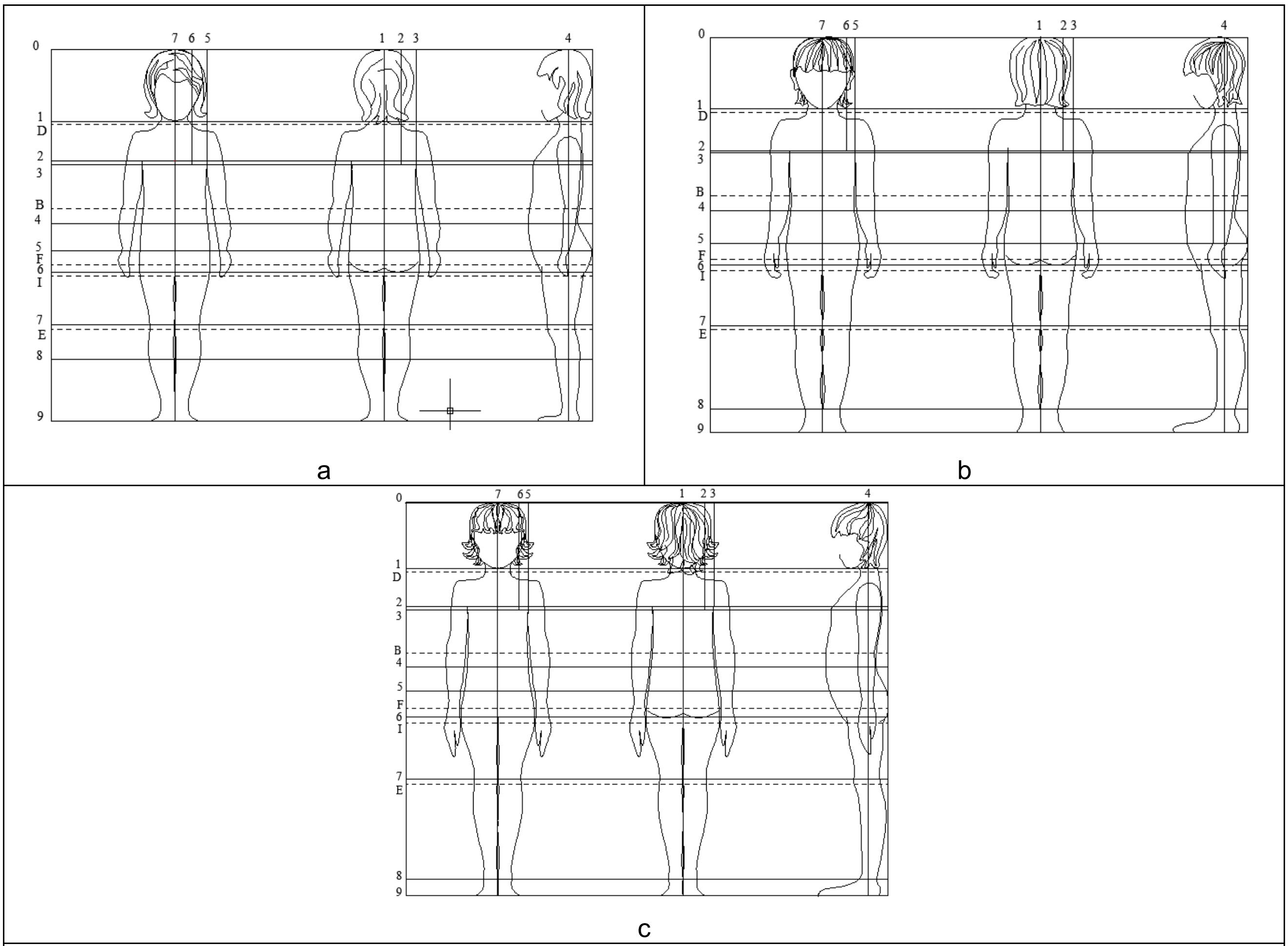

Figure 1: Schemes of constructive levels of children's bodies, preschool age:
a – common-type body 98-56-51;
b - common-type body 110-56-51;
c - common-type body 122-56-51.

Table 1: Anthropometric analysis of graphic models of common-type silhouettes of girls based on constructive levels

Dimension sign, as per GOST 17916-86	Value, см for common-type silhouettes			Deviations, cm	
	98-56-51	110-56-51	122-56-51	98-110	110-122
1	2	3	4	5	6
Frontal projection					
1	98	110	122	6	12
4	78,9	90,0	101,6	11,1	11,6
6	67,5	77,8	89,6	10,3	11,8
11	68,2	78,3	88,8	10,1	10,5
7	56,6	65,7	78,1	9,1	12,4
86	44,9	52,7	61,3	7,8	8,6
12	39,2	46,6	55,5	7,4	8,9
9	25,4	29,6	36,3	4,2	6,7
56	19,4	20,4	21,3	1,0	0,9
116	13,8	13,9	14,6	0,1	0,7
117	6,6	7,0	6,9	0,4	-0,1
Profile projection					
82	3,2	3,2	3,2	0	0
81	0,7	1,1	1,9	0,4	0,8
80	0,3	0,4	0,4	0,1	0
112	3,4	3,7	6,8	0,3	3,1
84	3,8	4,0	6,2	0,2	2,2
110	7,4	7,5	6,9	0,1	-0,6
95	13,7	13,8	13,9	0,1	0,1
111	16,6	17,1	18,2	0,5	1,1
67	16,1	17,8	19,2	1,7	1,4
115	16,6	16,8	16,9	0,2	0,1
116	13,8	13,9	14,6	0,1	0,7

The analysis of guide images of girls in frontal and profile projections allowed us to establish the main differences between the studied common-type silhouettes:

In the first subgroup the difference in dimension sign 4 amounts to 11,1 cm and in the second subgroup – 11,6 cm, this implies a fast growth of the child, especially after the age of 4,5…5 years;

The difference in the height of waistline constitutes 9,1 cm and 12,4 cm accordingly, this points to the changes in the main proportions of silhouette, these changes are uneven, they are slow in the beginning and gradually accelerate with process;

The deviations identified for the height of subfemoral fold - 7,8 cm and 8,6 cm accordingly, point to the elongation of lower extremities, this elongation being attributed to the elongation of angle, as the knee height changes first by 4,2 cm and then by 6,7 cm;

The shoulder height changes uniformly, first by 0,4 cm and then by 0,3 cm more, accordingly the shoulder inclination increases;

The hip width practically does not change, as the transversal hip diameter changes accounted to 1,0 cm in the first case and 0,9 cm in the second, i.e. the silhouette becomes more elongated;

Interesting changes occur to the foot width, it augments first by 0,4 cm and then decreases by 0,1 cm;

By analyzing the profile projection one may make a judgment on the child's posture. The back became rounder, the spine depth attained 0,4 cm, the waist depth increased (in average by 0,3 cm)

The body position also almost did not change, as the difference between the examined silhouettes constituted 0 cm.

The abdomen remains prominent, this is confirmed by small deviation values – 0,1 cm for the anterior and posterior waist diameter;

The thorax becomes wider, the anterior-posterior chest diameter changed first by 0,3 cm, and then quickly by 1,1 cm, however, the thorax relatively elongated upwards appears flatter;

The hip width changes uniformly, the difference accounting to 1,0 and 0,9 cm accordingly, the relatively small deviation values for the anterior-posterior waist diameter make the abdomen to seem more prominent;

Rapid changes occur to the neck width, since the anterior-posterior neck diameter practically does not change in the beginning – the difference for dimension sign 110 is 0,1 cm and then it is quickly reduced by 0,6 cm, making the neck thinner.

CONCLUSIONS

The data provided above allows to affirm that in the result of anthropometric measurement studies of girls of preschool age group significant differences have been determined between the chosen common-type silhouettes, affecting the visual perception of silhouettes in the context of elaborating harmonic models of products. For this purpose the authors propose to divide the preschool age group into **two subgroups** in order to elaborate products of different models, in accordance with the anthropomorphological structure of silhouettes in each subgroup. Thus, the common-type silhouettes with heights of 98 cm to 110 cm will constitute the first subgroup and the silhouettes with heights of 110 cm to 122 cm will constitute the second subgroup. The children with height of 110 cm will appear well in the models of both subgroups.

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USE OF BODY PROPORTIONING SYSTEMS IN DESIGNING NEW MODELS OF JACKETS FOR GIRLS AGED 3 … 6,5 YEARS

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Abstract: *The particularities of children's silhouettes are determined, first of all, by differences in the proportions of main elements. It is known that namely the proportions of silhouette represent the biggest age-related variability and affect the perception of silhouette in general.*
Therefore, the main objective of this work was to study the body proportioning systems for choosing a system capable of transposing its harmonization principles on the silhouette in general and the product in particular.
The problems considered in this work are actual, as the manufacturing of garments for children occupies a substantial share of textile industry. Garments for children are always highly demanded, as they need frequent renewal due to wearing particularities.
In the result of performed study, two systems of jackets for girls have been elaborated. All the external characteristics of models have been elaborated using the «golden ratio» rule that allowed to provide a harmonic external appearance adapted to the anthropomorphological characteristics of a child of preschool age.

Keywords: *proportioning systems, design of jackets, children of preschool age.*

INTRODUCTION

When elaborating the package of initial data for constructing garments, including garments for children one must properly understand not only the dimensions of silhouette, but also its proportions and constitution. Namely these indicators allow to include all the necessary changes into the construction at the initial stage so as to comply to the maximum extent with the particularities of specific silhouette.
The group of preschool age children as the one with the most changeable silhouettes is also characterized by specific operation of locomotion and other vital systems compared to the organism of an adult person and this is significant challenge for the design of adequate clothing [1].
One may affirm that the children are a separate group of wearers and establish the main problem of the designer: to design clothing taking into consideration all the age-related particularities for each age group.

ASPECTS OF DESIGNING GARMENTS BASED ON PROPORTIONALITY RELATIONS

Being the basis of structure of any product of art, proportions are a tool of artistic expression of objectively existing relationships in nature. The absence or failure to comply with the proportions results in the loss of harmony and integrity of depicted object. In practice, especially in architecture appeared numerous proportioning systems. So, for Ancient Epoch numeric and visually perceivable proportions were characteristic, for the Medieval Gothic – geometrical, immeasurable in numbers, hidden proportions, in the Renaissance epoch the leading notion of perfect proportion was the Golden Section widely applied in sculptural art. The study of proportions includes the main laws of suit composition: statics and dynamics, symmetry and asymmetry, rhythm and plastics [2].

In order to establish the required proportions in clothing an important element is the determination of product length and location of waistline. The different visual perception of the same silhouette is explained by the different division method, i.e. different location of product waistline at equal length. The natural division of a proportional silhouette by the waist line into two components is expressed by the Golden Section.

The Golden section is the basis of harmonic shapes, as it is the absolute law of shapes in the nature we are parts of. IN this manner one may conclude that the proportional relationships are based on the inequality of proportions. In the modeling of garments the proportional relationships are determined intuitively or set by the trends of fashion. Each direction of fashion implies its own proportional divisions of suit and of the man in that suit, accordingly.

Comfort is known to be of special importance for a child, but modern clothing is not always comfortable. Clothing must never interfere with the physiological development of children, it must be convenient both for the ergonomics and use of its separate elements. This is why when elaborating garments one is advised to determine the location of functional elements (divisions and constructive-decorative parts) with the particularities of constitution and proportions of children's silhouettes [3].

In the first period of childhood (4…7 years) the bones of skeleton grow tremendously and the body height increases (especially in the age of 5 to 7 years). The body proportions change. Changes occur mainly due to the reduction of relative dimensions of head and body and increasing relative length of extremities. The head height attains 1/6 of the body length. The speed of growth of the upper part of body decreases uniformly, as well as the length of feet, at the same time the length of arms and the body diameter increases (shoulders, fingers). Changes in the proportions of children's body parts in the process of growth are not uniform.

There are certain differences both in the constitution and entire external appearance within this age group of children. Two main silhouettes are characteristic for the clothing of girls belonging to this age group:
1) Extended to the lower end from shoulder or chest (A-like);
2) Free straight bodice extended at lower end (D-lile).
The first shape is obtained by elongated yoke, its line forms the raised waistline. The second shape is obtained by elongated bodice, its line lowers the waistline.

DESIGNING OF JACKETS FOR GIRLS BASED ON THE PROPORTIONING RELATIONSHIPS

GOST 17916-86 provides a quite large variety of common-type silhouettes in the examined age group, therefore the projection dimension signs of three common-type groups were examined: 98-56-51, 110-56-51 и 122-56-51.
The analysis of anthropometric measurements of girls of preschool age allowed to establish significant differences between the chosen common-type silhouettes affecting the visual perception of these silhouettes in the context of elaboration of harmonic models of garments. For these reasons it is proposed to divide the preschool age group into **two subgroups** and elaborate garments of various models for them in accordance with the anthropomorphological characteristics of silhouettes of each subgroup.
Jackets have been chosen as an object of design, as presently namely this type of products is the most preferred during the cold season – they have good thermal protection properties, provide efficient protection against wind and have a low weight, these are important characteristics for the children's wear.
As the main jacket fabrics are quite thin, it is possible to design inserts, tucks, frills. These materials are capable of holding the shape well, but the shape itself has to be obtained by constructive method, as the jacket fabrics do not shrink and do not support secondary thermal treatment.
The thermal protection functions of these products are assured owing to the use of additional thermal isolation materials. This allows to diversify the models additionally, as the thermal protection layer may be fixed on the basic fabric using simple or sophisticated padding.
Based on the main function of upper clothing – protection against cold – new models must have a certain length in order to provide for the ventilation of undercoat air layers – a specific volume provided by specially chosen values of constructive additions.
The analysis of common-type silhouettes of girls of preschool age has demonstrated that it is most suitable to elaborate models for the two subgroups with different proportions:
1. Common-type silhouettes of the height series 98...100 cm.
2. Common-type silhouettes of the height series 110…122 cm.
As the common-type silhouette of 110 cm is the intermediary ones and may use the models both for the first and second subgroup, since namely this common-type height has been taken as basis for the elaboration of new models of jackets for girls in this work.
Starting from the height of 98 cm the kids will appear best in the suits consisting of jackets and overall-type trousers, as they are very mobile and quickly growing, this will allow to use the product for several seasons in sequence. The garments for this age group is characterized by the following cut particularities as: folds, ruches, frills of various types, bodices, mostly straight silhouette lines.
The children of the second subgroup, starting from the height of 110 cm will appear more harmonically in longer jackets of specific cut, down to the knee line. Trapezoid silhouette jackets are preferred, with lower ruches, relief elements, bodices, horizontal and vertical padding, etc.

When elaborating technical sketches of models we used the Golden Section principles in order to harmonize the external appearance of wearers. Using the Fibonacci number φ to calculate the positions of main constructive and constructive-decorative lines in models (see figure 1).

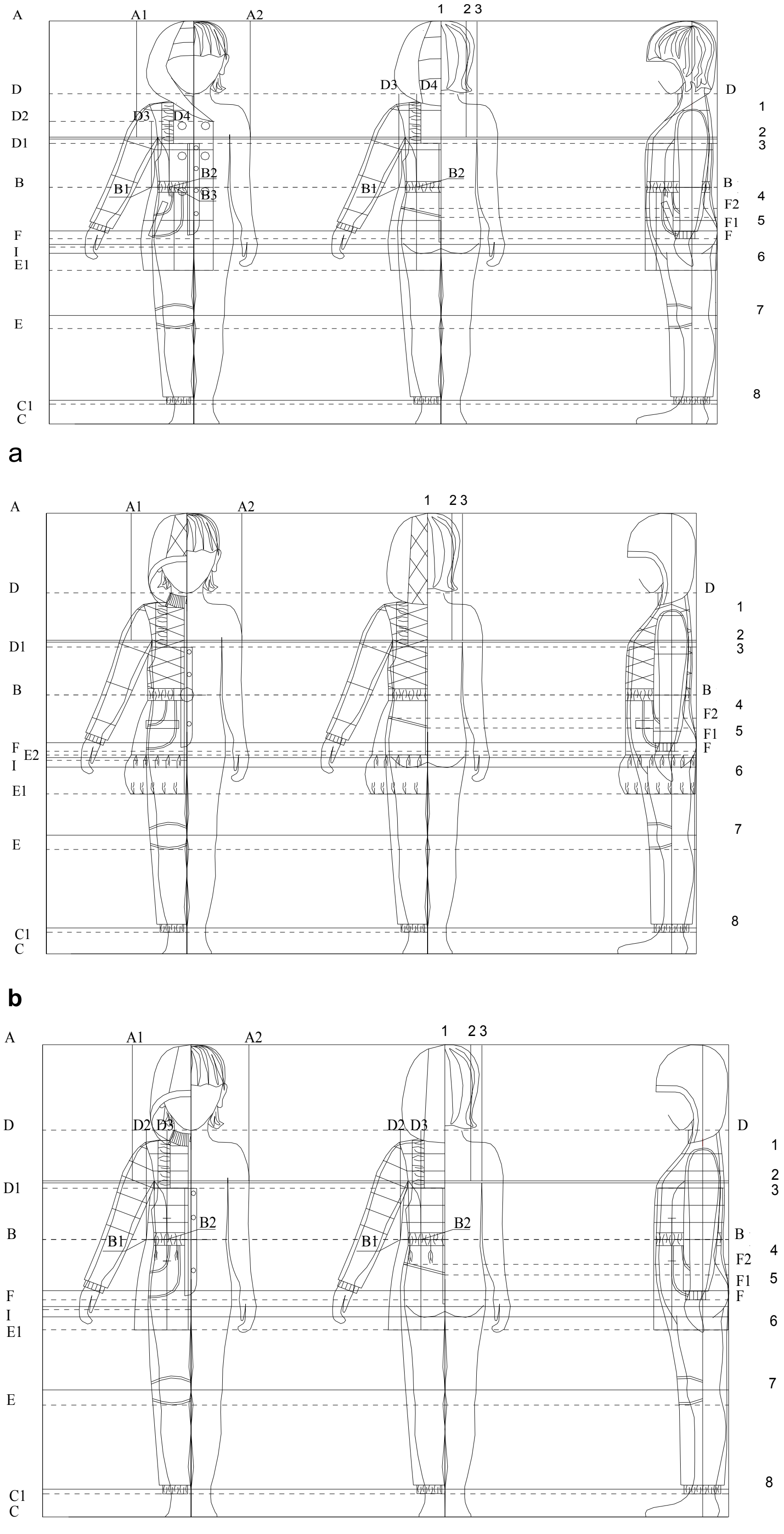

Figure 1: External appearance of jackets for girls elaborated using the harmonization laws:
a – model 1; b – model 2; c – model 3.

CONCLUSIONS

In the process of creation in general and in modeling of all types of garments for children the basic law is applied – dependence of shape and silhouette on the age-related particularities of constitution. The most important factor in determining the silhouette, shape and lines of children's garments are the relationships between the length of trunk, arms, legs and natural waistline position. Modern industrial design requires detailed analysis of proportions for age groups, i.e. determination of proportionality criteria for the parts of body and future products. Only the correctly proportioned garments are capable of harmonizing the wearer's external appearance.

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Scholarly communication paper

NATURAL DYES: PRINTING AND DYEING TECHNIQUES -INSPIRATION FOR FASHION AND INTERIOR DESIGN-

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Abstract: *Natural dyeing and printing with colours and dyes from nature belongs to the craft culture and is incorporeted to the research field of craft science.*
Since antiquity, natural dyes have been used by humans for dyeing and creating patterns on a variety of fabrics and materials and they were extensively used for dyeing fabrics for clothes and also for decorations. As civilization progressed, the art and practice of dyeing and printing with natural dyes that is used to cover human bodies came into existence.
By combining the research tradition of the two branches of science, craft science and organic chemistry, a more profound understanding of the dyeing fabrics for fashion and interior design may be obtained. Researchers attention is focused on revival of the old art of dyeing and printing with natural dyes and commercial dyers, artists and textile export houses started to look again for the maximum possibilities of using natural dyes for dyeing and printing fabrics.
Now, the application of natural dyes uses modern science and technology not only to revive the traditional dyeing and technique, but also to improve the rate of production cost effectivity and consistency in shades.

Keywords: *colour, shades, dyeing, printing, techniques, natural dyes*

INTRODUCTION (ARIAL, 10 pt., CAPITAL LETTERS, BOLD)

In recent times, all around the world, ecological conscience has influenced the textile industry and also the fashion industry. In this context, natural fibers, natural dyeing and printing is of a greater interest in the textile industry.
The design of textiles can involved a complete vision of development of new design aspects in textile products including the designing of fabric used in appareal, decorative textiles and many others.

STATE OF THE ART

From ancient times, nature was the most important source for dyes. Natural dyeing is an ancient art which predates written records [4,6]. The techniques for dyeing in ancient times included sticking plants to fabric or rubbing crushed pigments into cloth and then the methods became more sophisticated with the use of techniques of natural dyes from crushed fruits, berries and other plants, which were boiled into the fabric and gave light and water fastness [7,8,9].
Natural dyes are still being used in different places of world, especially in India, a country which has a very rich tradition of using natural dyes. As a craft, dyeing with natural dyes is conducted especially by women and now has, considerably, increased, particularly on workshops or hobby groups.

All the natural dyes from nature can offer not only a rich and varied source of dyestuff, but also the possibility of an income through sustainable harvest and economy. Various artists and practitioners of this craft and also some commercial dyers are recosidering the possibilities of using natural dyes for dyeing and printing for high value global markets. Besides these, some of the artists and practitioners of the craft of natural dyeing maintain that natural dyes has a superior aesthetic quality and beautiful colours which is much more pleasing to the eye and offer pastel colour effect apart from being eco-friendly in comparison with synthetic dyes.
Dyeing with natural dyes suggestes those refined, vivid colours, closer in tones to the natural colours from nature. Natural dyes are divided into three categories on the basis of their origin: plant/vegetable origin, insect/ animal origin and mineral origin. Some of the most used natural dyes are: Natural Indigo, Woad (Isatis tinctoria L.), Madder (Rubia tinctorum, Rubia peregrina (wild madder), and Rubia cordifolia (Indian madder), Brazil wood (Ceasalpinia echinata L.), Sappan wood (Ceasalpinia sappan L.), Cochineal (Coccus

cacti L.), Lac Dye (Coccus laccae), Hymalayan Rhubard (Rheum emodi),Turmeric (Curcuma longa), Chamomile (Anthemis tinctoria) and Weld (Reseda luteola).
The status of usage of natural dyes enhancing in every year, now are known more than 500 natural dye sources [11].

One importantly thing is that the artists and designers from all around the world have, effectively, utilized natural dyes as a design tool because the non-reproducibility and non-uniformity of shades make each creation unique and is used to create unique products, for example, various kinds of design production methods, like shibori, tie-dye, ikat, resist printing, stencilling, batik, kalamkari etc.

Today the dyeing is a complex and specialised science [10], natural dyes are mostly used by academic institutes for research, by artists or designers for fashion creations, appareals, home decorations, by traditional dyers and printers, hobby groups or also by the some companies from textile industry.

DYEING AND PRINTING METHODOLOGY

Mordants and methods of mordanting

From specialized literature, natural dyes, when used by themselves have many limitations of fastness and brilliancy of shade, but with uses of metallic mordants they can produce bright and fast colours. Natural dyes are mostly non-substantive and must be applied on textiles by the help of mordants, usually a metallic salt, having an affinity for both the colouring matter and the fibre.
The first step of the actual dyeing process is mordanting.The mordant is the life for the natural dyes, it acts as an agent between the fiber and the colour by helping the colour and penetrates into the fiber permanently, except in the case of natural dye Indigo [11].
Traditionally, mordants were found in nature, but nowadays, mostly the chemical mordants such as alum, copper sulphate, iron or chrome, are used. Mordants are substances which are used to fix a dye into the fibres and improve the take-up quality and help improve colour and light-fastness of the fabric.
The mordant can be added before, during or after the dyeing stage, although most recipes for dyeing with natural dyes call for mordanting to take place prior to dyeing.

As mentioned previously, the most commonly used mordant is *alum (Potassium aluminium sulphate)* and other mordants are:

Iron (Ferrous sulphate)
Tin (Stannous chloride and Stannic chloride)
Chromium (Potassium dichromate)
Copper (Copper sulphate)
Tannic acid
Oxalic acid.

The different tones of colours can be obtained depending upon the amount of mordant applied and using a different mordant with the same dyestuff can produce different shades, for example *Iron* is used as a ‘’saddener’’ and is used to darken colours, *Copper sulphate* also darkens but can give shades which are otherwise very difficult to obtain, *Tin* brightens colours, *Tannic acid*, used traditionally with other mordants, will add brilliancy, *Chrome* is good for obtaining yellows, *Oxalic acid* is good for extracting blues from berries [9,11,12,13,14].
Different mordants give different colours when combined with the same dye, for example cochineal dye used with alum sulfate produce a fuchsia colour, when used with tin the colour is more scarlet and with copper it is purplish.

Three ways of mordanting, mordants and dyes may be applied in three ways:

Pre-mordanting (the mordant is applied first followed by dyeing)
Post-mordanting (the dyeing is done first and then mordanting is carried out)
Simultaneous mordanting (the mordant and the dye are mixed together and applied).

Dyeing Methodology

Colour is applied to fabric by different methods of dyeing for different types of fiber and fabric and at different stages of the textile production process. Dyeing can be done during any stage in the textile manufacturing process because can may be dyed as fibre, as yarn, as fabric and also as garments.

From the specialized literature available, dyeing with natural dyes from nature can be carried out in a alkaline or neutral bath. In this sense, there are various reports on different methods of mordanting for dyeing. In the simplest form of dyeing a textile, the fabric is immersed in dye solution and gradually brought to the boil. Alternatively, the fibre is allowed to sit and soak for several hours or days.

Taking into account the colour theory, applying various mordant and mixing natural dyes can be obtained various kinds of shade and also new colours, which have been reported by many researcher in your studies, like *Gulrajani et.al.(1992)*, *Pate&Agarwal (2001)*, *Nanda et.al.*(2001), *Vankar et.al.(2001), Saxena et.al.* (2001) [2,3,12,15,16,17,18].

Recently, some studies and developments have demonstrated modification in natural dyeing after the use of pre-treatment or post-treatment agents of cationic and anionic groups for improvment in fastness, functional or colour characteristics.

There are a numerous methods of applying natural dyes, the most common method used is the *Vat Dyeing.* Other methods include *Conventional Dyeing*, *Sonicator Dyeing, Microwave Dyeing.*

Worldwide, nanotechnology increased attention for their potential in a wide range of end uses.
The application of ultrasonic energy on textile dyeing with natural dyes has a significant role in the concept of textile processing.
Dyeing of textiles with low and high frequency sound waves has been the subject of many researchers. Sonicator dyeing is a very innovative technique and fuel saver methodology, the dye uptake is very good in sonicator dyeing and the mechanical agitation causes slight rise in temperature which helps in dyeing.
It was demonstrated that ultrasonic energy provided easy efficient route for mordanting and dyeing processes in comparation with traditional methods and processes [19].

The use of ultrasonic energy in natural dyeing has numerous advantages such as: energy savings, reduced pollution, improved efficiency, lowered overall processing costs.

PRINTING AND DYEING TECHNIQUES FOR FASHION AND INTERIOR DESIGN

Basic Print Design Techniques:

Following innovative techniques for development of interesting surfaces: *Etching, Stencil, Collage, Intercutting, Resist(bleach/wax), Dry-brush, Photocopy, Sponge, Stamping.*

The types of Design and their categories: Toile prints, Pucci prints, Geometric, Graphic, Floral, Conversational, Liberty, County inspired, Scenic, Animal, Ethnic, Folklore prints.

Styles and Methods involved in printing textiles*: Direct, resist and discharge methods, Block printing style, Screen printing printing style, Roller printing printing style, Digital printing style, Transfer printing style, Foil printing style, Hand printing style, Sublimation.*

In the dyeing with natural dyes process, application of different techniques can create wonderful and extremely unusual effects on the fabric.
There are several dyeing techniques, among which *Batik, Shibori, Tie-dye, Ikat, Kalamkari, Katazome, Tsutsugaki* can be mentioned.
Batik, Shibori and *Tie-dye technique* are very familiar and also very used in thewhole world by artists, designers and traditional expert craftsmen.

Batik is a type of brightly-coloured fabric created through a wax-resist dyeing technique who creates multi-coloured design [1]. The process of batik begins by stretching the fabric over a wooden or metal frame and then the artist draws the design with a pencil, traces over it with hot wax dispensed from a traditional, copper stylus-like tool, called the *canting* . Upon completing the wax outlines, the artist paints on colored dyes with a brush to create shaded and multi-hued designs. Once painted, the fabric is immersed in a vat of dye, dried, then waxed and dyed again until the desired effect is achieved.
Usually made on fabrics such as cotton, linen and silk, the most common motifs on batik are leaves and flowers, but in recent years, modern influences have led to more contemporary designs.
Most of the artists and expert traditional craftsmen create natural dye colors from indigo plant, roots, barks and flowers, seeds.

Figure 1. The process of batik technique

Figure 2. Silk scarves painted in the technique of cold and hot by combining batik and shibori technique

Figure 3. *Gelar Batik Nusantara, Collection " Beat of Legacy",ESMOD Jakarta Alumni Show, 2013*

Figure 4. *Alleira International*, *Contemporary batik-inspired Collection, contemporary designs that are infused with prints inspired by batik techniques*

Shibori is a galaxy of resist techniques. All involving shaping the fabric in different ways then securing or binding it tightly so that dye does not affect the cloth where it is secured.
Shibori technique is a Japanese form of dyeing that revolves around different ways of binding and folding fabric to create different patterns, and is most commonly practiced with indigo dye.
The variety of techniques is truly astounding, varying from the familiar tie-dye to a wide range of stitched-and-bound techniques.

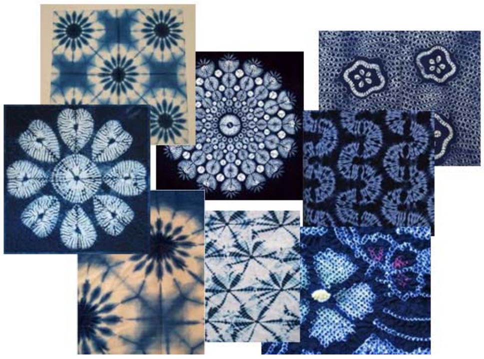

Figure 5. Effects created by shibori technique

Figure 6. *Shibori Art Couture Clothing Collection*

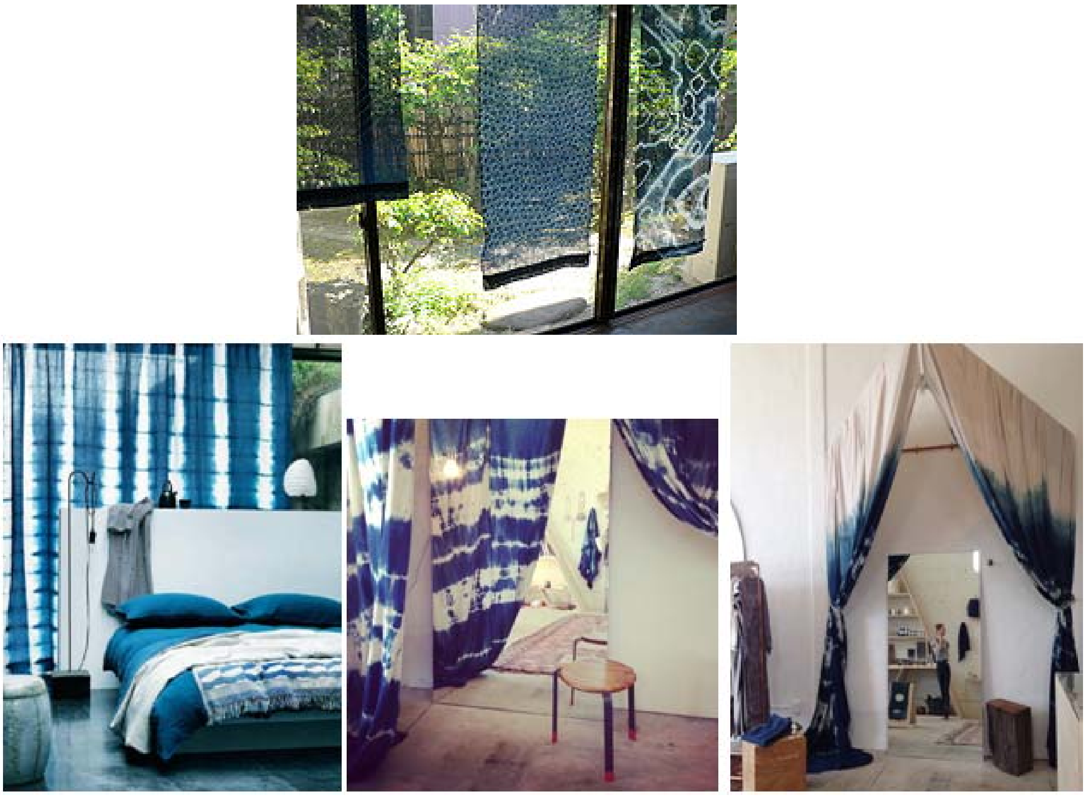

Figure 7. *Fabric Home Decor Design*, Shibori and Tie-Dye Inspiration

Tie-dye is a method of dying fabrics to create colorful patterns. There are various methods of tie-dyeing, each producing a significantly different design. The colorful results of tie-dye continue to capture our imagination. One popular tie-dye technique is the spiral.
The technique of tying fabric in folds to create patterns is referred to as tie-dye and allows artists to develop pattern graphics such as peace signs and hearts, while avoiding the silk screen process. It gives the fabric the illusion of a graphic printing, when in essence the art was created by hand using fabric dyes implementing the tie-dye method.

Figure 8. Creation inspired from tie-dye by *Stephane Rolland, Dries van Noten, Rodarte,Alexander Mc Queen, Adam*

Figure 9. Joel Janse Van Vuuren, *Tye-Dye Inspiration Collection*, Fashion Week, 2011

Figure10. Kate and Laura Mulleavy, Rodarte, New York Fashion Week, 2013-2014

CONCLUSIONS

Nowadays, all around the world, when aspects such as sustainability and ecology are in need of a revaluation, a review of traditional practices that were hitherto thought of as being unscientific and primitive, are outlined for their relevance and role in today's high-tech world. Evidently, natural resources involving natural organic dyes and pigments, and their industrial potential is now becoming again a major economic and cultural issue.
The techniques for dyeing, which can create unbelievable effects have been and still to continue to be an inspiration for many artists, fashion or interior designers on their path to new creations.

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Section 8: Innovations in Textile Finishing

TIO$_2$ NANOPARTICLES AND METHOD OF PHYSICAL DEPOSITION ON TEXTILES AND WOOD

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Abstract: *The paper presents some results of new photocatalytic textiles and wood with sensitivity in the visible solar spectrum, antibacterial and antifungal properties obtaining by coating with Nps TiO_2 and Ag/ TiO_2. The doped Nanostructured Anatase (sizes < 20nm) with extended absorption in visible region were synthesised through innovative hydrothermal technology in aqueous media, at low temperatures and high pressures, in one step. Stable colloidal suspensions of Nps Ag/TiO_2 were used to prepare uniform layers by electro-spraying and sintered targets of Nps Ag/TiO_2 were used to prepare uniform layers by sputtering.*
The textile substrates used had different chemical compositions (cotton and polyester). The textiles and wood with nanoparticles layers were analyzed in terms of morphology and elemental composition of the deposited layers and of the functional effects as: photocatalytic effect and effective antibacterial and antifungal properties.

Keywords: *TiO_2 nanoparticles, electro-spray coating, sputtering coating, photocatalytic textiles, durable wood*

1 INTRODUCTION

Antibacterial, antifungal and self-cleaning textiles are essential in medical field, military applications, home and public spaces. Self-cleaning effect could considerably reduce water and energy consumption necessary for washing of textile goods. Antimicrobial and antifungal properties of textiles used in healthcare limit the propagation of diseases. It is evident that textile industry holds a vast potential in the commercialization of this products.
Regarding wood, the amount of moisture is usually the most critical factor the fixation and development of wood degradation. The susceptibility to fungal degradation of wood varies widely depending on the species. Outdoor wood preservation against degradation is very important.
Classic, wood protection can be achieved by the oily, water-soluble substances and substances soluble in organic solvents. Wood treated with water-borne coatings is more susceptible to fungi and weathering and it also tends to discolor easily. A recent technique to hydrophobize wood surfaces is the use of electrical gas discharges (plasma)[1].
The recent trend for new photocatalytic products use as the photocatalytic materials is TiO_2. The chemical, optical, electrical properties and photocatalytic activity of TiO_2NPs depends on its crystalline structure, size, shape, specific surface area, surface hydroxyl group, etc. These characteristics mainly depend on the method applied for their synthesis. Three common crystalline structures of TiO2 (anatase, rutile and brookite) are well described in literature; the major practical work has been accomplished with anatase and rutile. It is reported that anatase is the most stable phase for NPs with sizes bellow 11 nm whereas rutile is the most stable in the NPs with sizes above 35 nm. Anatase is generally considered as a more active photocatlyst compared to rutile [2]. Actually, the TiO_2NPs simultaneously impart antibacterial, UV protective and self-cleaning properties to textile materials. Non-toxicity and photocatalytic action of nano TiO_2 for decomposing of some organic compounds is a well-known phenomenon. In addition, the effect of silver on TiO_2NPs photocatalytic and antimicrobial activity has been considered.
Different kinds of TiO_2 nanomaterials like nanoparticles, nanosheet, nanotube, or nanofiber have been fabricated using different method [3].
There are many different methods to prepare TiO_2 films, including sol–gel [2] [4], laser ablation, sputtering deposition [5], ultrasonic bath containing a colloidal aqueous solution of nano TiO_2 [6] and padding.

The paper presents the results obtaining by physical methods deposition of TiO_2 and TiO_2 doped with Ag in thin films on textile substrates and wood surfaces.
The novelty consists in the obtaining method of TiO_2 and TiO_2 doped with Ag nanopowders with extended absorption domain in the visible range. The method takes place in hydrothermal conditions at temperatures between 150-200 degrees Celsius and pressures bigger than 100 atm. By hydrothermal procedure can obtain nano crystalline materials, in one step. Hydrothermal procedure is an environmental friendly method; the synthesis takes place in a closed environment.
The original manufacture of new transparent flexible, smooth nanostructured layers on textile and wood surfaces through the improvement of advanced physical methods (direct atmospheric plasma and RF sputtering).
The deposition of NPs by sputtering technology on wood substrates in order to improve its time resistance to environmental conditions is an innovation.
In comparison with the other methods, the sputtering process presents some advantages, such as the high quality and homogeneity of obtained films. Furthermore, sputtering depositions should be one of the most promising techniques for a large-area of uniform coatings with a high packing density and strong adhesion. On the other hand, the structure and properties of the NPs films prepared by magnetron sputtering, can be modified and controlled via the process parameters like work pressure, sputtering power, substrate bias voltage and oxygen partial pressure.
Textile goods with incorporated Ag NPs are already available in the market, textiles modified with TiO_2NPs and TiO_2 doped with Ag are still on the level of research.

2 EXPERIMENTAL

2.1 Materials

Nanoparticles: TiO_2 and TiO_2/1%Ag nanocystalline powders synthesized in hydrothermal conditions, in one step was used for obtaining:

- stable solutions to be used in electrospray deposition. TiO_2 doped with 1.0% Ag was dispersed in 2 types of surfactants (PAAS- sodium salt of polyacrylic acid and PEI- polyethylene imine). The results indicated polyethylene imine was the best surfactant;
- preparation targets by compacting nanoparticle powders at 500^{0}C for sputtering deposition.

Textile substrates:

- Mihaela-Satin weave, 100% polyester (warp- shiny three lobe yarns, 76.3 den.; weft – matt microfilament yarns, 150 den), weight 133 g/m^2, for surgical gowns and drapes; symbolized 1s
- Perla-Crêpe weave, 100% polyester (textured yarns), 163 g/m^2 for covers and curtains used in public spaces; symbolized 2s
- Ivona –Combined pattern weave (vertical stripes), 100% cotton, 221 g/m^2, bed linen for hospital, home etc.; symbolized 3s;

Polyester fabric (PET) was used in this study because of special advantages and a wide range of applications in textile industry, especially for medical, sport, home and public areas.
Cotton fabric was selected for the experiments because its property to adsorb a large amount of moisture making this textile prone to microbial attack. With ambient temperature and humidity, cotton becomes a nutrient for bacterial and fungal growth.
Wood substrates:

- Oak, beech, cherry, linden Romanian species; symbolized L1, L2, L3, L4
- Oak and pine, Spanish species; symbolized L5, L6

The wood species were selected so to use outdoor and indoor or for art objects.

2.2 Samples preparation

Textile samples prior to any treatments were washed to remove any possible impurities which could adversely affect the fabric treatment.
Wood samples prior to any treatments were subjected to a drying process to remove moisture.
Rugosity and humidity are the only parameters usually provided by wood manufacturers. The optimum parameters for the experiments are 12% or less humidity and ideally rugosity is grit P150.

2.3 Nanoparticles deposition technology on the fabric and wood surfaces

2.3.1. RF magnetron sputtering deposition of NPs

The sputtering deposition take place in vacuum (2x10e^{-4} Pa) in argon flow. Prior to deposition, the samples were subjected to Glow discharge process, (a plasma treating process) for about 5 minutes for cleaning and activating the surfaces. The starting power was 50W and the working pressure was 2.3 Pa. The RF FWD power slowly increasing up to 200 W and maintaining the REF power for 10 minutes.

The sintered targets of TiO_2, TiO_2 /1% Ag and P25 Degusa TiO_2 (blank sample for results comparing) was bonding with an electrically conductive, silver-filled epoxy paste EPO-TEK E4110 on the copper backing plates. Bonding Sputtering Targets have some benefits as: the thickness of the target is reduced to half when it is bonded to a backing plate, transfer heat through a thinner thickness is faster, the target is in intimate contact with the conductive solder layer which draws the heat from the target surface and into the copper backing plate, bonded targets can usually continue to be used even after a target crack occurs, where typically an un-bonded target cannot.
The experiments was conducted with vacuum VU-2M equipment, up scaling with a TORUS 2'' HV circular sputtering source, R301 MKII radio frequency power supply, EJAT3 automatic matching network and EJMC2 matching network controller.
Wood samples were treated in the same manner as textile samples. The sputtering time was 10 minutes for all samples.

2.3.2. Electrospray deposition of NPs
Electrospray deposition is preceded by surface plasma treatment of textiles. Was used Dielectric Barrier Discharge (DBD) Plasma, non-thermal RF plasma with a gas discharge maintained between electrodes separated by a dielectric barrier. Atmospheric plasma cleans the surface from dirt or fat, decontaminates fabrics of the microorganism load and improves nanoparticles adhesion at textile surface by improving the soaking. The energy levels of the reactive species (typically 0.5-3eV) are similar to the chemical bonds energy level, thus it is possible to modify the bond structure of surfaces.
It was used a voltage generator working at a fixed 50 Hz frequency to excite the electrodes, at a high voltage up to 100 kV.
Was prepared two stable solutions for electro spray:
- one was prepared from TiO_2 powder doped with 0,5%mol Ag in a mixture solvent (water : Ethylic alcohol; 1.5:1) and as stabilizer the surfactant PAAS (salt of polyacrylic acid. Different voltage values, deposition distances and fluid rates were tested. Low deposition rates (1.6 ml/hour for 5 minutes) were used. The deposition was not homogeneous due to the high viscosity of the solution.
- other was prepared from TiO_2 powder doped with 1%mol Ag with reduced density of dilution by dispersing nanoparticles in water stabilizing them with NaCl and PEI.
Deposition condition: needle distance to the substrate-2,5cm; deposition time- 2.5 min/area; fluid rate- 3,6 ml/h. Samples were completely covered by nanoparticles but they present an intense brown color.

2.4 Analysis methods

2.4.1 Scanning electron microscopy (SEM) and EDX spectra
For Scanning Electron Microscopy analyze was used Quanta 200, FEI. The analysis applied on the treated fabrics indicate the nano TiO_2 particles loaded on the fabric surface and EDX spectra measures the weight percentages (W%) and atomic percentages (A%) of various detected elements on the treated samples.

2.4.2 Photocatalytic activity
The photocatalytic activity was evaluated by measurements of colorimetric coordinates of stained materials and degree of degradation. The stains was 0.02g/L Methyl Orange (MO) and 0.02g/L Methylene Blue(MB). The spotted materials have been exposed to artificial light according to standard ISO 105- B02:2013 in Apollo equipment with light fastness tester (power 2200W; simulate sunlight λ=300–700nm; moisture 45%; temperature 50^0C; the lamp radiation $42W/m^2$).

2.4.3 Antibacterial and antifungal activity
The bacterial properties were evaluated according to: SR EN ISO 20743:2013-Textiles. Determination of antibacterial activity of textile products (*Absorption* quantitative method -an evaluation method in which test bacterial suspension is inoculated directly onto samples); SR EN ISO 20645:2005 - Textile fabrics. Determination of antibacterial activity. Agar diffusion plate test – *qualitative method; ASTM E2149 – 10-* Standard Test Method for Determining the Antimicrobial Activity of Immobilized Agents Under Dynamic Contact Conditions (Method suitable for evaluating stressed or modified specimens after laundry, wear or abrasion, radiation, steam sterilization, UV exposure, temperature susceptibility)
The strains tested were: Fungal (Trichophyton interdigitale and Candida albicans); Gram-negative (Escherichia coli, Pseudomonas aeruginosa, Acinetobacter baumanii and Klebsiella pneumonia); Gram-positive: Enterococcus faecalis and Staphylococcus aureus)
Silver nanoparticles have high reactivity with proteins. They adversely affect cellular metabolism of bacteria and fungi, and restrain cell growth, along with decrease in respiration, basal metabolism of the electron transfer and the transport of the substrate into the microbial cell membrane. The act of the antimicrobial agent is affected by the kind of bacterium. The differences between gram-positive and gram-negative bacteria essentially rest in the structure of their respective cell walls. Gram-negative bacterium has an outer

layer, lipopolysaccharide, preventing silver nanoparticles penetration through the cell wall; hence, higher concentrations of silver nanoparticles are necessary.

2.4.4 Durability against washing

The durability of nano particles on the fabric surfaces after one washing cycle with EC was evaluate by comparison with the results of the initial sample, unwashed.

3. RESULTS AND DISCUSSION

3.1 Scanning electron microscopy (SEM) and EDX spectra

The presence of TiO_2 and the amount by mass of Ti and Ag on the surface of textile and wood substrate are shown in figure 1, figure 2, figure 3 and figure 4.

SEM images **EDX spectrum**

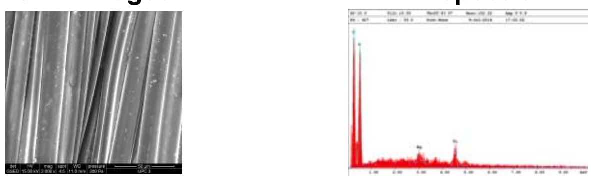
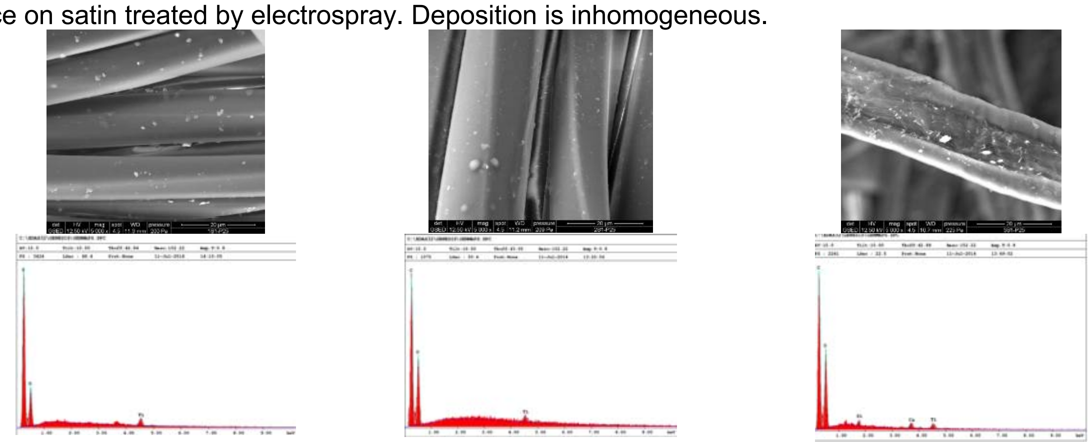


Figure 1: SEM and EDX images of satin samples treated by electrospray with TiO_2/1% Ag NPs

EDX spectrums are seen peaks characteristic for Ti and Ag. The chemical elements (e.g. C, O) present in the spectrum are due to organic compounds from textile fibers. Ti and Ag quantity is very small on the surface on satin treated by electrospray. Deposition is inhomogeneous.

SEM images

EDX spectrum



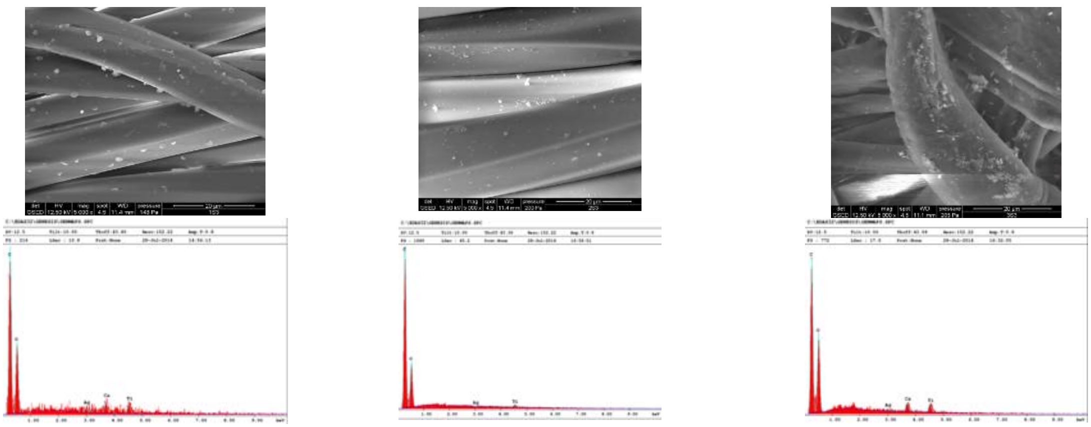
1s1 *2s1* *3s1*

Figure 2: SEM and EDX images of textile samples treated by sputtering with TiO_2 NPs

1s1 - the amount of Ti in layer is 5.62 % mass; 2s1 - the amount of Ti in layer is 4.78 % mass; 3s1 - the amount of Ti in layer is 3.35 % mass

SEM images

EDX spectrum



1s3 2s3 3s3

Figure 3: SEM and EDX images of textile samples treated by sputtering with TiO_2/1% Ag NPs

1s3- On the surface of sample the amount by mass of Ti is 9.3 % and Ag 4.72 %; 2s3- On the surface of sample the amount by mass of Ti is 3.45 % and Ag 0.59 %; 3s3 - On the surface of sample the amount by mass of Ti is 7.65 % and Ag 1.74 %

The amount of Ti and Ag NPs deposition on the substrate surfaces by sputtering depends on the chemical nature and weaving type of textile substrate. So, the satin which has a structure very compact the amount of NPs on the surface is greater than the crepe, although both are polyester.

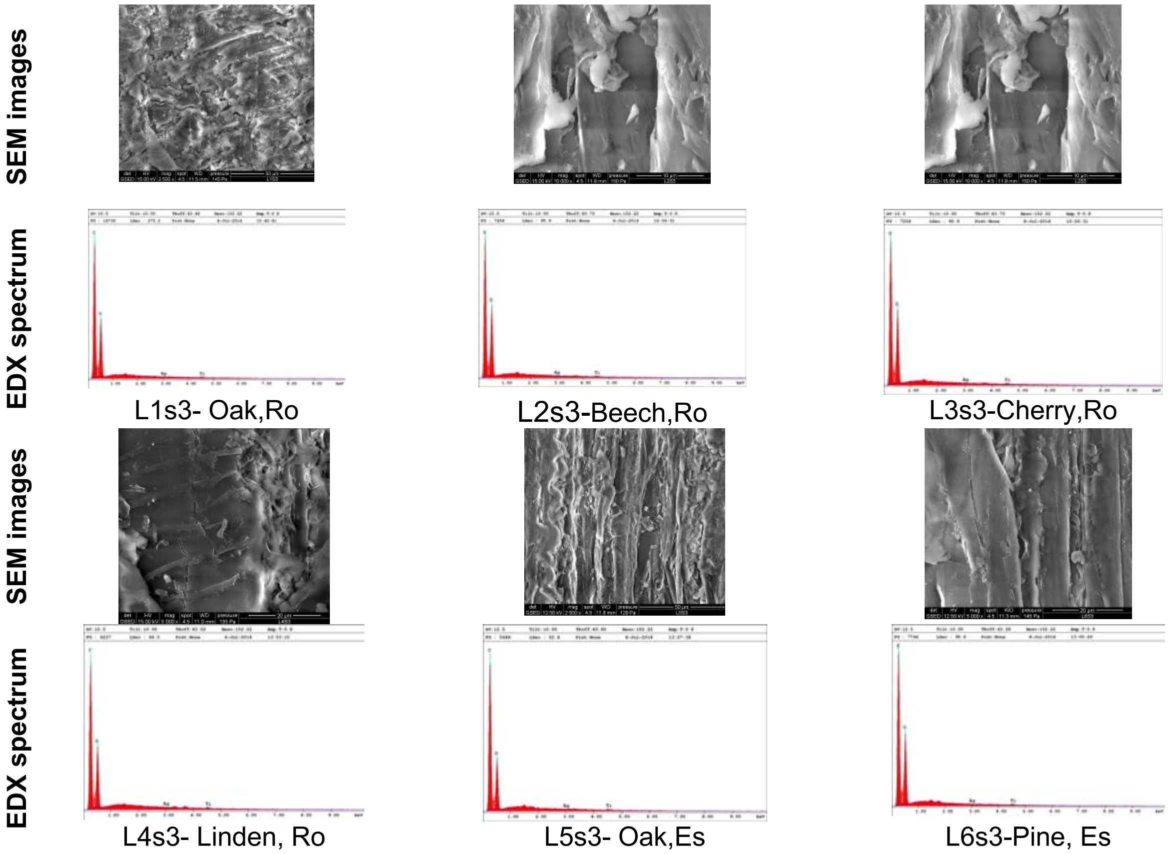


Figure 4: SEM and EDX images of wood samples treated by sputtering with TiO_2/1% Ag NPs

In EDX spectrum is observed absence of characteristic peaks for Ti and Ag, which not exceeding the noise spectrum (represented by the blue line along the spectrum). This does not confirm nor refute the Ag and Ti present in very low amounts (undetectable) analyzed surface. Other chemical elements (e.g. C, O) present in the spectrum are due to organic compounds from wood fibers.

3.2 Photocatalytic activity

3.2.1 Photocatalytic activity of textile samples

The textile samples were stained with methyl orange 0.02 % and exposed for 7 hours at Xenotest. The images of samples are presented in figure 5.

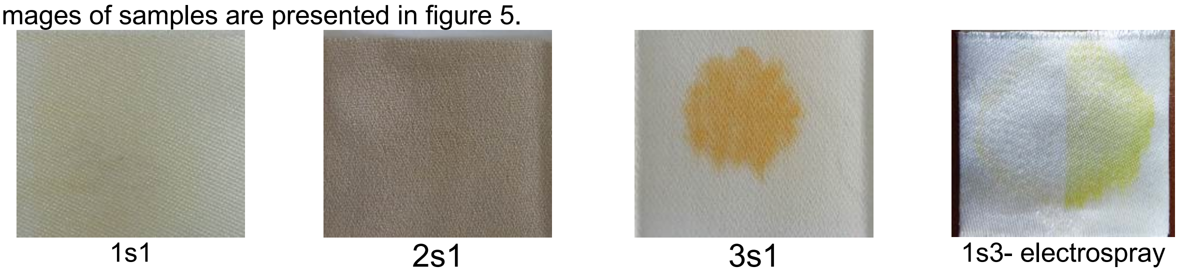


Figure 5: The images of stained material after exposure to artificial light

Satin and Crepe samples treated by sputtering with TiO_2 and TiO_2/1%Ag were stained hard and were completely cleaned after exposed for 7 h at Xenotest. Also, very good results were obtained on satin treated by electrospray. Plasma treatment applied to the fabric before electrospray and sputtering clean and activates surfaces material and contributes to a good depositions and effect of self-cleaning. Cotton samples treated by sputtering with TiO_2 and TiO_2/1%Ag were stained easily, extensively and cleaned very little after exposed for 7 h at Xenotest.

3.2.2 Photocatalytic activity of wood samples

The wood samples treated by sputtering with TiO_2 and TiO_2/1%Ag was stained with MO and exposed for 7 h at Xenotest. The images of stained wood samples after exposure to artificial light are presented in figure 6.

Figure 6: The images of stained wood samples after exposure to artificial light

Samples wood treated by sputtering was stained very hard. The stains were not cleaned and samples have gotten a grayish shade on the exposed side.

3.3 Antibacterial and antifungal activity

Comparison between Trichophyton interdigitale and Candida albicans in percentage and logarithmic reduction are presented in figure7.

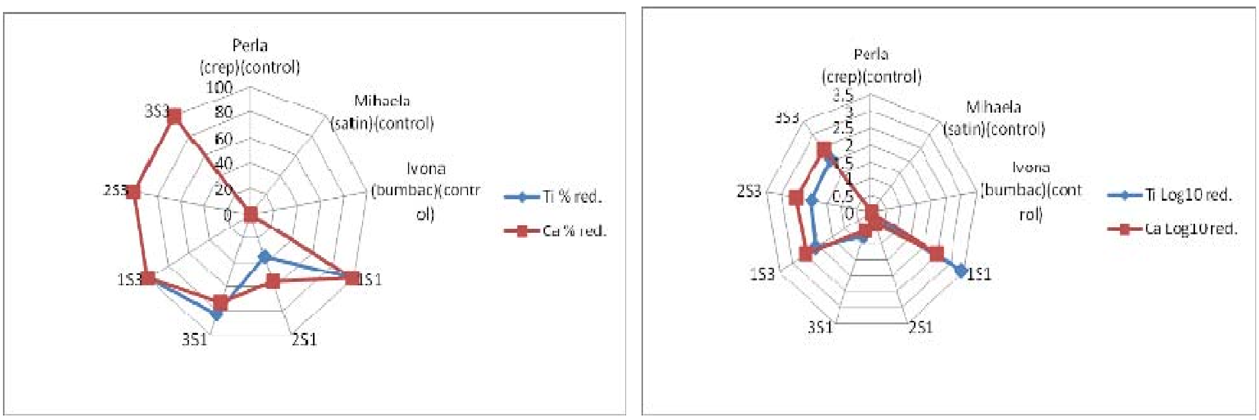


Figure 7: Antifungal effect: Comparison between Trichophyton interdigitale and Candida albicans.
a) Percentage representation of reduction; *b) Logarithmic representation of reduction.*

All samples treated with TiO_2 / 1% Ag present excellent antifungal reduction rates against both strains. Samples treated with only TiO_2 had reduction rates against the 2 fungal strains: 1s1 has 100% antimicrobial reduction rate against *Candida*; 2s1 have a reduction rate of 35% against *Trichophyton interdigitale* and 56.25% against *Candida albicans*; 3S1 have a reduction rate of 83% against *Trichophyton interdigitale and 73%* against *Candida albicans.*

The viable cell counts of microbial cells grown in liquid medium in the presence of different specimens were quantified at T0 (immediately after adding the textile specimens, T1 after 1 h and T2, after 24h). The obtained results were different, depending on the tested materials. The antimicrobial activity at different times of satin sample treated by sputtering with TiO_2 (1s1) and TiO_2 / 1% Ag (1s3) by comparison with control sample (C1) are presented in figure 8.

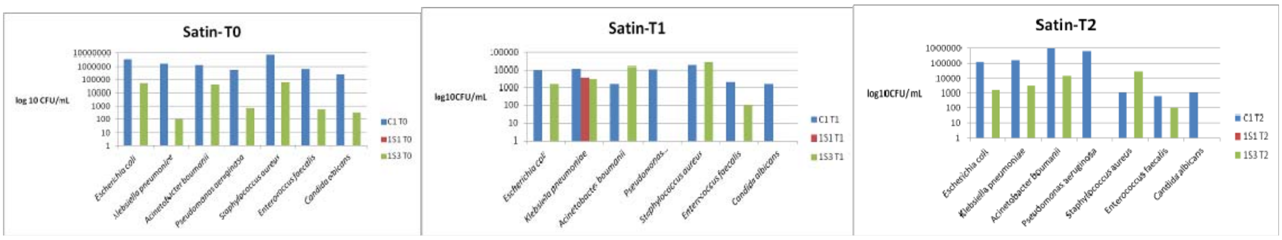


Figure 8: Antimicrobial activity at different times of satin sample treated by sputtering with TiO_2 and TiO_2/1%Ag.

At time T0 sample 1s1 completely inhibited the microbial growth of all tested microbial strains and sample 1s3 present also an antimicrobial activity against all tested microbial strain, but less intensive than the 1s1 compared with control sample (C1) At time T1 sample 1s1 presents good antimicrobial properties, completely abolishing the growth of all tested microbial strains, excepting *Klebsiella pneumoniae and 1s3* inhibited a little the growth of *E. coli, K. pneumoniae, P. aeruginosa, E. faecalis* and *C. albicans* except *Acinetobacter and Staphilococcus Aureus* compared with control sample (C1) At time T2 sample 1s1 presents good antimicrobial properties, completely abolishing the growth of all tested microbial strains, excepting *K. pneumoniae* 1s3 sample inhibited totally the growth of *P. aeruginosa* and *C. albicans.*

The antimicrobial activities at different times of crepe sample treated by sputtering with TiO2 and TiO2 / 1% Ag are presented in figure 9.

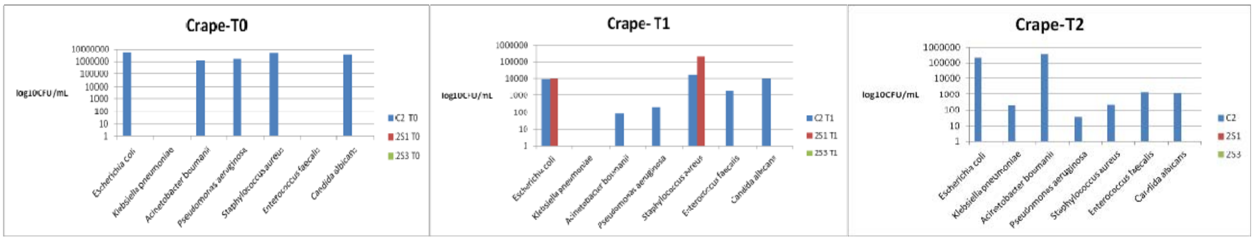


Figure 9: Antimicrobial activity at different times of Crepe sample treated by sputtering with TiO_2 and TiO_2 / 1% Ag.

At time T0: Samples 2s1 and 2s3 totally inhibited the growth of *Escherichia coli, Acinetobacter boumanii*, *Pseudomonas aeruginosa, Staphylococcus aureus* and *Candida albicans*, compared with the untreated control samples (C2). At time T1: Sample 2s1 inhibited, after 1h, the growth of *Acinetobacter boumanii, Pseudomonas aeruginosa* and *Candida albicans.* In exchange, in case of *Escherichia coli* and *Staphylococcus aureus,* the inhibitory activity of TiO_2 treated material was abolished Sample 2s3 maintained its inhibitory effect after 1h of incubation for all strains. At time T2, both samples 2s1and 2s3 totally inhibited the growth of the tested microbial strains. The antimicrobial activities at different times of cotton sample treated by sputtering with TiO2 and TiO2 / 1% Ag are presented in figure 10.

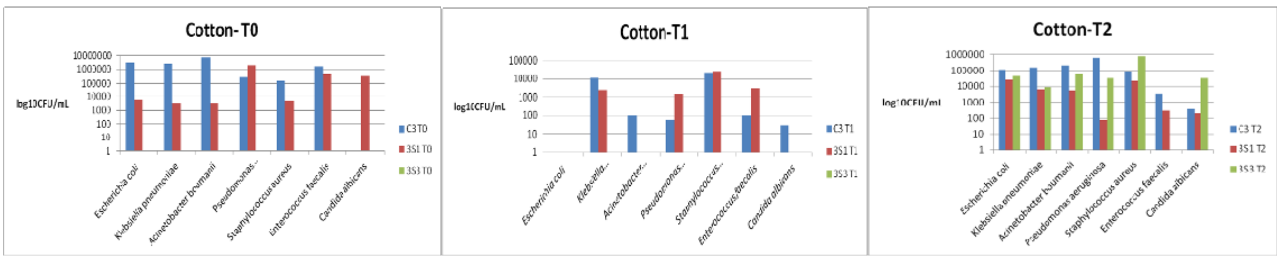


Figure 10: Antimicrobial activity at different times of Cotton sample treated by sputtering with TiO_2 and TiO_2 / 1% Ag.

At time T0 sample 3s1 exhibited a lower antimicrobial activity against all strains except *Pseudomonas aeruginosa* with lack of activity and 3s3 sample presents total inhibition of microbial growth**.** At time T1 the activity of 3s1 was maintained only against *Acinetobacter boumanii* and *Candida albicans* and 3s3 maintained the inhibitory effect for all tested strains. At time T2 the activity of 3s1 and 3s3 presents a lower antimicrobial activity except *Enteroccocus faecalis* that are totally inhibits the growth for 3s3. In case of *C. albicans* and *Staphylococcus aureus,* two of the most important nosocomial agents, the 3s3 sample promoted the microbial growth.

3.4 Durability against washing

Some of textile samples treated with TiO_2 and TiO_2 doped with Ag by sputtering and electrospray were washed in a single cycle with EC detergent after were stained with MO 0.02% and exposed to Xenotest for 7 hours. For comparison we worked in the same way with P25 Degussa.
The images of stained material after washing and exposure to artificial light are shown in figure 11.

1s1 2s1 2S1 with P25 1S3 1s3

Figure 11: The images of stained material after washing and exposure to artificial light
The results show that samples Satin and Crepe sputtering and electrospray with TiO2 and TiO2/Ag 1% were partially cleaned and samples Crepe sputtering with TiO2 P25 Degussa cleaned well.

CONCLUSIONS

1. Satin samples sputtering with TiO_2 and TiO_2/1% Ag presented a very well self-cleaning;
2. Crepe samples sputtering with TiO_2 presented a very well self-cleaning and samples sputtering with TiO_2/1% Ag the stain has partial cleaned;
3. On the Cotton samples the stains was slightly faded (discolored);
4. Samples wood treated by sputtering were stained very hard (what is desirable). The stains were not cleaned and samples have gotten a grayish shade on the exposed side;
5. The satin treated by sputtering with TiO_2 is 100% active against *Candida albicans* and of all tested microbial strains except *Klesbesiella pneumoniae;* The satin treated by sputtering with TiO_2/1%Ag reduced 100% *Candida albicans* and *Pseudomonas aeruginosa* and is inactive against *Staphylococcus aureus* and *Acinetobacter boumani*;
6. Crepe samples treated by sputtering with TiO_2 gives antibacterial effect against *Candida albicans;* Crepe samples treated by sputtering with TiO_2/1%Ag gives total inhibition of grow for *all strains*;
7. Cotton sample treated by sputtering with TiO_2 presents antimicrobial activity for all strains at T2; Cotton sample treated by sputtering with TiO_2/1%Ag gives total inhibition of grows for *all strains.*

The final conclusion is that the treatment technique and substrate should be selected according the application field.

ACKNOWLEDGEMENT
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DYEING OF POLYAMIDE FABRICS WITH A NATURAL DYE

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Abstract: *Recent years, concern for the enviroment has created an increasing interest in natural dyes. Taking into consideration the importance given to the enviroment, ecology and pollution control; it is told that natural dyes, that are non-toxic and obtained easily and safely, could be a good alternative to synthetic dyes. In this study, polyamide woven fabrics were dyed with red cabbage (Brassica oleracea var.ccapitata f.rubra). Pre-mordant and one-bath dyeing method was used. Aluminum sulfate, iron sulphate and copper sulphate as mordant were preferred for dyeing polyamide with red cabbage. Different mordant concentrations (1%, 2%, %3) were also applied Colorimetric properties of dyed polyamide fabrics were obtained CIELab values. Generally, samples have good wet fastness properties were obtained. According to the experimental results, it was found that red cabbage can be used in textile dyeing.*

Keywords: *textile, natural dye, mordant, polyamide*

1. INTRODUCTION

The textile processing industry is one of the major environmental polluters. Recently, there has been growing interest in using natural colorants for textile dyeing. The general belief is that natural colorants are more eco-friendly than synthetic dyes, exhibit better biodegradability and are more environmentally friendly. In order to process 1 t of textiles, 230-270 t of water may be required. This water could pollute the environment throughout dyeing and processing. To overcome these limitations, an alternative is to use natural colorants or dyes [1].

Natural dyes, according to the source that they are obtained, are classified as plant, animal and mineral dyes. Plants and herbs are the main sources of natural dyes and pigments are obtained from their trunk, bark, roots, leaves, seeds and shells. Vegetable dyes, are an indispensable part of natural dyeing because of both the majority of their numbers and the diversity of their color. Although natural dyes can be used in cotton dyeing, they are more common in wool. Synthetic fibers can also be dyed with natural dyes. Polyamide fibers are the most easily dyeable synthetic fibers with natural dyes due to having similar structure with wool. Although there are lots of studies on dyeing of wool fibers with natural dyes, there are limited articles in literature on dyeing of polyamide fibers with natural dyes[2].

The aim of this study is to optimize the fastness properties of polyamide fabrics dyed with red cabbage. For this aim mordanting method, mordant type and mordant concentration were chosen as variables in experiments and the most suitable mordanting method, mordant type and mordant concentration was determined according to the statistical evaluation.

2. EXPERIMENTAL

2.1 Materials

The red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*) is a sort of cabbage, also known as purple cabbage, red kraut, or blue kraut after preparation. Its leaves are coloured dark red/purple.

In this study, polyamide woven fabric (63 g/ m^2) was used. All experiments were carried out by using pure water. Three different mordanting agents; aluminium potassium sulfate dodecahydrate (AlK(SO4)2.12H2O), ferrous(II) sulfate heptahydrate (FeSO4.7H2O) and copper(II) sulfate pentahydrate (CuSO4.5H2O). were used. Different mordant concentrations (1%, 2%, %3) were also applied.

2.2 Extraction of dye

Red cabbage (*Brassica oleracea var.ccapitata f.rubra*) (100 g) was soaked 1 L water. Subsequently the solution was heated to boiling temperature and boiled for 2 hour and afterwards filtered.

2.3 Dyeing

100 ml of filtrated dye extract was used to provide the liquor ratio of 1:25 for 4 g material. Dyeing was carried out at extract solutions own pH value. Dyeing experiments were performed on Termal HT Dyeing Machine.Pre-mordant and one-bath dyeing method was used. The dyeing method used is shown *Figure 1* . and *Figure 2.* At the end of dyeing, the dyed sample was removed and rinsed throughly in tap water and allowed to dry in the open air.

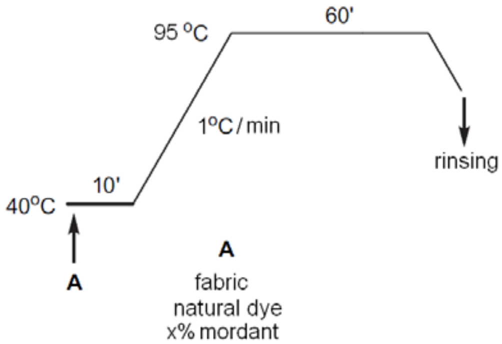


Figure 1: Dyeing method one-bath dyeing

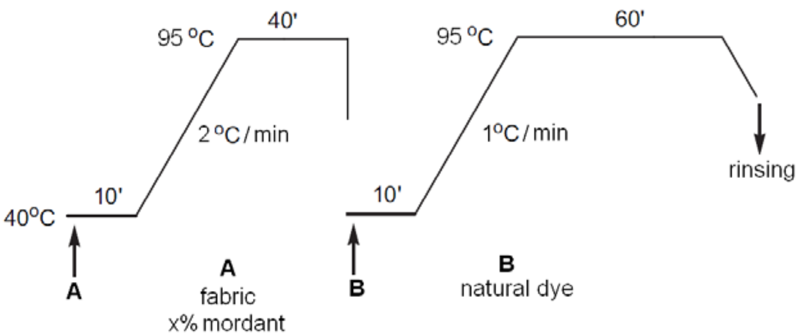


Figure 2: Dyeing method pre-mordanting

2.4 Measurement

Color characteristic values, L*, a*, b*, C*, h° of the dyed samples were evaluated by Gretag Macbetch Color-Eye 7000 A using an illuminant D65 and 10° standard observer. The dyed cotton fabrics were folded into two layers and four different positions were measured and averaged. L*, a*, b*, C*, h° are lightness, redness-greenness, yellowness-blueness, saturation and hue respectively.

Colorfastness to washing with detergent (ECE B) was evaluated according to ISO 105-C06:2010-A1S. Multifibre adjacent fabric (DW) was used and washed in detergent solution (4 g/L) at 40°C for 30 min. The staining of multifibre adjacent fabrics and colour change of the dyed cotton fabric samples were determined. Colorfastness to wet and dry rubbing were evaluated following ISO 105-X12:2001.

3. RESULTS and DISCUSSION

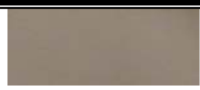
Washing and rubbing fastness values of dyed samples are listed below in *Table 1.*

According to the variance analysis, it was determined that while mordanting method has a statistically important effect on washing fastness for change in colour , mordant concentration and mordant type have not. As can be seen from *Table I*, while the worst results were obtained with one-bath mordanting method with iron sulphate. After the washing colour was fairly faded.

Table 1: Washing and rubbing fastnesses of dyed samples

	Mordant	Conc. %	staining						change in colour	Rubbing	
			Acetate	Cotton	Nylon	Polyester	Acrylic	Wool		Dry	Wet
	Without mordant	-	5	5	5	5	5	5	4-5	5	5
Pre-mordantig	Aluminum sulfate	1	5	5	5	5	5	5	3	4-5	5
		2	5	5	5	5	5	5	3	4-5	5
		3	5	5	5	5	5	5	3	4-5	4-5
	Copper sulphate	1	5	5	5	5	5	5	4-5	4-5	5
		2	5	5	5	5	5	5	4	4-5	4-5
		3	5	5	5	5	5	5	4	4-5	4-5
	Iron sulphate	1	5	5	5	5	5	5	3-4	3	2-3
		2	5	5	5	5	5	5	2-3	3	2-3
		3	5	5	5	5	5	5	2	2-3	2
Single bath mordanting	Aluminum sulfate	1	5	5	5	5	5	5	3	5	5
		2	5	5	5	5	5	5	3	5	4-5
		3	5	5	5	5	5	5	2-3	5	4-5
	Copper sulphate	1	5	5	5	5	5	5	4-5	5	5
		2	5	5	5	5	5	5	4-5	5	4-5
		3	5	5	5	5	5	5	4-5	4-5	4-5
	Iron sulphate	1	5	5	5	5	5	5	2	5	5
		2	5	5	5	5	5	5	2	5	4-5
		3	5	5	5	5	5	5	2-3	4-5	4

Table 2: Colorimetric data of dyed fabric

	Mordant	Conc. %	L*	a*	b*	C*	h°	Obtained colour
	Without mordant	-	75,23	1,41	10,42	10,52	82,29	
Pre-mordantig	Aluminum sulfate	1	75,32	1,58	9,98	10,10	81,01	
		2	79,94	1,29	7,65	7,76	80,40	
		3	79,34	2,04	9,57	9,78	77,98	
	Copper sulphate	1	75,23	3,74	13,91	14,41	74,94	
		2	73,70	4,47	15,57	16,20	73,98	
		3	73,99	4,76	16,08	16,77	73,52	
	Iron sulphate	1	68,93	9,78	23,10	25,09	67,05	
		2	70,48	8,53	21,97	23,57	68,78	
		3	65,75	13,45	25,81	29,10	62,48	
Single bath mordanting	Aluminum sulfate	1	77,07	0,36	5,90	5,91	81,33	
		2	78,18	0,58	3,83	3,88	81,33	
		3	78,15	1,06	5,15	5,26	78,42	
	Copper sulphate	1	70,28	4,79	17,66	18,29	74,83	
		2	69,74	4,07	17,95	18,40	77,22	
		3	69,32	3,67	17,63	18,01	78,24	
	Iron sulphate	1	63,16	1,99	8,87	9,09	77,36	
		2	64,00	1,13	8,24	8,31	82,19	
		3	62,60	1,49	9,47	9,59	81,08	

According to the variance analysis, it was determined that while mordanting method has statically important effect on dry rubbing fastness, mordanting concentration and mordant type have not. As can be seen from *Table 1* the worst results were obtained with pre-mordanting method with iron sulphate. Increasing the mordant concentration has a negative effect on wet and dry rubbing fastness values. The reason of this it thought to be the increase of the amounts which are bonded on to fibre surface when high concentration of mordant is used. These dye molecules that exist on the fibre surface will pass through the test fabric during rubbing fastness test.

As can be seen from *Table 2* by using red cabbage as natural dye colours were obtained on polyamide according to the mordant usage and its type.

4. CONCLUSIONS

In this study it was determined that that polyamide fabric can be dyed evenly with high washing and rubbing fastnesses by using red cabbage as a natural dye. According to the experimental test results and statistical evaluations, it can be concluded that the most suitable mordanting method is the one-bath mordanting method and the mordant concentration is 2% copper sulphate. Furthermore, samples dyed with red cabbage without using mordant also have good wet fastness properties. This is a very important point in terms of industrial applications, because it is avoided from the usage of mordants due to environmental pollution. If it is taken into account that the most important problem in dyeing with natural dyes is low fastnesses, it is thought that red cabbage which gives good wet fastness properties without the requirement of mordant can be a good alternative for dyeing polyamide fibers with natural dyes.

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MODIFIED ORGANIC PIGMENTS USED IN PRINTING OF COTTON FABRICS

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Abstract: *The organic pigments can change their colour under the influence of light, temperature or different chemical agents. The fastness of pigments depends on a series of parameters: the chemical structure of the pigment, the crystallization and the presence of stabilizing substancesThe paper had as an objective the properties improvement of the Yellow 17 pigment. In this way, the structure of the pigments has been changed through the treatment with different metalic salts. The synthesis of the new pigments was performed in alkaline medium under the following conditions: an aqueous solution of* $ZnCl_2$*,* $AlCl_3$ *and* Na_2SiO_3 *respectively was added to the pigment Yellow 17 pasted with 10 ml ethyl alcohol. The mixtures of pigment:* $ZnCl_2$*, pigment:* $AlCl_3$ *and pigment:* Na_2SiO_3 *respectively were stirred for 8 h. The pigments obtained in this way were filtered, washed with distilled water and dried at* 80^oC*. The modifications that appear in Yellow 17 pigment structure, through the treatment with metalic salts, were revealed by UV-visible diffuse reflectance and EDX analysis. The initial pigment and the modified pigments have been used in printing of the cotton samples which were cleared and bleached before. After printing, the samples were dried at 100°C. The colour changes which appear after the pigment treatment with metalic salts have been evaluated through the colour strengths and colour differences (highlighted by* ΔE^**,* ΔL^**,* ΔC^* *and chromatic parameters* Δa^**,* Δb^**) were also highlighted*

Keywords: *organic pigments, cotton fabric, colour measurements, light fastness*

INTRODUCTION

For fabrics and knits from native and regenerated cellulose fibers, the pigments printing is widely used nowadays, replacing the traditional printing method with vat dyes [1,2].

Permanent printing of pigment is very important from practical point of view for the manufacturer, as well as for the consumer. The colour fastness of textile fabrics printed with organic pigments depends on a series of parameters: the chemical structure of the pigment, their crystallization form and the printing paste composition [3-5]. The changes of textile materials properties can occur due to their exposure to light. The utilization of some compounds containing zinc, cerium and titanium can be considered as promising materials for UV protection [6- 10].

The aim of this paper is the modification of Yellow 17 pigment's structure, by treatment with metal salts ($Al_2(SO_4)_3$, $ZnCl_2$ şi Na_2SiO_3 in order to improve their properties and their using in printing cotton fabrics.

EXPERIMENTAL PART

1. The synthesis of the pigments

The synthesis of the new pigments was performed in alkaline medium under the following conditions: an aqueous solutions of $ZnCl_2$, $Al_2(SO_4)_3$ and Na_2SiO_3 respectively, were added to the pigment Yellow 17 pasted with 10 ml ethyl alcohol. The mixtures of the pigments: $ZnCl_2$, $Al_2(SO_4)_3$ and also the Na_2SiO_3 pigment were stirred for 8 hours. The pigments obtained in this way were filtered, washed with distilled water and dried at 80^oC. The working conditions are presented in Table 1.

Table1. The working conditions

Samples (Pigments)	Pigment Yellow 17 (moles)	$ZnCl_2$ (moles)	Na_2SiO_3 (moles)	$Al_2(SO_4)_3$ (moles)	NaOH (moles)
Zn1	0.003	0.006			0.005
Zn2	0.003	0.009			0.005
Al1	0.003		0.006		0.005
Al2	0.003		0.009		0.005
Si1	0.003			0.006	0.005
Si2	0.003			0.009	0.005

2. The printing of cotton textile with pigments

100% cotton samples cleared and bleached have been printed with pigments (the initial pigment and the complexed one), dried at 100^{0}C and condensated at 150^{0}C for 5 minutes. The paste used at printing has the following composition: pigment (3g), Sera Binder MHCD (15 g), Sera Print MPHC (2,3 g), Sera Foam M58K (1 g), Sera Soft MSIW (1.5 g), Sera Fast MLF (2 g) and water (75,2 g).

RESULTS AND DISCUSSIONS

1. Pigments analysis

The modifications that appear in the structure of the pigments Zn1, Zn2, Al1, Al2, Si1 and Si2 were assessed through the UV-Vis and EDX analyses.

1.1. UV-Vis analyses

The UV- visible diffuse reflectance spectra were measured with Shimadzu UV-2450 spectrophotometer equipped with an integrating sphere assembly. The obtained results are shown in Figure 1.

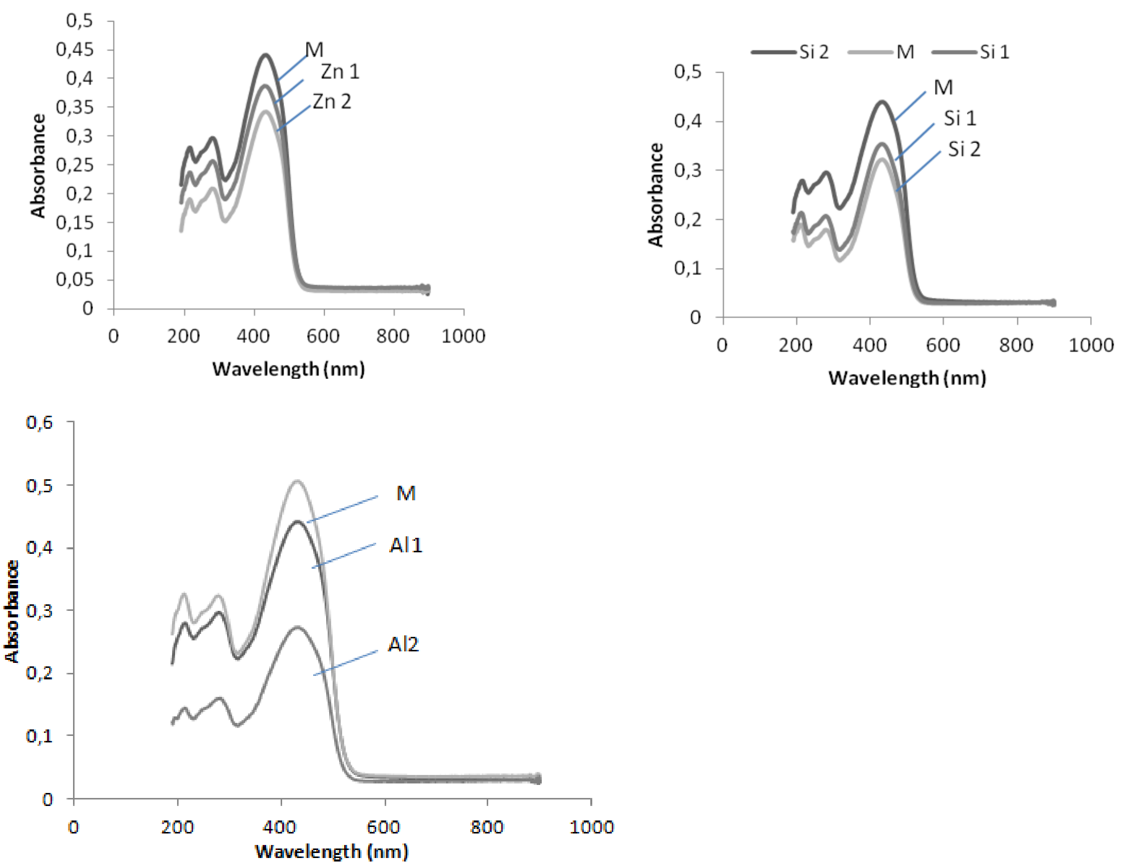


Figure 1. UV-Vis spectra of pigments

The hypochromic effects that appear in the case of the pigments modified by treatment with $ZnCl_2$, $Al_2(SO_4)_3$ and Na_2SiO_3 can be explained through the interaction between the Zn^{2+} and Al^{3+} ions with the auxochrome/chromophore groups of the pigment(in the case of its treatment with $ZnCl_2$ and $Al_2(SO_4)_3$), and respectively the formation of a thin film around the pigment treated with Na_2SiO_3.

1.2. EDX analyses

The EDX analyses were carried out with Quanta 200 (Fei) scanning electron microscope coupled with an energy dispersive X-rays analyzer. Samples were prepared by dispersing dry pigment on copper support and coated with gold by cathode deposition using an EMITECHK 550 apparatus.
The percentage composition of the synthesized pigments is shown in table 2.

Table 2. EdX analysis

Element	*Wt%*	*At%*
CK	70.25	80.10
NK	6.81	6.66
OK	11.17	9.56
ZnK	4.87	1.02
ClK	6.90	2.66

Pigment Zn1

Element	*Wt%*	*At%*
CK	67.11	78.38
NK	7.40	7.41
OK	11.25	9.87
ZnK	7.14	1.53
ClK	7.10	2.81

Pigment Zn2

Element	*Wt%*	*At%*
CK	71.72	80.07
NK	05.51	05.28
OK	12.83	10.75
AlK	01.24	00.62
ClK	08.70	03.29
Matrix	Correction	ZAF

Pigment Al1

Element	**Wt%**	**At%**
CK	70.99	78.81
NK	06.20	05.90
OK	14.17	11.81
AlK	01.73	00.85
ClK	06.18	02.32
Matrix	Correction	ZAF

Pigment Al2

Element	*Wt%*	*At%*
CK	72.78	81.01
NK	7.37	6.94
OK	10.05	8.28
SiK	2.53	1.18
ClK	7.27	2.59
Matrix	Correction	ZAF

Pigment Si1

Element	**Wt%**	**At%**
CK	71.48	80.68
NK	7.39	6.93
OK	10.03	8.27
SiK	3.83	1.48
ClK	7.27	2.64
Matrix	Correction	ZAF

Pigment Si2

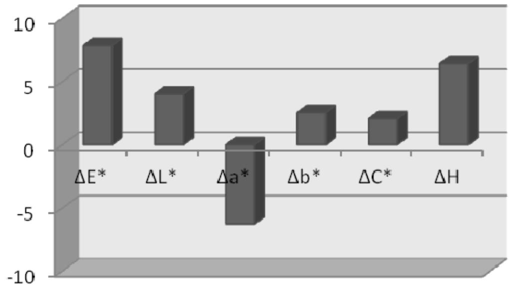
The obtained results indicate the presence of zinc, aluminum and silicon, respectively, in the composition of studied pigments, the embedded amount depending on the concentration of salt used in the treatment.

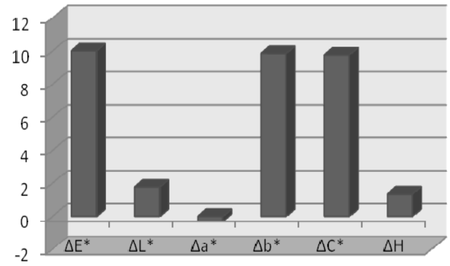
2. The printing of cotton fabrics

The synthesized pigments were used to print 100% cotton fabrics.
The printing materials have been analyzed from the point of view of the color change, the washing fastness and rubbing fastness,the UV fastness radiations.
The color changes that appear for the samples printed with the pigments modified by treatment with metal salts compared to the samples printed with the pigment unchanged, were assessed by chromatic parameters (figure 2).

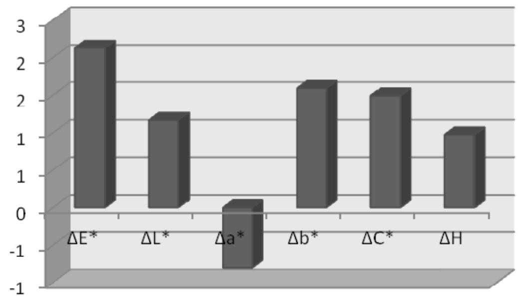
The results shown in Figure 2 show that the samples printed with pigments modified by treatment with $ZnCl_2$, $AlCl_3$ and Na_2SiO_3 are greener, more yellow and brighter compared to the unmodified pigment printed sample.
The printed fabrics have been analyzed from the point of view of washing fastness and rubbing fastness. [].
The rubbing fastness was assessed as color differences between the intensity of samples on which the pigment gave up color by rubbing and the intensity of the white samples.
The washing fastness was highlighted by the color changes of the printed samples which appear after washing(as color difference between the washed and unwashed printed sample) and by giving up pigment

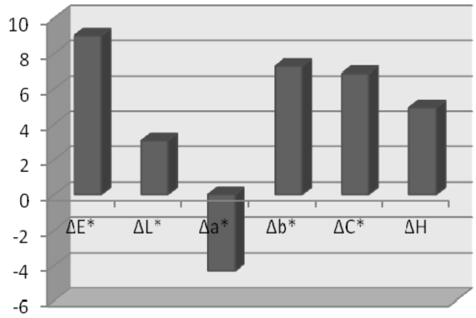
on the white fabric(as color difference between the sample that gave up the pigment by washing and the white sample).The obtained results are shown in the table 3



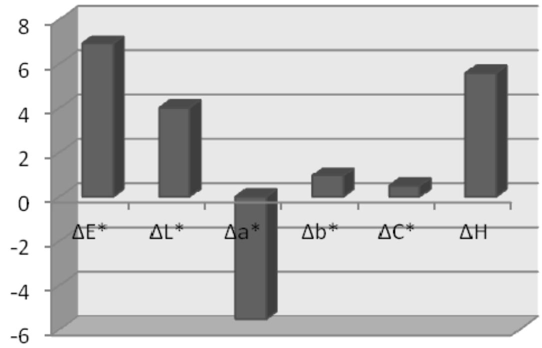


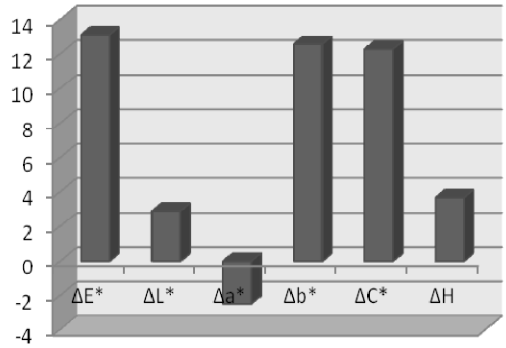
Al2 Al3
a.





Zn2 Zn3
b.





Si2 Si3
c.

Figure 2. The chromatic parameters for the samples printed with the synthesized pigments

Table 3. Washing fastness and rubbing fastness

Sample	Rubbing fastness		Washing fastness	
	dried	wet	Color change	Giving up on the white sample
Al1	0.82	0.90	2.571	1.317
Al2	0.79	0.87	2.245	1.069
Zn2	0.89	0.97	1.415	0.912
Zn3	0.86	0.95	1.295	0.688
Si2	0.94	0.89	2.977	1.474
Si3	0.92	0.84	2.554	1.455
M	0.95	1.07	2.869	1.578

By analyzing the results, one can see an improvement of rubbing fastness, especially to the wet rubbing fastness,for the samples printed with the modified pigments by treatment with aluminum salts. Regarding the washing fastness, the better results were obtained for samples printed with the modified pigments by treatment with zinc chloride.

The behavior of the pigments up against the UV radiations

The changes that appear after the UV irradiation of the fabrics printed with the studied pigments are shown as color difference between the irradiated sample and non-irradiated one, depending on the duration of irradiation (Figure 3).

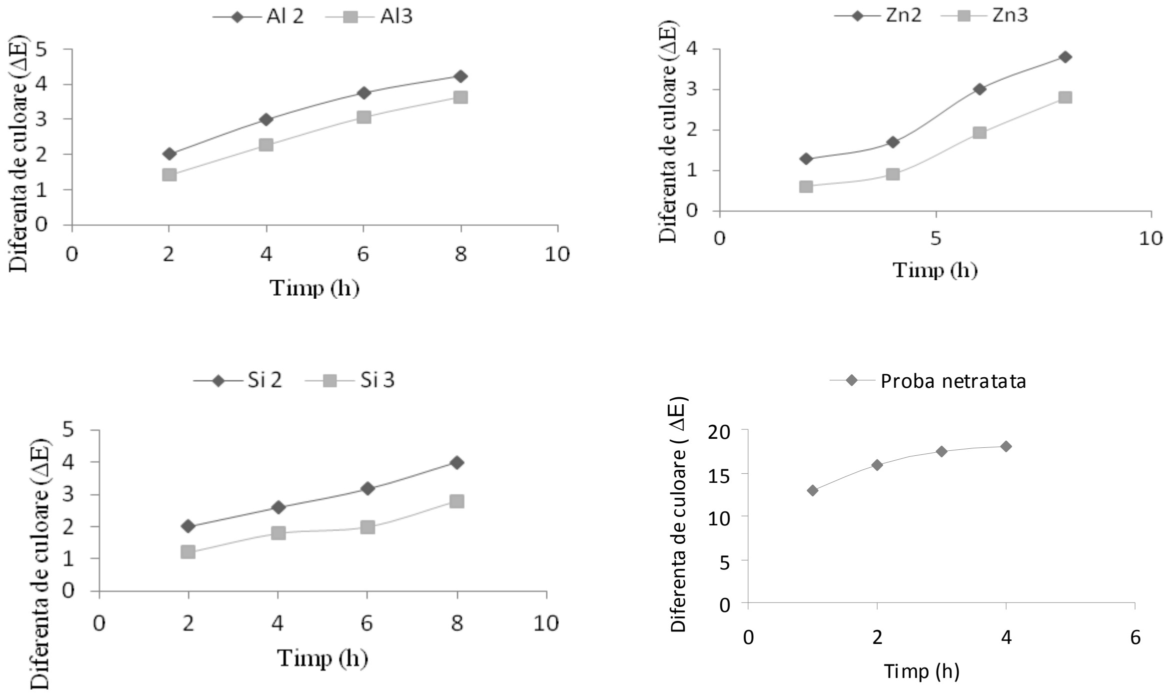


Figure 3. The color difference between the irradiated and the non-irradiated samples

The colour difference increases by the enlarging the irradiation time which indicates that the pigments photostability is changed in time.
According to the obtained results it can be seen that the samples printed with modified pigments show better resistances to UV radiation, compared with the printed sample with unmodified pigment.

3. CONCLUSIONS

The new pigments were synthetised by the treatment of pigment Yellow 17 with zinc chloride, aluminium sulphate and sodium silicate . The presence of zinc, aluminium and silicon in the obtained pigments was confirmed by EDX analyses. The modifications that appear in the structure of the pigment were highlighted by UV-Vis analysis and chromatic measurements. The cotton fabrics printed with the synthesized pigments show better UV fastness radiations.

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OPTIMIZING THE WASHING OF THE FLAKES FROM POLYETHYLENETEREPHTALATE

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Abstract: *The recovery of PET waste, represents the highest challenge, and not only in economic realization regarding the collecting of material sufficiently segregated to make the recycling viable. Because PET bottles contain many additives, which pollute the environment, before their recycling, it is necessary to wash them. After washing the PET flakes were analyzed, being appreciated the efficiency of the washing process by measuring the whiteness degree and final carboxyl groups from the polyester. For research, the experiments were made according to a mathematical optimization program, factorial program with two independent variables, central, rotatable compound of second order, considering independent variables X_1 is NaOH concentration 50%, cm^3/L and X_2 is period of washing, minutes. The graphs obtained using the Matlab program can be considered working monograms (diagrames) and can be used in the washing process of the flakes obtained from polyethyleneterephtalate bottles.*

Keywords: *washing process,flakes, poliethilenetereftalate,optimization*

INTRODUCTION

The ployethyleneterephtalate represents one of the most used polymers in the industry because of its high performances, low costs and recycling possibilities. Its use on a high scale in the food industry had as a consequence the production of an impressive number of packing (tanks, bottles, boxes, films, etc), which, after being used, turn into waste. [1-3]. Annually, worldwide, are used about five billion bottles mode of plastic, obtained from PET, which can`t be reused. This thing is forbidden not only by the hygiene requirements demended by the consumer protection rules, but also because of the degradations that happen al molecular level. The recycling of the PET waste, is a current problem and for its solving were elaborates many procedures and technics. [4-6].

Polyethleneterephtalate materials (PET) that are being used, have the highest percentage in the waste category from the last decodes. Because of the significant utilization of PET bottles, also appeared environmental problems all over the world. PET-s become waste very fast because of their short period of life. Packing waste don`t represent a high risc for the environment, yet, they raise segregation problems because of the volume they occupy. They can remain in the nature hundreds of years before degrading. For this purpose, it is necessary to organize the sorting and the collecting of the plastic waste and also to separate waste into categories [7-9].

The recovery of PET waste, represents the highest challenge, and not only in economic realization regarding the collecting of material sufficiently segregated to make the recycling viable. Because PET bottles contain many additives, which pollute the environment, before their recycling, it is necessary to wash them.
After sorting the PET-s, which is made according to a series of criteria (the important being their colour), the technological flow on mechanic recycling has the next stages: prewashing, chopping, washing, spinning, final drying.

EXPERIMENTAL PART

The research was made on PET flakes obtained from SC Greenfiber SA Buzau. The washing was made with next fleet composition:

- •3 g/L WBL Rucogen
- •X cm^3/ L NaOH 50% sol

•fleet washing temperature 85^o C
•fluctuating time periods (between 5- 40 minutes)

After washing, followed a rinsing with warm and cold water. In the end, the PET flakes were analyzed, being appreciated the efficiency of the washing process by measuring the whiteness degree and final carboxyl groups from the polyester.

The determination of the degree of white (whiteness)

The whiteness degree was appreciated through remission measurements, on a 300® Spectraflash spectrophotometer, from DATACOLOR, and then, using the Micromath 2000® program, was determined the whiteness degree. The analyzed samples, after being washed and dried, were submitted to a thermal treatment for 60 minutes at 190^o C, after that they were measured. The impurities left on the polyester material change its colour, contributing to the decreasing of the whiteness degree.

The determination of the carboxyl groups content

The content of the carboxyl groups was determined through the volumetric method on washed and dried samples, following the next procedures: in a glass with a stopper that contains 100 cm^3 NaOH solution, 0,01 M, are added about 0,1 g fibers (weighted on an analytical balance with an accuracy of for decimal). The content is stirred about 60 minutes, and then are taken samples from that solution (about 20 cm^3) and is titrated with 0,01 M HCl solution in the presence of phenolphthalein used as indicator. The obtained results are an average of three determinations for each sample. The carboxyl group content is determined using the next formula:

$$COOH\% = 5\,\frac{(V_{NaOH} * C_{NaOH} - V_{HCl} * c_{HCl})}{m(1-w)} \qquad (1)$$

Where: V_{NaOH} is the NaOH volume taken from titration, cm^3; V_{HCl} is the volume taken from titration,cm^3;C_{NaOH} is the molar concentration of the NaOH solution, mol/dm^3; C_{HCl} is the molar concentration of the HCl solution, mol/dm^3; m is fiber mass, g; w is fiber umidity, %.

For research, the experiments were made according to a mathematical optimization program, factorial program with two independent variables, central, rotatable compound of second order, considering independent variables (x_i) [10-13].
X_1 is NaOH concentration 50%, cm^3/L;
X_2 is period of washing, minutes.

The variation limits of independents variables was chosen to contain the whole domain possible to be accomplished from the technical point of view (table 1).

Table 1. The variation limit of the independent variables

enacted value / real value	-1,414	-1	0	+1	+1,414
X_1 (ml/L) NaOH 50%	0	4,39	15	25,61	30
X_2(min) washing period	5	10,12	22,37	34,74	40

As independent variables (purpose functions), noted with y, were considered:
Y_1 is the whiteness degree of the washed samples
Y_2 is the waste content of the final carboxylic groups of the flakes from the washed PET-s.
The functional relation between independent and dependent variable is an equation of regression, having the next form:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_{12}X_1X_2 + b_{11}X_1^2 + b_{22}X_2 \qquad (2)$$

The experimental plan and results are presented in table 6.

Tabel 4. The experimental plan and obtained results

Nr. exp.	Independent variables		Dependent variables	
	X_1	X_2	Y_1	Y_2
1	-1	-1	62,4	1,83
2	1	-1	60,4	1,85
3	-1	1	64,5	1,83
4	1	1	77,4	2,5
5	-1,414	0	42,1	1,80
6	+1,414	0	62,1	3,2
7	0	- 1,414	48,9	2,0
8	0	1,414	67,5	3,1
9	0	0	71,8	1,88
10	0	0	70,4	1,90
11	0	0	73,2	2,10
12	0	0	69,5	1,75
13	0	0	68,1	2,0

Statistical analysis of the equation of regression

The coefficients of the equation of regression were calculated based on the experimental data presented in table 6, using the smallest square`s method. Mathematical models were analysed statistically, by verifying the meaning of the coefficients, using the student test adequancy of the model using the Fisher test. In this way, were obtained the regression equations for the wanted features, their coefficients being written in table 7.
The obtained equations of regression were platted by response surfaces-constant level curves and are presented in fig 1-2.

Table 6. Experimental plan and the obtained results

Coefficient / variable y	b_0	b_1	b_2	b_{12}	b_{11}	b_{22}
Y_1	70,60	4,8975	5,6751	3,725	-6,4938	-3,4438
Y_2	1,9260	0,3337	0,2757	0,1625	0,1564	0,1814

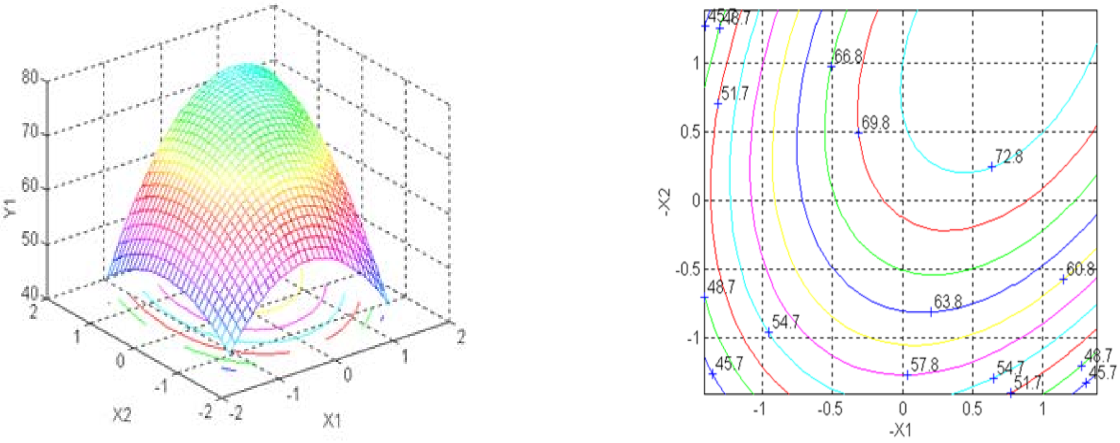
The significance of the purpose functions was tested with the "t" test (Student), being eliminated in this way, the unsignificant ones. The verification of the adequancy of the mathematical model, was done by calculating the value of the Fisher test, F [14-16].

5.The interpretation of mathematical models

The proposed mathematical model was plated using the Matlab program. The highlighting of the significant factors interaction`s effects on the proposed function (y_i) was realized by drawing the response surfaces and the constant level curves which represent the values of the dependent variables,
There are drown plan and space curves, from which the obtained values of the purpose function can be analysed and interpreted. In the end, can be calculated the optimum values of the independent variables and of the purpose function, and by transforming the coded values into real ones, are obtained the work parameters values to achieve the wanted values optimum.

5.1. The modification of the degree of white

The whiteness degree measured in the washed samples, gives a series of information about the ability to remove impurities from the PET flakes subjected to washing. A higher whiteness degree can indicate a more advanced removal of the impurities. The variation of the whiteness degree is presented in figure 1.



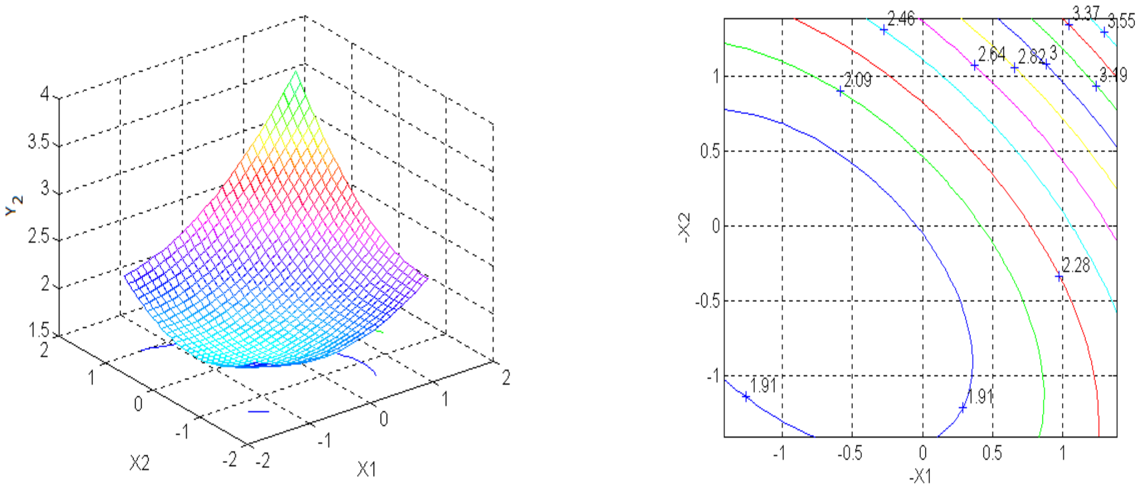
a. b.

Figure 1. The variation of the whiteness degree depending on the washing conditions (y_1): a. response surfaces; b. constant level curves.

From the figure, it results that both independent variables influence the degree of white, but the variation of the NaOH (x_1) is more pronounced than the washing period (x_2). By analyzing the constant level curves (fig.1b), one can observe that for a whiteness degree higher than 70%, the NaOH concentration used for washing is between -0,35 ÷1.414 (z_1= 11.287 ÷ 30cm^3 NaOH 50%) and the treatment period between -0.3 ÷ 1.414 (z_2 = 18.65 ÷ 40minutes). For the same whiteness degree can be chosen smaller NaOH concentrations and higher period for the washing process or the other way around. In this way, can be chosen pairs of values of those two variables for obtaining the desired whiteness degree.

5.2. The content of the final carboxyl groups

During washing, the sodium hydroxide has a crucial role in removing the impurities from the polyester flakes. In the first stage, takes place the saponification of some impurities and then, along with the used tensed the dislocation is done, the removal being realized by mechanical stirring, which usually accompanies the washing. In the same time with the saponification of some impurities, the sodium hydroxide reacts with the macromoleculare chains from the polyester, hydrolyzing same ester links, so, at the appearance os some additional carboxyl and hydroxyl groups. Through this attack, it happens a reducing of the macromolecular chain length, so, a degradation. According to literature data, as the carboxyl group content is higher, as more advanced degradation happens during the washing process, through saponification of the polyethyleneterephtalate under the action of NaOH [17].
The variation of the carboxyl groups is presented in figure 2.



a. b.

Figure 2. The variation of the carboxyl groups (y_2): a. response surfaces; b. constant level curves.

From figure 2, one can observe, as expected, a continue increase of the carboxyl groups along with the treatment concentrations growing and in a less extent of the duration.
At small concentrations of used NaOH in the washing process, until the central position zone of the experimental (area) domain (until x_1=+0,3), the content of the carboxyl groups has a small increase and is situated around 1,91 (z_1= 18,18 ml/L NaOH 50%). Next, by raising the NaOH concentration, the content of the carboxyl groups grows rapidly, and at the end of experimental domain x_1= 1.414 and x_2= 1.414, reaches the value.
Tacking into consideration the values obtained after calculating the stationary points, for obtaining the most efficient washing process, with the less degradation of the polyethylterephtalic polymer, I consider that the calculated values for the central zone of the experimental domain, when is obtained a whiteness degree correspond to the requirements:

$X_1 = 0 \rightarrow z_1 = 15\ cm^3/L$ NaOH 50%
$X_2 = 0 \rightarrow z_2 = 22{,}37$ minutes
$Y_1 = 70{,}6$ %
$Y_2 = 1{,}92$ %

6. CONCLUSIONS

The obtained results after the mathematical modeling of the washing of the polyethyleneterephatalate flakes, using the factorial central rotatable compositional program of 2^2, led to the next conclusions:
● were established mathematical expressions for those two proposed functions y_1- whiteness degree and y_2- the content of the final carboxyl groups.
● were validated the coefficients ant the proposed mathematical models using then ”t” test (Student) and the Fisher test.
● were obtained the best values of the purpose function which correspond to a maximum for function y_1 and to a minimum for function y_2.
● the graphs obtained using the Matlab program can be considered working monograms (diagrames) and can be used in the washing process of the flakes obtained from polyethyleneterephtalate bottles.
Are being proposed the next conditions for the washing process:

- 3g/l Rucogen WBL;
- 15 cm^3/l NaOH sol 50%;
- Fleet washing tempersture, 85^{0}C;
- time 22,37 minutes.

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Scholarly communication paper

INSPIRATION FROM NATURE: NATURAL DYES

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Abstract: *From ancient times, humans have been interested in improving their appearance by using colours. For this, Nature provides a wealth of plants which will yield their colour for the purpose of dyeing, many plants and flowers were used since antiquity to dye textiles.*
All of the natural dyes from nature can be found in a broad range of natural sources, such as plants, roots, stems, bark, leaves, berries, flowers, fungi (lichens and mushrooms), insects and molluscs.
Nowadays, natural dyes are gaining popularity all around the world for their use in textiles and are becoming more of interest due to environmental concerns.
Also, natural dyes are seen as an important ecologically sensitive alternative, an example of traditional wisdom that acknowledges the delicate balance between humans and Nature, and offer opportunities for future development.

Keywords: nature, colour, natural dyes, plants, natural sources

INTRODUCTION

For a greener world and a sustainable economy it is necessary to return to the nature and to all that it gives us, like natural dyes. Nature manifests itself in a wide spectrum of rainbow colours, the whole spectrum of colours can be obtained from a multitude of plants, flowers, insects, animals and minerals [1,5]. In this sense, natural dyes is like a gift from nature and can make the whole world more colorful.

REVIEW OF LITERATURE

The Textile Industry is one of the most chemically industries and also the biggest environmentally polluting industries. During the last period, there has been a real trend to revive the art of dyeing with natural dyes because natural dyes are advantageous compared to synthetic dyes.
Therefore, the pollution problems in synthetic dyes and pigments industry, the whole world is oriented towards to the manufacturing and uses of natural dyes and pigments [6].

In this moment, natural dyes are being mostly used by academic institutes, research associations or laboratories, traditional dyers and printers, hobby groups or designers and also by the industry.
The use of natural dyes for the dyeing of textiles has mainly been confined to small scall dyers and printers and craftsman [5,11,12]. Worldwide, are several small textile companies which using for dyeing textiles natural dyes, but India is still a major producer of most fabrics and textiles dyed with natural dyes [4,5].
To prevent environmental pollution and also to achieve ecological textiles, in the last period they have started looking at the possibilities of using these natural dyes on regular basis in dyeing and printing textiles [13].

Knowing the applications of natural dyes both in textile coloration and in antimicrobial finishing of textiles, UV protective cloth, antifeedant finishing of textiles, deodorizing finishing, food coloration, cosmetics and pharmaceutical, pH indicator, histological staining and dye sensitized cells.

Natural dyes are known for their use, but for use at industrial scale, the supplies must guarantee their quality. There are a small number of companies that are known to produce natural dyes, in this case, we can mentione some examples of the supply, including *Allegro Natural Dyes* in USA, which produce natural dyes under the Ecolour Label fir the textile industry, *Rubia Pigmenta Naturalia* in the Netherlands [7], which produces concentrated liquid or powdered colorant from madder, and in France can be mentioned *Couleurs de Plantes* [8] , which produces powder or liquid colorants from a wide range of dye plants, *consortium Bleu de Lectoure/CAPA/CATAR* [9], which producing indigo from woad, in Germany *Livos Pflanzenchemie*

Forschungs and *Entwicklungs GmbH*, and also *CON - Colors of Nature-Farben der Natur GmbH* in Austria [10].

In collaboration with the textile companies which use their products, *Rubia Pigmenta Naturalia* from Netherlands and *Couleurs de Plantes* from France have developed standardised processes for the use of their extracts and sell these together with precise descriptions of dyeing formulas and procedures, and also develop optimised processes for special applications. Another important aspect is that the *Couleurs de Plantes* offers a range of extracts, of different colours.

At this moment, there are several marks private of ecological certification, like *Ecotex, Swan White, Oekotex* and international standards, like *G.O.T.S (Global Organic Textile Standard), Soil Association (SA,UK), Internationaler Verband der Naturtextilwirtschaft (IVN, Germany), Organic Trade Organisation (OTA, USA)*. These standards for ecological textiles cover all the production, manufacturing, packing, labelling, exportations, importation and distribution.

Recently, natural dyes derived from nature, have emerged as one of the most important alternative to synthetic dyes, and beside this, application of natural dyes is growing at large scale in the textile industry and also in other industries.

NATURAL DYES

The word *"natural dye"* covers all dyes derived from the natural sources like plants,animals and minerals.
Natural dyes can be found in a broad range of natural sources (plants, roots, stems, bark, leaves, berries, flowers, fungi, insects and molluscs.

Since ancient times, natural dyes have been used by humans for colouring, dyeing and printing fabrics. The art of dyeing with natural extracts and plants from nature is as old as human civilization [1,2,3]. Ancient humans considered the colour as a basic necessity, essential like water. In the antiquity, the art and craft of dyeing fabrics and textiles has been practiced by traditional expert craftsmen.
Dyeing was first known as an art, humans started using natural dyes as soon as they were discovered 6000 BC or even earlier, but until the '50's most of the dyes were derived from plants or animal sources by elaborated and long processes [4,5].
The traditional knowledge is intimately connected with culture, art and symbols and may also be used in medicine, because most of the dye plants or animals are medicinal, many of the natural dyes are known to have medicinal or healing qualities for human bodies.

CLASSIFICATION OF NATURAL DYES

Natural dyes fall into three categories on the basis of their origin:

plant/vegetable origin
insect/animal origin
mineral origin.

Figure 1: Colours obtaining from Nature

COLOUR

The Theory of Colour presents certain rules that govern the art of the combining colours.
Basically, three primary colours are required to get any given hue or colour. Primary colours are yellow, blue, red and all other colours are made from them combination presented in *Figure 2.*

Secondary colours (green-violet-orange) are made by combining the two primary colours (yellow-blue-red). By combining yellow colour and blue colour obtaining green colour; blue colour and red colour give violet; red colour and yellow colour produce orange colour.

Intermediate colours are formed by combining a primary and a secondary colour (for example, by mixing yellow with green the colour obtained is yellow-green; blue with green a blue-green; red with blue a red-violet; red with orange a red orange and yellow with orange is obtaining yellow-orange).

Complementary colours are pairs of opposites, as yellow and violet or red and green, opposite intermediates are also complementary.

The properties which describe a colour are:

Hue: is the name of the colour such as yellow or green

Value: means the depth or the lightness/darkness of a color measured in terms of white/black light value approaching white are named tints and dark value approaching black are called shades

Intensity: the brightness of a hue of a pure colour.

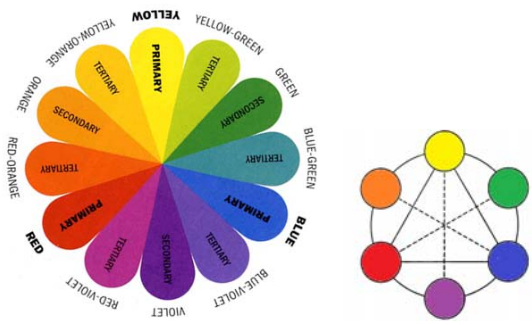

Figure 2. Primary colours (yellow, blue, red) and secondary colours (green, violet, orange)

In art of the dyeing, tints can be obtained by using less dye in proportion to the weight of fabric and shades can be obtaining by increasing the relative amount of the dye by adding darks colour, like black.

NATURAL DYES FROM NATURE

In the *Colour Index* the natural dyes are classified according to the hue.

Yellow Dyes:

Yellow is one of the most common colour in the natural dyes.
The most of yellow dyes are flavonoids, they produce pale shade with quicker fading, except Turmeric dyes. Sources of some important yellow dyes: *Hymalayan Rhubard (Rheum emodi),Turmeric (Curcuma longa),Chamomile (Anthemis tinctoria)* and *Weld (Reseda luteola),* which produces an excellent light and washfast yellow and is a strong clear yellow to combine with indigo for emerald and leaf greens.

Figure 3: *Hymalayan Rhubard,Turmeric,Chamomile* and *Weld*

Blue Dyes:

Natural Indigo, *Woad (Isatis tinctoria L.)*, the flowers of the *Japanesse "Tsuykusa"*. *Natural Indigo* is obtained by fermeting the leaves of various species of Indigofera, running off the liquor and oxidizing it to precipitate the dye.

Natural Indigo has higher affinity and the dyed fabrics have a better fastness. This dye is the legendary source of colourfast blues and its ability to produce a wide range of shades has made it the most successful dye plant ever known.

Woad (Isatis tinctoria L.) is another source of indigo. Indigotin and indirubin are the main ingredients of natural indigo. The leaves of the woad plant contain the same dye as Indian Indigo Indigofera tinctoria, although in a weaker concentration, the shades obtained from woad are slightly different from indigo and this makes colouring with woad a much more subtle and delicate art.

Figure 4: Natural Indigo and Woad

Red Dyes:

Most red dyes are almost invariably based on antraquinone and its derivates. Red dyes are hidden in roots, barks of plants or in the bodies of insects. The most important red dyes are *Madder (*Rubia tinctorum L. (common madder), Rubia peregrina (wild madder), and Rubia cordifolia (Indian madder), *Brazil wood (Ceasalpinia echinata L.)Sappan wood (Ceasalpinia sappan L.), Cochineal (Coccus cacti L.), Lac Dye (Coccus laccae).* All these dyes are based on antraquinone molecule except Brazil and Sappan wood based dyes.

Madder is one of the oldest dyestuffs known. It is most frequently used to produce turkey reds, mulberry, orange-red, terracotta, and in combination with other dyes and dyeing procedures can yield crimson, purple, rust, browns, and near black. The colourants in *Rubia tinctorum L.* are the antraquinones, alizarin, purpuroxanthin, rubiadin, manjistin, purpirin, pseudopurpurin. The main colouring component of *Rubia Cordifolia L.* is manjistin, purpurin, pseudopurpurin, purpuroxanthin.
An important red dyes.is *Cochineal (Coccus cacti L.),* the most important of the insect dyes. This dye is found mostly in food, drugs and cosmetics. *Cochineal* has excellent light and washfastness and produces a powerful range of fuchsias, reds and purples.
Lac Dye (Coccus laccae) is the same important red dye and also oldest, with four colouring components, designated as laccaic acids A,B,C,D.

Figure 5: Madder Rubia tinctorum, Rubia peregrina, Rubia cordifolia

Figure 6: Brazil wood and Sappan wood

Figure 7: Cochineal and Lac Dye

FASHION INSPIRED BY NATURE AND COLOUR

Nature always fascinated through shapes and brilliant colours. Also, the nature has been and still to continues to be a important theme of inspiration for artists and designers of fashion. In the last years, various artists, designers and companies from textile and fashion industry have created many collections by using natural dyes. In the collections presented the focus was on fashion, because it is the key factor that influences the whole production and fashion.
Natural dyes can make Fashion Show Collections both environmentally friendly and produce creations of exquisite beauty. Fashion is art.

Designer *Zuhal Ruvan Mills* describes her embellishments as ”biomorphic drawings, paintings and sculptures” and her viewing on her creations as more than fashion, rather, textile artworks delivering a message [14]. These unique, naturally hand-dyed pieces from the collection, utilize a subtle blend of complimentary fabrics, soft felted Merino, placed to work with playful pleats and glamorous flowing folds.
The care with which the designer has spun, dyed, felted, stitched and embroidered these exquisite “textile sculptures for the body” is testament to her dedication to quality and sustainability.

Figure 8. Designer Zuhal Ruvan Mills, *Collection “Connected to Land”*

Designer *Arthur Bispo do Rosario* created a exquisite and interesting collection with inspiration from nature, based on geometrical patterns, draped and pleated large quantities of different natural fabrics to create oversized garments and decorated with embroidered motifs using fabrics dyed with natural dyes Brazilian wood.

Figure 9. Arthur Bispo do Rosario, *Fashion Collection* dyed with natural dyes

One important designer, recognized for her organic, natural hand-dyed artisan garments, woven jacquard designs and knits is *Katrien Van Hecke* from Belgia. Modern artisanal luxury with a focus on silk and hand-dyed couture, the designer starts from raw white materials as a canvas to find structures and prints.
The collections are a reinterpretation of age-old techniques brought back into the 21st Century and spiced up with nowadays technology. Her interest in painting has led her to apply a painter's approach towards fabrics and so she experimented with herbs and spices such as turmeric, woad, sandalwood, nettle and cochineal to obtain some unbelievable effects.

Figure 10. *Fashion creation* realized by designer Katrien Van Hecke

The brand *Eco Logika* is an famous ecotextile and clothing manufacture from Australia. The designer of this brand, Charlene O Brien is a textile artist and designer of eco-luxury- Fashion Conscience, specialised in creation of eco-couture of natural fibres and natural dyes using various techniques [15].

Figure 11. *Creation* by designer Charlene O Brien

CONCLUSIONS

Because the human body is an object of informational energy, which emits vibrations, the colour is one of the most important aspects by acting directly with the human body, both physically and spiritually and being one of the elements of nature that made the human living more aesthetic and fascinating in the world.
As we can see in the present study, the dyeing with natural dyes shows a great importance through the creation of fabrics and textile products of exquisite beauty, with uniqueness, wonderful and extremely unusual effects on fabric.
Exploration of natural dyeing with natural dyes and also the dyeing technique in the textile industry is very promising for future developments because the natural dyes, the colours from nature, provide real alternatives and benefits to the complex world of synthetic dyes and also create unbelievable effects. The market for natural dyes is extending, it is a niche market designed to increase environmental awareness of the consumers. Likewise, market opportunities exist, especially, in the green textile industry. With an increased number of companies that are certified or exploring the commercial opportunities of green market and green product, the demand for natural dyes is expected to increase to a greater extent.

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Section 9: Advances in Leather Processing

THERMAL COMFORT PROPERTIES OF THE UPHOLSTERED LEATHER FURNITURE

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Abstract
Contemporary furniture should provide high level of the sensorial and thermal comfort to its users, both in dry state and after partial wetting due to the increased air humidity and sweating of the seated persons. In the paper, thermal resistance, thermal conductivity and thermal contact feeling (thermal absorbtivity) of 10 oxhide and 5 artificial leather samples used for the upholsted furniture were experimentally determined. The measurements involved the samples both in dry and wet state. It was found, that with the increased relative moisture of the samples, their thermal resistance decreases rapidly, and the feeling of coollnes increases.

Keywords: *thermal comfort, leather, upholstery furniture*

INTRODUCTION

Upholstered furniture is a common part of rooms, offices, bedrooms and public spaces. Seated people will feel comfortable, when the heat and moisture transfer between their body and the furniture will maintain thermal equilibrium of their bodies without sweating or shivering. Thus, the level of thermal and evaporation resistance of the furniture is very important. Part of this resistance levels depends on thermophysiological parameters of the fabrics creating the furniture surface. Surface of this furniture can be created by textile fabrics or by natural or artificial leather [1].

Important part of total comfort of the furniture is the sensorial comfort, which involves selected mechanical and thermal parameters of the used surface fabrics, namely:

Friction + profile
Moisture behaviour characteristics influencing the fabric / skin friction
Thickness + compressibility
Bending + shearing stiffness (at low and large deformations)
Elasticity, tenacity
Warm-cool feeling (transient heat transfer)

In this study, besides thermal resistance and thermal conductivity of the furniture fabrics, also the thermal-contact feeling properties of these fabrics were studied.

Humidity is another important aspect of thermal comfort [2]. A seated person will usually feel uncomfortable when humidity builds up at the skin's surface because moist skin creates increased friction coefficients, causing it to stick to clothing or chair upholstery and inhibiting the small movements required to shift weight off pressure points. Unfortunately, there are no papers available in the scientific literature, in which the effect of moisture on the selected thermal and sensorial properties of upholstery fabrics were systematically studied.

That is why the main objective of the paper is the experimental analysis of the effect of moisture on thermal resistance, thermal conductivity and thermal contact feeling (thermal absorbtivity) of 10 cowhide and 5 artificial leather samples used for the upholsted furniture. These properties were measured at several levels of their relative moisture U % related to their ultra-dry mass. The used measuring instrument was the ALAMBETA, which enable non-destructive and fast testing of fabric samples in wet state also. The achieved results were statistically treated and the comfort properties of the studied samples were plotted as the function of their moisture. The samples which offered the highest thermal resistance and the dryest thermal contact feeleing were recommended for the production of the upholstered furniture with the best thermal comfort [3].

EXPERIMENTAL

The used instrument and tested properties

The ALAMBETA instrument used in this study measures thermal conductivity, thermal absorbtivity, thermal resis-tance and sample thickness. Its principle depends in mathematical processing of time course of heat flow passing through the tested fabric due to different temperatures of bottom measuring plate and measuring head. When the measuring head touches the fabric starts the measurement lasting several minutes only. Thus, reliable measurements on wet fabrics are possible, during which the sample moisture keeps almost constant [3].

Thermal conductivity coefficient λ of polymers is quite low, from 0,2 to 0,4 W/m.K, and that of textil-es ranges from 0,033 to 0,01 W/m.K. Thermal conductivity of steady air by 20°C is 0,026 W/m.K while thermal conductivity of water is 0,6 W/m.K, which is 25times more. That is why the water presence in textile materials is undesirable [4].

Thermal resistance R depends on fabric thickness h and thermal conductivity λ:

$$R = h/\lambda \ [m^2K/W] \qquad (1)$$

Thermal absorbtivity b of fabrics was introduced by Hes [5] to characterise thermal feeling during short contact of human skin with the fabric surface. The measured fabric was simplified into semi-infinite block with thermal capacity ρc [J/m^3] and initial temperature t_2. Unsteady temperature field between the human skin (with temperature t_1) and fabric with respect to of boundary conditions offers a relationship, which enables to determine the heat flow q [W/m^2] course passing through the fabric:

$$q = b\,(t_1 - t_2)/(\pi\tau)^{1/2}, \quad b = (\lambda\rho c)^{1/2} \ [Ws^{1/2}/m^2/K] \qquad (2)$$

where ρc [J/m^3] is thermal capacity of the fabric and the term b presents its thermal absorbtivity. The higher is thermal absorbtivity of the fabric, the cooler is its feeling. In the textile praxis this parameter ranges from 20 Ws$^{1/2}$/m^{2}K for fine webs to 600 Ws$^{1/2}$/m^{2}K for heavy wet fabrics.

The tested samples

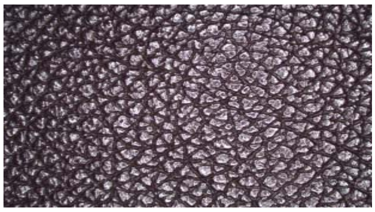


Figure 1: The new ALAMBETA tester **Figure 2**: The upholsted furniture **Figure 3:** The cowhide surface

Table 1: Composition and properties of the tested samples (the cowhide and the laminated knitted fabric)

Sample	Composition	Substrate	Thickness mm	Thermal absorbtivity Ws$^{1/2}$/(m^{2}K) at U = 10%
1	Cowhide		0,54	356
2	Cowhide		0,77	270
3	Cowhide		0,86	275
4	Cowhide		0,89	276
5	Cowhide		1,01	291
6	Cowhide		1,12	277
7	Cowhide		1,19	306
8	Cowhide		1,47	297
9	Cowhide		1,55	284

10	Cowhide		1,63	281
11	PU coating 60%	PES knit 40%	0,67	315
12	PU coating 60%	PES knit 40%	0,79	297
13	PU coating 70%	PES knit 40%	1,05	420
14	PU coating 70%	PES knit 40%	1,13	390
15	PU coating 70%	PES knit 40%	1,18	374

Results of measurements at contact pressure 200Pa and their evaluation

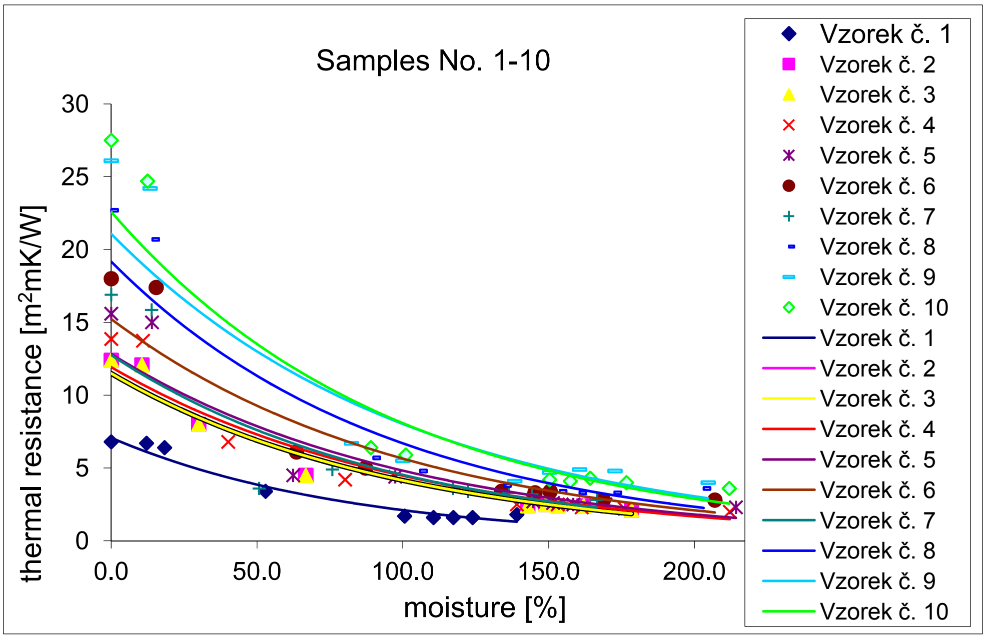


Figure 4: Thermal resistance levels determined on the wetted samples made of natural cowhide leather. The resistance decrease with the increased moisture seems quite but this is just caused by the large moisture extension, as the natural leather is very hydrophilic. At the medium moisture levels thermal resistance of the natural leather surface of the furniture is still high. This feature makes the natural leather very comfortable. The Czech word „Vzorek“ means the „sample“.

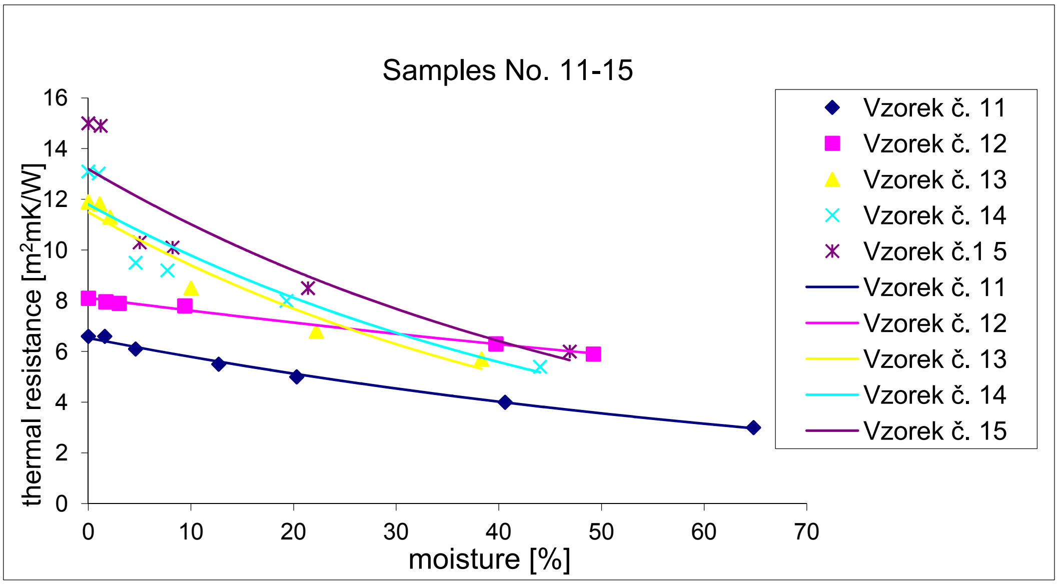
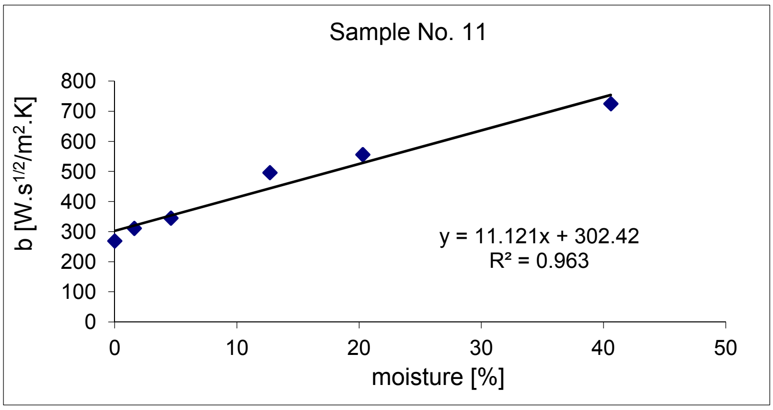
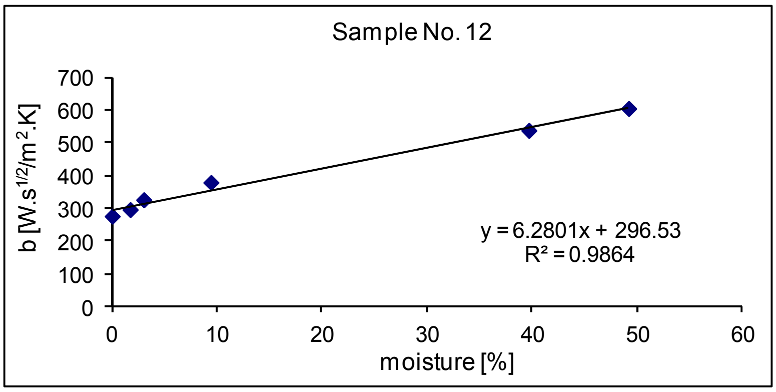
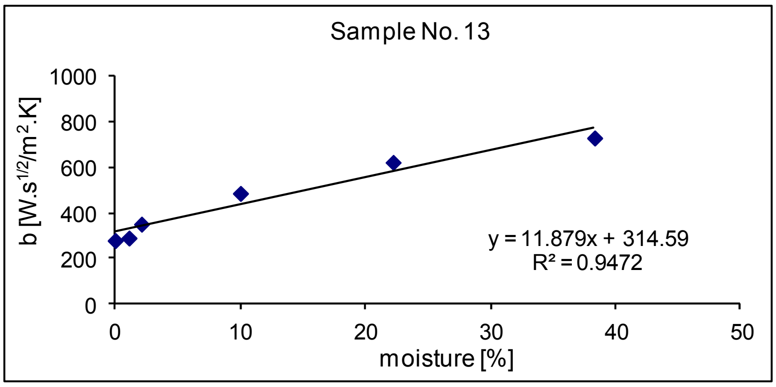


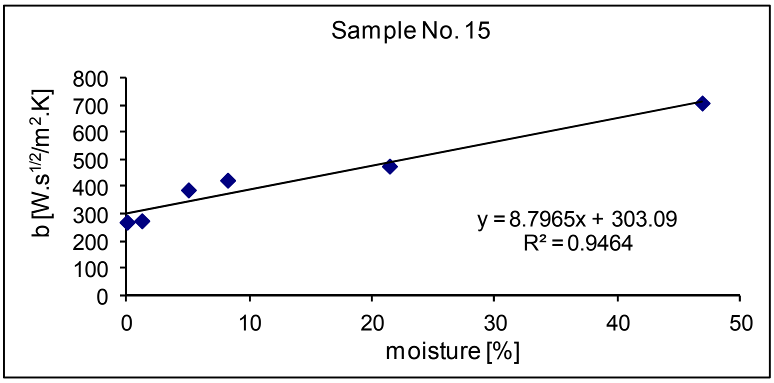
Figure 5: Thermal resistance levels determined on the wetted samples made of artificial leather. The resis-ance decrease with the increased moisture seems relatively slow, but this is just caused by the low moisture

extension, as the artificial leather is almost hydrophobic. This Czech word „Vzorek“ means again the „sample“.

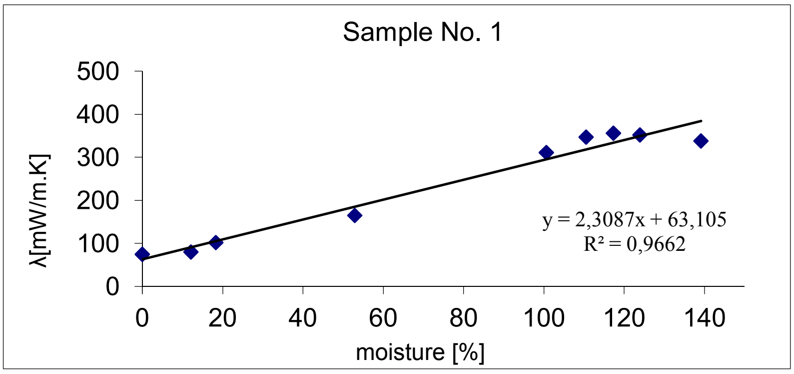


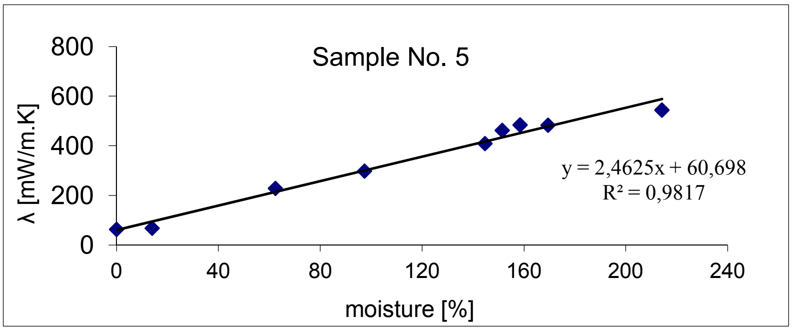


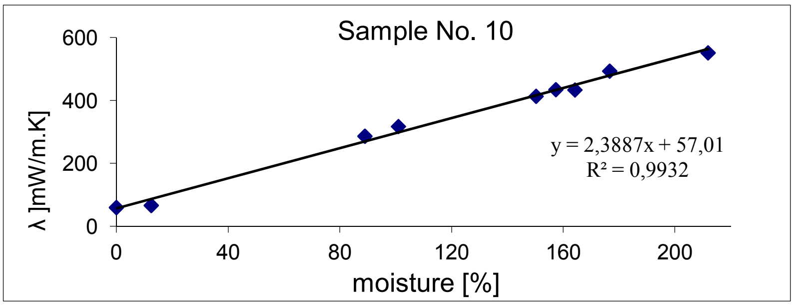


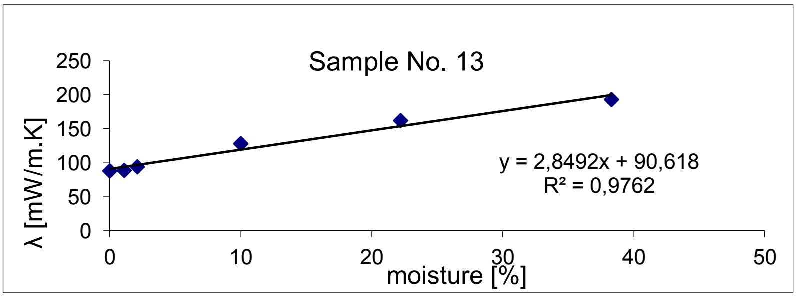


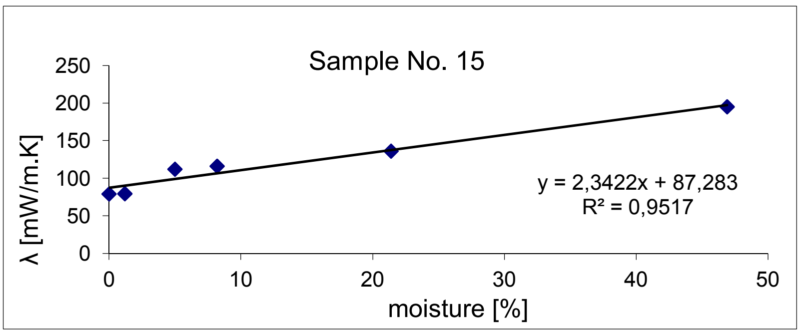
Figures 6 - 9: Thermal absorbtivity levels determined on the wetted samples of artificial leather. The cool feeling inrease with the increased moisture is quick despite small moisture extension, as the artificial leather is not very hydrophilic and the moisture is kept in the surface layers of the upholstery fabrics. The cold feeling felt at at higher moisture levels makes the artificial leather quite discomfortable.











Figures 10 - 15: Thermal conductivity λ determined on the wetted samples of natural (sample 1-10) and artificial leather. Initial (dry) and medium levels of thermal conductivity of natural leather are lower. The thermal conductivity inrease at the artificial leather with the increased moisture is quick despite small moisture extension, as the artificial leather is quite hydrophobic. The initial low thermal resistance levels (as follows from the Eq. 1) can make the furniture covered by artificial leather in some extent discomfortable.

CONCLUSIONS

In the study, thermal resistance, thermal conductivity and thermal contact feeling (thermal absorbtivity) of 10 oxhide and 5 artificial leather samples used for the upholsted furniture were determined, both in dry and wet state. The measurement was based on the use of the fast testing ALAMBETA instrument. It was found, that with the increased relative moisture of the samples, their thermal resistance decreased rapidly, and the feeling of coolnes increases.

Samples made of natural leather exhibited always lower thermal conductivity and their thermal absorbivity was always warmer (drier) that that of artificial leather. The moisture absorbed at the levels typical for the practical use of the furniture resulted in slower decrease ot thermal resistance of the natural leather samples and slower increase of the cool feeling, if compared with the artificial leather. The warmest thermal contact feeling exhibited the sample No. 2.

Full analysis of the comfort properties of the upholstering fabrics would require also the determination of their water vapour permeability.

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EXPERIMENTAL RESEARCH ON THE MECHANICAL PROPERTIES OF THE POLYURETHANE SYNTHETIC LEATHER

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Abstract: *Knowledge on the mechanical properties of the polyurethane (PU) synthetic leather is particularly important for the developing finite element analysis models of products made from such materials.*
The main objective of this paper is to evaluat the mechanical properties of synthetic leather having polyurethane coating on knitted fabric support. The mechanical properties were determined based on the angle between the direction of the knitted mesh row and loading direction.
Tensile tests were conducted in accordance with specific standard on a tensile testing machine type ZWICK ROELL Group 5 KN equipped with automatic system of data acquisition and processing.
There have been attemptseds several categories of polyurethane synthetic leather, materials commonly used in furniture industry (armchairs, chairs, etc).
Based on the performed tensile tests ISO 3376:2002 [1] the following features were determined : maximum tensile strength, tensile stress at break, tensile stress at yield, tensile strain, tensile strain at break, modulus of elasticity, Poisson's ratio and respectively the elongation at break.
The experimental results showed a high dependence of the mechanical properties of synthetic leather on the direction of the knitted mesh row in relation with the loading direction.The mechanical properties determined in this study are basic parameters for designing synthetic leathers but also for developing numerical models for the details of the structures used in polyurethane synthetic leather for furniture.

Keywords: *mechanical properties, polyurethane synthetic leather, knitted fabric.*

INTRODUCTION

Over the last years the manufacturing technologies for raw materials used in various industriesy have been developed into a very high rate. Among the leather substitutes the synthetic leather with polyurethane (PU) and polyvinyl chloride (PVC) coatings are detached due to health and environmental properties and respectively to the softness and technical aspect of their properties. The products covered by PU synthetic leather are used in the manufacture of clothing, footwear and furniture or automotive upholstery [2]. Polyurethanes are polyaddition compounds, fomed from glycol and hexametildiizocianat and they are used to manufacture non-flammable and insoluble films. The polyurethanes have high stability to the action of air, acids and alkalis. The polyurethane lacquers can be strengthen at room temperature and have high adhesion to the textile, paper, leather, rubber, etc. The lacquers may be coloured, have high gloss, are resistant to weathering or cold and they have non permeability to gases.

Over the time the mechanical properties of synthetic leathers which have been coated with polyurethane were analyzed through the consumer's preferences on fashionable articles [3, 4, 5]. The mechanical properties of these synthetic leathers are more or less similar to genuine leather.

In various cases, as a clothing product or as a product of upholstery for furniture or car seats covers, the strength of these synthetic materials with polyurethane coatings on a woven or knitted support was analyzed. As result of investigation of the mechanical properties of PU synthetic leathers it was found that synthetic leathers were preferred for clothes due to their compressibility and flexibility. For purses are preferred those PU synthetic leathers having a compressive elasticity and excellent compression, for bags are preferred those that have been deformed by compression and not easily expanded. For furniture are preferred those that haved a smooth surface and are flexible. The chemical properties of leather substitutes and the basic parameters of materials were also investigated. When using leather substitutes, their physical-mechanical properties are important but also the quality of the seams are also very important. In addition to the ergonomic features of car seats it is important that the passenger feels no body tiredness as a result of discomfort state. Pleasant contact between body and seat depends on the upholstery material [6]. The nonwoven material is within the seat and it is used for the alignment of solid components of the car. The outer material which is in contact with the body should also have good aesthetics and good resistance, toughness and abrasion resistance for the life of the car. The material must be flame retardant, resistant to ultraviolet rays of the sun and should have a stable resistance to finishing works. The synthetic leathers possess almost all the properties expected for the car seat upholstery. The stability of upholstery materials can be improved with laminated woven or knitted fabric, which is obtained by thermal accession. The thermal accession of woven or knitted materials with polyurethane foam on the back of the synthetic leather is achieved by coating a thin film of dried adhesive over a high temperature that bonds well with the surface. Woven fabric provides a high stability and resistance for synthetic leather and the knitted fabric gives a highly elasticity [7].

In addition to these advantages the use of leather substitutes has disadvantages, among these is the lower durability as compared with the products made of genuine leather.
The low durability is determined by the mechanical degradation phenomena caused by seams, folds, bends for garments made of artificial leather.
Increased durability of products made from leather substitutes requires a complex study of phenomena that generate mechanical degradation (cracking, flaking and tearing). Conducting such studies require knowledge on mechanical properties of these materials.

MATERIAL AND METHOD

In this paper an experimental study on the leather substitute with polyurethane into a woven matrix was conducted. The samples were obtained from technical material for upholstery having the following characteristics:
- fibber content: 65 % polyester and 35 % cotton;
- weft fabric – the fabric is obtained by successive looping of one or more threads in the transverse direction, resulting fabric mesh with the following parameters: the pitch eye (A) of 0.57 mm, the height of the eye (B) of 1.44 mm and the diameter of the yarn (F) of 0.02 mm, Fig.1.

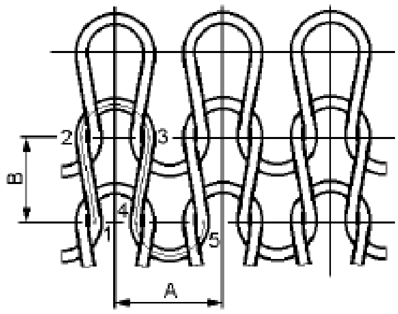


Figure 1: The parameters of the fabric structure

The samples have a specific weight γ = 584.57 g/m^2 and have been cut to four directions (0º, 30º, 60º and 90º) with the length l = 110 cm, l1 = 50 cm, l2 = 30 cm, R1=5 cm, width b1= 35 cm, b = 10 cm, and a thickness of 1 mm, Fig. 2.

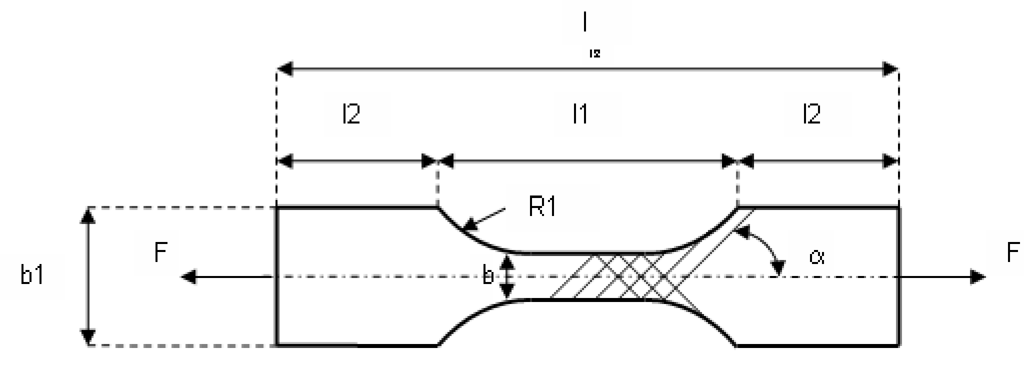
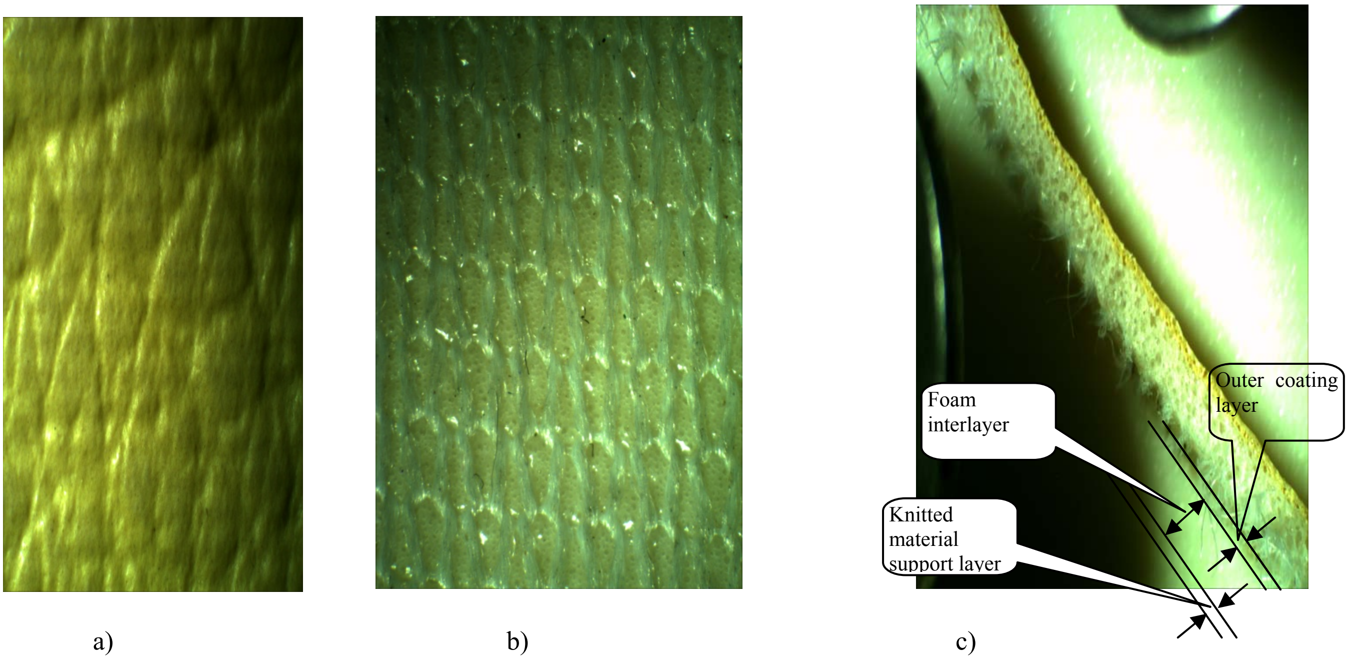


Figure 2: Tensile specimen used for evaluation of mechanical properties.

The samples were examined using an optical microscope, Kruss-Optronic Germany, both on face (upper and bottom) and thickness direction as shown in Figure 3.



a) b) c)

Figure 3: Fabric for furniture upholstery: a) face of the support material; b) bottom of the support material; c) section on polyurethane material with knitted fabric.

On the thickness direction, fig. 1.c, the material has a finished outer coating layer with a thickness of 0.14 mm, a foam interlayer with a thickness of 0.64 mm and the knitted material support layer with a thickness of 0.25 mm.
The material was produced by wet coagulation processes, including a polyurethane resin on the knitting base material and covered with polyurethane foam.
Tensile tests were conducted according to ISO 3376:2002 [1] and ASTM D-4000 [8] standards, at room temperature of 23 ºC and humidity of 50 ±5 %. The experimental tests were performed on a testing machine, Zwick Roell, of 5 kN, fig. 4. Also, a video system composed of a camera, model Samsung SIR-4160, fig. 5, and digital video recorder, Amax DVR H264, was used to monitoring the elongation of the samples during tensile tests. By manually synchronizing the video recording with tensile loading rate it could make a proper correlation between the applied load and sample elongation. Also, a frame-by-frame analysis was performed to determine the sample elongation corresponding to each loading level. The image processing was done using SigmaScan software, [9].

Figure 4: The testing equipment used for experimental analysis of the fabric material

Figure: 5 The video recording system

RESULTS

In Figure 6 are given the force-displacement curves for the four groups of samples drawn at 0º, 30º, 60º and 90º in relation to the mesh row direction of the fabric. There have been carried out 6 tensile tests for each of the four types of samples. Based on the force-displacement curves recorded the stress-strain curves (shown in Figure 7) were obtained.
Also, based on the stress-strain curves the mechanical properties of each type of samples (given in Table 1) were determined.

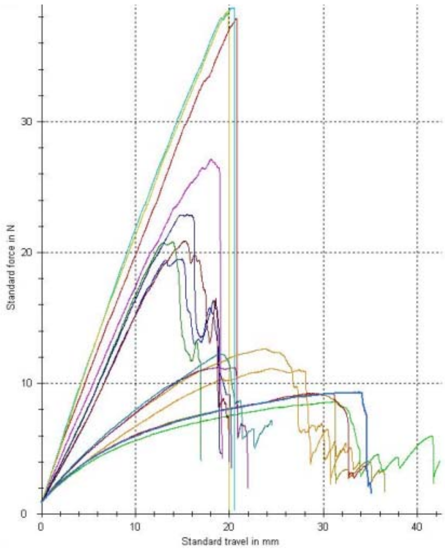


Figure 6: The force-displacement curves during tensile tests

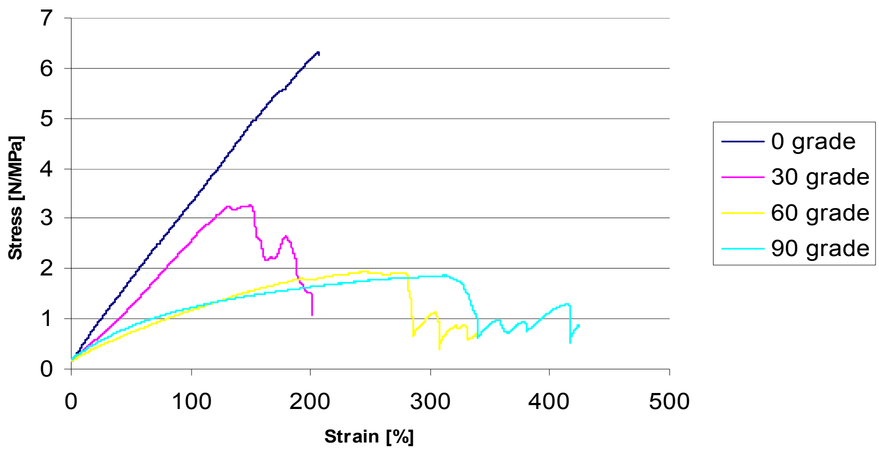


Figure 7: The stress-strain curves for each type of the samples

Table 1: The mechanical properties of the synthetic material with polyurethane on knitted fabric matrix

The angle of the material sample [°]	Tensile strength [N/MPa]	Tensile stress at break [N/MPa]	Tensile stress at yield [N/MPa]	Elongation at break [%]	Elongation at yield [%]	Modulus of elasticity [N/m]	Poisson's ratio
0	5.17	5.08	4.3	1.9	0.93	5.82	0.48
30	2.28	2.29	4.16	1.48	1.9	2.91	0.43
60	2.04	1.995	1.46	2.45	1.47	1.025	0.405
90	1.695	1.69	1.37	3.04	1.15	0.35	0.285

DISCUSSION

According to the results given in Table 1, the mechanical properties of the analyzed material are dependent by the loading direction in relation to the mesh row of the knitted fabric matrix. The variations of the mechanical properties function of the loading direction are shown in Figures 8-13. Figure 8 presents the variation of tensile strength on the direction of the knitted row. The tensile strength decreases severely in the range of 0º to 30º angle with up to 55 %. In the range of 30º to 60º the variation of tensile strength is insignificant, with a value of 13 % and in the range of 60º to 90º the variation is about 15 %. Instead, in the case of yield strength is noticed a decrease of up to 64 % for angles between loading direction and knitted mesh row from 30º to 60º. Nevertheless for ranges of 0º - 30º and 60º - 90º the yield strength haS insignificant variations (3 – 6 %), Fig. 9.

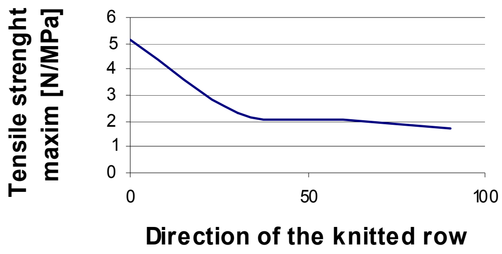


Figure 8: Variation of the tensile strength on the direction of the knitted row

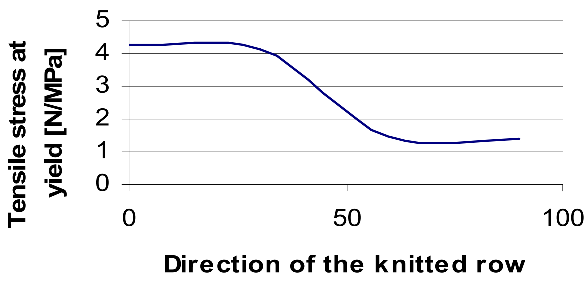


Figure 9: Variation of the tensile strength at yield on the direction of the knitted row

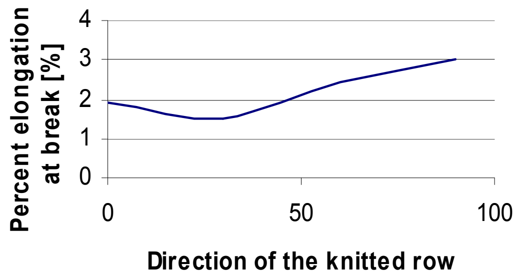


Figure 10: Variation of the percent elongation at break on the direction of the knitted row

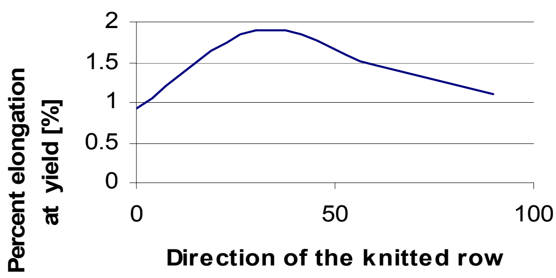


Figure 11: Variation of the perecent elongation .. at yield on the direction of the knitted row

The figure 10 shows the variation of the percentage of elongation at break depending on the direction of the knitted row in relation to the loading direction. The elongation at break decreases in the range of 0º to 30º angles with up to 22 % followed by a continuously increasing for angles between 30º and 90º.
The variation of elongation corresponding to yielding point in relation to direction of the row is shown in Figure 11 and it is observed an increase with up to 22.6 % for the range of 0º to 30º followed by continuously decreasing for angles between 30º and 90º.

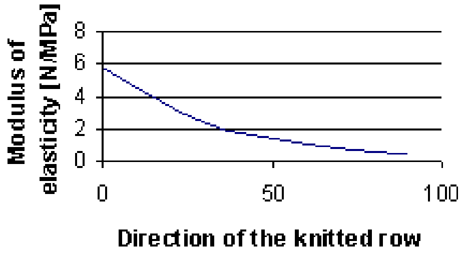


Figure 12: Variation of the modulus of elasticity on the direction of the knitted row

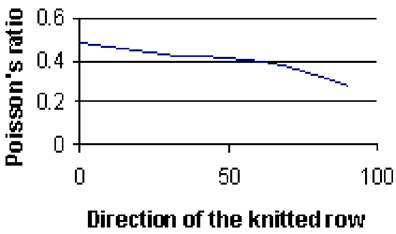


Figure 13: Variation of Poisson's ratio on on the direction of the knitted row

The Young's modulus is maximum for the angle of 0º and it decreases as the angle increases to 90º. A more significant decrease is observed in the range of 0º - 30º, fig. 12.
In Figure 13 is given the variation of Poisson's ratio, with a decrease of up to 10.4 % in the range of 0º - 30º. A smaller decrease was registered in the range of 30º to 60º angles, up to 5.8 %, while in the range of 60º - 90º the decrease was 29.6 %.

CONCLUSIONS

The leather substitutes with polyurethane (PU) cotings textile matrix made from weft knitted fabric having fibber composition of 65 % polyester and 35 % cotton is a composite material those mechanical properties are dependent by the loading direction.
The direction of the mesh row in the knitted fabric has a determinant role on the mechanical properties of the composite materials as polyuretan synthetic leathers are. The tensile strength, yield strength, Young's modulus and Poisson's ratio have maximum values in the direction of the mesh row of the knitted fabric (the samples with 0º angle). The deformation properties, elongation at yield stress and elongation at break have maximum values for 30 º angles between the direction of the mesh row of the knitted fabric and the loading direction. From the analysis of the tensile stress-strain curves it is noted the quasi-linear elastic behaviour of the material to its final failure. Also, the higher value of tensile strain reflects the nonlinear behavior of the analyzed composite material.
The mechanical properties which are experimentally determined in this study are signifiant parameters for designing such materials but also for modelling of the material behaviour in order to develop numerical analysis by finite element method.

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FOOTWEAR INDUSTRY: USE OF NANOPARTICLES TO DEVELOP MATERIALS WITH ANTIMICROBIAL PROPERTIES

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Abstract: *Footwear industry pursues the continuous development of added value fashion or technical comfortable shoes. Therefore the footwear and allied trade sectors have been investing in the development of new functional leathers with antimicrobial properties based in nanoparticles (NPs). Ag, ZnO, CuO and Cu NPs were prepared using wet chemical processes. The antibacterial activity of NPs was evaluated by contacting them with E. coli for 1 and 24 hours at 37 ºC, spreading the solution in a nutrient agar plate followed by incubation at 37 ºC for 24 hours. In the tested conditions Ag, CuO and Cu NPs suspensions showed antibacterial activity. The prepared NPs were applied to leather surface. The antibacterial activity of leather samples modified with NPs was assessed by the formation of zone of inhibition, following a CTCP method based on standard AATCC 147:2004. Ag, ZnO and Cu NPs were able to induce antibacterial activity.*

Keywords: *Footwear, Antibacterial properties, Silver nanoparticles, Zinc oxide nanoparticles, Cooper oxide nanoparticles and Cooper nanoparticles.*

1. INTRODUCTION

In the last decades nanoparticles (NPs) have been a subject of a great interest among scientists due to their remarkable properties such as antibacterial, antifungal, self-cleaning or hydrophobicity [1-10]. Due to these notable properties the use of nanoparticles is being explored on the production of different materials and products (e.g. nanocomposites, textiles, multifunctional materials, consumer goods, paints, cosmetic products, medical devices) at laboratory but also at industrial scale. Also footwear industry is exploring the use of nanotechnologies in the development of functional and added value products to get competitive solutions and meet the consumers' expectations.

Footwear is a closed system that may promote the temperature increase and moisture accumulation, favourable to bacterial and fungal growth, that are responsible for the generation of malodours, some foot skin problems and material attack. The modification of footwear materials surface (e.g. leather and other fibres) with nanoparticles is an approach that can be studied to contribute to manage these topics and develop materials and products with higher antibacterial and antifungal properties. Nanoparticles have greater surface area per weight than larger materials making them more reactive and potentially effective. Normally, a lesser amount of NPs is needed to get higher functionalities and a more durable effect due to the slow release.

Silver (Ag), Zinc Oxide (ZnO), Copper Oxide (CuO) and Cu NPs are probably the most studied NPs with the aim of modifying several materials (e.g. cotton, polyester, dental resins, textiles, among others) to get antibacterial and antifungal properties [1-9, 12-15]. In the last years, CTCP and UPORTO have been working together on the preparation, characterization and application of these types of nanoparticles to get leather with antibacterial and antifungal properties [16-18].

The present work aims to contribute to develop materials with antibacterial properties to be used on footwear products manufacture to increase comfort. The work presented consists in the synthesis of Ag, ZnO, CuO and Cu NPs, modification of leathers surfaces applying selected prepared NPs and evaluation of the NPs and leathers antimicrobial properties.

The following step is the use of commercial NPs to develop advanced and innovative nanotechnology based solutions for leathers and footwear products, aiming a new sustainable and customer-driven production of consumer goods; where the health, environment, high quality of components, fair marketing communication and competitive sales price are combined to promote the competitiveness of the companies. This step is being developed in the frame of the European project (FP7-SME-2013 Research for the Benefit of SMEs) NANOFOOT – Materials, components and footwear with enhanced comfort properties http://nanofoot.ctcp.pt).

NANOFOOT consortium is constituted by 9 members: 5 SMEs and 4 RTD institutions. A balanced and interdisciplinary team is formed by combining the know-how of SMEs with the expertise of the university and technology research centres.

NANOFOOT research, development and technical activities include:
Screening of commercially available cost-effective nanoparticles;

- Investigation of the functionalization of processing products, coatings and leathers using nanoparticles.
- Investigation and development of polymeric nanocomposites and footwear components.
- Develop advanced footwear.
- Develop an integrated environmental approach to safeguard consumers, workers, workplace and environmental.
- Perform prototype demonstrators and dissemination actions.
- Prepare results exploitation by the SMEs and IPR protection.

During the first 9 month of the project realization, the team focused in the selection, screening and preliminary application of the selected NPs to functionalize upper and insole materials with promising results.

NANOFOOT SME's have the ambition of exploring the potentialities and the benefits of nanoparticles (NPs) available in the market on the development of new functional materials & products. The final objective is to get differentiated, high added value and marketable materials and footwear consumer goods; that satisfy the needs and expectations of the final consumers.

2. EXPERIMENTAL

2.1 Materials and reagents

Two bovine tanned crust leathers presenting general properties usual in shoe manufacture were collected. All reagents used were of adequate analytical grade.

2.2 NPs preparation

The Ag NPs were synthesized by reduction of $AgNO_3$ salt by $NaBH_4$ and stabilized using polyvinyl alcohol (PVA). The Ag NPs preparation process can be described as follows: 100 mL of a solution containing $AgNO_3$ in a concentration of 0.25 mM and PVA in a concentration of 3.8 g/L was prepared and stirred for 30 s. Then 25 mL of $NaBH_4$ 1 mM (freshly prepared) was added quickly to the mixture. The solution immediately turned to yellow. The synthesis process was performed in the darkness in an acclimatized environment of 23 ± 2 ºC.

ZnO NPs were prepared in diethylene glycol (DEG) based on the method described by Jézéquel *et al.* [19] and can be described as follows: 100 mL of a solution of zinc acetate dehydrate 0.1 M in diethylene glycol (DEG) was prepared and heated in an oil bath until reach the temperature of 180 ºC. The mixture was vigorously stirred until form a beige precipitate, then the temperature was decreased until 150 ºC and the reaction continued for 1 hour. The mixture was cooled at room temperature, the precipitate was centrifuged and washed several times with ethanol. The precipitate was dried at room temperature.

Copper oxide NPs were synthetized by precipitation method by using copper acetate and sodium hydroxide [20] and can be described as follows: Under constant stirring 1 mL glacial acetic acid was added to 300 mL of copper acetate 0.2 M solution. The aqueous mixture was heated to 100 ^{o}C. pH was adjusted to 6-7 by addition of 1 M NaOH solution. The mixture was cooled at room temperature, the precipitate was centrifuged and washed several times with ethanol. The precipitate was dried in the oven.

Additionally, Cu polyvinylpyrrolidone (PVP) NPs were prepared by adding 50 mL of copper chloride 0.01 M in PVP solution (20 g/L) to 50 mL ascorbic acid 0.4 M prepared in PVP 20 g/L. The aqueous mixture was heated to 60 ^{o}C and stirred for 3 hours. The mixture was cooled at room temperature and stored in darkness in an acclimatized environment of 23 ± 2 ºC.

2.3 Leather surface modification

Leather surface material was modified by immersion of the leather in the NPs solution. In the preliminary application tests approximately 0.20 mL of solution was applied per square centimetre of leather. The samples were allowed to dry overnight.

2.4 NPs morphological characterization

The nanoparticles were analysed using UV-Vis spectrophotometer Perkin Elmer Lambda 25, ZnO and CuO NPs were also analysed by Scanning Electron Microscope (FEI Quanta 400 FEG ESEM / EDAX Genesis X4M) and Ag NPs due to smaller size were analysed by transmission electron microscope (Hitachi H-8100).

2.5 NPs and modified leather antibacterial activity evaluation

The antibacterial activity of nanoparticles was evaluated against *E. coli.* The test can be described as follow: (1) 20 mL of each NPs solution were measured to a tube and the *E.Coli* was added to get a final concentration of 1.5-3.0X10^5 CFU/mL; (2) the tubes were placed at 37 ºC for 1 and 24 hours; (3) 100 µL of each solution were spread over a Nutrient Agar (NA); (4) the plates were incubated at 37 ºC for 24 hours and (5) the bacterial growth was evaluated.

The antibacterial activity of leather samples modified with nanoparticles was assessed by the formation of zone of inhibition, following the CTCP method based on standard AATCC 147:2004. The inoculum is prepared by diluting the 24 h broth culture 10 and 10^3 times. The samples are cut and placed on a NA plate inoculated with 100 µl of prepared inoculum. The plates are incubated at 37 ± 2 ºC for 24 hours and the zone of inhibition is evaluated.

3. RESULTS AND DISCUSSION

3.1 NPs synthesis and morphological characterization

The reduction of silver nitrate ($AgNO_3$) by sodium borohydride ($NaBH_4$), in presence of polyvinyl alcohol (PVA) is a very fast process at room temperature. The colourless reactant mixture immediately turned to yellow which is considered to be indication of the presence of isolated colloidal Ag NPs [21,22]. By the opposite the hydrothermal methods used in the preparation of the ZnO and CuO nanoparticles, although conducted at atmospheric pressure require a large number of steps which makes more difficult to obtain a good size dispersion of the nanoparticles.

Figures 1a and 1d shows the TEM image and UV-Vis spectra of Ag NPs, respectively. The absorption spectra of Ag colloids stabilized by PVA is very similar to those measured to Ag NPs stabilized by citrate reported in a previews study presenting a $\square_{max}$ around 400 nm [16]. The information gathered by UV-Vis spectra was complemented by TEM images (Fig. 1a). The Ag NPs prepared in PVA are spherical with an average size of 9.6 ± 3.4 nm (slight higher than Ag NPs stabilised in citrate).

UV-Vis absorption spectra of zinc oxide NPs prepared in diethylene glycol is presented in figure 1b and reveal an absorption peak at 380 nm. The SEM image of figure 1e shows that ZnO NPs are spherical shape with an average size of 358 ±161 nm.

Figures 1c and 1f present the UV-Vis spectra and SEM images of CuO NPs, respectively. The UV-Vis spectra reveal a broader absorption peak at 362 nm and the SEM images show that NPs are non-spherical with an elongated shape with an average size dimension of 230 x 82 (nm x nm). UV-Vis spectra (not shown) of Cu NPs confirm the NPs formation.

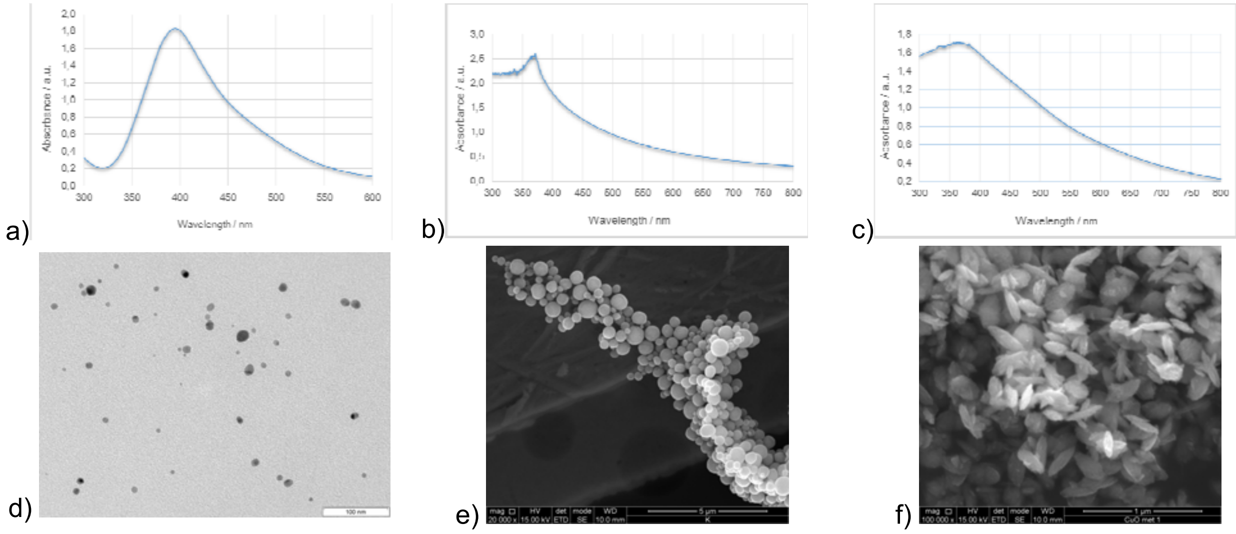
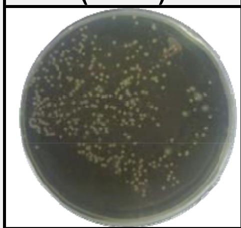
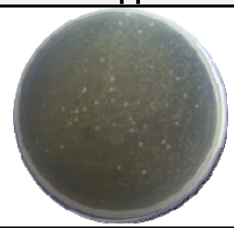
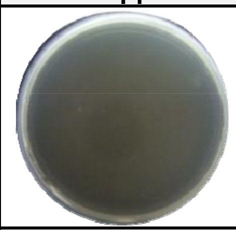
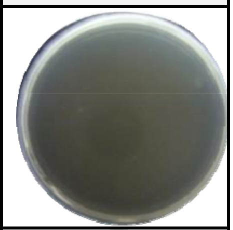


Figure 1: UV-Vis spectra and TEM images of Ag NPs (a, d); UV-Vis spectra and SEM images of ZnO NPs (b, e) and UV-Vis spectra and SEM of CuO NPs.

3.2 NPs antibacterial activity evaluation

The antibacterial activity of Ag NPs, ZnO NPs (100, 250 and 500 ppm), CuO NPs (100, 250 and 500 ppm) and Cu NPs was evaluated against *E. coli* (in a concentration of 1.5-3.0X10^5 CFU/mL) by contact for 1 and 24 hours. After the contact time 100 µL of each NPs solution was spread in a NA plate and incubated at 37 ºC for 24 hours.
In table 1 are presented digital images of selected plates after incubation (control-water, Ag NPs, ZnO NPs – 100 ppm, CuO NPs – 100 ppm and Cu NPs). The results obtained for higher concentrations of Zno and CuO NPs are similar.

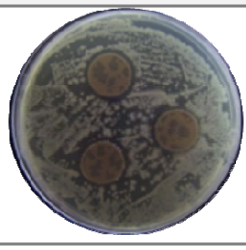
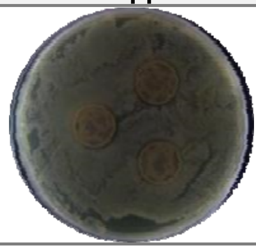
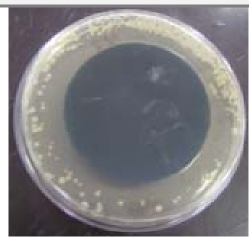
Table 1: Digital images of NA plates after incubation (for 1 and 24 hours of contact time): Ag NPs 50 ppm, ZnO NPs 100 ppm and CuO NPs 100 ppm.

Time of contact / h		Control (water)	Ag NPs	ZnO NPs 100 ppm	CuO NPs 100 ppm	Cu NPs
	24					
	1					

Results clearly show that, in the NA plates containing ZnO NPs, the growth of bacteria colony is observed. Plates where the solutions that have been in contact with Ag, CuO and Cu NPs were spread, show no evidence of bacteria colony growth for a period of contact of 1 and 24 hours at 37 ºC thus bacterial activity reduction > 99 %. From these results it is possible to conclude that, in the tested conditions, Ag, CuO and Cu NPs presented antibacterial activity. The ZnO NPs for this test condition have no antibacterial activity.This result could be explained by higher size of ZnO NPs and deposition during the contact time with *E. coli*. The deposition of ZnO NPs in suspension prevents the contact between NPs and *E. coli* decreasing the antibacterial activity.

3.3 Modified leathers antibacterial activity evaluation

The antibacterial activity of leather surfaces modified with Ag, ZnO and Cu NPs was evaluated against *E. coli* following the zone of inhibition test. In table 2 are presented digital images of selected plates after incubation. The results obtained indicate that these NPs were able to induce antibacterial activity in leather.

Test results – Zone of inhibition (24 hour broth culture dilution 10^3 x)	**Control (leather)**	**Ag NPs**	**ZnO NPs 100 ppm**	**Cu NPs**
				

CONCLUSIONS

Ag, CuO and Cu NPs suspensions showed antibacterial activity (bacterial activity reduction > 99 %) against *E. Coli* for a contact time of 1 and 24 hours. The ZnO NPs show no antibacterial activity in the tested conditions. These results could be explained by large size of ZnO NPs and the deposition of the nanoparticles during the periods of contacting, limiting the antibacterial activity. It is necessary synthesise ZnO NPs of smaller size and /or improve their stability and to study their antibacterial effect.

Leather surface modified with Ag, ZnO and Cu NPs suspensions following the zone of inhibition test showed that these NPs could induce antibacterial activity in leather against *E. Coli.*
The application of Ag, ZnO, CuO and Cu NPs among others is being studied on the functionalization of leather materials to get antibacterial, antifungal and hydrophobic properties.

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THE APPARENTLY TRIVIAL KERATIN, USEFUL FOR ADVANCED APPLICATIONS. A MINIREVIEW

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Abstract: *Keratin is a ubiquitous presence in vertebrata subphylum, as intracellular intermediate filaments, and is visible and abundant as morphological structures at the level of integuments and their products. The keratin sources and resources are exploitable for usual textile goods and chemical auxiliaries production, but their are of obvious interest for advanced applications, like biomaterials and tissue engineering. The condition to include keratin species in such applications is to extract them in a quasi-native state, starting from pristine sources. The present paper briefly discuss the properties which sustain the use of keratins in biomedical applications, together with some principles of solubilizing keratin sources in a protective maneer, so that new material characteristics to result by specific processing.*

Keywords: *Keratins, intrinsic properties, sources, resources, extraction, biomedical applications.*

INTRODUCTION

Keratins represent privileged protein sources in developing advanced materials, but they are quasi-neglected resources for technological applications. This fact is due to the high discrepancy between the starting biostructural properties of native keratins, and the final requirements in producing (bio)materials having reproducible designed characteristics. As biomacromolecules, keratins are mixtures of high-sulfur content fibrous proteins, able to generate hierarchically structured assemblies of morphological relevance, which exhibit high physico-chemical, enzyme, and physico-mechanical resistances, and which function as interfaces and/or barriers against the animal's external environment. In contrast, engineering applications impose the acquiring of new material properties, to sustain the range of the new demands of either advanced or common uses, addressed to the keratin constructs.

Bio-oriented applications exploit the intrinsic biocompatibility, biodegradability, and biochemical stability properties of keratins, whereas technological ones make use of their stiffness, strength and resistance against aggressive environmental agents. To ensure the adequacy to the final application requirements, the keratins resources, sources, and processing pathways must be considered when the ranges of possible transformation are chosen for converting a "biologic material" to an "engineered" one.

The present paper aims to resume the current solutions applied to derive advanced characteristics from the native properties of keratin sources, in order to confer a range of bio-oriented functionality, specifically suited for tissue engineering applications.

Generally, biomedical applications of proteins emphasize the issue of their deviation from the native state, the only state which provides their biochemical functionality. When this particular kind of functionality must be preserved and transferred to the engineered (bio)materials as final products, the pathway of processing keratin biological sources is subjected to severe constrains regarding the methods of isolation, extraction and purification. Whenever such a pathway is possible, feasible, and reproducible, the preferred strategy to obtain biofunctional keratins is the "*protected stepwise deconstruction*" of the natural sources, but, especially in the case of less demanding applications (such as those of external, or pharmaco-cosmetic uses), the strategy of "*nonspecific partial degradation*" is also acceptable. In the case of highly demanding applications, when the biochemical peculiarities of keratins are of strict interest in generating biofunctional structures, the usually extracted protein species cannot offer the imposed molecular properties, given the fact that chemically-driven processes massively and irreversibly affect some of the compositional and conformational characteristics of the extracted proteins. Therefore, a special way of producing keratins is mandatory to be used: the specific expression in cultured cells, by the so-called *recombinant genetic technology* [1,2]. It provides free (non-crosslinked) individual keratin molecules of precise structure and conformation, belonging to a genetically encoded well-defined keratin species. These forms are generically called *recombinant keratins*.

The first mention of using keratin as components of medicines and of rudimentary medical devices dates came from the 16th century, when more than 11,000 references were made on this subject in *Ben Cao Gang Mu*, the Chinese Compendium of Materia Medica [3]. Systematic studies on keratin extraction were initiated between 1949 and 1979, to develop increasingly sophisticated techniques able to provide quasi-native forms, applicable in biomedical, cosmetic and technical domains [4]. In parallel, a large number of studies were and still are conducted to establish technically feasible and economically optimal methods to recover and recycle the keratins from waste and by-products [5], both for agri-industrial uses [6-10], and for eco-friendly controlled degradation of keratin-containing products stored in large waste deposits [11-13]. If appropriate techniques of protected extraction are applied to recently collected unaltered keratinous biological products, valuable quasi-native keratin species can be obtained. Starting from them, biological-active keratin forms can be prepared and conditioned to be used in cell culturing, tissue engineering and biomaterials producing applications [10,14-18]. In the following, the present paper discusses the main issues and constraints in obtaining such biological-active keratin forms, in relation with the keratin types and characteristics.

A MINIMAL PHYSICAL-CHEMICAL PORTRAIT OF KERATINS

Keratins are exclusively intracellular fibril-forming proteins, confined to the epithelial tissues of vertebrates [19]. Even if all epithelial cells are able to biosynthesize keratins in the form of intermediate filaments [20], only specialized tissues produce predominantly keratinic morphological structures, exploitable to extract keratins. In this respect, vertebrate integuments are the main representatives. As a general rule, there are two structural components of the integuments that contain keratins: the epidermis, and the epidermal products (mainly the hair, nails, feathers, reptilian scales etc.) and appendages (hair follicles, sebaceous glands, eccrine glands, appocrine glands). Regardless the histological location, a large variety of specialized keratin types ensure distinct structural and regulatory (cell signaling) functions, both at cell and at tissue level [21]. The main structural function of keratins consists in generating a supracellular scaffold that connect cells and stabilize morphological structures of epithelial origin. To fulfill such a function, during the phylogenetic evolution, some of the keratin species have acquired particular molecular characteristics. These characteristics sketch the physico-chemical portrait of keratins, especially of those playing structural roles.

There are usually five viewpoints to classify keratins [22, 23]: (**i**) the morphological entities of animal body which comprise them (*intracytoplasmatic* or “soft”, and *morphologic* or “hard” keratins), (**ii**) the primacy of biosynthesis (“primary” or *normally synthesized in basal keratinocytes*, and “secondary” or *optionally (in addition or instead) synthesized*), (**iii**) the predominant amino acids in their composition (“type I” or *acidic*, and "type II” or *neutral-alkaline*), (**iv**) the observed X-ray pattern (“alpha keratin” which includes *α-helix-rich domain*s, “beta keratin” consisting in *β-sheet packed macromolecules*, and “gamma keratin” which represents the low molecular weight *keratin associated proteins (KAP)*, that hold the keratin intermediate filaments together by embedding them in a protein matrix, at the level of epidermal products), and (**v**) the average molecular weight (“low weight keratins” with a molecular mass less than 40 kDa, “intermediate weight keratins”, of 40 to 57 kDa, and “high weight keratins”, of more than 57 kDa; the range of the values of molecular weight for α-, β- and γ-keratins are 40÷68, 10÷22, and 10÷18 kDa respectively).

At molecular level, there are noticeable differences between keratins of different animal species, and of different intraspecies histologic localization [23]. The differences in amino acid composition and concatenation sequence determine the folding, and the supramolecular association and spatial packing of different keratins. As an example, mammalian hair predominantly contains alpha keratins, while in avian feathers and in reptilian scales prevail beta keratins. Therefore, mammalian epidermal products are softer and easier to chemically degrade, in comparison with those of birds and reptiles, which are stiffer and abrasive. At the level of epidermal products, the differences are accentuated by the presence, abundance, chemical properties, and types of keratin-associated proteins [24]. The macroscopic shape of the keratinized structures (as the hair “curliness”) is also influenced by the presence, amount, and physical-chemical characteristics of keratin-associated proteins [25], particularly by their ratios between the various types of constituent amino acids. The supramolecular packing characteristics of “hard” keratins are in a dynamic state equilibrium. In special circumstances (30 % relative humidity, intense mechanical stretching of keratin fibers), a putative structural / conformational transition can occurs to transform α-helix domains into denser β-sheet form [26]. The newly aquired β conformation is stable until enough moisture difusses into the intimate structure of keratin, when the α-helical conformation is gradually recovered.

To date, 54 keratin species are known to be present in the human body, as revealed by the genome analysis. According to the newest nomenclature [27], 38 of them are *epithelial keratins* which are present as intracellular cytoskeleton in the cells of the layered epithelia (including skin epidermis), and the other 16 are *hair keratins* which are involved in the formation of hard keratinized structures such as hairs, nails, claws, etc. [28,29].

Keratins are medium-sized polypeptides having, in average, 400 to 644 amino acids. In terms of colloidal chemistry, keratins are amphoteric polyelectrolytes with defined values of isoelectric domains, which depend on the types and numbers of constituent amino acids (acidic, type I: 40÷64 kDa, pH_i 4.7÷6.1; neutral-basic, type II: 52÷68 kDa, pH_i 5.4÷8.4) [30]. The sequence of amino acids in the α-keratins macromolecule shows a characteristic structural motif: the succession of heptad repeats (seven amino acids constrained to form two consecutive turns in the helix structure) along the polypeptide chain [31]. The first and the fourth amino acid in every heptad have small nonpolar side chains (leucine, isoleucine, methionine, and valine) and are placed on the same face of the helix, creating a continuous hydrophobic lateral stripe, which permit a longitudinal assembling as pairs of helices. The pairs further generate spatial aggregates of increasing complexity, which conclude by forming filamentary assemblies, and finally bundles of microscopic diameters and mesoscopic lengths. In the case of β-keratins, a large number of hydrogen bonds are formed, in a regular manner, between the amino and carboxyl groups of peptide bonds on adjacent polypeptide chains, which facilitates a long range parallel alignment into spatial structures of folded sheets type. By supramolecular assembling, the folded sheets generate strongly binded, dense, planar morphologic structures of extended dimensions.

As compared to other fibrous proteins (especially of extracellular type, like collagen and fibroin), the most prominent chemical characteristic of keratins consists in the high content of disulfide covalent bridges (resulted by reaction between the sulfhydryl groups of cysteine amino acids located on adiacent polypeptidic chains, generating a cystine residue) which consolidate their supramolecular aggregates [32]. The amount of cysteine is strictly dependent on the biolo-morphological function of keratins, being (reported in grams per 100 grams of dry keratin) of 16.6÷18.0% in human hair, 2.3÷3.8% in human epidermis, less than 0.1% in monostratified epithelia, 11.0÷13.7 in sheep wool, 10.5÷15.7 in cattle horn, and about 2.11% in feather keratin [33,34].

In biomedical applications (including tissue engineering and biomaterials producing) one of the most important properties of the involved macromolecular compounds is their immunogenic and antigenic potential. Immunogenicity defines the ability of (bio)chemical compounds to trigger an immune response through involved cells and antibodies, while antigenicity refers to the ability of the so called antigenic determinants (or epitopes) to specifically interact with antibodies [35]. Proteins immunogenicity is conferred by the presence of some amino acids and particular sequences of amino acids in their polypeptide chains (resulting in a defined local chain conformation), which acts as antigenic determinants. Extended studies revealed that even if some epitopes exist in keratin macromolecules (because monoclonal antibodies can be produced in response to the contact of health tissues with various extracted keratin species), keratins are safe to be used in biomedical applications [36].

KERATINS SOURCES AND VARIABLITY

Keratins are among the most widespread proteins in the animal kingdom, predominantly in the chordate phylum. The only invertebrates which produce significant quantities of keratins are the parasitic platyhelminthes [37], but these “inferior” animals still biosynthesize intracellular intermediate filaments [38], even if they use chitin in their external “shields”, instead of keratins. A large variety of keratins can be extracted from different biological sources, in which they are abundantly located to form macroscopic morphological structures. The usual keratins sources are the wool, the hair, and the avian feathers, but some “exotic” ones can be also considered, like epidermis, nails, claws, hooves, horns, beaks, and reptilian scales and scutes. When large amounts of keratins and keratin derivatives must be obtained, the abundance and quality of the resources (defined as the “volume” of available particular sources, feasible to be exploited in technical and economic terms) represent one of the main issues. If, for example, agro-industrial applications are had in view, large scale extraction must be considered, and the only appropriate resources are the wool and the feathers. In this particular case, raw collected keratin sources, together with wastes and various by-products which contain keratin (including chemical and industrial processed products) represent feasible options. Such sources and resources are not able to provide quasi-native extracted keratins, but only keratin derivatives, mainly hydrolysates, which are prohibitively expensive or even forbidden to be used in biomedical domains. For advanced and biomedical applications, keratin forms bearing compositionally and conformational intact cell recognition domains must be considered, and that is why the use of pristine sources of keratins is primordial, the resources being not a limiting factor. In this case, if and only if human hair or nails are unavailable or adversely affected, wool and feathers harvested from supervised livestock (selected animals breeded in controlled regime) represent the default source of choices.

METHODS FOR KERATINS SOLUBILIZATION

Only the macroscopic keratinized morphological components of vertebrate bodies can be used as sources for keratins extraction, when keratin-based engineered constructs are to be produced. Due to keratins intrinsic hydrophobicity and to the presence of multiple bridges (both of covalent and non-covalent types) between their macromolecules, and because of the compact structure of keratinized entities, keratins sources are practically insoluble in water and in usual solvents. Usually, chemical treatments and/or physical-chemical processes must to be applied to them in order to initialize and to perform solubilization.

There are two ways to solubilize keratin sources: (i) an *unprotected* one, which irregularly and unsystematically detach keratins macromolecules or parts of them, by degrading covalent bonds of both the polypeptides and disulfide bridges, and (ii) a *protected* one, which maximize the systematic deconstruction of keratin source, by specifically cleaving only the covalent bridges, and by vigorously disrupting the hydrogen bonds between the keratins macromolecules. Excepting the case of advanced degrading treatments (probably to occur according to the first way of solubilization, when keratin hydrolysates of low molecular weight are obtained), both the mentioned ways confront with the difficulty to maintain solubilized polypeptides in colloidal state, as stable aqueous solutions. Freshly solubilized keratins (and keratin segments) are prone to precipitation (even in solutions having pH values far from the isoelectric range, and with low salts content), because of their hydrophobicity and of the unavoidable tendency of disulfide bridges to disorderly (statistically, chaotically) reassemble starting from the new resulted sulfhydryl groups. As a consequence, a complex mixture of unfolded, missfolded, and unregular supramolecular aggregates results, which tends to physically separate as flocs with pronounced tendency to association through hydrophobic interactions. When quasi-native intact keratin macromolecules must be obtained, a particular method derived from the protected way of solubilization, named *reactive extraction*, is the only option. This method implies the cleavage of disulfide bridges and the concomitant consumption of sulfhydryl groups, as they are formed.

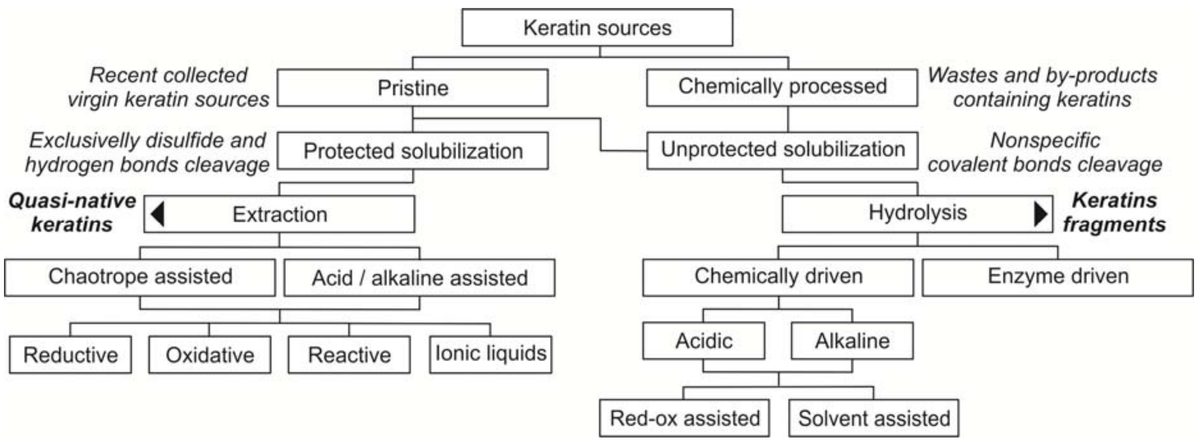

Figure 1: Schematic diagram of keratin solubilization pathways.

Figure 1 resumes the pathways of keratin sources solubilization, and specifies the initial characteristics of the raw sources, the nature of the mainly involved chemical processes, and the resulted keratin forms. The *chaotrop assisted reductive extraction* is the recommended method to obtain quasi-native keratins suitable for biomedical applications. Two versions of this method were originally described in references [39] and [40], the second one being reported as effective for solubilizing β-keratins [41]. An efficient alternative is presented in reference [42], and reference [43] reports a method for γ-keratins isolation and purification. As a rule, pristine keratin sources must be used, which are collected from alive individuals or just sacrificed animals, then frozen in liquid nitrogen immediately after harvesting, and stored at -80°C until the start of extraction process.

ENGINEERED SUBSTRATA AND MATERIAL WHICH INCLUDE EXTRACTED KERATINS

The general way to produce solid substrata and materials starting from (bio)macromolecules in colloidal solution consists in inducing strong and/or multiple, sufficiently stable “bridges” between their chains. Depending on the desired mechano-rheological and responsive properties of the final products, the “bridges” are designed from the viewpoint of their type (direct, or mediated connection), length (of "zero-length", or of finite dimension), stiffness (rigid, or flexible), strength (the energy needed to elongate or to bend them), stability (the factors able to destructuring them), and reactivity (the ability to interact with low-molecular chemical species). The "bridges" between extracted keratins molecules can be induced by three kinds of cross-linking processes: (i) dehydro-thermal treatments, (ii) physical-type bonding, and (iii) chemical reactions, the last ones possibly mediated by short-chain bi- or multi-functional molecules. Depending of the particular application, the resulted products of the "bridging" can have one of the following states: *hydrogel* (if they are highly hydrated), *cryogel* (if they were freeze-dried starting from a hydrogel), *dry films* (when colloidal solutions or hydrogels are dehydrated), *vitrigels* (if the obtained cryogels or films are controlled rehydrated), and *dry solid blocks* (if colloidal solutions or hydrogels are compounded and then dehydrated). Another applicable form of keratins, which does not involve intentional crosslinking, are the *powders* resulted by grinding the purified keratin sources, or by freeze-drying the extracted keratin precipitates. In any of the mentioned states, the products are able to act as materials, buiding-blocks, and solid forms suitable for biomedical applications.

The most frequent advanced applications of extracted keratin are the following: hemostatic hydrogels [44,45], absorbent films and powders for wound dressing [46,47], films and sponges for controlled drug delivery [48-50], porous films and hydrogels for cell culturing [14,51], compact films for skin epidermis physical models [52,53], surrogates for extracellular matrix (due to the presence of cell adhesion sequences, arginine - glycine - aspartic acid (RGD), and leucine - aspartic acid - valine (LDV)) useful for tissue engineering [54-56], 3D constructs for implants and tissue engineering [57-60].

CONCLUSION

Even if widespread and apparently trivial as resource, keratins represent a valuable source and resource for advanced applications, mainly in biomedical domain. Their physico-chemical properties which sustain such applications and the methods of their protective extraction are summary reviewed in the present paper.

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Section 10: Footwear Design and Technology

INVESTIGATION ON CUSHIOING BEHAVIOURS OF PU FOAM MATERIALS AS FOOTWER INSERTS FOR HIGHER BMI PEOPLE

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Abstract: *The people across the world are primarily concerned on the importance of inserts in footwear in terms of its effectiveness to accomplish therapeutic benefits. The body weight has been implicated as a factor in plantar heel pain [4,11,12]. The main aim of research is to scientifically investigate the characteristics and behaviours of PU foams as inserts in footwear exclusively for high BMI individuals. The foot orthoses are commonly used in the conservative treatment of plantar fasciitis and are helpful to reduce the symptoms of strain in the fascia during standing and ambulation [1, 5, 6, 7]. None studies have been attempted to investigate the effectiveness of footwear inserts and their impact especially for high BMI People. Hence, the research on PU foams is warranted to identify an ideal material rendering comfort for high BMI Individuals. This paper presents details on physical characteristics of Polyurethane foam materials and its efficacy on functional performances as footwear inserts. The polyurethane foam materials possessing uniform substance of 4mm with varied densities such as D55, D75, D95 and D120 have been assessed on various physical characteristics such as Density, Hardness, Compression set followed Resiliency and cushioning behaviours. Out of the four densities evaluated, the resiliency on static and dynamic condition of D120 resulted to the highest value and is superior to others. The cushion energy behaviours in respect of Walking/Running on static and dynamic condition resulted to superior possessing better cushioning performance on footwear applications. Hence, it is finally concluded that the PU foam material of D120 is the best material of choice as footwear insert for alleviating the foot and ankle pain related problems and ease therapeutic benefits for high BMI individuals.*

Keywords: *Body Mass Index (BMI), Polyurethane (PU), Plantar Pressure, Overweight &Obese.*

INTRODUCTION

In the world population, overweight and obese people are constantly growing and the future scenario will witness a major proportion of high BMI populace amongst the overall strength of people in the global map. The people who fall under the category of high BMI are prone towards an important medical condition which otherwise termed as Obesity. It is a major threatening factor for the problems relating to foot namely foot and ankle pain, musculoskeletal disorders, plantar fasciitis, arthritis and other innumerable foot complications [9].

The common concern encountered by the high BMI people is choosing the right choice of footwear and foot comfort materials during their walks of life. The people of overweight and obese are prone towards ill foot health complications due to their body weight /mass and the generation of excessive plantar pressures on the foot in the phases of locomotion [9]. The foot related problems of the high BMI People necessitates the possible ways and means to explore identity of comfort providing materials, mechanical characteristics and behaviours thereby providing desirable comfort properties to accomplish end users satisfaction. The footwear being manufactured and sold are predominantly meant for common population and the obese people, in general, experience difficulties in search of footwear ideally meeting their foot anthropometric parameters. Hence, the design and development of footwear exclusively for overweight/obese people and identification of footwear inserts to help alleviate the foot pain symptoms being experienced by high BMI people have been felt imperative in the research activities of footwear technology.

In this paper, the significant role of foot care materials namely PU foams as footwear inserts especially for high BMI people have been proposed for research studies and applications. The foot orthoses are commonly used in the non-surgical treatment option for improving the wellbeing of heavy weight people while using footwear [2,3,8,10]. The main objective of research is to investigate the cushioning behaviours of PU foam materials for adding comfort in footwear as there is so far no such studies have been attempted to investigate the efficacy of footwear inserts and their impact especially for high BMI People. The scientific analysis on the materials' characteristics would suggest the best material ideally suitable for alleviating all foot relevant problems and provide therapeutic advantages for the overweight/obese people.

The Polyurethane foam is used in hundreds of consumer products to provide comfort, support, safety and durability. The PU foam is one of the most versatile materials ever created and is significant for its qualities such as light weight, resilient, low odour and resistant to common allergies. The unique character of PU foam is the best cushioning material of choice and hence, this material has been regarded as a potential material for foot comfort solutions in footwear. The PU foam is manufactured as a product of the reaction of two key raw materials, a polyol and a di-isocyanate with water. During the composition of raw materials, the bubbles are formed and the mixture expanded like rising of bread. The duration of process consumes lesser time and the mixture is converted into a usable product. The PU foam material is increasingly being used in green technologies because it possesses numerous environmental friendly properties including recyclability. The material specifications were designed exclusively to cater the comfort of the people of high BMI categories The polyurethane foam materials of varied density characters ranging shore hardness from 55, 75, 90 and 120 with the uniform substance of 4mm were supplied by **M/S Mariam foams (P) Ltd, Chennai, India.**

MATERIALS AND METHODS

Methods

The evaluation proposed on the varied characteristics of PU Materials was aimed at ascertain the mechanical behaviours and its impact on the health parameters of foot of overweight/obese people. The SATRA Specifications and Standards for assessing the materials aided to play a pivotal role to understand the characteristics of materials and their applications for desirable end results. The physical test methods such as Hardness, Density, Compression set; Static and Dynamic compression and cushioning were emphasized for investigation and subsequently the best material of choice would be revealed based on performance criteria to satisfy the requirements of overweight/Obese people.
In the physical test assessment methods, the Polyurethane foam materials of different density characters were experimented using varied apparatus and devices at the testing laboratory, SDDC, CLRI. This lab has been equipped with all the testing equipments' for assessing the footwear materials, components and accessories. The personnel engaged in the lab are awarded with SATRA accreditation certificate and the lab is in continuous association with SATRA –UK.

The test method ; SATRA TM 205,1999,Hardness of Rubber and Plastics- Durometer method was employed to determine the hardness of PU foam materials of varying densities D55,D75,D90 and D120. The apparatus SATRA-STD 226, Modules to ISO868, ASTM D 2240 was used for the evaluation of hardness properties of PU foam materials.

The test method: SATRA TM68, 1992 was adopted to determine the density character of PU foam materials. In this method, an apparatus has a balance capable of measuring mass up to 100 g with the accuracy of three decimal places. The dial thickness gauge as described in BS 903; SATRA TM 136 applies pressure on the test specimen of 22 plus or minus 5Kpa.

The test method SATRA TM 64, 1996, Method-2, Compression set- Constant stress method was used to determine the compression set of the varied PU foam materials. The basic principle of the compression set device is the percentage change in thickness calculated after the compression with a pre-defined pressure for a set of time and allowed to recover for a further set of time on the PU foam materials.

COMPRESSION SET APPARATUS

The test method: SATRA TM 159, Cushioning properties, 2002 was employed to determine the cushioning properties of PU foam materials. This method was used for assessing the Cushion energy and Cushion factor under static condition of cushioning of varied density PU foam materials.

UNIVERSAL TESTING MACHINE

A Universal tensile testing machine, INSTRON 3369, possesses the capability of measuring forces up to 1KN. A jaw speed of 20.0 plus or minus 0.5 has been set to determine the cushion energy mm/min of materials.
The energy required to gradually compress a specimen of a material up to a standard pressure is termed as cushion energy (CE) and is measured using a tensile testing machine.
The pressure on the surface of the test specimen at a predefined loading is multiplied by the volume of test specimen under no load and is divided by the cushion energy of the specimen at the predefined load is termed as cushion factor (CF).

DYNAMIC COMPRESSION TESTER

Finally, the Dynamic Compression Tester- SATR STM 480 was used to determine the cushioning energy after dynamic compression.

RESULTS

Physical test methods conducted on PU foam materials
The physical test methods such as Hardness, Density, Compression set %(Static&Dynamic) and Compression Spread (%) were conducted on the PU foam materials of varying densities viz., D55.D75, D95 and D120 and the data is presented in Table1.

Table 1: Physical test parameters of PU foam inserts of varying densities

Description	D55	D75	D95	D120
Density (g/cc)	0.047	0.073	0.092	0.102
Hardness (00 Scale)	31	33	37	38
Compression Set %(Static)	12.0	9.33	6.74	6.17
Compression Set % (Dynamic)	3.82	5.9	4.8	2.3
Compression Spread (%)	8.97	8.2	6.7	6.57

The density D120 as anticipated was determined to have highest density and hardness in comparison to other PU inserts. . The hardness values ranging between 31 and 38 estimated were determined for varied density PU inserts ranging between D55 and D120. Out of the values on hardness of PU Materials, D120 represented with highest value of 38 while comparing with other materials .The tests on compression set for static and dynamic condition were carried out by the test method SATRA TM 64 and the results obtained were furnished in the above. The compression set values of D55, D75, D95& D120 materials in respect of static condition resulted to the values of 12.0, 9.33, 6.74 and 6.17 respectively wherein D120 represented with lowest value of 6.17 amongst the materials assessed in the laboratory.
Subsequent to this evaluation, the compression set values of D55, D75, D95 and D120 materials in respect of dynamic condition resulted with the values of 3.82, 5.9, 4.8 and 2.3 respectively wherein D120 represented with lowest value of 2.3 amongst the materials assessed in the laboratory. With respect to the

compression spread (%) on the PU Materials of D55, D75, D95 and D120, the values obtained were 8.97, 8.2, 6.7 &6.5 wherein D120 represented with the lowest value of 6.57 while comparing others.
The physical characters such as cushion energy and cushion factor of the PU Materials of D55, D75, D90 and D120 were assessed and evaluated on walking and running conditions. The results obtained are given in the following graphical presentations.

1. PU Foam materials (Walking-Static condition)

The PU Foam materials with respect to Walking- Static Condition is defined as the energy absorbed by the varied density test specimen when subjected to pressures with the applied force of 113 Newton similar to those experienced during walking.

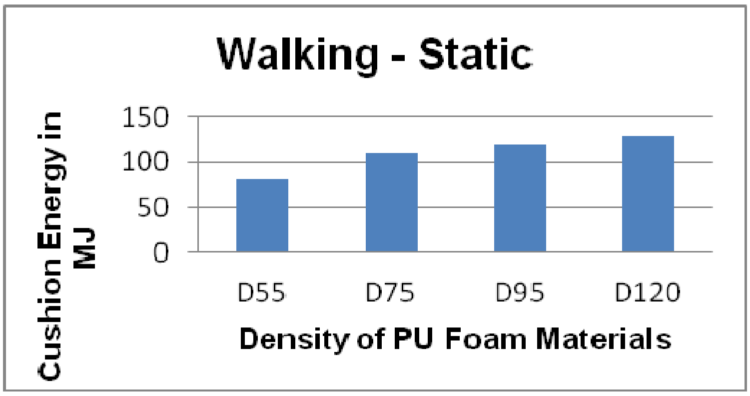

Figure 1: Comparison of Cushion Energy with Density parameters of PU foam materials

In Figure 1, the varied density parameters of PU Foam materials and their respective cushion energy characteristics in respect of Walking- Static condition are dealt in detailed manner. The density D55 is represented with the cushion energy value of 80MJ followed by D75 represented of 110MJ, D95 represented of 120MJ and finally D120 is represented with the highest cushion energy value of 130MJ.

2. PU Foam materials (Walking- Dynamic condition)

The PU Foam materials with respect to Walking- Dynamic Condition is defined as the energy absorbed by the varied density test specimen when subjected to pressures with the applied force of 113 Newton similar to those experienced during walking.

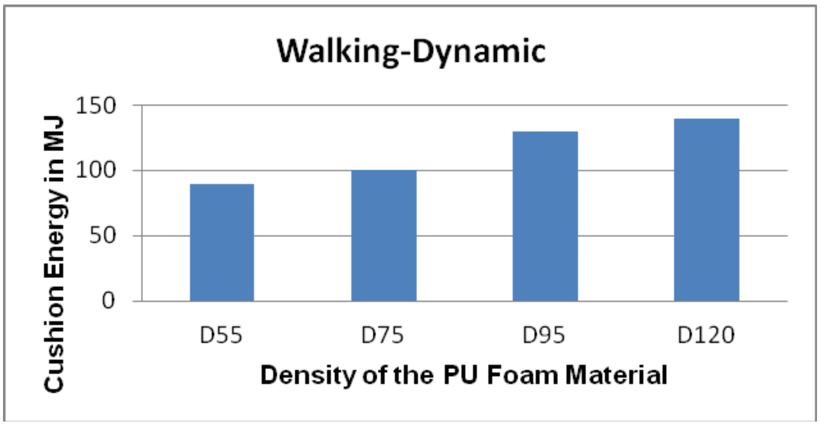

Figure 2: Comparison of Cushion Energy with Density Parameters of PU foam materials

In Figure 2, the varied density parameters of PU Foam materials and their respective cushion energy characteristics in respect of Walking-Dynamic condition are dealt with clear understanding. The density D55 is represented with the cushion energy value of 90MJ followed by D75 represented of 100MJ, D95 represented of 130MJ and finally D120 is represented with the highest cushion energy value of 140MJ.

3. PU Foam materials (Running-Static Condition)

The PU Foam materials with respect to Running-Static Condition is defined as the energy absorbed by the varied density test specimen when subjected to pressures with the applied force of 216 Newton similar to those experienced during running.

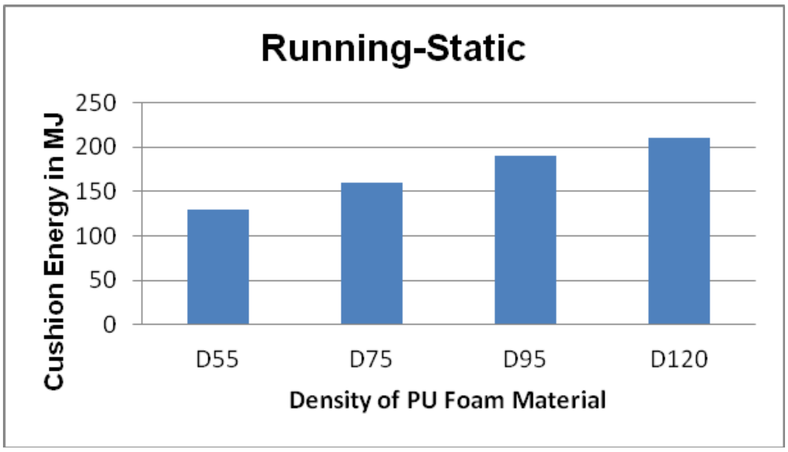

Figure 3: Comparison of Cushion Energy with Density parameters of PU foam materials

In Figure 3, the varied density parameters of PU Foam materials and their respective cushion energy characteristics in respect of Running- Static condition are dealt clearly. The density D55 is represented with the cushion energy value of 130MJ followed by D75 represented of 160MJ, D95 represented of 190MJ and finally D120 is represented with the highest cushion energy value of 210MJ.

4. PU Foam materials (Running-Dynamic Condition)

The PU Foam materials with respect to Running-Dynamic Condition is defined as the energy absorbed by the varied density test specimen when subjected to pressures with the applied force of 216Newton similar to those experienced during running.

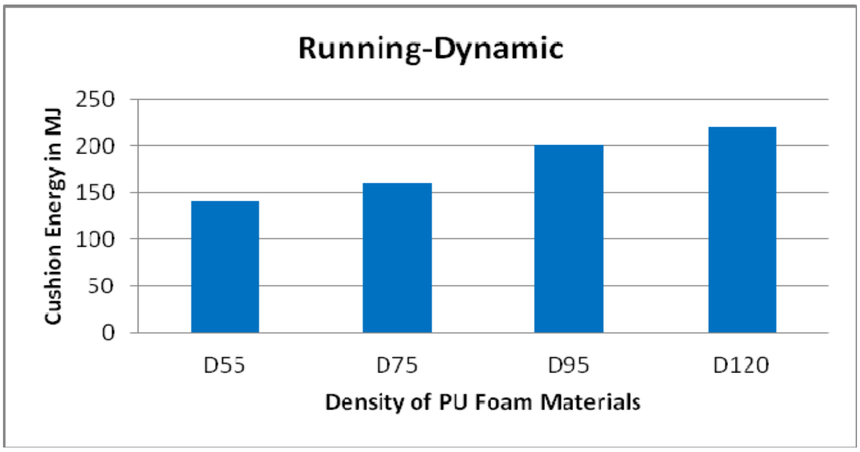

Figure 4: Comparison of Cushion Energy with Density parameters of PU foam materials

In Figure 4, the varied density parameters of PU Foam materials and their respective cushion energy characteristics in respect of Running- Dynamic condition are dealt clearly. The density D55 is represented with the cushion energy value of 140MJ followed by D75 represented of 160MJ, D95 represented of 200MJ and finally D120 is represented with the highest cushion energy value of 220MJ.
To substantiate the results obtained from the physical testing experiments on the cushion energy parameter of varied density PU foam materials, statistical test method was carried out. Based on the analysis of variance (ANOVA) test, it was inferred there was a significant difference between varied densities of PU foam materials as the p-value is less than 0.05 on static and dynamic conditions. Subsequently, Bonferroni multiple comparison test was performed to ascertain what the differing groups are pertaining to diverse

density characteristics of PU foam materials. From the test, it was observed that there were significant differences found on cushion energy characters amongst the densities 55D, 75D, 95D and 120D and it was also found on each pair of test, the p-value is less than 0.05.The summary measures of the PU foam materials are given in Table2.

Table 2: Mean & Standard Deviation for Cushion Energy of Different density of PU foam materials

Cushion Energy	Density	Mean ± S.D.
(Static Condition)	55D	88.33 ± 4.082
	75D	106.67 ± 5.164
	95D	125 ± 5.477
	120D	138.33 ± 4.082
(Dynamic Condition)	55D	136.67 ± 5.164
	75D	160 ± 0.001
	95D	195 ± 5.477
	120D	215 ± 5.477

From Table 2, it was observed that both static and dynamic conditions, the cushion energy was maximum and highest for 120D while comparing other PU foam materials. From overall observation, it was revealed the PU foam material of D120 possessing higher values on hardness, Compression set followed with Cushion energy characters amongst others.

DISCUSSION

The PU foam materials with the varied densities such as D55, D75, D95 and D120 were assessed and subsequently revealed that D120 PU foam material was considered as an ideal material for overweight/obese individuals. Out of the samples assessed, the PU foam material D120 possessed higher hardness (00) value of 38, higher density value of 0.102, Compression set value of 6.17 and 2.3 on static and dynamic condition respectively and these values are comparatively superior to others. Besides, the compression spread % of D120 represented with the lowest value of 6.57 amongst the rest of materials. The higher values on density and hardness characters of D120 material would help resist the loading generated by higher BMI individuals and these properties would impart added materials' stability as well as longevity as ideal inserts in footwear applications. Besides, the higher density and hardness features would support the entire weight bearing regions beneath the feet and help control the function of the feet.

The Compression set values on static and dynamic condition of D120 were evaluated as best amongst others mainly due to its greater degree of resiliency/recovery behaviours. The resiliency signifies the importance of D120 PU foam characteristics during the exertion of force generated at the varied phases of human locomotion. The recovery behaviour is very much needed for the insert materials to suit the desirable foot comfort requirements of overweight/obese individuals. The higher density, hardness and resiliency characteristics of D120 would be helpful in lessening higher peak pressures underneath the plantar surface of the foot experienced by overweight and obese people. The resiliency character displayed by D120PU foam material would aid in lessening the impact and reduce / relieve the stress placed on feet in the case of excessive weight of the overweight/obese individuals. The added benefit of D120 PU foam material would act as shock absorber in footwear to remedy the pain and discomfort experienced by the heavier BMI individuals.

The overweight/obese individuals, in general, display higher values of foot dimensions as well as increased plantar contact area compared to non-obese counterparts [9]. The PU foam materials were evaluated on Cushion energy characteristics - Static before compression followed Dynamic after compression on Walking and Running condition. In these test, the D120 PU foam material resulted 130 MJ in respect of Cushion energy walking (Static before compression), 140 MJ in respect of Cushion energy walking (Dynamic after compression), 210MJ in respect of Cushion energy running (Static before compression) and 220MJ in respect of Cushion energy running (Dynamic after compression). From the results, it was understood that D120 PU foam material possessed higher values representing its meritorious characteristics to provide therapeutic advantages /benefits especially on the plantar regions of feet of overweight/obese individuals. The Statistical testing procedures also support the inference obtained from Physical testing analysis.

The higher values on cushion characters of D120 PU foam would aid in cushioning the excessive plantar pressure distributions generated by Overweight/Obese individuals thereby lower the peak pressures on the entire region of feet. It was also revealed that the higher degrees of cushioning behaviour attenuate impact forces and reduce plantar pressures during the locomotion of overweight/obese individuals. The higher values on cushioning characteristics of D120 PU foam material aids in absorbing energy in footwear specially designed and developed for overweight/obese individuals. The cushioning behaviour of D120 PU foam material would be ideal for decreasing peak impact forces and minimising the occurrence of lower extremity injuries and low back pain symptoms of overweight/obese individuals. Additionally, the higher cushioning character of D120 PU foam material would be effective in reducing heel pressure and the magnitude of impact at heel strike phase of locomotion of overweight/obese individuals. Hence, it is finally recommended based on the research findings that the D120 is the best material of choice as footwear insert for alleviating the foot and ankle pain related problems and ease therapeutic benefits for high BMI individuals.

CONCLUSION

The Polyurethane foam materials of varied density characteristics were investigated for its suitability as footwear inserts in footwear especially for high BMI individuals. The main objective of choosing PU foam materials was mainly due to its inherent physical properties and its wider acceptance in footwear applications. The investigation analysis on PU foam materials mainly undertaken in this paper was to ascertain its physical characteristics and its suitability as footwear inserts to provide enhanced comfort parameters and therapeutic benefits for overweight/obese individuals. The varied physical test evaluation methods were carried out scientifically and the data obtained were presented in tabular/graphical presentations in this paper. Of the polyurethane foam materials possessing the densities ranging D55, D75, D95 and D120 investigated on Cushioning and other physical characteristics, the material D120 PU foam stands as an ideal and meritorious component for footwear insert application from the research findings. Hence, it is finally concluded that the PU foam material of D120 is the best material of choice recommendable in footwear for alleviating the foot and ankle pain related problems and ease therapeutic benefits for high BMI People.

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EVALUATION BY DIGITAL MICROSCOPY OF INSOLES ANIZOTROPIC STRUCTURES SUBJECTED TO MECHANICAL DEFORMATIONS

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Abstract: *Insoles, as composite materials products, made of various materials and using different manufacturing technologies are analysed from the point of view of behaviour to mechanical stress, accompanied by effects of temperature and moisture, the effects being visualized by means of digital microscopy. In the first part of the paper, the insoles options subjected to analysis are presented from constructive, dimensional point of view, these being selected following a study related to use frequency and effects upon the plantar comfort expressed by the subjects. In this respect, the analysis procedure developed in the paper is presented in the second part of the paper, aiming at highlighting the microscopic aspects of the insoles structure before and after the changes occurred after subjecting them to mechanical deformations, corresponding to exertion of gravitational forces action on footwear. Also, at the same time these changes are evaluated and measured by specific methods of image processing. In the final part of the paper, the obtained results and conclusions are presented, following the methodology application on a series of 7 different insoles constructive options.*

Keywords: *plantar pressure, insoles, digital microscopy, mechanical deformation.*

INTRODUCTION

Insoles as props for shoes of any kind, is a very important structure in terms of interactions with the environment, human factors and those with shoes. From this point of view, the studies conducted to date have highlighted the impact of these factors on the quality constructive posture of structural change or changes in planting areas shoes structure. Current research studies have addressed less applied, some analysis about the influence of environmental conditions, humidity, ambient temperature, the force exerted on the surface of insoles but also on the overall shape and structure of the shoe-insole-foot assembly (SIFA).[7]

In many applications of biomechanical studies, the insoles are employed to improve the gait and to avoid further damages or injuries of the joints structures of patient's foot. In biomechanics or in orthopedics field there are different concepts used to build different insole shapes, with different materials or with different destinations. ”The concept of the senso-motoric insole is to change directly the muscle length and for this reason the simulation pattern of the gait”. [2]

Using a concept like this it is possible, for many patients, to improve their gait activities without any surgery intervention on the musculo-skeletal system. For that the goal of the orthopedic specialist is to recognize and to investigate correctly the opportunities and the choices of hardness/softness material, the creation of the insoles surfaces and the adaptation to the dedicated patient. [7]

Comfort is other important aspect for footwear and insole and footwear associated with insole comfort has an influence on injury or foot health. The development of new materials is considered as the important point for manufacturing functional insole and in this moment there are a lot of insoles variants on the market [1].

Because there are a lot of types of insoles, regarding the use of composite materials or in terms of shape and size and for that is necessary to analyze them in function with different aspects. We can find, on the insoles market, types like: directly molded insoles/support insoles, accommodative insoles and functional insoles. “In case of false posture and position, like directly molded insoles/support insoles, first a congruent copy of the foot is made in order to manufacture true-to-pattern arch supports. The insole supports the foot at its weak points – in the heel region (pes valgus), in the longitudinal arch region (flatfoot) or in the region of the forefoot (splayfoot) depending on the deformity of the foot. The aim is to maintain the form of the foot under load conditions”.[3]

For accommodative insoles, “as already expressed by its name, this insole is cushioning and unloading the foot by re-distributing the pressure in specific areas. At the same time, the foot can be protected by using shock-absorbent materials. Thereby this type of insole distributes the weight of the body evenly and broadly.

Accommodative insoles are used for instance to correct *flat feet* or *pes equinocavus* as well as in the case of diabetic, neuropathic and rheumatic feet. However, stable or appropriate footwear is recommended for care purposes". [3]
As shown in the study of paper [ref3], in the case of the functional insole, "the compensating insole is an insole for growth control. The intention is to explicitly correct mal-positions of the foot and to prevent further impairment. The insole is primarily used for children or teenagers till the end of the growth, on the condition that the malposition of a growing foot can be corrected manually and without great effort. Compensating insoles can be prescribed in the case of *pes planovalgus*, *pes varus* (after treatment with plaster) and *pes adductus* or *pes metatarsus*".[3]
The materials they are made insoles are extremely diverse in terms of mechanical, thermal and geometrical properties, but one of the most important properties of these materials is viscoelasticity.Viscoelasticity is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation. Viscous materials, like honey, resist shear flow and strain linearly with time when a stress is applied. Elastic materials strain instantaneously when stretched and just as quickly return to their original state once the stress is removed. Viscoelastic materials have elements of both of these properties and, as such, exhibit time dependent strain. Whereas elasticity is usually the result of stretching along crystallographic planes in an ordered solid, viscosity is the result of the diffusion of molecules inside an amorphous material. Viscoelasticity value can vary in function of temperature or other given value. [5] The viscosity of a viscoelastic substance gives the substance a strain rate dependent on time. Purely elastic materials do not dissipate energy (heat) when a load is applied; however, a viscoelastic substance loses energy when a load is applied, then removed. Since viscosity is the resistance to thermally activated plastic deformation, a viscous material will lose energy through a loading cycle. Plastic deformation results in lost energy, which is uncharacteristic of a purely elastic material's reaction to a loading cycle. [5]
The producer of shoes finds an interesting and useful application of this material for Memory Foam Shoe Insoles (MFSI) or permanent inserts and this derives from the fact that shoes are a common used item, and it doesn't need a big amount of this special and expensive material. Also another efficient characteristic of this material is that material can be done like "memory foam hypo-allergenic, anti-bacterial, and anti-microbial. As result, these insoles won't breed foot fungi". [5]
Other materials are used for common shoe insoles that bring unprecedented relief without creating extra bulk like rigid non universal EVA foam support or new and inexpensive gel insoles- whose rigid volumes actually resist foot contours.
A composite material used in the construction of insoles with beneficial effects on the surface of the foot is the material with magnetic parts that help achieve plantar reflexology.
The major benefits of reflexology to stimulate reflex points recorded are on and around the plantar surface of the feet. The goal of reflexology is to correct the three negative factors involved in the disease process: congestion, inflammation and blood tension. Congestive disorders are responsible for the appearance of tumors; inflammatory diseases such as colitis, bronchitis or sinusitis; blood tension is responsible for reducing the efficiency of the immune system. Reflexology sessions aimed primarily at improving the circulation in the body and accelerate the elimination of waste, so no longer accumulate toxins in harmful concentrations in liver, kidney and intestine. Also, the reflex to decrease the sensation of pain can be achieved by stimulating the release of endorphins - natural analgesic body - the pituitary gland in the brain to the blood stream. Reflexology is the action most effective when used to treat the whole body and not just for certain diseases. In this way, it improves all functions of the body, which stimulates the natural healing process, making it faster and more efficiently.[8]
Insoles with active carbon active filter, another type of insole are used for sportive shoes and for people wearing long time the same shoes. These insoles provide control of foot and shoe odor through an activated carbon filter which is made of latex backing. This type of insole stops foot odor and assures comfort, being soft like velvet. The fabric material on the inside of insole is making up the insole absorbent, airy and endurance, being also easy to cut.
Another material used for building insoles, it is silicone. These insoles made of silicone are specially designed, so that on the entire surface there are small bumps, in relief (with different sizes and distributions on the plantar surface). These special shapes of the silicon insoles are stimulating blood circulation and improving plantar prevent and relieve foot pain caused by impact with the ground during walking, reduce the proportion of 40% pressing the heel and the ante-foot, near the metatarsal points, offers comfort and lightweight feet feeling, reduce pressure and blows in driving further improving them and distributing pressure evenly throughout the foot. Wearing regular silicone insoles relieves the knees, hips and legs and can be used in any type of footwear.
Insoles are made of 100% silicone, without additives or any kind of oil; the silicon insole has high viscosity and protects the load points and areas of pressure, obtaining a uniform distribution of pressure. Silicone insoles have a strong indirect effect adapting faced pressing and absorbing impacts and provide comfort feet with sensitivities or extended effort walking or standing, especially less comfortable shoes. All tests show

that silicone insoles are hypoallergenic products that do not allow the growth of bacteria and are not toxic and of course, it is no releasing of mineral oil and does not change color over time.

In order to obtain a highest comfort feet in shoes, footwear manufacturers have created gel insoles. The insoles are made of thermal polyurethane (TPU), a breathable material, extremely durable and flexible, comfortable and soft. These insoles are filled with a special solution, non-toxic glycerin and then individually tested at a weight of 600 kg. This serves as support insole and shock damping feet while walking or jogging. Also these types of insoles show a basic anti-slip sole for greater safety. Liquid gel from insoles spreads over the entire sole and acts on feet soles with massage effect. This massage stimulates blood and oxygen flow to the plantar surface.[7]

A variation of material used for insoles is the one composed of latex or polyurethane foam covered with natural wool which can add aluminum foil thermal protective order. (Fig.1)

EXPERIMENTAL SETUP

The purpose of this study was to analyze the effect of foot pressure distribution on functional insole materials and the behavior of the insoles in contact with water and low temperature. For that, were selected 7 types of insoles and each of them was divided in 10 parts with same weight and dimensions.

Figure1. Samples of insoles used in the study: 1. Insoles with active carbon, 2. Insoles with foam and active carbon, 3. Insoles silicone magnetic pill, 4. Insoles Gel, 5. Insoles foam, 6. Insoles with polyurethane, wool and aluminum foil, 7. Insoles with wool and latex.[10]

From these insoles were cut 10 samples of the same size and weight approximately equal to be passed by all versions of tests (mechanical deformation, water immersion and cooling at constant temperature). These samples are cut from the surface insoles, so they are "covered" all areas of interest in which the plantar surface supports the human body and it is in contact with the ground or shoes (in contact areas). (Fig.2) [4]

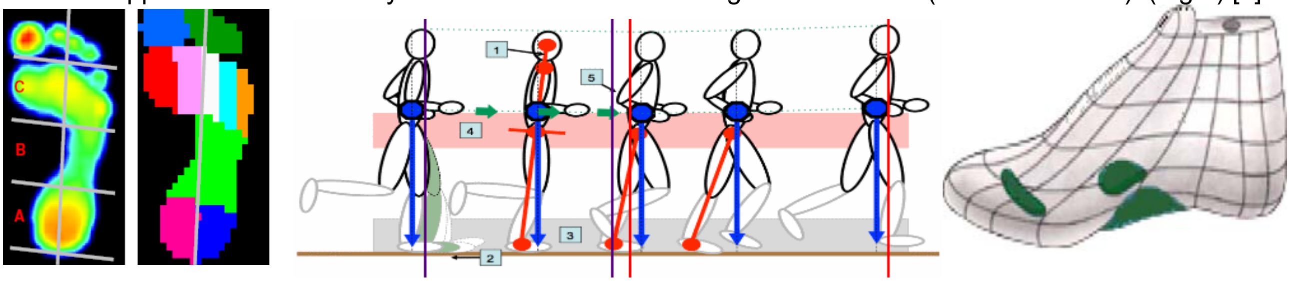


Figure 2. Plantar surface contact area with the ground (left), walk cycle (middle) and areas of interest to eliminate perspiration, humidity effects (right)[4]

Analysis methodology includes several steps that insoles samples were weighed (Fig. 3), analyzed by digital microscope for recording images of original structure, then subjected to mechanical deformation (Fig. 4), immersed in water and immediately checked the variation weight (Fig. 5), cooled at -18° C and finally reweighed.

Figure 3. Weighing samples, symmetrically cut from sagittal plane (along the leg) [10]

These samples were maintained under the conditions imposed by the analysis for 168 hours and was achieved by recording images insoles same period for each sample.

Figure 4. The mechanical load of samples [10]

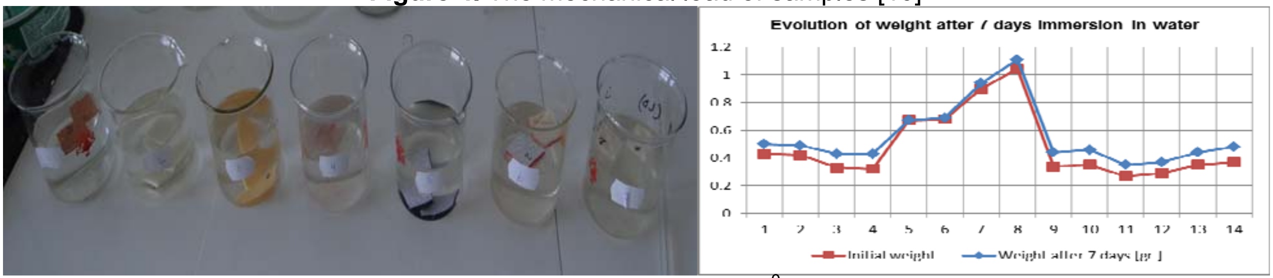


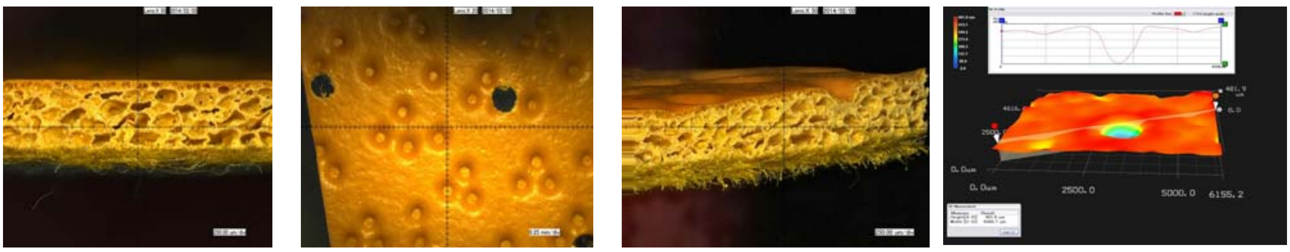
Figure 5. Samples immersed in water at ambient temperature 19^0 C (left) and weight variation of insoles samples after 168 hours (right) [10]

Figure 6. Digital microscop type Keyence VHX-600 with magnification 20x-5000x and dedicated software [9]

Acquisition and image analysis insoles, every step was performed using a digital microscope type KEYENCE VHX-600 at magnification 20x to 5000x, those with dedicated software (Fig. 6), thus yielding a set of images of the surface of the sample in the respective section initial phase, after mechanical deformation, after immersion in water and that after keeping in the temperature low environment.

RESULTS AND CONCLUSIONS

After image acquisition and their processing after each action (initial phase Fig. 7-Fig. 13) on the insoles samples were obtained a set of information about their behavior after the controlled "assault" like strain mechanical, water immersion and cooling.



a) b) c) d)

Figure 7: Insoles with active carbon

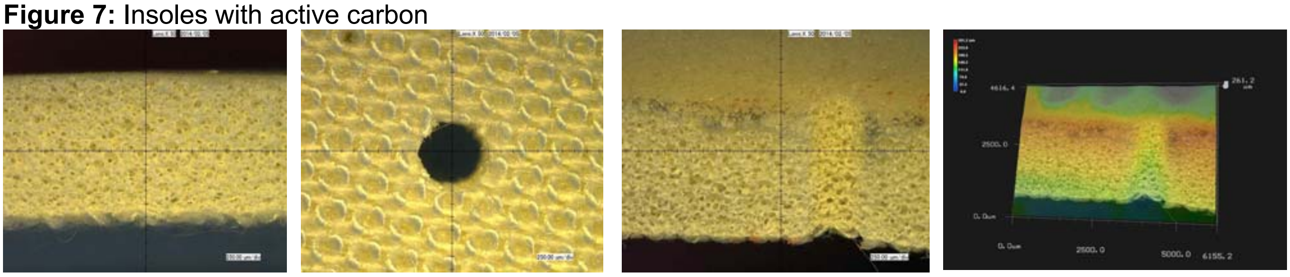


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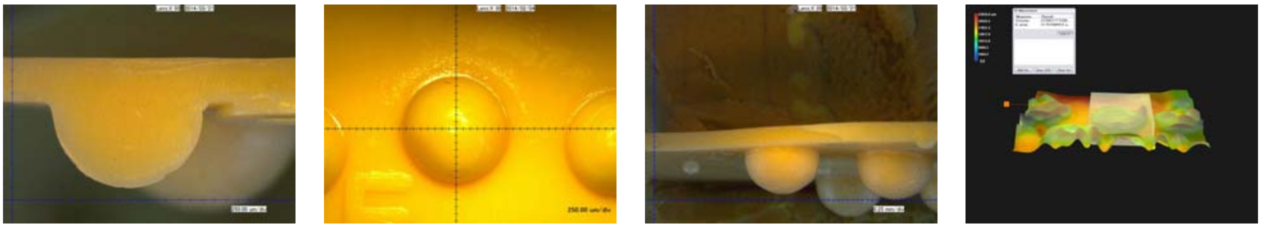
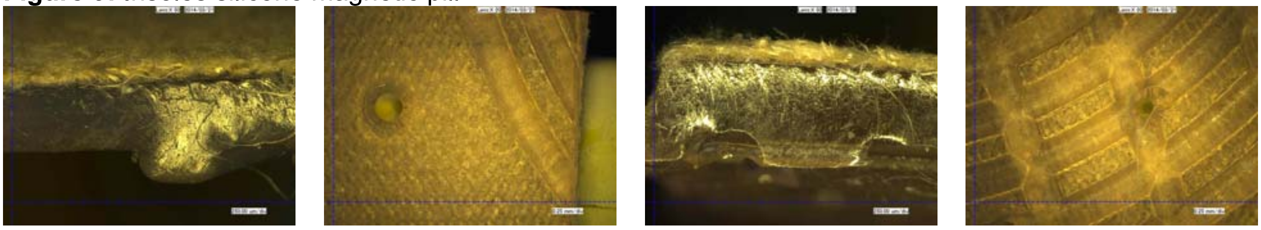
Figure 8:. Insoles with foam and active carbon



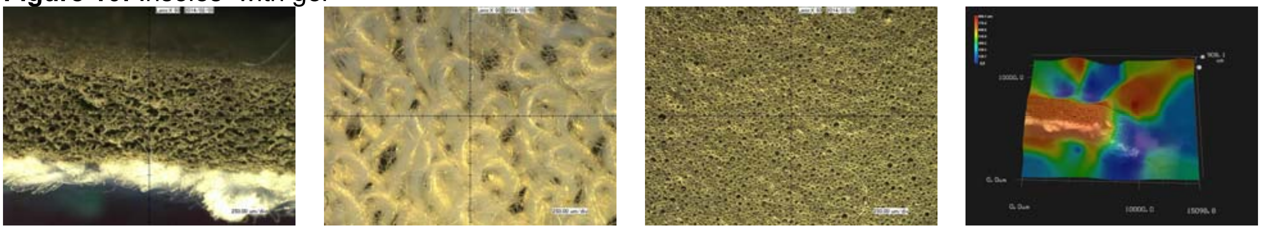
a) b) c) d)

Figure 9: Insoles silicone magnetic pill



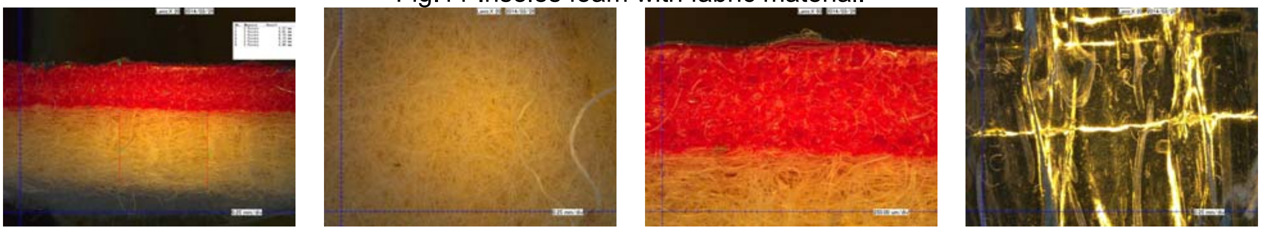
a) b) c) d)

Figure 10: Insoles with gel



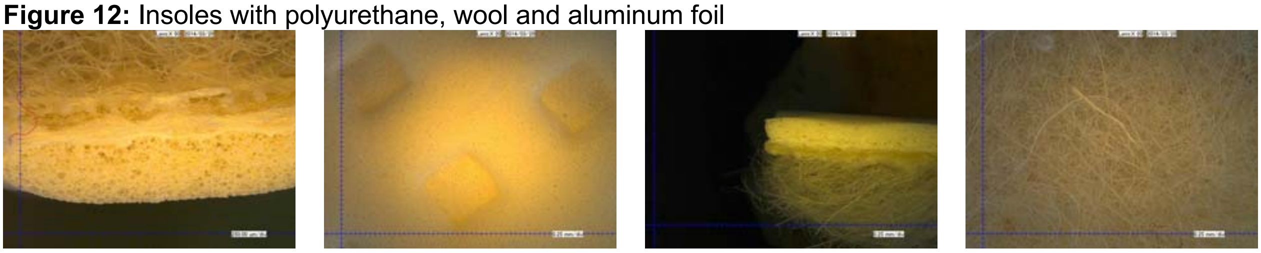
a) b) c) d)

Fig.11 Insoles foam with fabric material.



a) b) c) d)

Figure 12: Insoles with polyurethane, wool and aluminum foil



a) b) c) d)

Figure 13: Insoles with wool and latex

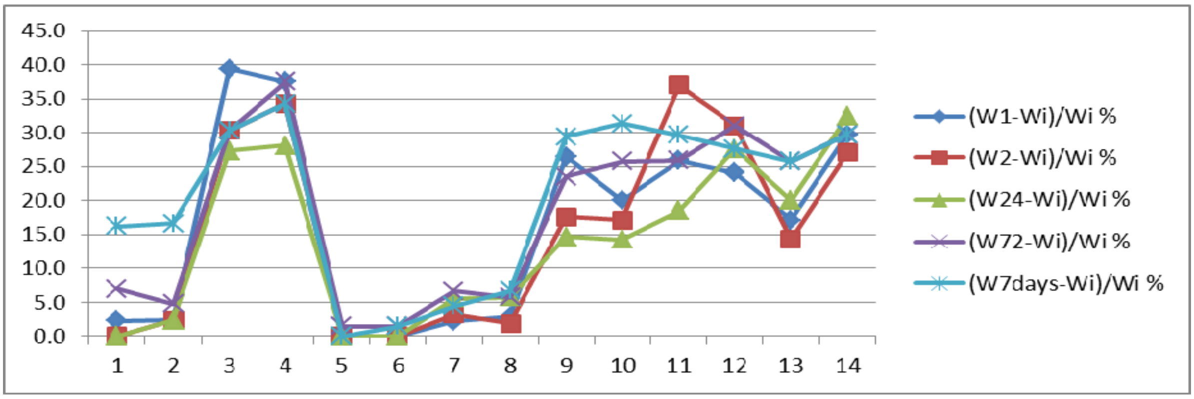


Figure 14: Relative variation of sample weights over 168 hours of water immersion

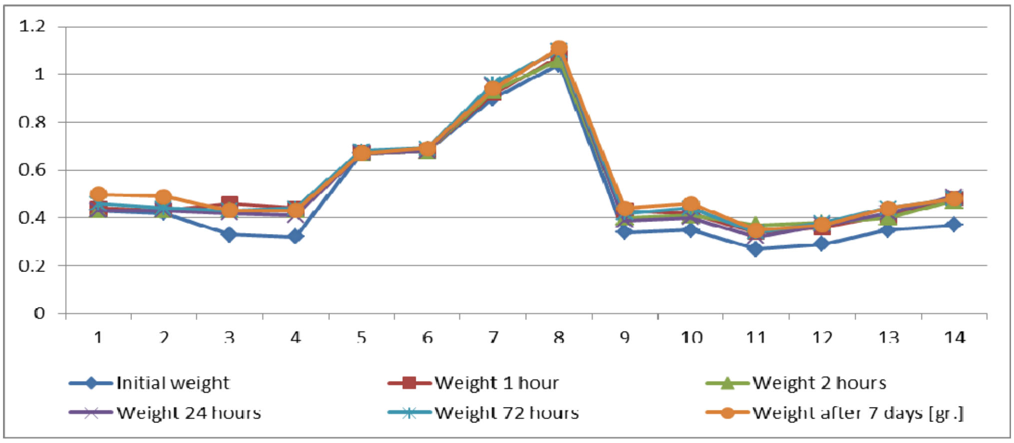


Figure15: Variation of sample weight during 168 hours of cooling

Mechanical deformation of insoles samples was performed using a weight of 10kg which was placed on the surface thereof (4 cm^2) over 168 hours. After this period, the images acquired and processed by digital microscope highlight a change in the downward average sample thickness of the order of 5% compared to the initial thickness.

Measurement of water absorption evolution in insoles samples revealed a total variation for increasing the absolute value of the weight that applies to almost of insoles.

The exception to this behavior made insole silicone magnetic parts, where the variation was on average equal to 0.44% as opposed to other types of insoles which the evolution of increasing weight is between 4.5% and 32.9%.

When samples insoles dry, were placed in inciting cooling at-18^0 C, they were maintained throughout 168 hours and weighed after 1, 2, 24, 72 and 168 hours.

Finally the influence of the most important of the three trials was determined by immersion in water, in which the weight of the sample was substantially modified and altered the structure of the substrate and type of insoles 1,2,4,5 and 6. Insoles of type 3 (silicone magnetic pill) and 7 (latex with wool) have undergone structural changes due to immersion but have become more rigid when controlled cooling.

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CORRELATIVE ANALYSIS METHODOLOGY FOR PLANTAR PRESSURE VERSUS FOOTWEAR TYPE DURING GAIT CYCLE

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Abstract: *Pressure developed on the plantar surface in contact with the walking surface during the displacement of the human subject has a variable evolution versus the footwear type (sports, urban, special, home etc.), depending on the material, shape and dimension of the shoes and not last, on the health state of the subject's loco-motor system. In this respect, the analysis methodology developed in this paper, presented in the second part, aims at highlighting a simple and efficient mechanism of assessing the size, shape and action area of the plantar pressure correlated with a certain type of footwear worn by the human subjects sample during the action of gait cycle. This mechanism is thus designed to allow that for each analysed footwear type, we establish according to the developed forces (direction, magnitude) and respectively according to the stability area during the gait cycle or climbing/descending stairs action, the effect upon the stability degree (SD) and also upon the postural comfort degree (PCD). In the final part of the paper, the results and conclusions obtained following the methodology on a target group of 10 human subjects are presented.*

Keywords: *plantar pressure, heeled shoes, gait, correlation.*

INTRODUCTION

The locomotion structure, by its components (bones, muscles and joints) allows the displacement process of the individual in space and his permanent interaction with the external environment. The totality of bones forms the human skeleton, contributing to the human body shape and posture. Bones are connected by joints thus making human mobility and displacement possible. The passive part of the locomotion system consists of bones and joints; while the active part consists of muscles totality, due to which motion is possible. The components of the locomotion system represent a big part of the entire mass of the human body, respectively 52% of the entire mass of an adult. Out of this value, a percent of 38 % is represented by muscles and 14% by the skeleton. These values are variable according to the individual's age and physical training, also in connection with other components of the human body. Particularly important is the connection between locomotion system and nervous system. In the absence of the nervous system, as stated in [1], the locomotion system "would be an inert mass or an assembly working non-homogeneous and anarchic".

From the point of view of obtaining static and dynamic stability as performing as possible we may state that the plantar surface of the locomotion system represents an important subassembly of the human body, this is why any additional load of the structure is firstly felt at this level. Besides any change of posture (by wearing high heels shoes, with variable heights, shapes and dimensions) or gait type (normal, running, added step gait, march etc.) some changes of the plantar pressure distribution can be highlighted, also changes of the plantar surface and maybe not last by inducing some deformations or contact aggressions at foot sole level.

Wearing an inadequate footwear, smaller or bigger, made of allergenic materials, with shapes and structures which are inadequate to the foot shape represent frequent causes favoring the development of some opportunities of trauma, anatomical deformations, specific allergenic or bacterial diseases occurrence with powerful effects on the gait cycle and/or stability.

Some extensive researches present these aspects as analysis determined by the specific requirements of the subjects' sample or footwear type, studies which are meant to highlight the particular important manifestations related to the human body stability.[3,]

Normal human gait and running can be defined as "a locomotion method involving the use of the two feet, alternatively, both for support and propulsion". To exclude running we need to add "…at least one foot in contact with the ground at any moment".[3]

An extremely important problem which is to be considered when the gait cycle is studied is represented by the shape, dimensions and health state of the plantar surface. *The foot sole*, in the complexity of its structure may be responsible of 90% of the asymmetries considering that a small discrepancy between the feet soles can lead to a considerable variation between feet dimensions. Subsequently, the pelvis will be affected. There are 3 axes in the foot: transversal axis (allows flexing and stretching the foot sole), longitudinal axis (allows rotation of foot) and sagital axis (allows pronation and supination motions). Even the points supporting the body weight are 3 and are located in the heel, the edge of the first and second metatarsal bone, the edge of the fourth and fifth metatarsal bone. In some situations, the support points can be one or two, thus the foot is different classified, cases being shown in the following images (red points are the weight support points). These weight support points can be highlighted by help of a platform used for measuring plantar pressure, e.g. *footscan* type pressure platform.

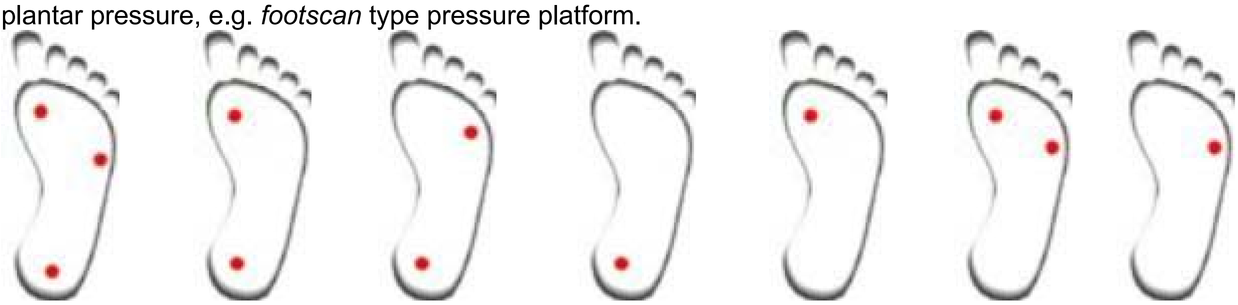


Figure 1: Weight support points for: a) normal foot; b) flat foot; c) foot base brought to front and supinated; d) lifted tip; e) bended and pronated foot; f) weight falls on front and tip is bended; g) equinovarus [2]

When the abnormal contact of the foot with the support surface is accomplished, the foot can be loaded so that the human body weight is supported just on one of the four quadrants. The heel load is pulled up in extreme dorso-flexion, due to a muscular unbalance. As a follow, weight is never overtaken by the front side of the foot and the terminal balance phase is lost, reducing thus the step length. [4]

Another deformation of the plantar surface, also called crooking of toes is comparative to the plantar flexion of the foot front and especially to the foot muscles rigidity. In this case the foot can move on flat ground but the heel will be never in contact with the ground, this is why the contact will be accomplished only by the metatarsal area and by comparison the initial balance will shorten the gait cycle duration.

In the same respect, the excessive medial contact shape is also analyzed due to muscular rigidity by means of which the foot is bent towards the exterior with a diminished medial arc, retrieves the most part of the human body weight. [5]

As a follow, all these deformations of the plantar surface or of the entire foot can be emphasized by non-suitable wear of some inadequate footwear shapes (with/without heels) obtained by non-conform materials or in extreme models. Emphasizing some deformation in time is accomplished starting with transient manifestations, partial manifestations and reaching painful forms, with edema or skin alterations.

Also, wearing some footwear without considering the anthropometric dimensions of the foot and of the entire human body may determine a change of posture, of gait cycle, of stability in static and dynamic regime and not last a change in the quality of the plantar surface. [6]

EXPERIMENTAL SETUP

For the analysis of wearing effects for different footwear options, with different heights for women, the design of a flexible methodology was necessary involving the possibility of correlating the recorded data with the footwear type versus the medium age of the subjects' sample. In this respect specific data acquisition, analysis and information interpretation strategies and procedures were designed and developed and correlated. [7]

When designing the methodology used within the research the following study parameters were considered: constant environmental conditions, research space should be within the parameters required by gait analysis and as few as possible perturbing factors. For the environmental conditions we considered the environmental temperature (19°C±1°C), relative humidity of air (50%), noises and vibrations (there are not any), general illumination (210 lx), and atmospheric pressure (740 mmHg). Practical analysis of recordings was accomplished by connecting the following equipment, as shown in fig.2: thermal camera FLIR IRC57-B Bcam SD (1),Footscan RSScan platform (2), an amplification system Footscan (3), a computer (4), photo camera (5) and their interconnection cables (6), respectively the analyzed subject (7).

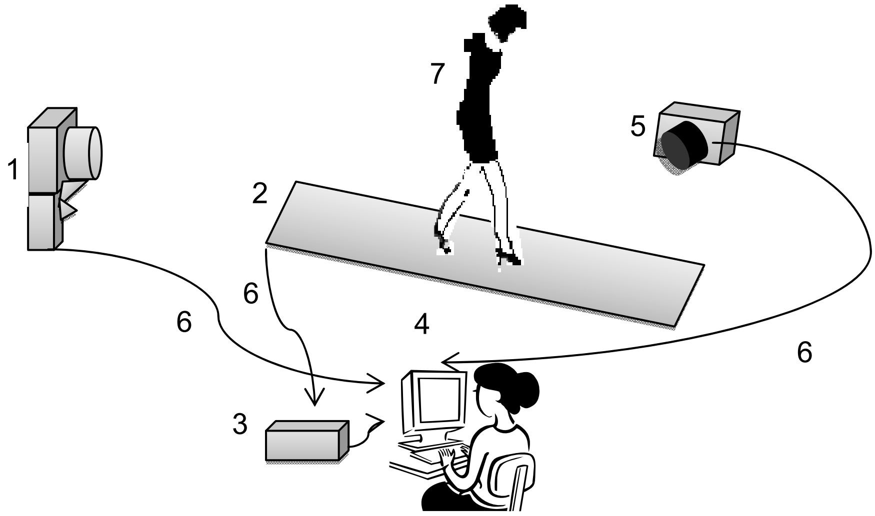


Figure 2: Block diagram of the recording system

By developing the diagram of the used procedure for the comparative analysis of the plantar pressure, when different types of footwear are used we are able to determine the correlation between the temperature established at the level of plantar surface and the type of footwear (heel height).
The first elements considered in the procedure are the parameters of the environment for which we aimed at maintaining within constant limits along the entire procedure, but also at the same values for all the analyzed subjects. The considered parameters are: environmental temperature, pressure, humidity, noises and vibrations and illumination. The next initial stage consisting of the analysis of the subject according to the anthropometric data: height, weight, foot dimensions; as well as physiological data: body temperature, pulse, blood pressure, general health state.
The procedure consisted of three main stages.
The first stage is important for the subject's training by specific training, accommodation, analysis of footwear type procedures.

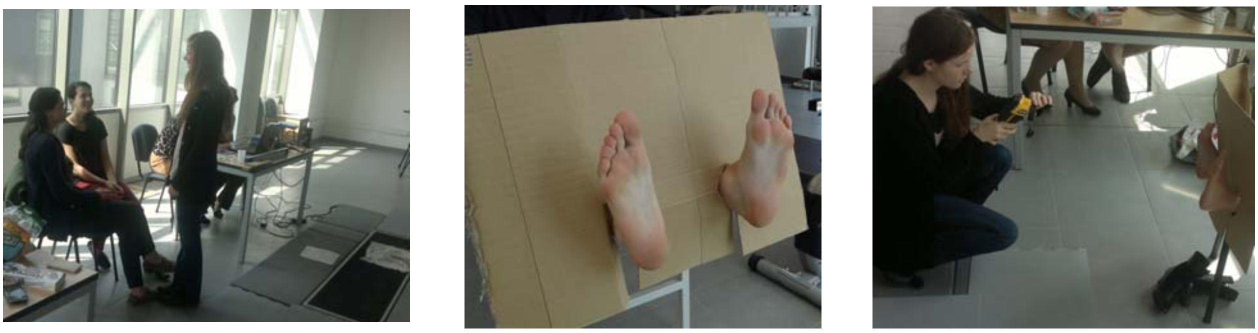
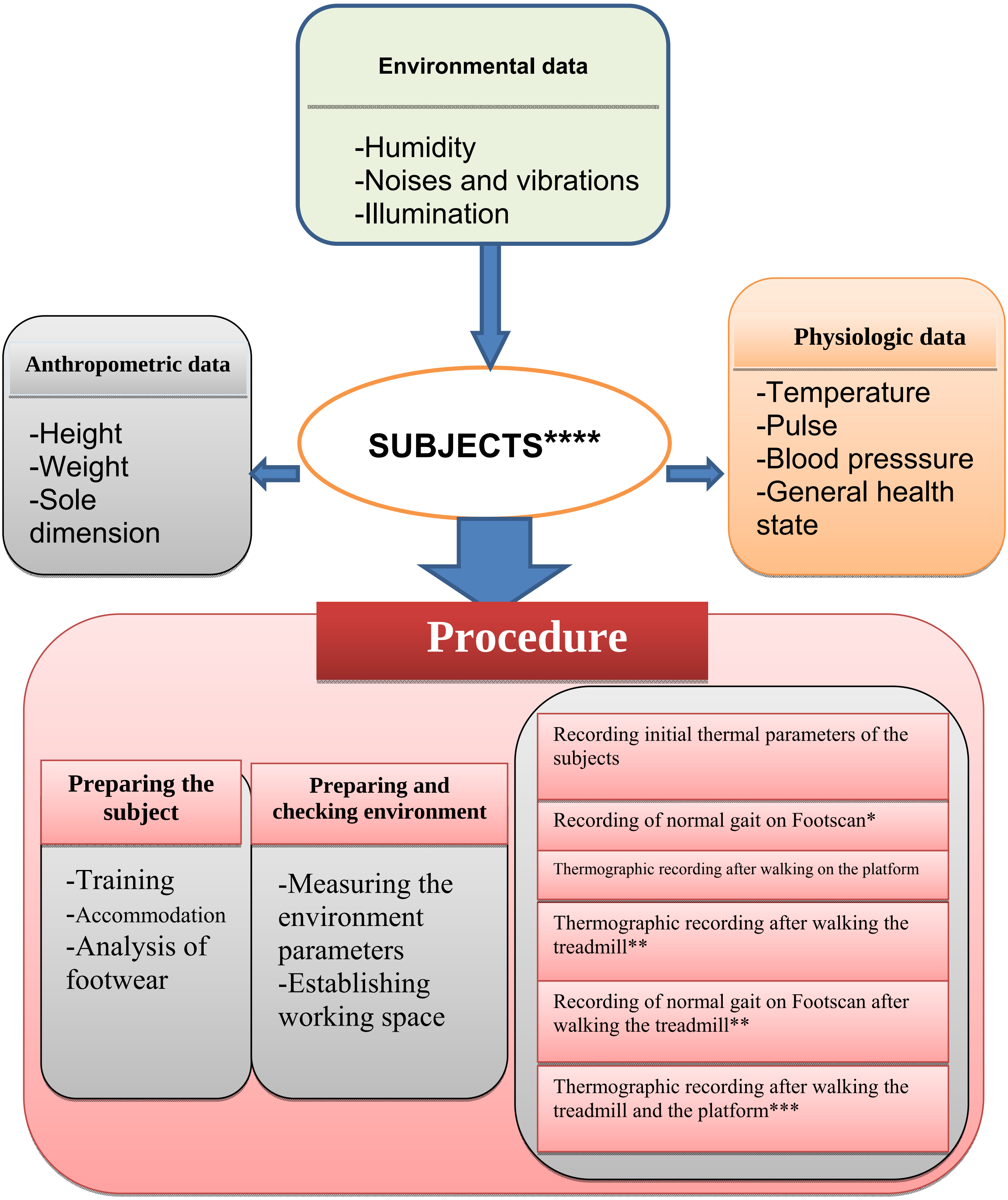


Figure 3: Stages of the analysis, training, positioning and thermographic evaluation of the subjects

The training involves explanations regarding the recordings required for the analysis, explanations upon the equipment, upon the posture during data sampling, upon the data confidentiality ș.a.
Another important element is the subject's accommodation to the environment, equipment, and operator. The analysis of footwear type consisted of an evaluation of the footwear type; these elements should be cotton or another material that does not retain heat, in order to avoid influencing the measured parameters.
The second stage of the procedure is the one of checking and preparing the environmental conditions. It consists of measuring environmental parameters and establishing the working space.[8]
The third stage consists of the recordings of temperature gradient developed at plantar level surface. First time, the initial thermal parameters of the subjects were recorded by thermovision camera. Immediately after, the parameters of the plantar pressure were recorded by *Footscan* platform, and after a few seconds, the thermal data of the foot sole were recorded again. In order to stimulate and simulate longer wear duration of the footwear, the subject performed a set of gait cycles on the treadmill according to a previous established program. The next recording was accomplished with the thermographic camera after walking the treadmill, immediately after that the pressure platform data were acquired.



**- subjects are barefoot*
***- subjects will use the program P1 on the treadmill*
****- subjects are recorded three times after walking on the platform*
*****- procedure is applied for barefoot subjects then with the footwear options selected for study (adidas, footwear height 4 and 10 cm)*

Figure 4: Block diagram of the analysis and evaluation methodology

This sequence of recordings was performed for several types of footwear: bare foot, adidas, footwear with 4 cm heel and footwear with 10 cm heel.

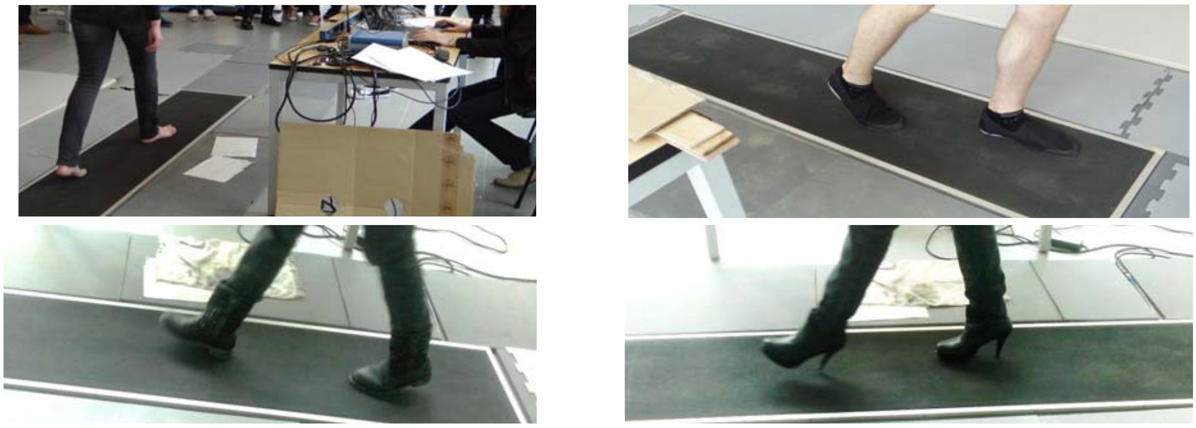
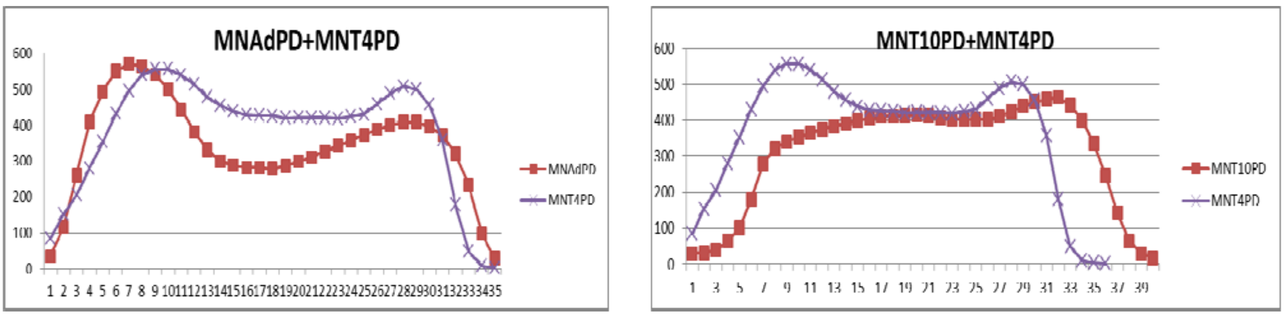


Figure 5: Recordings on Footscan platform of the subjects: bare foot (upper, left); wearing adidas (upper, right); wearing 4 cm heels (down, left); wearing 10 cm heels (down, right)

RESULTS AND CONCLUSIONS

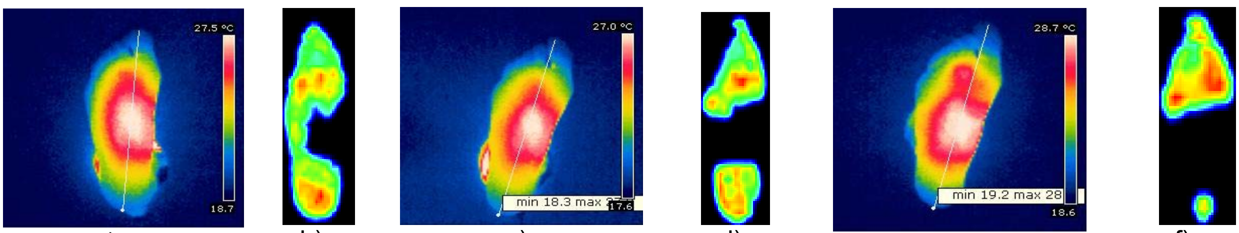
As an example we present the analysis performed on subject 1 both from the point of view of thermal gradient developed on the plantar surface of the right foot by comparison to the left foot, in all four categories of recordings of the influence of heel height as well as the analysis of plantar pressure during the gait cycle. The correlation of these values may emphasize the evolution of the thermal gradient versus the plantar pressure recorded in different situations (footwear with/without heels) and can initiate the determination of the postural comfort degree (PCD).



a) b)

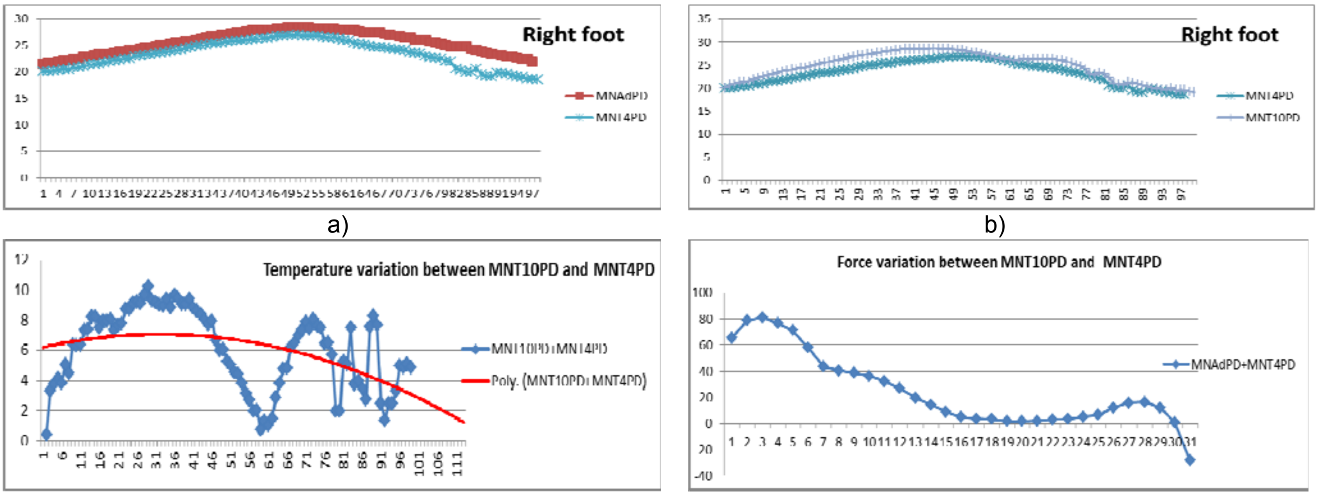
Figure 6: a) Comparison between the normal gait cycle with addidas and 4 cm heels; b) comparison between the forces developed in the normal gait cycle with 4 cm heel and 10 cm heel

Thus according to the gait type (normal) and heels height we find by comparison a substantial change of the forces measured on the *footscan* platform (fig.6). thus in the gait cycle using addidas type footwear, the subject presses more on the heel and less on the toes, by comparison to the 4 cm heel, when the subject presses constantly both on the heel and on the toes. Also, we are able to observe that the gait cycle with 10 cm heels “forces” the subjects to move its center of gravity and respectively the action of the contact forces more towards the toes and less to the heel. This aspect indicates a higher “concentration” of plantar pressure which is reflected by changing in respect of growth of the temperature gradient in this area.
Following the study performed on the 10 subjects sample we found the following aspects: the subjects’ analysis was performed as they were relaxed, without being subjected to a previous locomotion effort;



a) b) c) d) e) f)

Figure 7: Thermographic and plantar pressure images for addidas type shoes (a and b), shoes with 4 cm heels (c and d) and 10 cm heels (e and f)



c) d)

Figure 8: Temperature variation in case of normal gait with addidas type and 4 cm heels shoes (a); gait cycle on 4 cm heels and 10 cm heels (b);

recordings on footscan were performed on all subjects having the same physiological state; during the investigations the subjects presented changes of temperature in the area of plantar surface without these being induced by another factor than the investigated one; we found for most of the subjects (80%) that temperature increases proportionally to the heel height and this indicates the fact that age, lifestyle and activity dynamics of the investigated category of subjects (average age 23.4 years) requires a good postural comfort and this is obtained by using adidas type footwear and by using 4 cm heels. From the conclusions drawn following the analysis we may notice that the 10 cm heel creates thermal discomfort materialized by the growth of temperature with an average of 33% with respect to the temperature measured by wearing addidas type shoes and may determine in time a change of the postural comfort degree. We also determined the correlation coefficient (0.88) between the temperature gradient by wearing 10 cm heels and variation of plantar pressure in the same situation, coefficient allowing the PCD evaluation in different analysis conditions.
An important aspect is represented by the determination of PCD (by thermographic evaluation) in case the subjects are going up/down the stairs, frequently, because the concentration of plantar pressure especially for high heels (higher or equal to 10 cm) may drop this value under the limit of postural stability degree (SD).

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Project presentation

CREATIVE TRANSFER OF INNOVATIVE SOFTWARE SOLUTIONS AND 3D TECHNOLOGIES FOR COMPUTER-AIDED FOOTWEAR DESIGN

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Abstract: *The Creative Transfer of Competence in 3D Footwear CAD to VET Professionals Project, acronym - INGA 3D, aims to transfer and extend innovative software solutions and 3D technologies for computer-aided footwear design. The project brings together universities, research and training centres, adult education providers and IT companies from four European countries. The project products will introduce innovative solutions for e- learning in order to test and to validate new teaching methodologies and approaches suitable for vocational training in footwear computer-aided design. It will contribute to developing skills and competencies of VET professionals in order to face with the future challenges.*

Keywords: *footwear CAD, vocational training, virtual environment, practical and theoretical knowledge*

INTRODUCTION

The e-learning methods promise to improve human resource capability by utilizing new technological capabilities, and resulted in improvements in organizational capabilities as well.[1]

Although 3D CAD is a widely used and highly effective tool in design, it also has its drawbacks: mastery of CAD skills is rather complex and time-consuming, e-learning could be used in a successful CAD training.[2]

E-learning refers to training initiatives which provide learning material, course communications, and it delivers the course content electronically, through technology mediation.[3] Learning systems do not generally adapt to learners' profiles [4], proving that the footwear area selected for developing this multimedia tool is an appropriated one. Such a tool has to implement the adaptive self-consistent learning object as visual language, in order to define classes of learners by stereotypes and to specify the more suited adaptive learning process for each class of learners. [5, 6]

A student-centred approach is required for online learning and it can be used to create a community of learners. [7, 8] A flexible teaching strategy has to be developed and it has to be oriented towards the students' needs for training and learning. [8, 9]

SUMMARY

The Creative Transfer of Competence in 3D Footwear CAD to VET Professionals project is funded by European Union within the Lifelong Learning - Transfer of Innovation Program. INGA 3D project aims to transfer and extend innovative software solutions and 3D technologies for computer-aided footwear design, namely ICad3D+, produced by Spain.
INGA 3D project, aims to transfer and extend innovative software solutions and 3D technologies for computer-aided footwear design. This will be achieved through four complementary activities:

- by transferring the innovation from Spain to other countries, namely Romania, Portugal, and UK;
- by developing skills and competencies in 3D footwear computer-aided design in VET professionals (teachers, trainers and tutors) so that they can teach ICT based technical courses that support creativity and innovation among their own VET students/trainees;
- by developing new training content and supportive e-learning tools based on units of learning outcomes and competencies. This will ensure effective assessment, evaluation and validation;

by setting up an Online Learning Platform.

The project brings together universities, research and training centres, adult education providers and IT companies. The consortium has partners with great pedagogical experience in development and evaluation of methodologies for education and technical vocational training. Also, there are partners with experience in vocational training, and research and development for the footwear industry.

Project partners:

- Gheorghe Asachi Technical University of Iasi
- INESCOP - Instituto Technologico del Calzado
- Virtual Campus Lda.
- IED - Istituto Europeo di Design Madrid
- University of Salford
- RED 21 SL

BACKGROUND

All over the Europe, one critical problem of VET study programs is the gap between the level of technical knowledge and professional skills that the learners acquire and the required competencies expected by employers (European Commission's Report - 'New Skills for New Jobs: Action Now' , 2010). Footwear companies all over the Europe can find it challenging to recruit VET graduates competent and skilled in Computer Aided Design (CAD) of footwear. VET providers for footwear sectors could reduce this gap by widening their existing curricula to new available CAD/CAM technologies and software solutions that are developed through the latest research and commercial developments. At this point one main question appears: Do teachers/tutors/trainers from VET institutions have the right skills and competencies to teach Footwear Computer Aided Design ?
A preliminary investigation that was undertaken by partners in the preparatory stage of this proposal (in RO, ES, PT and UK) revealed:
- VET institutions which are running study programs for footwear sector have ICT based content in their curriculum, but it is designed to cover the only key competencies for generic skills (keyboarding, word-processing, desktop publishing and using the Internet for research and communication).
-Working with CAD/CAM technologies are occupational specific ICT literacy skills and VET curricula rarely cover these in detail. The reason for this varies, as:
1) staff do not have right skills and competencies in CAD;
2) there is lack of teaching resources for footwear CAD.
3) the software developers for footwear CAD offer tutorials that do not meet pedagogical needs of VET system;
4) some training centres use their own curricula and methods for footwear CAD and these differ from those in the public VET schools.

RESULTS

The rationale behind choosing the Icad 3D software solution as basis for INGA 3D project

The footwear CAD solution Icad 3D was developed by INESCOP (partner P1) and RED 21 (partner P5) is faster and more precise than other commercial products, and gives an immediate feedback both to teacher and to student/trainee. It allows detailed and accurate visualization of footwear prototypes in a virtual space. Through INGA 3D, the knowledge and the skills for developing patterns and footwear prototypes will be transmitted by VET teachers and trainers to their students and trainees in a dynamic and effective way. It will stimulate creative thinking among VET students and trainees, and it will increase attractiveness of VET study/training programs.

How does INGA 3D project use these results?

The INGA 3D partnership will work to produce, test and evaluate new results:

- 3D Footwear Computer Aided Design – Handbook. The new training content will be designed in an effective educational approach to modules/units of learning and competencies.
- Supportive Multimedia tools for VET teachers, trainers and tutors
- Online Learning Platform

Added value of INGA 3D project compared to the previous projects

The project products (Handbook, Guide and Internet-based platform) will introduce innovative training content and solutions for e- learning in order to test and to validate new teaching methodologies and approaches suitable for vocational training in footwear computer-aided design. These products will be designed and developed in order to meet the needs and the expectations of VET professionals (teachers, trainers, tutors). The online platform will integrate various flexible learning scenarios for accommodating various supportive tools for learning, like tutorial lessons, videos, and interactive texts and listening.

CONCLUSIONS

The project products will introduce innovative solutions for e- learning in order to test and to validate new teaching methodologies and approaches suitable for vocational training in footwear computer-aided design. The online platform will integrate various flexible learning scenarios and supportive tools for learning. The new training content and its supportive guide will be designed, developed, tested and evaluated in line with the best practices identified by partners in their institutions, countries and elsewhere in Europe. It will contribute to developing skills and competencies of VET professionals in order to face with the future challenges.

ACKNOWLEDGEMENTS

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ADVANCED CAD SOLLUTIONS FOR FOOTWEAR

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Abstract: *The aim of this article is to present a modern application for customized footwear design using MindCAD software. These CAD systems are the next generation of design solutions and engineering for the footwear industry. Designed entirely for use with modern operating systems and environments, it provides a full range of instruments, intuitive and easy to use. 3D computer aided design techniques (3D CAD) enables direct modelling of footwear on the last, so even before the product is fabricated, it can be analysed in terms of visual, functional, industrial and financial criteria. Starting with a shoe last (digitized, scanned or from database), it can quickly be designed a complete footwear model, in any colour or material combination. The result is a 3D realistic view of the product, ideal for presenting it to the buyers, customers or producers.*

Keywords: *computer aided-design, shoe last, footwear design, 3D modelling*

INTRODUCTION

The foot plays an important role in body balance and its support. An abnormal gait changes both balance of the human body and foot normal functions. [1].
Feet are repeatedly subjected to substantial forces during everyday activities. The force of impact and shock wave caused by it are some of the primary etiological agents that contribute to joint and musculoskeletal system injuries [2, 3, 4].
In engineering, computerization is important because it facilitates solving complex problems. Engineers apply computer techniques - DPS (Distributed problem solving) and simulation activities to industrial manufacture (eg structures' modelling) [5, 6].
Customers are looking for two basic characteristics when they purchase a footwear product: footwear appearance and its dimensional comfort. The footwear that does not correspond to the foot shape and dimensions and also it does not take over/ absorb the foot modifications that appear while walking is the main cause for prevalence and evolution of structural and functional foot anomalies. Thus, the health of the entire body is affected, too [7, 8].
For a long period of time manual methods were used to retrieve the foot and respectively the shoe parameters, but the development of 3D scanning devices and the possibility of 3D visualization and modelling, the automatically analysis, the finding and interpreting patterns made it possible to develop different models of footwear depending on the foot conformation.[9]
The last is the basic instrument for the footwear constructive design and for footwear manufacturing process. The lasting process is done with the uppers on the last, so, the shape and dimensions of the last will determine the shape and dimensions of the footwear. Dimensional comfort when wearing a footwear product is determined by this correspondence between the foot and the interior space of the shoe. [10, 11]
Wearing an uncomfortable footwear product has direct consequences on foot and leads to making worse the anomalies that are already installed or development of others. Dimensional adaptability of footwear depending on the dynamic loads intensity, that occur in the foot is a feature that helps to increase user's performance. [11, 12, 13].

METHOD

Footwear role in ensuring correct body posture and balance condition during static or dynamic phase requires the study of ergonomic factors in product design. It is applying a new design concept; footwear product should reflect the normal anatomical and functional state on the foot and gives a natural feeling of barefoot walking.

In shoe modelling and design activities a series steps have to be followed, which must fulfil the footwear criteria, namely: aesthetic, functional, economic and technological. Current 3D CAD systems enables direct modelling of shoe last, so that even before the producers made the product, it can be analyzed in terms of these criteria.

RESULTS

MindCAD is the perfect solution for the product designer and engineer, offering a balanced mix of creative and technical 2D and 3D CAD tools [***14].
The unique and innovative features of MindCAD solutions contribute decisively to your effectiveness and productivity.
MindCAD SOLUTIONS

- 3D Design & Engineering for Footwear
- 3D Viewer
- 2D Design & Engineering for Footwear
- 2D Design & Engineering for Luggage
- 2D Design & Engineering for Automotive
- 2D Design & Engineering for Furniture

Main features of MindCAD 3D Design & Engineering for Footwear are:

- Last digitizing and editing (see in figure 1 and figure 2)
- Sketch style lines (see in figure 1 and figure 2)
- 3D upper part modelling (see in figure 1 and figure 2)
- Sole modelling (see in figure 1 and figure 2)

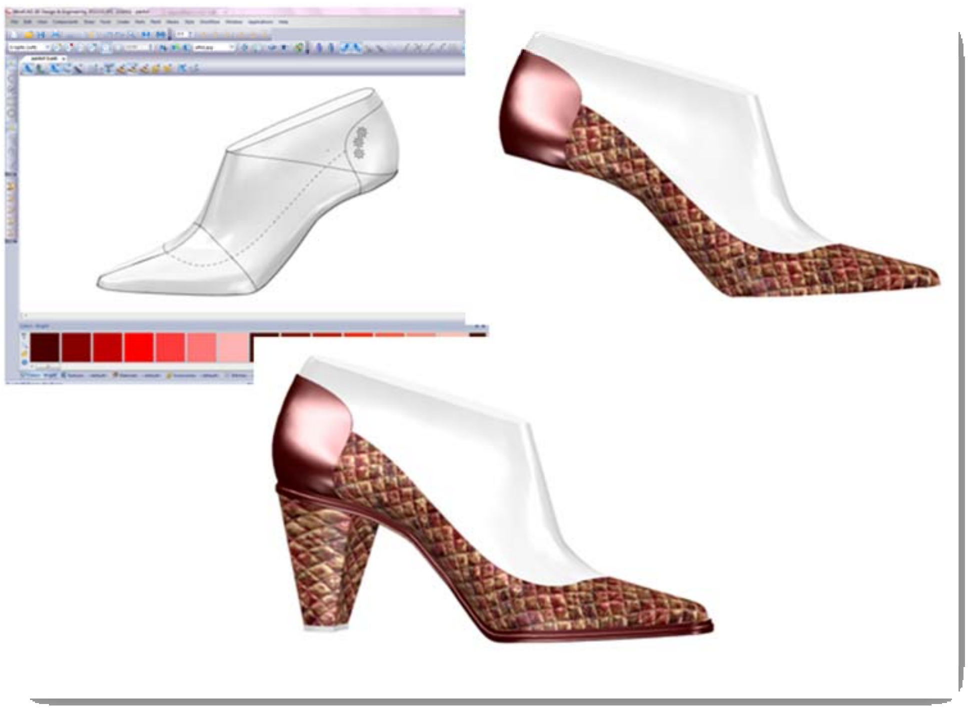

Figure 1. Women court shoe 3D modelling

Figure 1. Women trainer shoe 3D modelling

Starting with a last, it can be rapidly designed a complete footwear model, in any colour or texture combination [12, 13]. The result is a 3D realistic view of the product, ideal for presenting it to the customers, buyers or producers.
The main advantages of MindCAD compared to other software applications are:

- An intuitive interface that allows the user to work in a productive way
- The interaction in real time with the design (see in figure 1)
- A realistic representation of the product (see in figure 2)
- The integration between 3D and 2D applications: for example, a change made in 3D reflects in 2D in the same time and also form 2D to 3D (see in figure 3)
- The instruments, the way of using it, the interface, are similar from 3D to 2D, so the user doesn’t have to learn how to use 2 applications
- The software producers stay in touch with all their partners and clients form industry and schools, so the software benefits from their feedback
- A precise method of patterns grading and a full range of size numbers that can be obtained

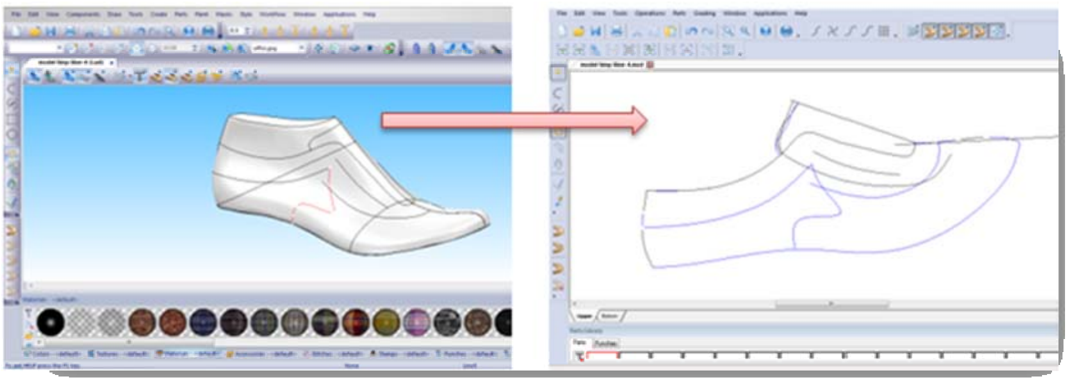

Figure 3. Integration between 3D and 2D applications

CONCLUSIONS

CAD / CAM revolutionary systems solutions represent the next generation of computer-aided design and engineering in the shoe industry. Unlike manual methods for retrieving foot measurements and shoe design, the development of current systems allow designing different models according to feet structure. There are used procedures and techniques that were not possible in the case of manual methods, such as 3D scanning and 3D modelling, 3D viewing, automatic analysis of forms, extracting and interpreting patterns.
Dimensional correspondence of the foot with the shoe size (length, width, circumference, height) is a very important requirement to ensure dimensional comfort. To ensure this requirement, the shoe must be designed and produced in order to allow the foot to function normally without severe constraints, both in static and dynamic conditions.
The main advantages of using MindCAD: reduces the number of physical samples; a fast way to design a product; modifying operation directly on the model; applying or eliminating new components; model visualization from different angles by interactively rotating the last.

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CUSTOM MADE FOOTWEAR INSOLES MODELLING USING COMPUTER AIDED DESIGN TECHNIQUES

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Abstract: *This paper presents 3D modelling design principles of custom footwear insoles using dedicated Power Shape software from Delcam Crispin. The design stages are represented by scanning, analysing, modelling, design validation and rapid prototyping. Scanning stage involves a process of 3D scanning of subject's feet. Analyse stage involves obtaining and interpreting the anthropometrical dimension of scanned feet. Modelling stage involves designing the 3D shape of the insole based on subject feet plantar surface shape and dimensions. Design validation stage involves a finite element analysis. Rapid prototyping stages involve the use of 3D printers or computer numerical control machines for final validations of custom made insoles. The advantage of custom made insoles over the mass production is the enhanced functional and therapeutic effects. Custom made insoles are recommended for subjects with diabetes, flat foot, plantar fasciitis, metatarsals pain and/or fractures and for subjects who conduct intensive physical activities like the athletes and the soldiers.*

Keywords: *footwear insoles, design, CAD, 3D scanning.*

INTRODUCTION

Although exists a large variation of footwear products available [1], individualized depending on the performed activity of the user, different fields of use (medicine, sport, military) and different weather and climate conditions the solutions offered to customers regarding personalized products are very limited. The advantage of custom made insoles over the mass production ones is the enhanced functional and therapeutic effects. The use of both computer aided design techniques and finite element analysis presents the advantage of obtaining fast and objective results. The computer aided design techniques for footwear insoles generates accurate 3D shapes based on subject feet plantar surface shape and dimensions. With finite element analysis (FEA) the deformation and pressure distributions based on different materials properties can be quantified [2]. Custom made insoles are recommended for subjects with diabetes, flat foot, plantar fasciitis, metatarsals pain and/or fractures and for subjects who conduct intensive physical activities like the athletes and soldiers. Also, the custom made insoles reduce the peak plantar pressure and increases the contact area with the foot. Anatomical shape shoe insoles provide a heel-cup and an arch-support mechanism that better resemble the plantar shape and can reduce the heel pressure by 5% and forefoot pressure by 5% and increase the foot arch pressure by 5% and that situated plantar stress under an equalized condition that offered better comfort for wearing the shoes [3]. Modern computer aided design techniques offers the possibility of customizing products according to the customer needs and computational methods based on finite element method (FEM) modeling give a valuable support to experimental investigations [4].

METHODS

2.1 Acquiring of 3D shape of subject foot

The first step for modelling and obtaining the 3D shape of anatomical insoles is the obtaining the 3D shape of the subjects feet plantar surface. The feet 3D shape was obtained using INFOOT USB scanning system, consisting from a 3D scanner and dedicated Measure 2.8 software. This system allows the acquiring of 3D images and the export of this in different file types (.stl, .dfx, .vrlm). Also, when a 3D scanned model is exported polygon size, that defines the number of elements and the resolution of the 3D object, can be defined. The scanned 3D shape of the subject foot was exported in three different variants with polygon size of 1, 3 and 5 mm. The best 3D shape resolution was obtained for 1 mm polygon size, but the number of resulting elements significantly increases the computational requirements of 3D shape modelling. For the 5 mm polygon size variant, the number of shape elements is reduced, demanding very few computational resources, but also the shape is distorted due to low resolution. The best results were obtained for 3 mm polygon size variant, medium shape resolution and number of elements. File containing scanned shape data was exported with *.stl extension. An STL file describes a raw unstructured triangulated surface [5]. A 3D shape saved into a *.stl file format is basically a drawing mesh with no properties. To be able to work with this shape the reconstruction of it is necessary. For modelling and obtaining the 3D shape of the anatomical insole Power Shape software offered by Delcam Crispin was used. Power Shape is an integrated solid, surface and triangle modelling software.

The 3D shape of the subject foot was simplified remaining only the plantar surface. This fact leads to fewer steps and reduced time for modelling and obtaining the insole shape.

The steps that must be followed in order to obtain the foot 3D shape are represented by:

1. Scanning the subject foot, obtaining its 3D shape and saving it in *.stl file format with 3mm polygon size.
2. Importing the 3D shape of the foot in Autocad and converting its mesh in surfaces using Automesher add-on (Figure 1.)
3. Importing foot 3D shape from Autocad in Power Shape and simplify it by selecting and erasing the unnecessary parts, as illustrated in figure 2.

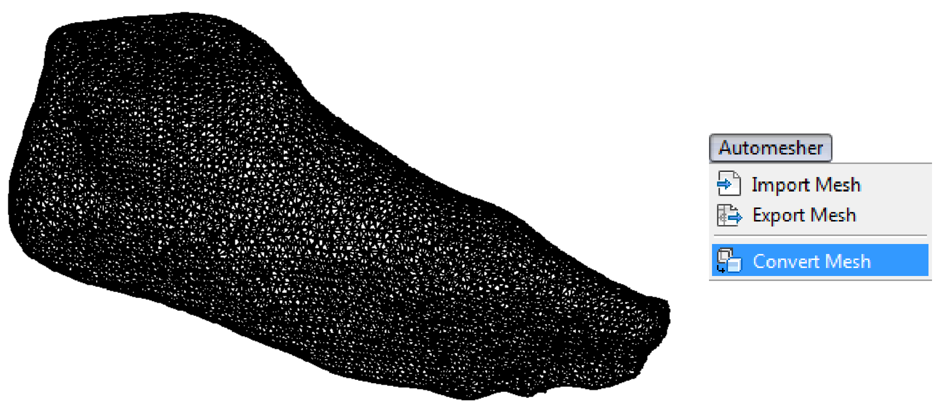


Figure 1: Converted the 3D shape of the foot using Automesher.

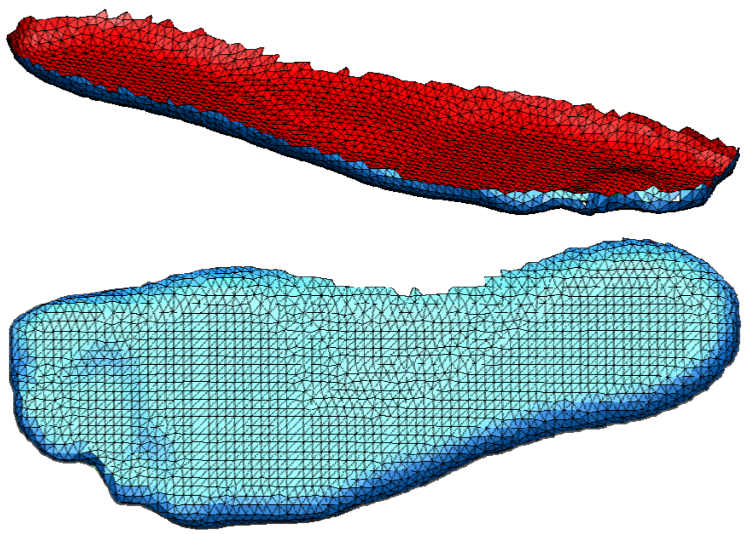


Figure 2: Simplified shape of the foot.

4. Reconstruction of the plantar region of the foot in order to obtain a grid based surface.
   4.1. Converting the 3D shape into a solid object, that allows the drawing of poly-lines on the object surface.

4.2. Obtaining the upper contour of the shape by creating a horizontal intersection plane, as illustrated in figure 3. with yellow.

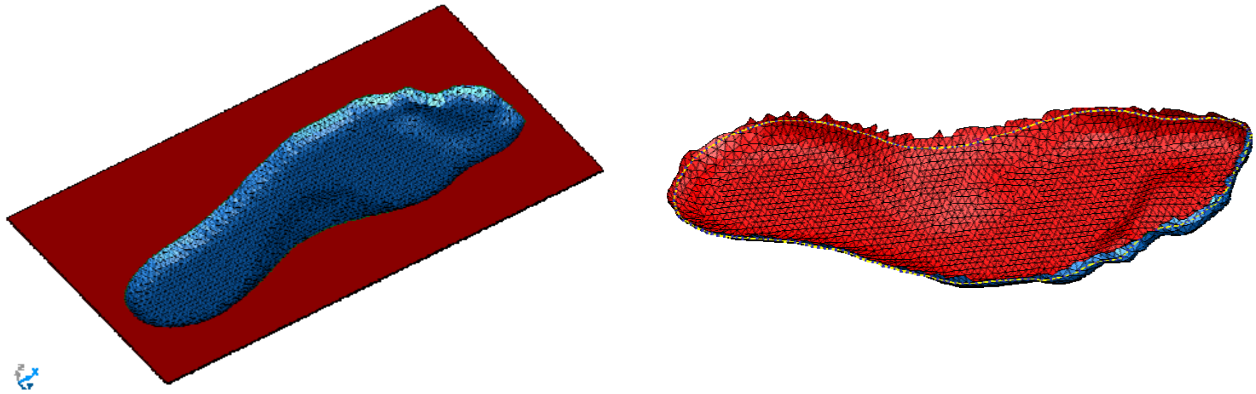


Figure 3: The upper contour of the plantar area of the foot.

4.3. Draw a transversal and longitudinal lines network in a horizontal plane placed below the 3D shape (Figure 4.).
4.4. Create vertical planes from the transversal and longitudinal lines using the Extrusion function and intersect planes with the foot solid object in order to obtain a network of lines on the solid surface, as illustrated in figure 5.
4.5. Erase the foot solid object and keeping only the lines network that will be used for modelling the upper surface of the anatomical insole.

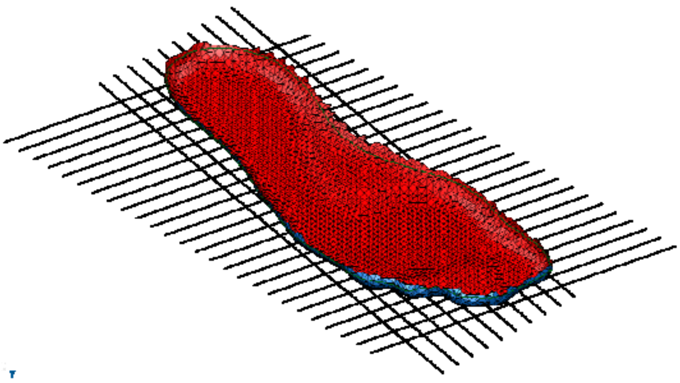


Figure 4: Transversal and longitudinal lines network.

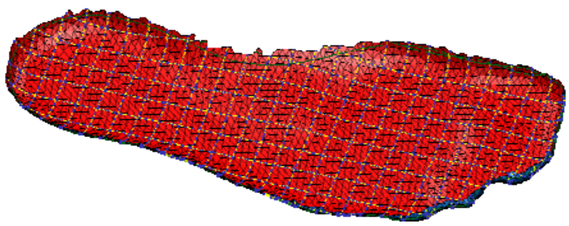


Figure 5: Lines network on the surface of the plantar area of the foot.

2.2 Obtaining the insole contour

The insole contour is the same with the lower contour of the last (figure 6.). It was obtained using Delcam Crispin Last Maker software application, which gives the possibility to recognise and export the contour [6]. Infoot USB scanning system also offers the possibility of obtaining scanned subject foot anthropometrical dimensions. A suitable last can be imported from the LastMaker application database after the anthropometrical dimensions of the subject feet were determined. Also, if the selected last from database does not math exactly the subject feet anthropometrical dimensions, the software offers the possibility to modify it accordingly to subject feet dimensions.

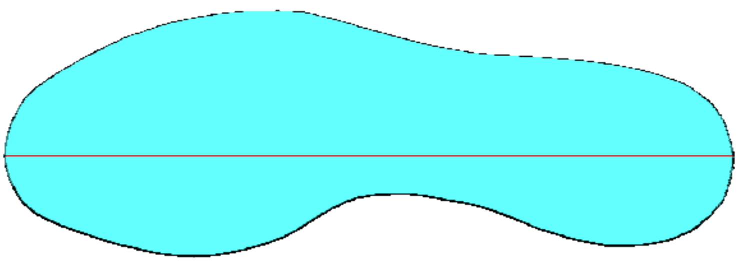


Figure 6: Insole contour shape.

2.3 Modelling the 3D shape of the anatomical insole

The steps that must be followed in order to obtain a 3D shape of the anatomical insole are:

1. Import the insole contour and position it under the lines network, as illustrated in figure 7.

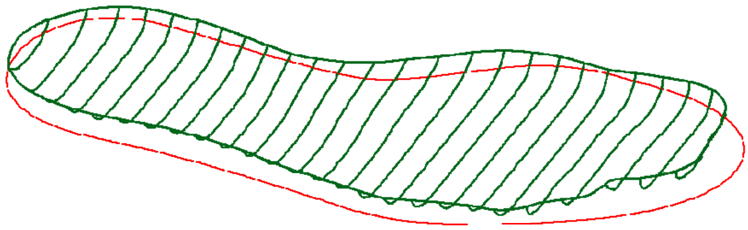


Figure 7: Insole contour positioned under the lines network.

2. Model the insole curvature, represented by the yellow lines in Figure 8. The curvature of the insole assures the transition from the insole anatomical area to the insole planar area. The curvatures lines are positioned at a distance of 10 mm back from the foot toe line.

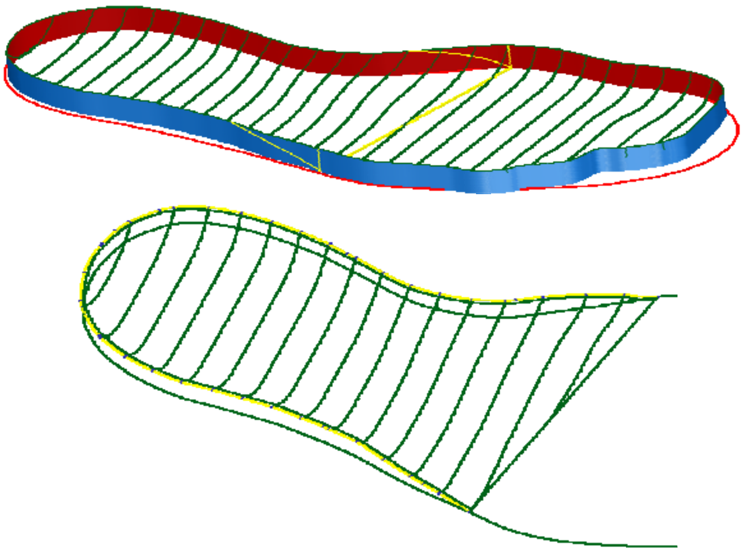


Figure 8: Insole curvature.

3. Draw the inferior contour of the insole by duplicating the imported insole contour.
4. Draw transversal lines that connect both interior and exterior insole contour and draw the vertical lines that connect the inferior and superior insole contours. These lines consists the base for defining the insole surfaces and are represented with yellow in Figure 9.

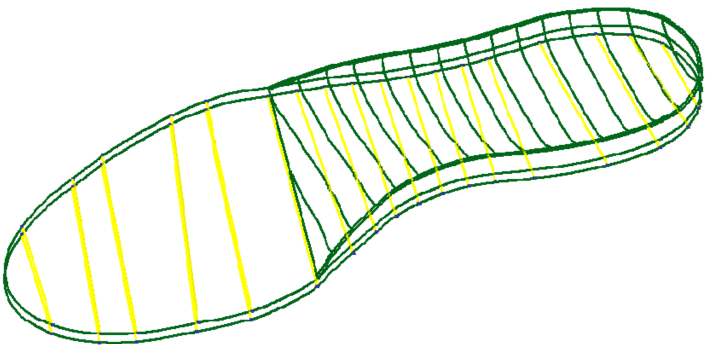
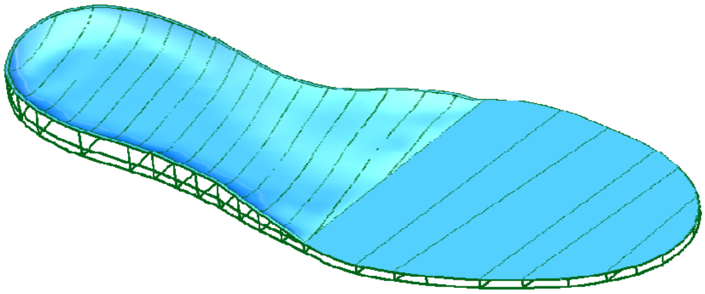
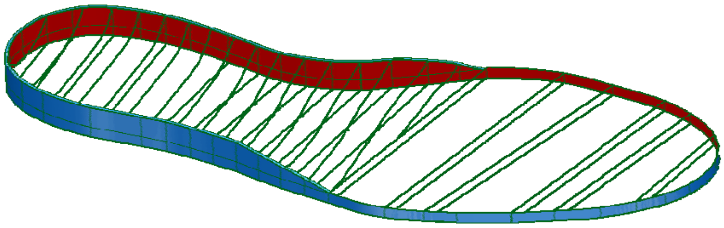


Figure 9: Base lines for insole surfaces.

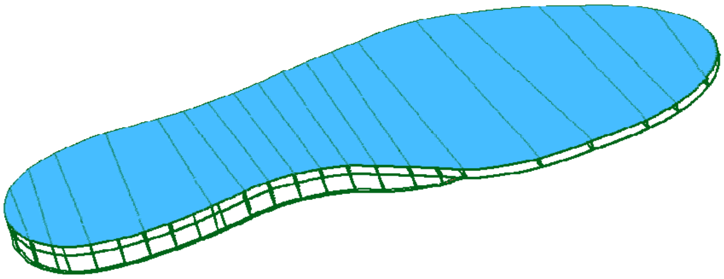
5. Create the 3D surfaces of the anatomical insole shape based on the lines network that was created before. The surfaces are generated using “Smart Surfacer” tool as illustrated in figure 10.



a) The upper surface of the insole



b) The lateral surface of the insole



c) The bottom surface of the insole

Figure 10: The anatomical insole 3D surfaces.

6. Obtain the 3D solid type shape of the anatomical insole.

The 3D solid shape of the anatomical insole is obtained by selecting the three component surfaces of the insole (upper, lateral and bottom surfaces) and using “Create Solid” tool. After the solid is created, the software automatically launches the “Solid Doctor” tool (Figure 11.) in order to verify if the solid is watertight. After running the analysis of the solid shape if any faults (gaps, overlapping faces) are identified the software offers the possibility to fix this faults automatically or manual. The final 3D shape of the anatomical insole is illustrated in figure 12.

Figure 11: Identifying and fixing solid shape faults.

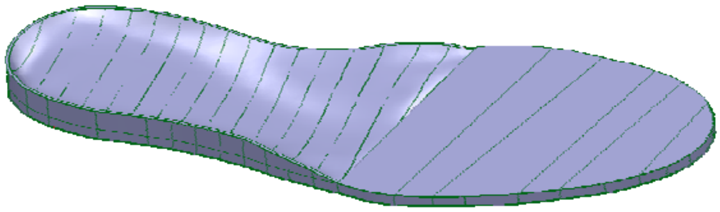


Figure 12: Anatomical insole 3D shape.

CONCLUSIONS

Resources from different software programs and systems were used in order to define the design principles of 3D modelling of custom made footwear insoles. Infoot USB 3D scanning system, Autocad software add-on Automesher and Delcam Crispin PowerShape and LastMaker software applications were used to define the design principles of 3D modelling of custom made footwear insoles. The 3D model of the anatomical insole is based on subject feet shape and dimensions. An accurate and detailed 3D model of anatomically insole shape was obtained using integrating scanning techniques and computer aided design techniques. Custom made anatomical insoles increases the contact area with the foot. Modelled insole shape is ready be used with dedicated finite element analysis software in order to quantify the deformation and pressure distributions based on different materials properties.

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INNER SHAPE FOOTWEAR DESIGN OF THE PATIENS WITH DIABETES

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Abstract: *This paper presents new principle of design and validates inner shape footwear designed specifically for people with diabetes. The shoe inner dimension provides the relevant inner dimensions for a particular shoe such as length, joint girth, instep girth, and any other dimension upon request. Is used by manufactures because it improves the design of shoe lasts, improves the accuracy of shoe production and the uniformity of the inner dimensions of shoes, and detects and analyzes undesired differences. However, tools for designing shoes for people with diabetes do not currently have the capacity to modify the last in order to reduce the risk of foot ulceration, whilst at the same time preserving the style of the shoe. The paper describes the procedures and the geometrical algorithms to handle the last geometry. Finally a case study is reported to show the advantages provided by the proposed approach in terms of achieved quality of the design process and expected footwear performance.*

Keywords: *inner shape footwear, design, last, diabetes.*

INTRODUCTION

In the present orthopedic trade, the last-maker starts from a basis last which may be well-removed from the final shape which he requires, and then proceeds to adjust the shape with reference only to the limited measures of the foot. This requires a great deal of skill to maintain acceptable last characteristics. Additionally, the last is not made as an exact match to the foot measures, but a system of “last allowances” (ie. differences between specified foot and last measures) is employed. Suggested last allowances are not available in published literature, and initial discussions suggest that they vary from company to company, are not used consistently, and are adapted for individual orthotics to compensate for tendencies to measure loose or tightly). The target areas in last design should therefore include a study of the influence of basis last choice on the final design, formalization of last allowances, and development of a system of last assessment.

Diabetic foot is a common complication of diabetes. Diabetic foot care is very important because any injury, even a minor one can lead to serious complications. Due to peripheral nerve lesions (diabetic neuropathy) and blood vessel injuries, small injuries occurring at this level can be easily overlooked and can get over infected. The patient does not feel pain caused by various injuries, in some cases even the discomfort caused by inappropriate footwear. These injuries can cause the foot deformation [3].

It is common practice to prescribe customized footwear to people with diabetes to reduce the risk of foot ulceration. Although shoe customizing systems have been proposed, effective tools for designing shoe lasts for diabetic patients are lacking. The shape of the lasts must meet certain biomechanical objectives, while maintaining the style of the shoe. The main contributions of this work are as follows: the creation of an artificial-neural-network-based framework to correlate foot measurements and medical data to required footwear features; the definition of repeatable geometrical procedures to measure foot and last; and the definition of geometrical operators to modify the last shape according to its original aesthetic and specific footwear parameters. These parameters are by a knowledge-based system on the basis of the patient's pathology and best practices of experienced technicians. Dedicated systems integrated in a common platform are implemented to support the last design process. Test case studies and a survey show the advantages provided by the proposed approach in terms of achieved quality and shoe developing time. A design framework with dedicated tools is proposed for the customization of shoe lasts for diabetic patients. Further research should be focused on tools to design the insole, outsole and other shoe components.

The shoe last is the ultimate determinant of fit of a shoe, since it determines the space within the shoe. The characteristic features of lasts have been developed over centuries for the volume trade, and last design and making is an established and documented skill in that trade.

METHODS AND TOOLS

Research has shown that specific parts of the upper shoe, and as a consequence also the shoe last, affect the shoe fit [1-4]. However, in its shape, the last reflects the characteristic of the outsole and insole of the diabetic shoe. In particular, the following four areas of the foot appear to be critical:

Counter : the part of the shoe extending around the heel;
Toe box : the part that covers the toe area;
Vamp: the part that covers the instep;
Throat: the part at the bottom of the laces.

The method to design bespoke diabetic footwear is based on the definitions of the biomechanical variables relevant to footwear design. These variables effectively characterize the intrinsic properties of the foot, therefore they will subsequently be referred to as foot is the high pressures under the 1st MTP (metatarsophalangeal) joint. For every possible shoe design, the term footwear design features is used to refer to the individual characteristic, such as geometry, dimension and material, which are used to specify the design. For instance, the most important features of a rocker sole are: the rocker angle, the sole stiffness, the apex position and the apex angle. The design of diabetic footwear must be based on a in-depth understanding of the interaction between the footwear design features and the biomechanical characteristics of the foot. In order to draw these relationships, analyses have been accomplished on patients with diabetes measuring and monitoring a wide range of the biomechanical parameters [3].

Table 1: Relationships among footwear design features, biomechanical objectives and last parameters to be modified.

Footwear design feature	Biomechanical objective	Last parameters to be modified
Width of metatarsal heads, ball girth, instep girth, heel girth	Accommodate insole to realise plantar pressure Minimise changes in foot shape during walking	Ball circumference Ball width Instep circumference Heel circumference
Total foot length, metatarsal width and navicular drop	Minimise changes in foot shape during walking Minimise shear load on the forefoot	Last length Ball circumference Ball width
Toe box height, toe girth	Minimise pressure on dorsal aspect of the forefoot and toes Minimise pressure on the 5th metatarsal base	Toe circumference
Rocker sole: rocker angle, apex position, apex angle	Minimise pressure under 1st MTP joint and toe Minimise pressure under 2^{nd}-5^{th} metatarsal heads Minimise vertical shear loading at the posterior aspect Minimise pressure under the mid foot	Heel height Ball width
Toe spring	Minimise pressure under 1st MTP joint and toe Minimise pressure under 2^{nd}-5^{th} metatarsal heads Minimise vertical shear loading at the posterior aspect Minimise pressure under the mid foot	Toe spring height
Hell height	Minimise over pull on the Tendon Achilles and the pressure under the forefoot	Hell height
Size of shoe entry	Minimise pressure on dorsal aspect of the forefoot and toes Minimise vertical shear loading at the posterior aspect Minimise pressure on the 5th metatarsal base	Ankle circumference Heel circumference

An outlook on the obtained results is provided by the table1. In particular, a selection of the footwear design features which have a direct influence on the last definitions process is reported. The third column shows the last geometrical parameters which have result to influence the preventive function of the footwear. However, from the analyses of the gathered data, the following consideration can be drawn:

- The hell height represents the height of the back of the sole. The correct last hell height is combining the apex position, the rocker angle and intrinsic parameters of the chosen last.
- The apex angle determines a release of the foot pressure on the sole while walking. Such an effect must be facilitated providing a customized last shape in the metatarsal zone.
- A shoe that has a high and rounded toe box provides the best fit allowing the toes to fit and move comfortably inside the shoe.
- Finally, ankle circumference and heel circumference determine the size of the shoe entry and must be balanced with the pressure at the foot to hold the foot within the shoe during the gait.

The experimentation has allowed the list of the footwear features to be drawn and the range of variability of the parameters to be determined.

CASE STUDY

The approach described in the previous sections has been developed of the Research Project 07. 420.16. INDA have been conducted in the Republican Center Experimental Prosthesis, Orthopedics and Rehabilitation (CREPOR), Republic of Moldova [5] . The evaluation of the case study has been only patient with diabetes (men, 58 years). In the experimentation phase, the last design process has been obtained foot casts by weight bearing, used plaster of Paris splint and next section in plane longitudinal and transversal. They are based where construction last section is used to refer to the individual characteristic and the biomechanical characteristics of the foot (fig.1-2).

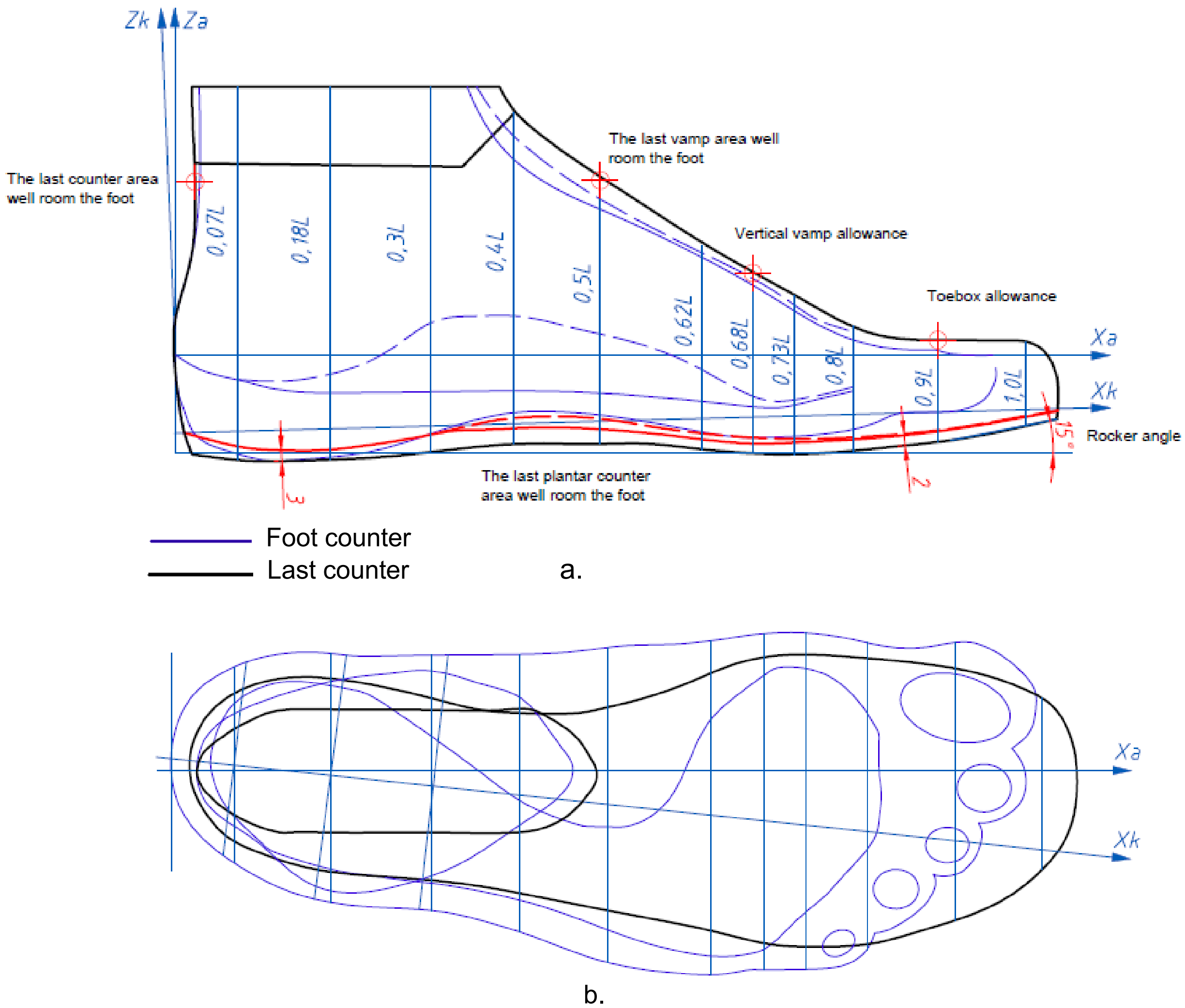

Figure1: Frontal (a) and horizontal (b) foot/last projection (patient (men) with diabetes, shoe size 43)

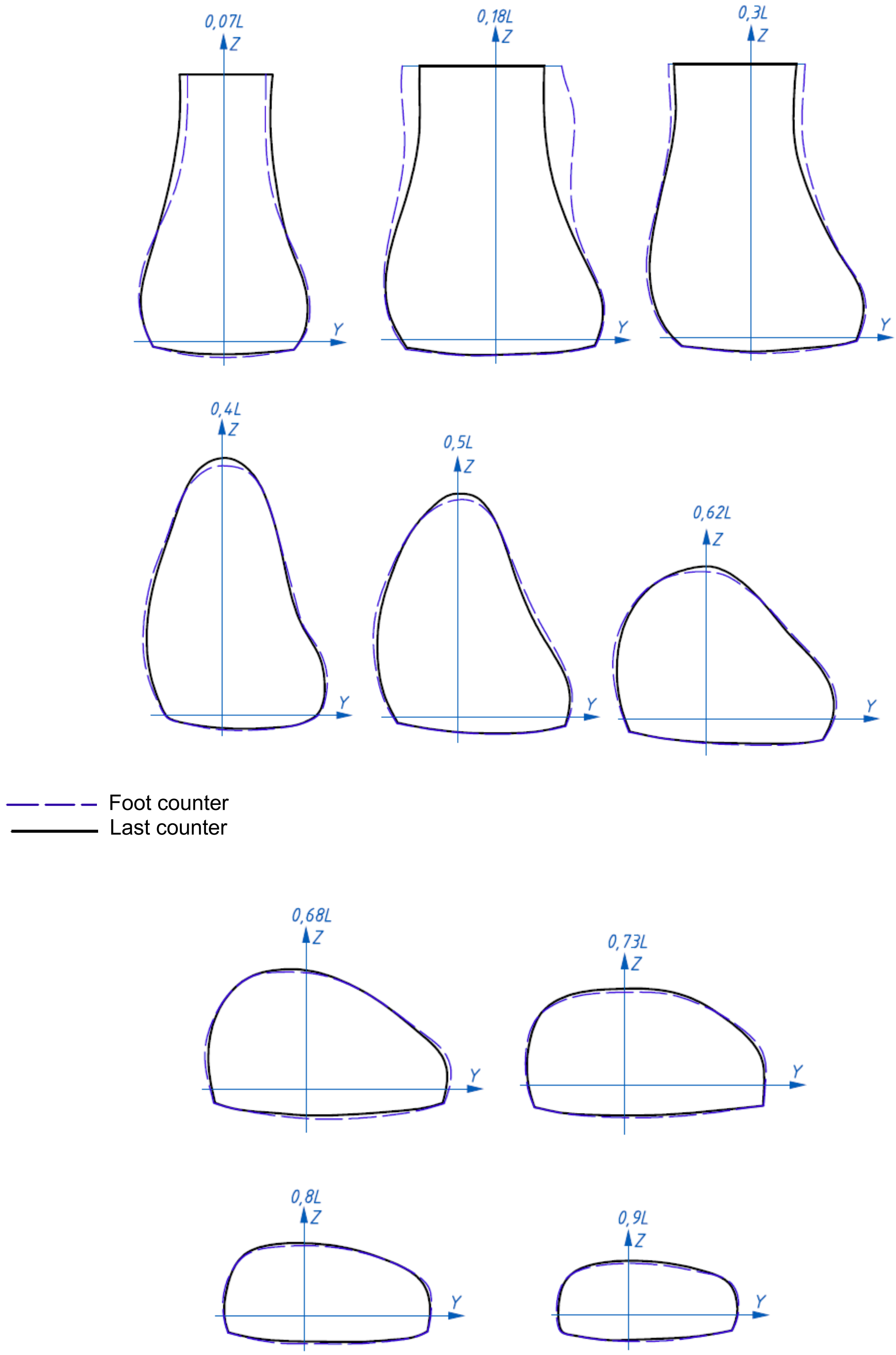

Figure 2: Design counter transversal-vertical foot/last section (patient (men) with diabetes, shoe size 43)

CONCLUSION

The paper proposed a new approach which is based around the idea that inner shoes for patient with diabetes should address the specific biomechanical objective of minimizing the pressure. The approach is implemented as a multi-phased approach. The major novelty introduced by the paper consists of a requirement to design shoes with the objective of minimizing the pressure under the foot. Such a method is specifically designed for individuals with diabetes and aims to reduce the rate of ulceration and subsequent complication. Benefits for shoe manufacturers:

Improve accuracy of shoe production by measuring the actual dimensions of the shoes coming off the production line Improve production uniformity of shoe inner dimensions

Compare the last to the shoe produced and analyze undesired differences

Improve the design of shoe lasts to improve shoe fit.

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A DESIGN METHOD FOR FLAT FOOTWEAR SOLES USING DELCAM PowerSHAPE-e

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Abstract: *This paper presents a 3D design method for obtaining footwear soles using PowerSHAPE-e software of Delcam system. Computer-aided design used in this paper highlights several important advantages that include: design increased quality; soles three dimensional viewing, which can lead to immediate decisions, regarding the acceptance of newly developed models; it can be appreciated the complexity of mould cavities execution, without the need of making prototypes; the outlines of construction templates are accurately obtained for the mould cavities and for all size numbers; there can easily be done calculations for determining the soles volume for the entire size number volumes, with implications on estimating polymer blend consumption and so on.*

Keywords: *footwear, mould, shoes soles, design*

1. INTRODUCTION

The CAD/CAM kind design systems have been largely developed including the domain of footwear uppers and footwear soles. Among the high performance systems used in the design of footwear soles and moulds for shoe soles, we may mention: Delcam Shoe Solution (3D), Delcam PowerSHAPE-e (2D and 3D) [1], [2] Padsy II (2D) and Padsy III (3D), Shoe Master System (2D and 3D), Lectra System (2D and 3D), Parmel System (2D), ATOS II System (3D). These systems are equipped with colour graphical displays, plotters, digitizers, terminals and other peripheral equipment needed for computer assisted activities.

The footwear soles are produced as flat footwear soles, as partially spatial zed footwear soles and as spatial zed footwear soles [3]. The complexity of footwear soles design and of mould cavities increases with the spatialization degree The Delcam Shoe Solutions and Delcam PowerSHAPE-e applications provide the user with the needed tools for designing the most complex footwear soles and footwear moulds.

In this paper is presented a method [4], [5] developed by the authors, for the 3D design of the footwear flat soles which are formed in moulds, using the PowerSHAPE-e application.

2. FLAT SOLES FOOTWEAR DESIGN in PowerSHAPE-e .CASE STUDY

The flat sole is the easiest kind of sole to design from the geometrical point of view. A set of steps is followed to design the flat footwear soles [4], [5].

Step 1. Copying the shoe last
The bottom of the shoe last is copied as a patter using one of the known methods. This pattern represents the shoe last insole.

Step 2. Inputting the insole outline, drawing the main axis and positioning the basic foot anatomical points
These operations are shown in Figure 1. **T**he insole outline is drawn as a Bezier curve using the **Create a Bezier Curve** tool under the **Curve** function.
After inputting the insole outline, the two axes are drawn: the insole axis and the shankpiece axis. These axes are drawn using the **Create a single line** tool in the **Line** function as simple lines, by specifying the coordinates.
The main anatomical points are positioned on the insole axis represented by the segment 1-7 in the Figure 1.b. Their coordinates are calculated according to the foot length Lp. The value of the foot length is equal with the footwear last size number in centimetres. The reference points used for the footwear sole design

are: 0 – rear foot curvature amplitude; 2 – heel centre; 3 – middle of the foot arch; 4 – centre of metatarso-phalangeal articulations I-V and 5 – extremity of toe V. The positions of these points, respectively the length of the segments relative to the point 1, are calculated with the following relations: 0-1=0.025*L_p; 0-2=0.18*L_p; 0-3=0.48*L_p; 0-4=0.66*L_p; 0-5=0.81*L_p; 0-6=L_p. The length of the segment 6-7, represents the length of the footwear last tip whose size is variable and depends on the tip shape.

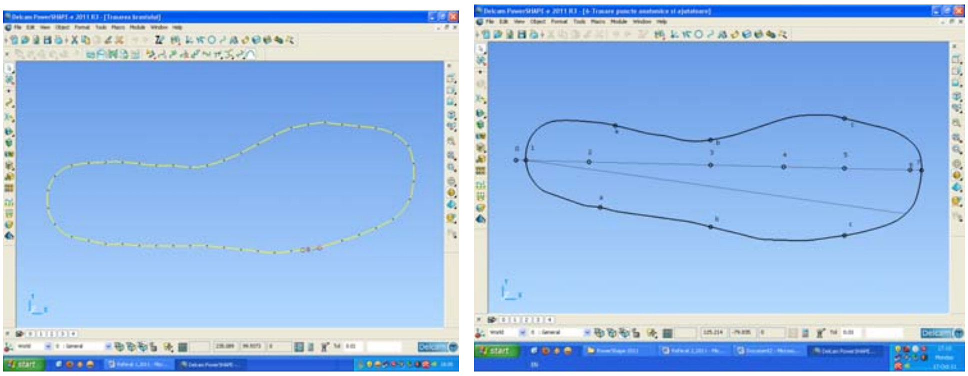

Figure 1: Step 1 and Step 2.

The posterior extreme point 0 is obtained by extending the insole axis in the rear zone. In order to accomplish this, a work-plane is positioned with its origin in point 1 and its ox axis overlapping the insole axis. To create this work-plane follow this procedure: select the **Workplane** function and then the **Create a single workplane** tool and position the new work-plane with its origin in the point 1; reposition this plane's ox axis along the insole axis; open de insole axis parameters editor; select the newly created work-plane as the value of the **Workspace** field; fill the 1-0 segment inverted length in the X field of the start point.

To position the points 2, 3, 4, 5 on the insole axis follow this procedure : select the circle drawing tool; open the position dialog box; select the **Along** option; select the insole axis by clicking next to the start point; fill in the **Proportion** field with the corresponding proportion (e.g.: 0.18 for the point 2); click on **Apply** and then on **OK.**

The position of the point 6 will be determined using the **Line** function and drawing an added line whose length will be equal with the foot length. After positioning the point 6 the added line should be erased using the option **Delete.** The **Horizontal text** tool in the **Annotation** function is used in order to label the points. The position of the points will be marked by circles which are drawn using the **Create a full arc** tool in the **Arc** function. The radius value will be filled in the **Radius** field. The **Name** field is filled automatically with a number generated in the order of creation. However, each circle name can be manually set.

Step 3. Drawing the footwear sole interior contour

The sole interior contour so drawn is presented in Figure 2.

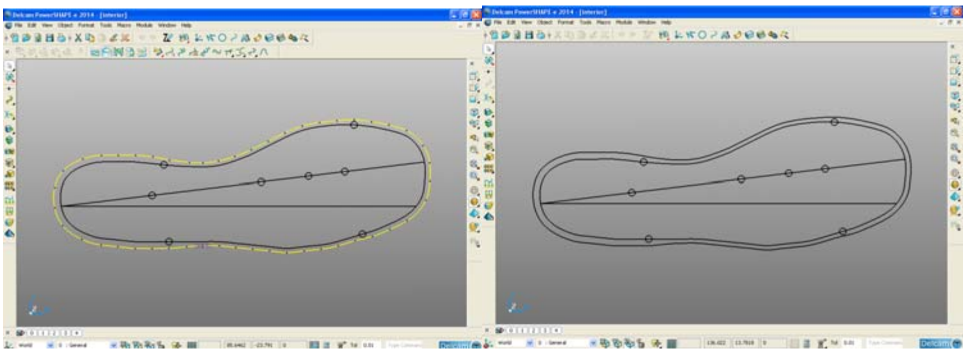

Figure 2: Step.3.

The sole interior contour is obtained by adding the thickness of the upper parts to the insole contour. This thickness varies along the insole perimeter depending on the number and the thickness of the layers. From the thickness variation point of view, the zones a-1-a, a-b, b-c and c-7-c are distinguished on the insole contour, represented in Figure 1. The positioning of the points that separates these zones is accomplished by constructing a set of added lines as Bezier curves. The curves will be drawn in the outside direction using the point 1 as start point

The distance at which will be positioned the sole interior contour in relation with the insole contour is variable. To draw this contour, the **Variable offset** tool in **General edit options** is used. In the **Offset** window associated with this tool, the set of points for each zone is selected individually. If the transition from one zone to the other is not smooth, the curve should be fine-tuned to obtain a smooth curve.

Step 4. Drawing the footwear sole exterior contour
The sole exterior contour, presented in Figure 3, is drawn at a constant distance in relation with the interior contour. This distance varies depending on the footwear sole model between 0 and 8 mm. The **Offset items** tool in the **General edit options** is used to draw this curve. Select the sole interior contour and then select the **Offset items** tool. The offset value is specified in the associated window. In order to keep the sole interior contour the **Keep original** button must be activated.

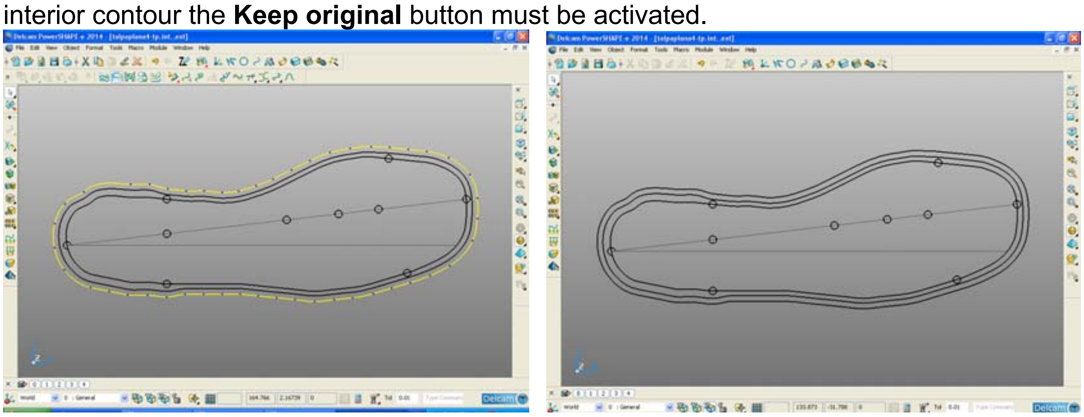

Figure 3: Step 4

Step 5. Defining the footwear sole gluing surface
The gluing surface, represented in Figure 4, is the area where the upper and sole are assembled by gluing. This surface is continuous, without weight removal cavities and its width is of 14-15 mm. The exterior of the gluing surface is delimited by the sole interior contour. The interior limit of the gluing surface is obtained by drawing a contour parallel to the sole interior contour, at a distance equal with the gluing surface width. The tool used is **Offset items** in the **general edit options**. After selecting the sole interior contour click the **Offset items** tool and then specify the offset distance and activate the keep original.

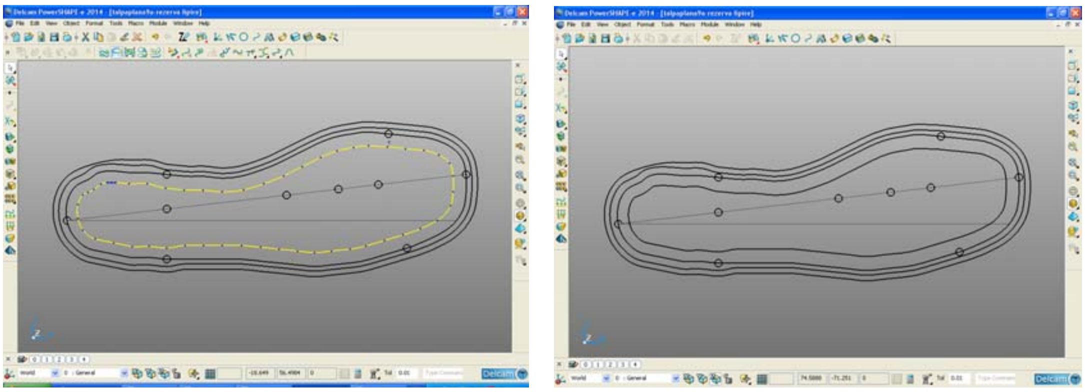

Figure 4: Step 5

Step 6. Creating the solid that defines the volume occupied by the upper in the sole volume
In order to assemble by gluing the footwear upper with the sole a cavity in the sole volume is needed. This cavity represents the volume occupied by the lasted upper in the sole volume.

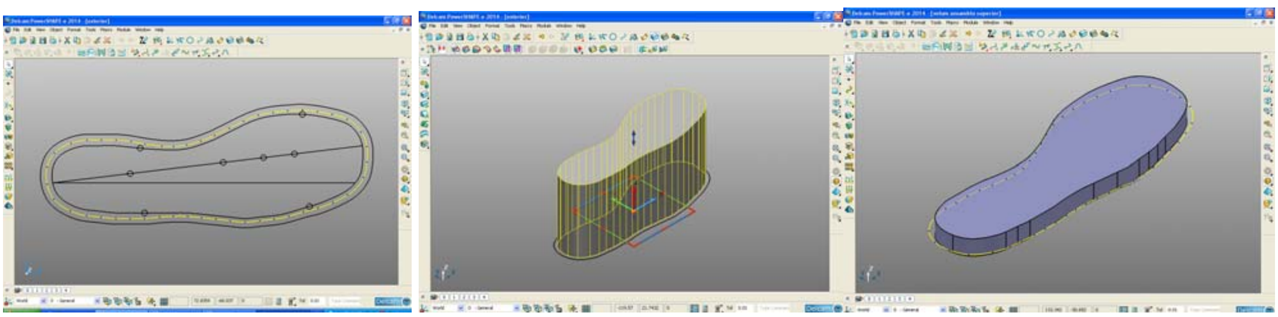

Figure 5: Step 6

To accomplish this, an extrusion solid is created starting from the interior contour of the sole. This solid enters in the sole volume on a distance equal with the cavity height. This volume will be removed from the sole volume. Select the sole interior contour and using the **Create one or more solid extrusions** tool from the **Solid** function the solid is created. The solid extrusion height will be specified in the parameter editor for this solid in the **Negative Length** field. The **Length** occupied by the solid above the sole will be established big enough to allow an easy selection of the solid. In Figure 5 there are shown stages of the step.

Step 7. Creating the solid that defines the sole volume. Obtaining the sole cavity
The thickness of the sole is obtained by summing the heel height, the sole cavity height and the sole thickness in the front sole zone.

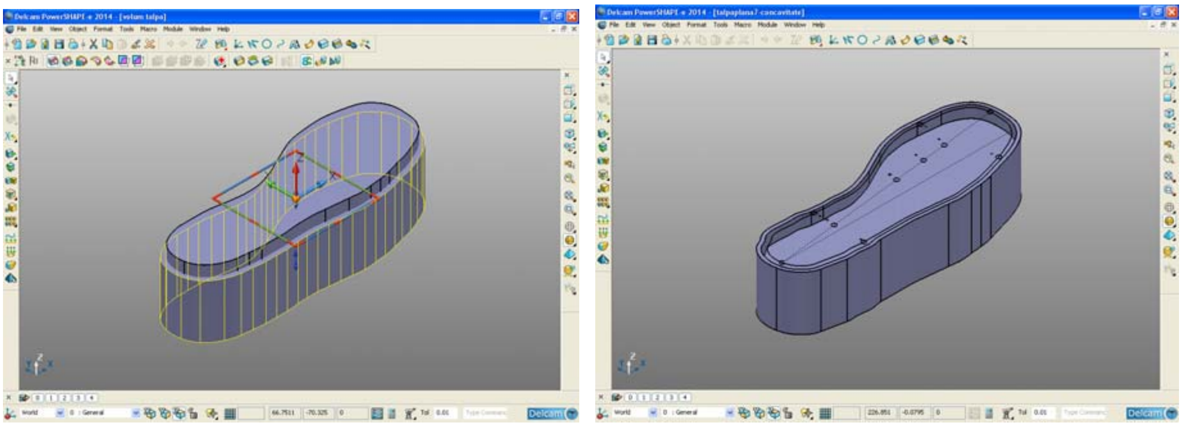

Figure 6: Step 7

Initially, the sole will be defined as a monolith solid, obtained by extruding in negative direction the exterior contour on a distance equal with the sole thickness. In order to accomplish this, the sole exterior contour is selected, the solid is created using the **Create one or more solid extrusions** tool in the **Solid** function and the value of the sole thickness is filled in the **Negative Length** field. The field **Length** is filled with the zero value because the sole will be delimited above by the XOY plane of the coordinate system associated to the work-plane. The sole cavity height is obtained by eliminating the solid that defines the cavity from the solid that defines the total sole volume. To operate on the solid that defines the sole, this solid must be activated by checking the option **Active.**
The tool used for solid removal is **Remove the selected solid, surface or symbol from the active solid** in the function **Feature.** Several operations are in Figure 6.

Step 8. Defining the heel volume
The heel volume is obtained by removing an auxiliary solid from the solid that defines total volume of the sole. he auxiliary solid contour is obtained by drawing a set of straight line segments and/or curves which will be converted in a composite curve. After selecting the contour as a composite curve, the auxiliary solid is created using the **Create one or more solid extrusions** tool in the **Solid** function. The dimensioning of the auxiliary solid is done using the parameters editor: in the **Workspace** section is specified the vertical position of the auxiliary solid in relation with the bottom limit of the sole; in the **Dimensions** section is specified the **Negative Length** so that the auxiliary solid will pass the bottom limit of the sole; the **Length** is set to zero because the top limit is the vertical position of the contour set in the **Workspace** section. The removal of the auxiliary solid is obtained using the **Remove the selected solid, surface or symbol from the active solid** tool in the **Feature** function. The sequence of operations that led to the definition of the heel shape and volume is presented in Figure 7.

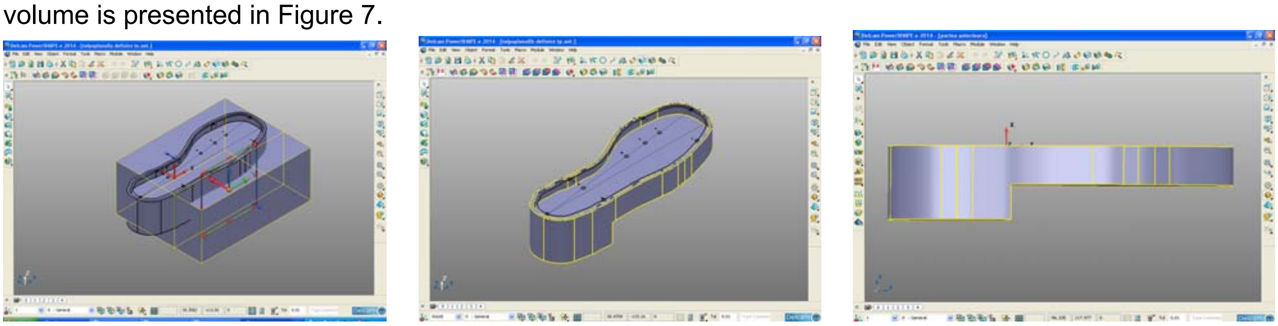

Figure 7: Step 8

Step 9. Obtaining the sole weight removal cavities

A fast and precise method of drawing the weight removal cavities consists in using an auxiliary construction. Using the compound curve tool, each individual weight removal cavity contour is drawn. The auxiliary solids are created by extrusion using this contours solids which will be removed from the sole solid. The extrusion is done in negative direction on a length equal with the depth of the weight removal cavities. The weight removal cavities were obtained by removing the auxiliary solids from the sole volume using the **Remove the selected solid, surface or symbol from the active solid** tool in the **Feature** function. Several operations are in Figure 8.

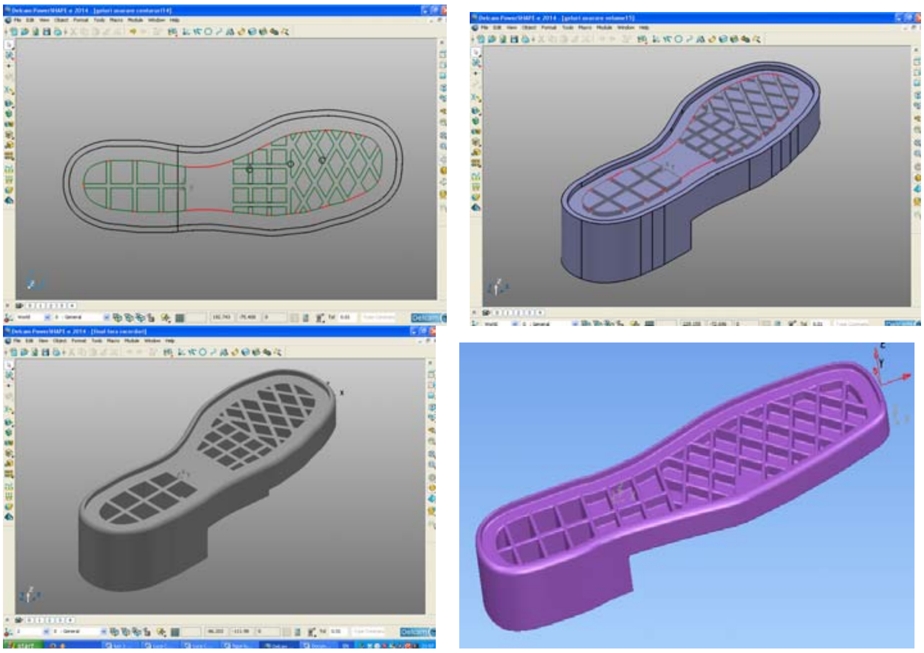

Figure 8: Step 9

Step 10. Obtaining the anti-skid relief

The work method is similar to that used to obtain the weight removal cavities. On the surface of the solid on which the anti-skid relief will be made, an auxiliary network is drawn which will be used to obtain the contours of the auxiliary solids that will be removed from the sole volume. Because the surface of the heel and the surface of the sole are situated on different levels an auxiliary network will be drawn for each of this two zones. For each of the two surfaces a work-plane will be associated. The tool used for the creation of the work-planes is **Create a single workplane.** In order to draw the anti-skid relief design the **Create a single line** tool from the **Line** function and **Curve** function will be used.

Finally the drawings are used to obtain the composite curves using the **Create a Composite Curve by tracing** tool. The composite curves are used to obtain the auxiliary solids using the **Create one or more solid extrusion** tool in the **Solid** function.

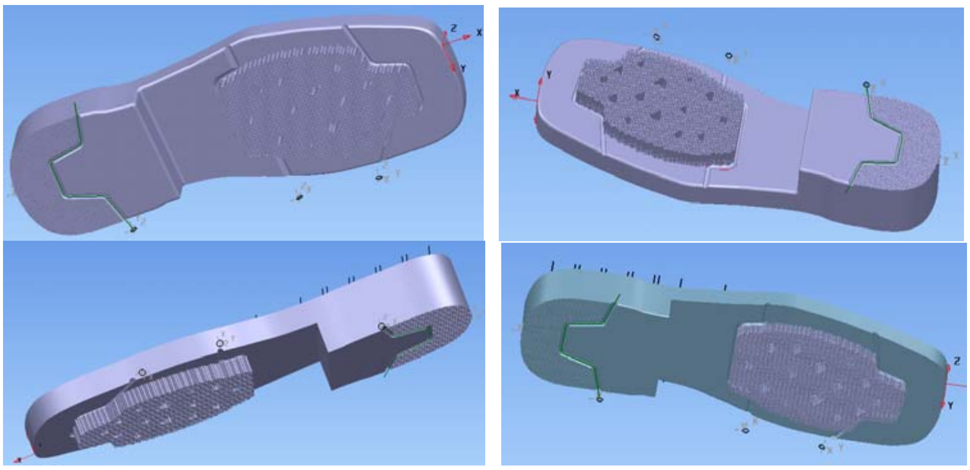

Figure 9: Step 10

The anti-skid relief will be obtained by removing or ading the auxiliary solids volume to the sole volume using the **Remove/Add the selected solid, surface or symbol to the active solid** tool in the **Feature** function. Steps the anti-skid relief drawing are shown in Figure 9.

Step 11. Obtaining the sole templates, designing the mould cavities manufacturing templates
By designing the sole the following templates are obtained: sole interior contour, sole exterior contour, sole contour with antiskid relief and longitudinal cross-section through the sole axis. To design the mould cavity, these templates will be increased by one of the available methods, using the contraction coefficient value of the polymeric blends used for the sole.

CONCLUSIONS

The CAD/CAM systems developed by the big software companies are remarkable but most of them can be used under commercial licence. The Delcam PowerSHAPE-e application, which was used for the development of the method presented in this paper, doesn't need a commercial licence. It can be downloaded free of charge from the developer company website.

The Delcam PowerSHAPE-e application provides a complete and intuitive environment for computer aided design. Unlike other CAD environments, in PowerSHAPE-e the surfaces and 3D solids are created with a minimum effort. The method presented in this paper is approachable to any category of designers with basic skills in CAD systems.

The developed method for the soles and mould design is suitable for both beginner and advanced designers. The hybrid modelling in PowerSHAPE-e, combines perfectly the solid and surface modelling, providing the necessary flexibility to develop complex shapes like the footwear soles and mould cavities.

The developed method allows the inputting of the 3D last contour, the 3D sole design, inexhaustible diversification possibilities of the soles, the three-dimensional visualization of the sole models, obtaining the patterns or casts needed for the execution of the mould nests, determining the polymer blends volume needed to obtain the soles, etc.

- The method elaborated can be used in advanced mould design where the soles are formed.

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Topic: Footwear design and technology

A DESIGN METHOD FOR SPATIAL FOOTWEAR SOLES USING DELCAM PowerSHAPE-e CAD APLICATION

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Abstract: *The Delcam PowerSHAPE-e application comes with a complete and easy to use CAD environment. Unlike other CAD environments, PowerSHAPE-e requires a minimum of effort to create surfaces and 3D solids. The mould nests in which the shoe soles are formed have complex shapes. Their complexity increases with the spatialization degree of the shoe sole and with the design complexity of the anti-skid pattern and weight removal cavities. This application is suited for both the beginners and the experimented designers. In this paper is presented a 3D design method developed by the authors for mould nests in which the shoe soles are formed. The developed method provides a fast and precise way of designing this mould nests.*

Keywords: *footwear, mould's, footwear soles, designing CAD/CAM*

1. INTRODUCTION

The introduction and the development of the electronic computing systems, informatics and electronics in the field of shoe design, led to the development of CAD/CAM systems [1]. Initially the developed CAD/CAM systems were bi-dimensional (2D). This allowed the automation of all the classic methods activities specific to footwear design and forming devices. The subsequently developed tri-dimensional (3D) CAD/CAM systems, equipped with 3D digitizers, allowed the design to be made based on a dataset collected directly from the shoe last, performing automated design. Among the high performance systems for footwear design we can mention: Delcam Shoe Solution (3D), Delcam PowerSHAPE-e (2D and 3D), Padsy II (2D) and Padsy III (3D), Shoemaster System (2D and 3D), Lectra System (2D and 3D), Parmel System (2D), ATOS II System (3D) [2], [3]. These systems are equipped with graphical colour displays, plotters, digitizers, accessories and other equipment needed in order to perform computer assisted activities.
The 3D model design using computers removes the inherent ambiguities of 2D drawings, reducing the errors and the remanufacturing [4].
Not all CAD/CAM applications are accessible to all categories of users because the procurement costs are often prohibitive to home users. The high cost applications are intended for footwear factories with high productivity.
The shoe soles are produced as flat shoe soles partially spatialized shoe soles and spatialized shoe soles. The design complexity increases with the spatialization degree of the shoe sole.
The applications like Delcam Shoe Solutions, Delcam PowerSHAPE-e, provides the user with the tools needed to design the most complex shoe soles and the moulds nests in which are formed.
The hybrid modelling in PowerSHAPE-e combines perfectly the solid modelling and surface modelling, having the flexibility to develop complex shapes, such as shoe soles and mould nests in which are formed. This application can be downloaded free of charge from the producer website.
In this paper is presented a design method for mould nests [5] in which are formed the spatialized shoe soles, by using the PowerSHAPE-e application.

2. SPATIAL FOOTWEAR SOLES DESIGN in PowerSHAPE-e . CASE STUDY

2.1 Primary data

To use this design method, it is necessary to digitize or scan the shoe last in a 3D file format recognized by PowerSHAPE-e [1]. The recommended file format is IGS. The last in IGS format is imported in the application environment. The shoe last. as in Figure 1. is defined as a set of surfaces. In order to use it in the design process, it is converted to a solid form.

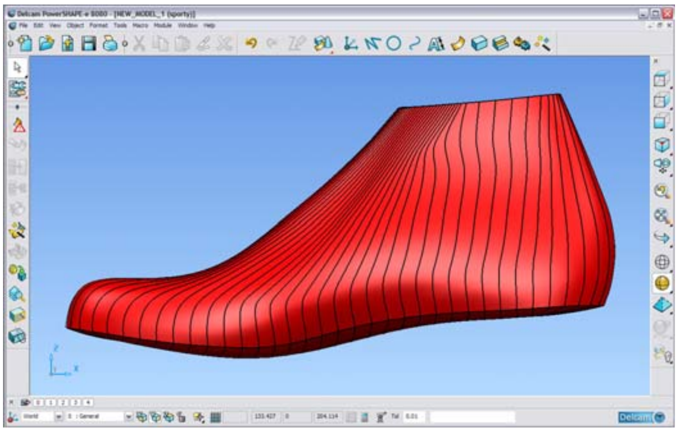

Figure 1: Importing the shoe last

2.2. Designing the spatial footwear sole

For this method, the spatial footwear sole design is accomplished [5] by modelling a parallelepiped solid, sized to completely include the designed shoe sole, as in Figure 2.

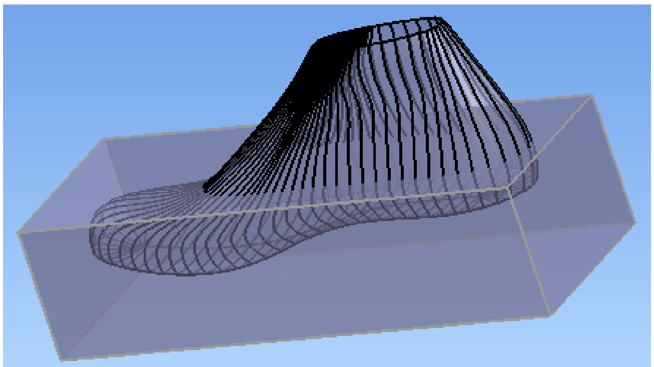

Figure 2: The parallelepiped solid

The profile of the spatial footwear sole at the top is drawn initially as a Bezier curve. Using this curve is created the sectioning surface. After sectioning the solid and removing the surplus, the top side profile of the spatial footwear becomes visible as in Figure 3.

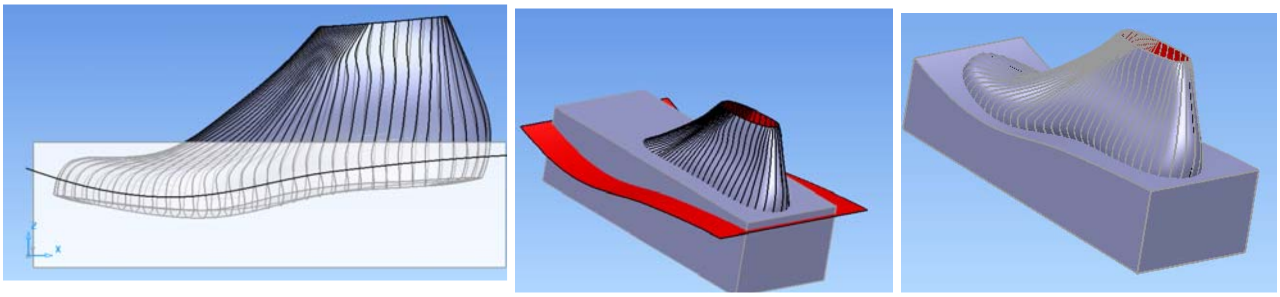

Figure 3: The sectioning surface and the top side profile of the spatial footwear sole

The exterior shape of the spatial footwear sole can be drawn in different ways depending on the complexity of this shape. If the exterior shape doesn't follow the shoe last surface shape or its shape has a complex form, it can be manually drawn using a combination of line segments and/or curves. To obtain a contour positioned at a constant distance in relation with the surface of the shoe last, first is created an intermediate contour at the intersection between the shoe last and the modelled solid as in Figure 3. Then the exterior contour of the spatial footwear sole is drawn as an offset of the intermediate contour. A contour with complex forms can be obtained also by editing the offset contour. This editing can be done even by treating it as a continuous curve in which each segment position depends on the position of the adjacent segments or by treating each segment individually. The position of each node can be modified and new nodes can be added as well as old ones removed. Using the footwear sole exterior contour is defined the sectioning surface as in Figure 4.

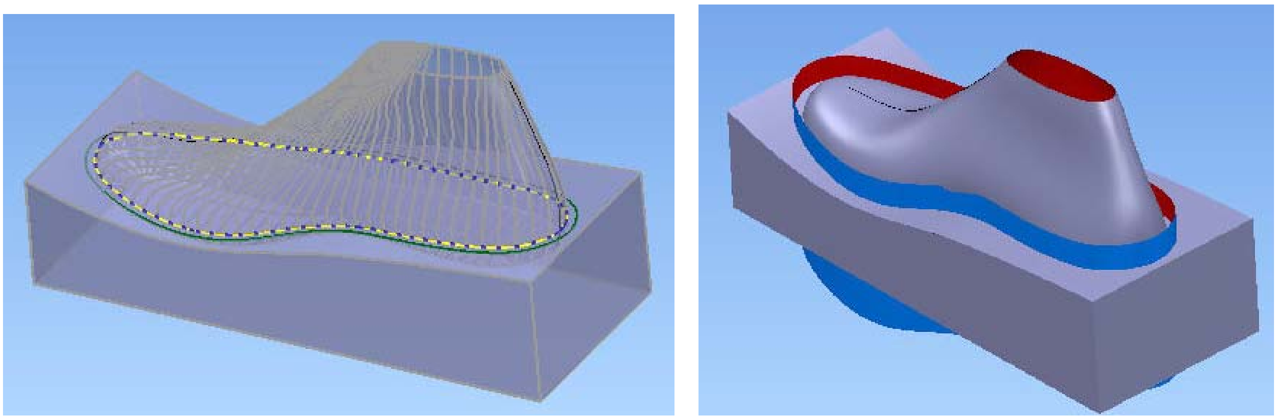

Figure 4: The exterior contour of the spatial footwear sole

The exterior surface shape of the spatial footwear sole is obtained after sectioning the solid and removing the surplus, as in Figure 5.

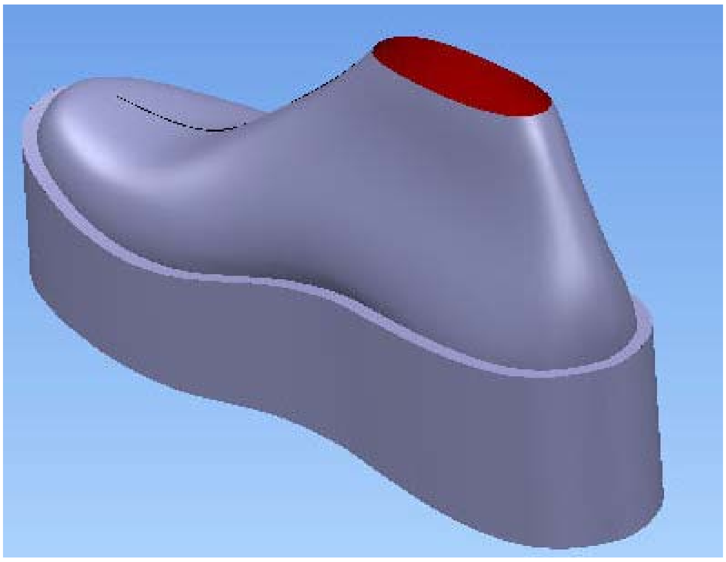

Figure 5: Defining the exterior surface of the spatial footwear sole

The bottom profile is made in the same manner as the top profile. Initially is drawn the profile, which can be composed of line segments and/or curves. The sectioning surface is obtained using the drawn profile. After sectioning the solid and removing the surplus, is obtained the shape at the bottom side as in Figure 6.

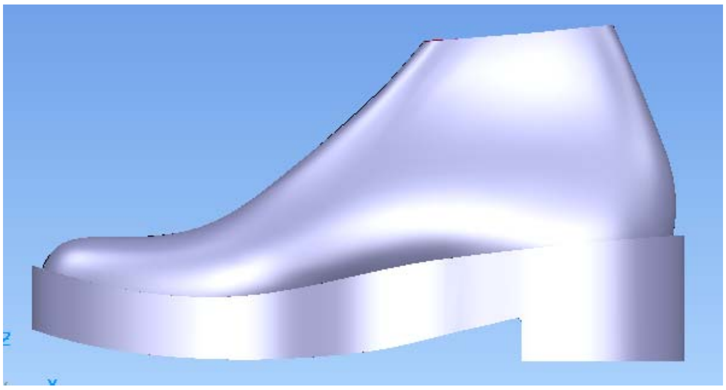

Figure 6. The spatial footwear sole profile at the bottom side

The cavity inside the sole where the upper part of the shoe is mounted is obtained by removing from the solid volume the intersection between the solid and the shoe last. This cavity is similar to the one represented in Figure 7.

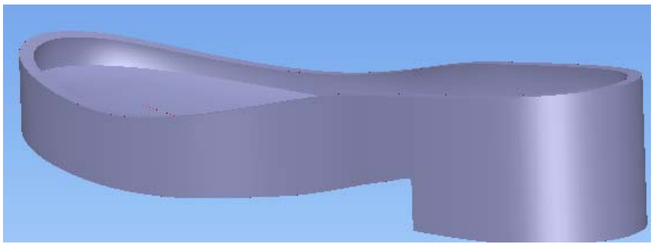

Figure 7. The top side footwear sole

2.3 Shape rectifications

Depending on the design requirements, a set of footwear sole shape rectifications may be needed. For example: the rounding of the exterior edge on the top side. This rectification, illustrated in Figure 8 is obtained by filleting the top surface with the side surface.

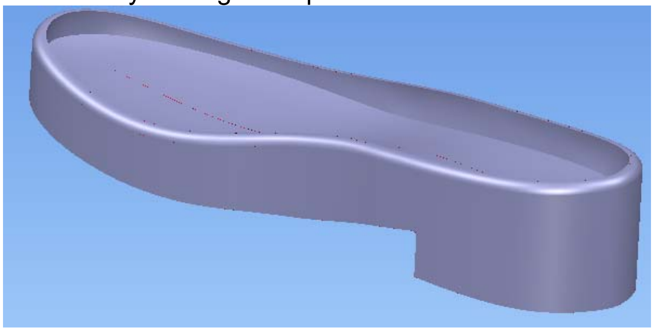

Figure 8. Footwear sole shape rectifications

2.4 Designing the anti-skid pattern

The anti-skid pattern of the shoe sole can be designed as negative, positive or as a combination of the two. If the anti-skid pattern is designed in negative mode, are designed the spaces between the anti-skid pattern elements and then, the designed spaces are removed from the shoe sole volume. In the mould nest, this kind of anti-skid patter has a positive appearance. If the anti-skid pattern is designed as positive, are designed the anti-skid pattern elements and after that, the designed elements are attached to the shoe sole volume, obtaining in the mould nest a negative appearance.

Whatever mode is used, designing the spaces between the anti-skid pattern elements or designing the anti-skid pattern element or a combination of the two, the designed pattern is on the bottom surface to respect its shape.

To design various elements on the bottom surface is created a construction network, as in Figure 9 which respects the spatial shape of the bottom surface. This construction network can have various forms depending on the design necessities.

The first step in making the construction network consists in drawing a set of line segments and/or curves. All these segments are made in a plan.

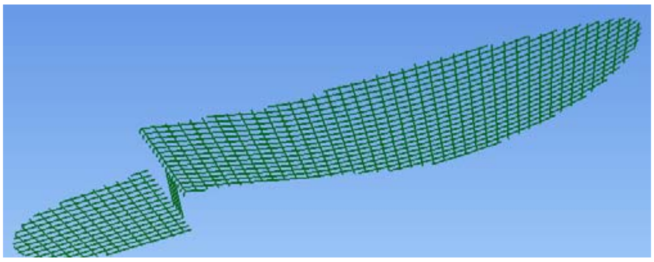

Figure 9. Construction network

By projecting this network on the bottom surface, is obtained the construction network in space, respecting the spatial shape of the bottom surface on the mould nest in rough form. As long as the spatial shape of the bottom surface is respected, the antiskid pattern elements defined as solids can be designed using any available method (primitive solid, generate solid, constructed solid). In Figure 10 is presented the method of generating a set of solids using a base contour (section) and a trajectory.

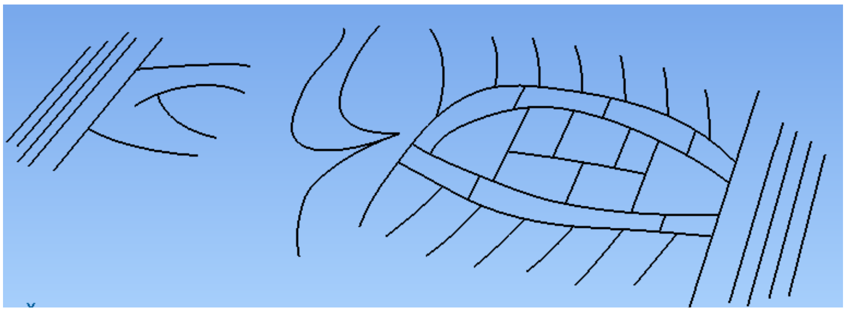

Figure 10. Solid generation trajectories

To accomplish this, are drawn the trajectories for each of the solids. If the anti-skid pattern is designed as negative and it has to reach the exterior contour, the trajectories will be drawn to pass the exterior contour. This will ensure the elimination of the negative element totally, whatever the similarity of the sides.
By visualizing the deigned solid and the trajectories, can be checked if the bottom surface of the footwear soles respected, like in Figure 11.

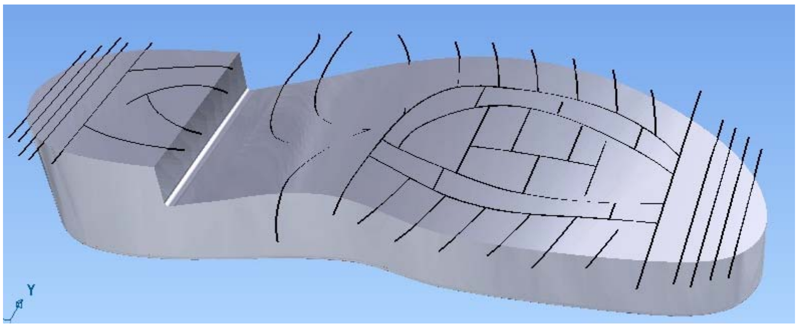

Figure 11: Verifying if the trajectories respect the bottom surface

For each designed trajectory is drawn the base contour (section). Using this sections and the associated trajectories, are generated the solids that define the anti-skid pattern, as in Figure 12.

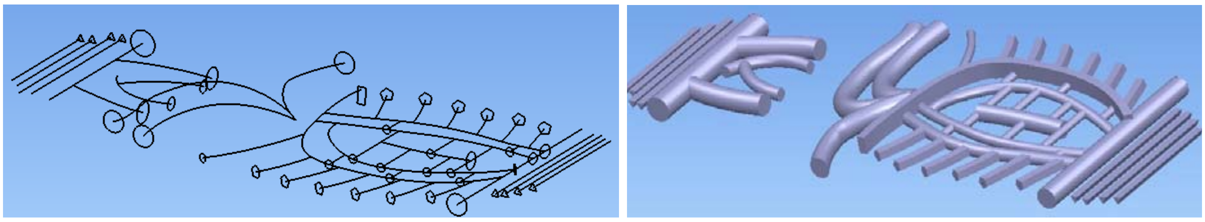

Figure 12: Sections and generated solids that define the anti-skid pattern

The generated solids are positioned on the bottom surface of the mould nest and are removed from the solid as in Figure 13. The formed cavities represent the anti-skid pattern of the shoe sole.

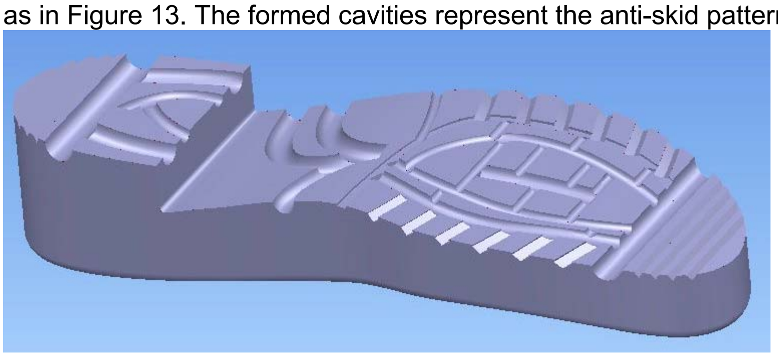

Figure 13: Generated solids on the bottom surface and the anti-skid pattern aspect

Depending on the design requirements, this anti-skid pattern can be rectified using the available design tools. In Figure 14 is illustrated the final aspect of the shoe sole obtained in the mould nest designed using the method presented in this paper.

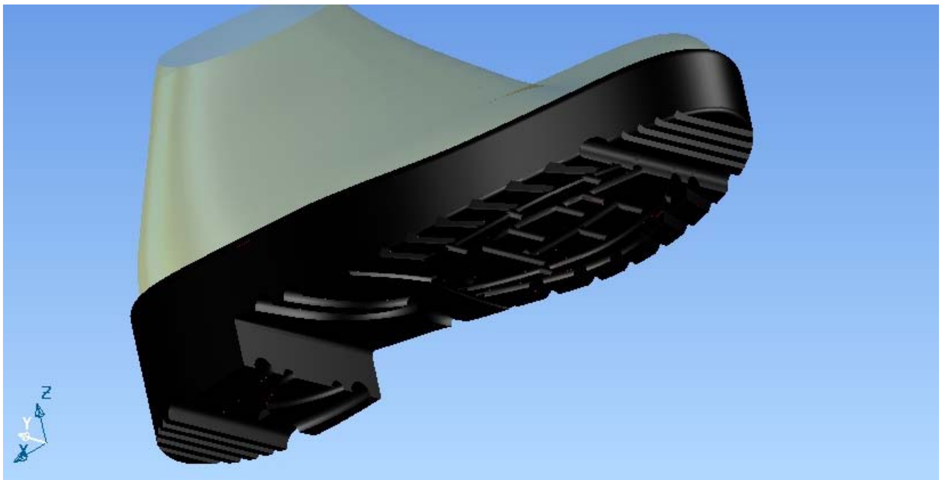

Figure 14: The shoe sole shape after injection

Unlike classical CAD methods for footwear soles and mould nests in which these are formed, the developed method presented in this paper is recommended for both beginners and highly skilled designers. The obtained design can be used for the practical execution of the mould by classical means, using execution patterns, and by CNC machines.

CONCLUSIONS

One great advantage offered by the developed method is the reusability of the design. The designer is able to obtain an inexhaustible diversification of the footwear sole for the same shoe last by redesigning the anti-skid pattern, weight removal cavities and even by fine tuning the shape.

Before sending the design to the execution department, by using this method the designer can calculate the exact amount of polymer blend needed to fabricate the footwear sole.

Once designed the mould nest using this method for the average number in the sizes series, the designer is able to grade the dimensions for the other size number in the series in no time.

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USING CONJOINT ANALISYS FOR SPORT FOOTWEAR DESIGN

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Abstract: *Sports footwear defines shoes designed for practising a physical activity. The consumer needs are generally expressed by precise requirements whereas the footwear's functions are translated into design parameters. Developing new products is a core element of the competitiveness of sport goods companies in a context of market instability. Conjoint analysis together with the QFD method (Quality Function Deployment) is a useful tool for developing new sport products. This marketing research technique allows ordering the choices of consumers in terms of product characteristics for a better expression of design features. Conjoint analysis indicates the consumer's attitude towards the potential attractiveness of a product, thus avoiding an extensive and costly development of a prototype. The purpose of the present study was to assess the optimal combination of features for sport footwear using the conjoint analysis. The methodology implied developing a multivariate questionnaire, the results of this study indicating the sport footwear characteristics most requested by the consumer.*

Keywords: *conjoint analysis, sport, footwear, design*

1. INTRODUCTION

The global market of sport footwear industry is characterized by an intense competition, with presence of a large number of players, being exposed to continuous changes in consumer preferences. Developing new products is a core element of enterprise competitiveness in a context of market instability and need for optimizing investments [1].
Conjoint analysis is a technique used to measure, analyse and predict consumer's response to new products. This allows companies to decompose consumer's preferences for products (usually in the form of descriptions and images) in value associated with each level of product attribute. Conjoint analysis assumes that products can be classified into categories by a particular set of attributes. For example, sport footwear can have the following attributes: style, lightweight, brand, fit, stability, comfort, cushioning, flexibility etc. Each footwear item can then be described as a combination of the levels of those attributes. Still, the number of attributes is limited because considering too many features make it difficult for the respondents to answer.
From a technical point of view footwear comfort may be defined as combination of several factors: adaptability, internal climate, humidity level, plantar pressures distribution and ground impact forces [4]. Consumer's evaluation is conducted so that it can be broken down into categories based on the values consumers attach to each attribute of the product.
A classical conjoint analysis comprises three phases, figure 1: 1) design the questionnaire; 2) collect the data from respondents; 3) analyse the simulated market response. Initially the profile of the end user is identified. A product being described according to a set of characteristics, only the relevant ones are evaluated. In the present study, using conjoint analysis the "right" attributes of sport footwear are defined.

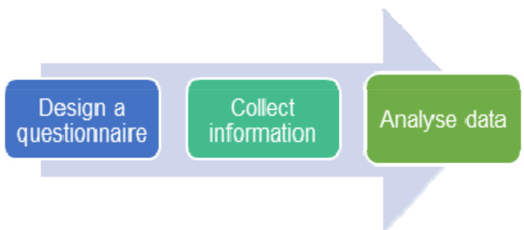

Figure 1 Steps in a classical conjoint analysis

2. METHOD

The instrument used for conducting this research was a multi-variate questionnaire. Questions aimed to gather the necessary information that meets consumer demands. In this sense, it was assured that questions do not suggest or influence answers. Moreover the number of options was limited in order to avoid simplification strategies from the respondents. From this perspective, participants were made aware of the importance of the interview process. The main objective of the questionnaire was to mark out features that the consumer would like to meet in sports shoes.

3. RESULTS AND ANALYSIS

3.1 Descriptive analysis of respondents

Among the participants, 71.4% are female and 28.6% are male with the age above 18 years old. 67% of our respondents are between 25 to 45 years old. The majority of our respondents are currently working in private companies, which contributed around 53% of all respondents. There were only 3% who are running their own business, 35% are students and the remaining are those who work for state owned enterprises (table 1).

Table 1: Descriptive analysis of respondents

Classified By		Percent(%)
Gender	Female	71.4
	Male	28.6
Age	18-25	40.4
	26-35	28.6
	36-45	24.6
	46-55	5.6
	More than 55 yrs	0.8
Occupation	Business Owner	3.2
	Private Company Employee	52.4
	State Enterprise Employee	9.5
	Student	34.9

3.2 The benefits of sport

The development of mass physical activities remains limited in Romania even though public institutions communicate on the possibilities of social improvement by competition and the functional benefits of physical activity [11].
Sport, as a means of preventing one's health, is unanimously recognised by the respondents, figure 2.

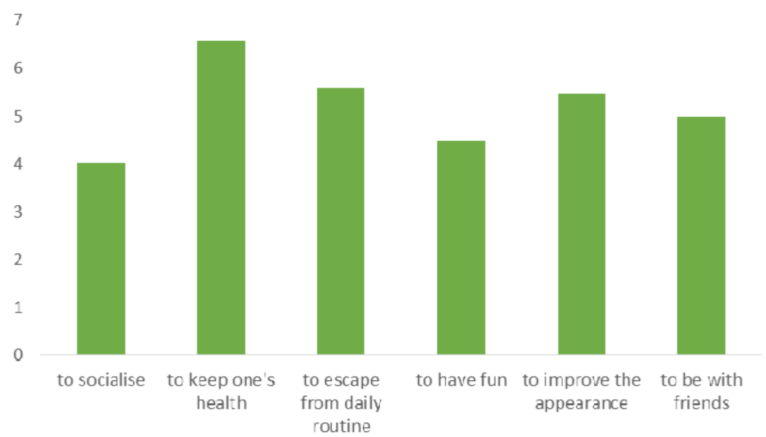

Figure 1: Benefits of sport

On a seven point scale practicing sport has registered a mean value of 4.49, showing a good frequency of sports practice activity The main motivation in playing a sport is enjoying nature, figure 3.

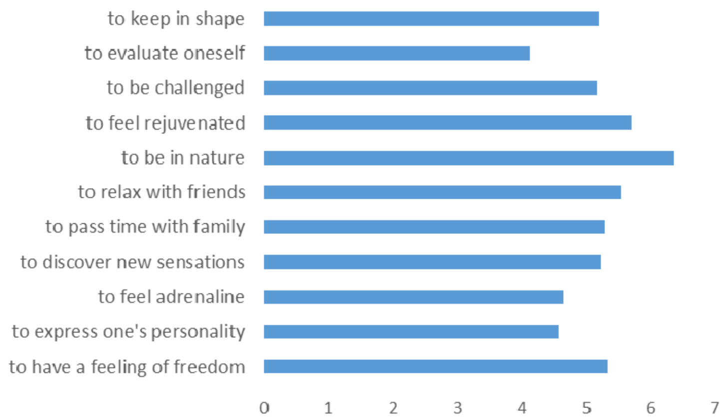

Figure 3 Reasons for practicing a sport

Most sports require special equipment for practicing in good and safe conditions. Purchasing sports equipment was evaluated by respondents at a score of importance of 3.89 where: 7 corresponds to the statement “I am looking for the best sports equipment and I am ready to pay the price accordingly.” and 1 corresponds to the statement “I'm not looking as long as the equipment is comfortable and fits me, that's all that matters.” Consumers are more likely to buy a sports equipment that helps them to progress and that has specific technical features. The brand is an important attribute as respondents affirmed using sports equipment of recognized sports brands. Fashion and being in trends as for sports footwear are least demanded by the respondents.

Sports footwear include several sub-categories as function of where the physical activity takes place: outdoor or indoor. When developing a new line of sport footwear items it is important to know the preferences for physical activities. The sport activity most often practiced by the respondents is jogging, followed by cycling, figure 4.

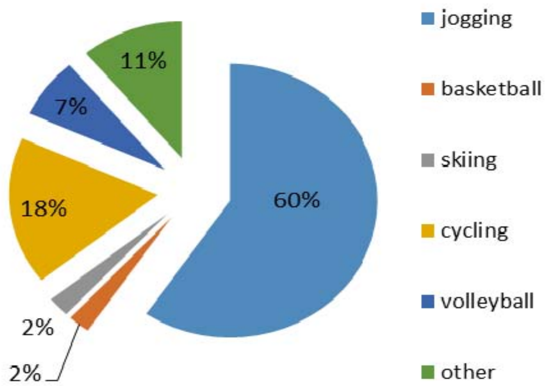

Figure 4 Favorite sports

The three most important functional design factors for sport shoes are: injury prevention, performance and comfort [7]. Enke et al. showed that a majority of adolescent runners identifies arch type and shoe design as the most important factors in choosing a running shoe. In their study a total of 73.1% of survey participants identified arch type compatibility with shoe design as the most important factor in choosing a running shoe; however, only 57.0% reported knowing their arch type [10]. The respondents rated breathability (or the maintenance of good in-shoe conditions) as the characteristic the most particularly important in active sports footwear, figure 5. This essential quality for comfort and cleanliness allows air and moisture pass through the shoe uppers. Moreover respondents consider that footwear must have an important role of foot protection and thus of prevention from various injuries that can occur in sport practice. Flexibility is as well an essential characteristic because the foot’s natural motion must not be restrained.

Figure 4 Characteristics of sport footwear

4. CONCLUSIONS

As function of the various sport disciplines, the demands of consumers are addressed by specialized footwear constructions. Conjoint analysis is a useful technique that determines how people evaluate different features that make up an individual product, being mainly applied in the design phase. The objective is to identify the combination of attributes or design elements that the product must have to satisfy the needs, expectations and preferences of the end users. Thus the development of new products is better fitted to the consumers' demand. The results extracted are concrete and therefore useful for decision making in the design of a new model of sport shoes. The present study statistically deduced what sport footwear features are most desired and which attributes have the most impact on consumer's choice.

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FOOT COMFORT – CASE STUDY

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Abstract: *The aim of the study is the analysis of the foot – footwear – environment relation. It has two different parts. One part is started with a feet health evaluation, using ESP questionnaire, proceed than with a visual identification of the feet disorders and anomalies and then with the footprint and the gait analysis.*
In order, the ESP score of the subject is 35.93. This score indicates a very good health status with minor health problems. Obviously, this score must be correlated with subject age. This result of ESP questionnaire should be an enough reason for a deeper research because, in this case, the subject is young.
The footprint analysis highlights a semi high arch foot and the gait analysis emphasizes two important abnormal aspects.
The second part included the analysis of a pair of shoes and calculating of the shoe quality index. It was chosen a comfortable shoe, used for few seasons.

Keywords: *comfort, foot, footwear, quality index, shoes.*

INTRODUCTION

In the comfort analyse are involved 3 variables in a close relation: individual (foot) – footwear – environment [1]. They are making an integrated system where they are in a complex and continuously interaction.
In this relation the individual come with anatomical and physiological characteristics (heat emission and moisture exhalation to feet level), motor characteristics (movement necessities) and psychological features (temperament, aesthetic sense, education level, etc.).
The environment can be assessed by measurable indicators as: temperature, moisture, pressure, wind speed, ground quality of movement (soil, gravel, asphalt, concrete, sand, wood, etc.).
Between the foot and the environment is the footwear. On the one hand, the footwear is necessary to satisfy the feet anatomical and functional limitations, and on the other hand, to offer an answer to the environment requirements. In order, the footwear should be able to provide thermo-physiological, sensorial and psychological comfort.

METHOD USED

For research of the relation between feet, footwear and environment were two steps. First, it was evaluated the feet health status using: ESP questionnaire, visual examination, static and dynamic footprint analyse and gait analyse. Second, a pair of used and comfortable (subject opinion) shoes was analyzed and it was calculated quality index.
To this case study was selected a young, female subject of 28 years old. She has a normal BMI (body mass index) 20.1 because her high is 170 cm and her weight is 58 kg. She is a well educated person (resident doctor in cardiology), lively, sociable, the fashion preference is for elegant classic clothing. She is doing sport regular, three times per week. She is „a child of asphalt", living in urban environment without expose to extreme condition of weather.

RESULTS AND DISCUTION

To foot health evaluation, the subject answered to questions of ESP questionnaire [2]. The answer can be choosing between five possibilities of Likert scale, for each question. The questionnaire has six domains: symptom, pain, function in daily activities, function in sport and recreation activities, footwear and quality of life. It was calculated ESP score and the scores for each domain. The result can be placed between 0 and 100. It is a scale with five levels which indicate health status of feet: perfect health (0 – 20), very good health

with small health problems (20 – 40), good health with moderate problems (40 – 60), low health with serious health problems (60 – 80) and very low health with extremely health problems (80 – 100).
ESP score for subject is 35.93; it is placed on second level, this mean a very good health with small problems of feet. Obviously, this score should be correlated with subject age. For a young person, as the subject is, this score is an enough reason for a deeper research.
The subscale scores point out only three of them: symptoms, footwear and quality of life. The score for quality of life subscale is normal to be to the same with ESP score. The score for this domain is an indicator of subject objectivity and sincerity. For example, it is abnormal to have not affected the quality of life if the subject has big pains in feet. Also, it is abnormal too, a lower score for ESP (perfect health) and a very high score for quality of life domain. In this situation, this can be a clue of some psychological problems.

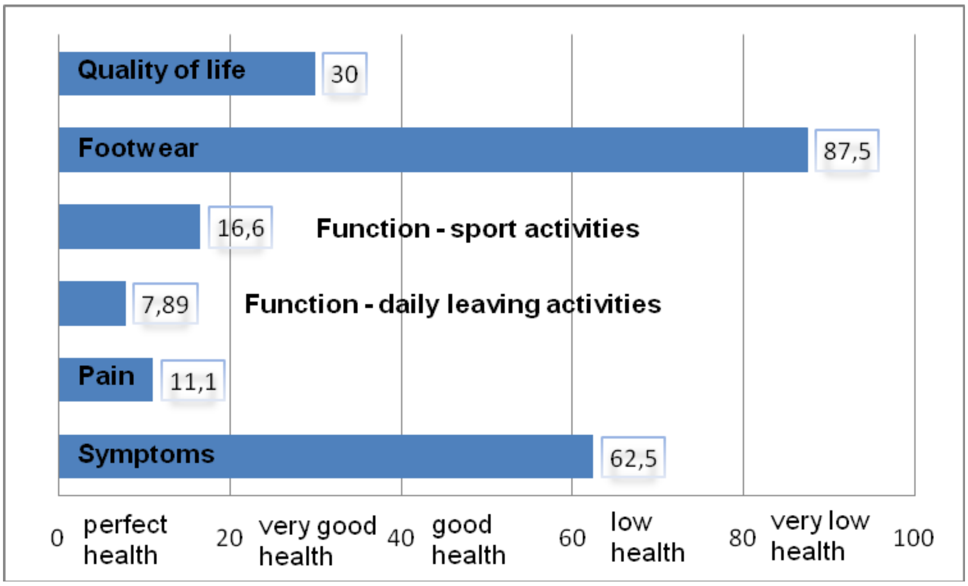

Figure 1: Health evaluation using ESP questionnaire

The score for Symptoms is on low health level. The subject has swelling feet, noises in feet joints and rich sweat frequently, has muscle cramps sometime, many corns and the shape of feet is moderate modify.
The swelling feet can be a symptom of peripheral blood circulation disorders in many diseases or it can be a feet reaction to the upper shoes pressure.
The muscle cramps can be generating by the insufficient quantity of minerals in the body or they can be a body defence response to overstressing.
The corns are produced by high plantar pressure and friction between foot and footwear.
In this particular case, the Symptom domain can be correlated with Footwear domain only. The subject has serious difficulties to find well fitted and comfortable shoes. Also, she is hampered by the shoes she has to wear it.
The feet shape modification is given by a malformation of metatarsophalangeal joint.

Figure 2: General view of subject

Figure 3: Footprint in statics

Figure 4: Footprint in movement

feet
Because of this, the position of finger IV is in other plan above the foot fingers plan. From support to superior limit of finger V are 2 cm, to superior limit of finger IV are 4 cm and to superior limit of finger I are 3 cm.
In Figure 2 is highlight the flexion foot lines, a connection line between the metatarsophalangeal joints I and V. This line corresponds with the repeated bending line of shoe.

The footprint exam of left foot in statics (Figure 3) shows a loss of contact of toe V with support surface and footprint represents 53% of transversal dimension of plantar surface in the centre of „high arch" of foot.
The footprint exam of right foot in statics (Figure 3) shows a light contact of toe V with support surface and the footprint represents 44% of transversal dimension of plantar surface in the centre of „high arch" of foot.
The angles between metatarsals V and I with horizontal is approximately 10° and 25° (the normal values are 5° and 20°). Those values highlight an increase of forefoot plantar pressure. In conclusion, the subject has a mild pes cavus.

The cause of difference support between the middle area of left foot and middle area of right foot, couldn´t be clearly determined. That support difference can be produced by a compensated mild difference in length between left leg and right leg (less than 2 cm) or it can be a result of unequal growth of muscle – ligamentary system.
The dynamic footprint (Figure 4) was taken through plantar rolling on support surface covered with a special paper. The image reveals the contact of finger V with the ground and gives a confirmation of different support from static.

Figure 5: The contact of right foot with ground in first phase of gait

Figure 6: Propulsion phase of gait for left feet

The gait analyse reveals two important issues. In first phase of gait (Figure 5), the foot get contact with the ground through heel and lateral midfoot, in the same time, and because of this the rolling movement is almost inexistent. In propulsion phase of gait (Figure 6), flexion of forefoot is reduced without anatomical causes because she can do complete flexion of forefoot. This gait pattern is result of interaction between foot and footwear, like a necessity to prevent the foot trauma produce by repeated bending I-IV line of footwear. This gait pattern was adopted in growth and development years of the subject.

Also, like result of foot-footwear interaction is the corns (left and right leg, between toes III and V and right leg, between toes II and III), callosities (in lateral of metatarsophalangeal and phalangeal joints of toe V and dorsal face of toe IV), hammer toe (toe IV) and light deflection of the toe V to IV. Those are made by the friction, compression and poor dimension fit of the footwear. The plantar callosities (Figure 8), on the other hand, are generated by some points of high plantar pressures.

Figure 7: Toe corns and callosities

Figure 8: Plantar callosities

The shoe category analysed is a pump for spring and autumn with 5 cm high heel, the upper made by split leather is divided in two parts: vamp with outside quarter and inside quarter. The upper parts are stitching on mid line of heel (quarter with quarter) and lateral (inside quarter with vamp).

The lining is made from good quality leather substitute. The leather substitute is composed of three layers: the finishing porous layer, the knitting reinforce layer and the base porous layer with open pores. The lining is divided in two parts: quarters and vamp lining is a part and counter pocket. The toe cap is made by low hardness material. In Figure 9, the discontinuous blue line is the edge of toe cap; blue line crosses the red line of foot shape only in top of toe I. As it can see, the foot has enough space inside of shoe and the fishtail toe doesn't influence the inside volume of shoes.

Figure 9: General view of shoes

Figure 10: General view of heel

Figure 11: The effect of wear on insole

The level of wear provides a frequent use but, also, a good fitted.
The heel shape of shoes is well preserved because of good quality stiffener and the stiffener wings doesn´t let the superior edge of quarter to be excessively deformed. Because of that, the shoes are stable and well fixed to the rearfoot.

However, lining finishing is destroyed in friction areas: superior edge of quarters and lining vamp. The deformations of vamp, cause by toe IV, is not visible because of decorative straps.
As it can see in Figure 11, the insole doesn´t offer a uniform plantar pressure distribution and between high arch and insole is not existed any contact.

It is useful to calculate the quality index [3]. This index can be calculated by expert before the footwear to be use or after use, with or without subject opinion about it. Of course, the results can be different.
In order for index quality calculation are giving and calculating scores for each request, function and attribute.

The comfort index was calculated through laboratory analyses of water vapour permeability, air permeability and insulation for upper materials. For any other request was provided the maximal score (100) if that request is fully satisfied.

Table 1: Quality index note for shoes

Attribute	Note AT	Footwear functions	Pct Fî	n_{CR}	Request	Pct
Comfort	3,12 from 4	Physiological hygienically function	82	5	Comfort index	210
					Flexibility	100
					Non-allergenic action	100
		Dimensional function	87,5	4	Weight	100
					Framed in dimension range	100
					Framed in specific dynamic effect	50
					Dimensional stability	100
		Biomechanics function	62,5	4	High arch support	0
					Plantar pressure balance	50
					Balance in statics and dynamics	100
					Well function of joints	100
		Ergonomic function	80	5	Shock absorption	100
					Forming of foot bed	50
					Slipping on different support (ice, wet, sandstone, parquet, etc.)	100
					Effortlessly in put on and take off the shoes	100
					Correspondence between foot and footwear	50
Performance in wear	2,5 din 3	Reliability function	66,6	3	Mechanical strength of materials and joining	100
					Wearing strength	50
					Finishing resistance	50
		Maintenance function	100	2	Results to washing	100
					Results to actions of chemical maintenance products	100
		Safety function	83,3	3	Coverage degree of foot	100
					Protection against mechanical trauma	100
					Protection against environment agents	50
Aspect and stylistic content	1,75 din 2	Gnoseological function	100	3	Information about product (price, number, materials types, using and cleaning conditions)	100
					Company & brand information	100
					Information about custom (personality, style)	100
		Stylistics and composition function	75	2	Stylistic content	50
					Design (shoe categories)	100

In this case, the quality index was calculated after use, and it was take in consideration subject opinion about it. The quality index score for this footwear is 7.37. A pair of shoes with a score between 7 and 9 is superior quality in medium quality level. The footwear with this quality level is addressed at 9% of customers.
For the same pair of shoes, the quality index made, without taking in consideration subject opinion, is 6.82. A pair of shoes with a score between 5 and 7 is intermediary quality in medium quality level. This product is addressed to approximately 25% of customers.

CONCLUSIONS

In conclusion, it is recommended resection of toe IV, to this subject. This will not affect the balance in statics or dynamics and the gait will be improve with exercises, because propulsion will not be cut. The surgery can be traumatizing and it can request a recovery and inactivity.
If this surgery is not an option, the subject should use only custom shoes. The last should be reproducing, as much as possible, the feet shapes. The biomechanical studies can be set the optimal high of heel for an optimal pressure distribution and to avoid an evolution of pes cavus, also it is necessary to be used preformed insoles.
The shoes should be made by leather, especially the lining. The feet sweat can be increased because of lining from leather substitute.
The gait pattern is a result of interaction between foot and footwear and not a consequence of her feet anomaly (the flexion and extension of forefoot are normal).
The quality index score is subjective. It is influence by the subject experiences and needs. The most important requests for this subject are: inside volume of forefoot to be enough, the edge of vamp or stitching to not touch toe IV and the footwear to be in fashion. Any shoe provides this requests is considered comfortable from her point of view.
In this moment, the subject has two options: to do or to do nothing. If she will do nothing, in few years, she will get pain in her feet and the function will be seriously damage.

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DEVELOPMENT AND VALIDATION OF HEALH FOOT EVALUATION QUESTIONNAIRE

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Abstract: *The feet are the foundation and support for most of the human activities. The feet problems, even small ones, have influence to work ability and freedom to do all kind of activities, limiting individual options and have impact to quality of life.*
The aim of this study was to apply the principles of content and validation in order to develop a new questionnaire specifically designed to measure foot health status.
In this way, a group of experts was put to set the domains and to develop the questions of questionnaire. The items were than evaluated by a validation group. 141 persons evaluate each item. The evaluation gave information about the importance of each domain and the impact of each question to foot health.

Keywords: *foot, physical function, pain, footwear.*

INTRODUCTION

The questionnaires have a main status in foot heath evaluation. Generally speaking, the questionnaires are based on isolation and revelation of sensations which are feeling in the feet.

Frequently, the foot discomfort can be a sign of foot affections (corns, ingrown nails, flat foot, finger deformities) or a sign of systemic disease (rheumatoid arthritis, lupus), metabolic diseases (diabetes, gout), vascular or neuron diseases (angiopathies, neuropathies).
In rheumatoid arthritis, for example, frequently, the foot is the first affected area, so that till diagnostic, approximate 16% of patients have the foot affected and the percentage increase till 100% for the patients with 10 years old disease [1].

The most frequently gout symptoms are inflammation, pain, swelling and stiffness of affected joint. The initial manifestation of gout is usually an acute attack of peripheral joint, most commonly the hallux, for 56 – 78% of patients [2]. However, 59 – 89% of patients have this joint affected [3] and 25 – 50% has affected the knee and ankle.

Peripheral neuropathy caused by diabetes leads to loss of sensation of pain, touch, thermal and vibration perception. Among of diabetic patients approximately 23 – 42% have peripheral neuropathy and the rate increases till 50 – 60% for patients with diabetes type 2 [4]. For 75 – 80% of patients, the abnormal running of peripheral nervous system is announced by a several symptoms as burning sensation, pins and needles in the feet, sharp and stabbing pain and muscle cramps.

In the last decades was design more questionnaires which can help to evaluate and measure of the feet health. Example of specific heath measure include Arthritis Impact Measurement [5, 6], Sickness Impact Profile [7], Foot Function Index [8], American Academy of Orthopaedic Surgeons Lower Limb Outcomes Assessment Instruments: Foot and Ankle Questionnaire [9], Western Ontario and McMaster University Osteoarthritis Index (WOMAC) [10], McGill Pain Questionnaire [11] but was develop questionnaire to measure general health as Foot Health Status Questionnaire (FHSQ) [12] and The Podiatry Health Questionnaire [13], the impact feet problem to life quality as The Bristol Foot Score [14] or the comfort provide of the shoes as The Shoe Comfort Scale.

More or less these questionnaires have like objective the recognition and quantification of different types of feet discomfort in relation with footwear and lifestyle.

METHOD USED

In order to develop the questions of Health Foot Evaluation (ESP) was create a focus group composed of doctors and shoe design and shoe making experts. The first task of group was to isolate the most relevant perceptions and to associate them with a certain type of discomfort: tactile, visual, olfactory or acoustic.
Those uncomfortable sensations were grouped in 5 domains: *Symptoms, Pain, Function, Footwear and Quality of life*. Using Brainstorming method, for each item was designed more questions and, in the end, resulted 53 questions.

Table 1: Styles in use in the preparation of this document

Domain	Questions	Cod	No.
Symptom	Do you have swelling in your foot?	S1	7
	Do you hear noises when your feet moves?	S2	
	Do you have muscle cramps when your feet moves?	S3	
	Do you have rich sweat in your fot?	S4	
	Do you have burning sensation in your feet?	S5	
	Do you have corns?	S6	
	Is it modify the shape of your foot?	S7	
Pain	How ofen do you experience foot pain?	D1	9
	Which is the intensity of pain during the twisting/pivoting on your foot?	D2	
	Which is the intensity of pain during the straightening foot fully?	D3	
	Which is the intensity of pain during the bending foot fully?	D4	
	Which is the intensity of pain during the walting on the flat surface?	D5	
	Which is the intensity of pain during the going up or down stairs?	D6	
	Which is the intensity of pain during the sleeping, in the night?	D7	
	Which is the intensity of pain during the sitting or lying?	D8	
	Which is the intensity of pain after a day of work?	D9	
Function	Are you able to straighten your foot fully?	C1	29
	Are you able to bend your foor fully?	C2	
	Which is the degree of difficulty you have experienced if you are sitting?	C3	
	Which is the degree of difficulty you have experienced if you are standing?	C4	
	How sever is your stiffness of foot after first wakening in the morning?	C5	
	How sever is your stiffness of foot after resting, sitting or lying later in the day?	C6	
	Which is the degree of difficulty you have experienced if you are going downstairs?	C7	
	Which is the degree of difficulty you have experienced if you are going upstairs?	C8	
	Which is the degree of difficulty you have experienced if you are rising from sitting?	C9	
	Which is the degree of difficulty you have experienced if you are bendind to floor and pick up an object?	C10	
	Which is the degree of difficulty you have experienced if you are walking on flat surface?	C11	
	Which is the degree of difficulty you have experienced if you are getting in/out of car?	C12	
	Which is the degree of difficulty you have experienced if you are standing on tip toe?	C13	
	Which is the degree of difficulty you have experienced putting on/takeing off the socks?	C14	
	Which is the degree of difficulty you have experienced rising from bed?	C15	
	Which is the degree of difficulty you have experienced if you are going up on a slope?	C16	

Domain	Questions	Cod	No.
	Which is the degree of difficulty you have experienced if you are going down on a slope?	C17	
	Which is the degree of difficulty you have experienced if you are lying in bed?	C18	
	Which is the degree of difficulty you have experienced if you are getting in/out bath?	C19	
	Which is the degree of difficulty you have experienced if you are gettin/off toilet?	C20	
	Which is the degree of difficulty you have experienced if you are doing heavy domestic duties (moving heavu boxes, scrubbing floor, etc.)?	C21	
	Which is the degree of difficulty you have experienced if you are doing light domestic duties (cooking, dusting, etc.)?	C22	
	Which is the degree of difficulty you have experienced if you are doing exercises in squatting?	Sp1	
	Which is the degree of difficulty you have experienced if you are running?	Sp2	
	Which is the degree of difficulty you have experienced if you are jumping?	Sp3	
	Which is the degree of difficulty you have experienced if you are turning/twisting your foot?	Sp4	
	Which is the degree of difficulty you have experienced if you are doing exercises in kneeling?	Sp5	
	Which is the degree of difficulty you have experienced if you are doing the lunge exercises?	Sp6	
Footwear	Do you have dificulties to find comfortable shoes?	I1	4
	Do you have dificulties to find shoes to fits you?	I2	
	Are you hampered by your shoes you have to wear it?	I3	
	What types of shoes can you wear comfortable?	I4	
Quality of life	How ofen are you aware of your foot problems?	Q1	5
	Have you modified your daily program to avoid potentially damaging activities to your foot?	Q2	
	How trouble are you with lack of confidence in your foot?	Q3	
	In general, how much difficulty do you have because of your foot?	Q4	
	Do you feel uncomfortable with your foot appearenceand shape?	Q5	

In the second stage of ESP design, all those questions were validated by 141 members of a group composed of women and men, aged between 20 and 70 years, well educated and active on the labour market. Individually, they decide about relevance/irrelevance of each question

Table 2: Demographic characteristics of the study population

Age (year0	% from all	Men	Women
20 - 30	17,02	50%	50%
30 - 40	29,78	28%	72%
40 - 50	27,66	30%	70%
50 - 60	17,02	37%	63%
60 – 70	8,52	50%	50%

In the third stage, all answer was analysed, and we decide to remove and to not take in to account that questionnaires with relevant/irrelevant answers for more than 97% of questions, without answers or with both options selected. To the end, 78,72% of questionnaires were keep for analyse.

RESULTS and DISCUTIONS

The first analyse and discussion is about the importance of domain. It is somehow surprising but the most relevant domain for foot health is ***Function 2***. The questions of Function 2 are about physical function when the subject is active on a higher level during the sports and recreational activities

An explanation of this rate for Function 2 can consist in one of the selection criterions of validation's group members – persons which are active on labour market. Regularly, they have activities with higher level of difficulty.
Also, if it will compare Function 1 with Function 2, the higher rate of the second can be a result of very clear, simple, concise and applied expression of the questions. Function 1 domain includes questions about ability to move around and take care of own person in daily living activities.
The bigger number of question was removed from this domain. After remove, the importance of domain is increse more than 62%.

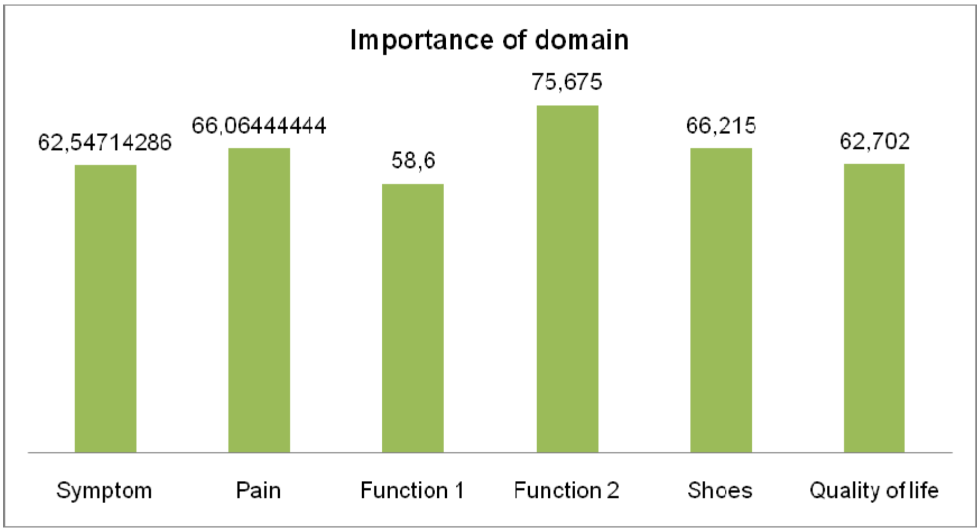

Figure 1: Impact assessment domains to health foot status

In second phase of analyse, it was accounted the score for each question. A question is validated if exceed a level of validation about minimal 40%. If a question is considered irrelevant for more than 40% of the participants, than that question doesn't pass the validation test and it will be removing.

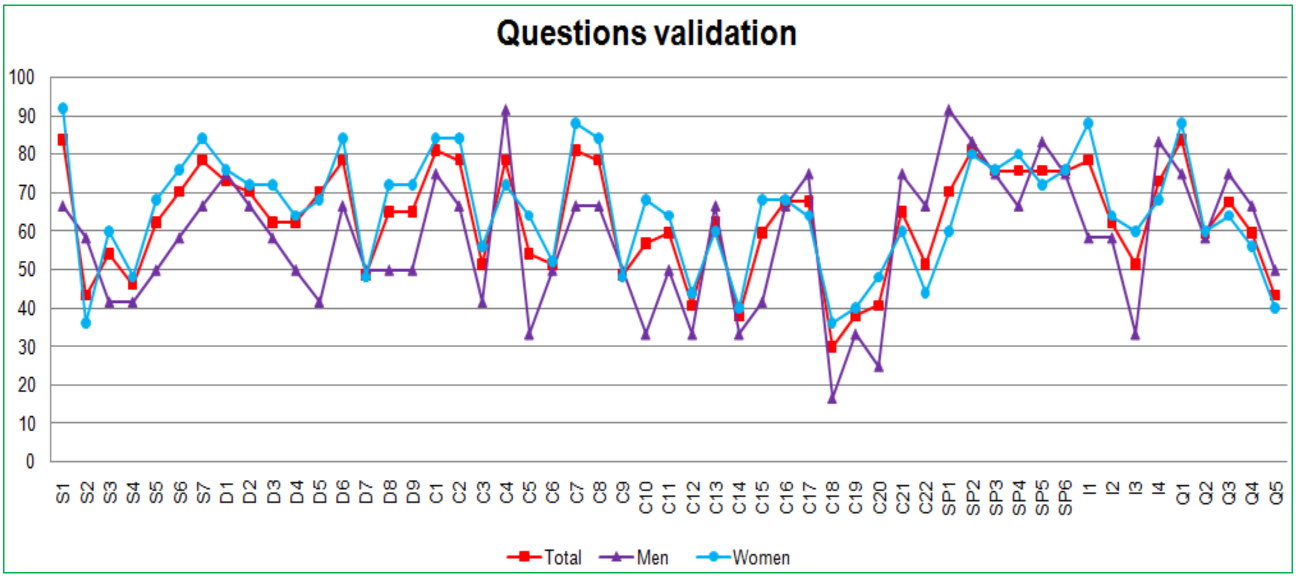

Figure 2: Result of validation process

As it is easy to see in figure 2, only 3 questions, C14, C18 and C19 are removed because they was find irrelevant for evaluation of foot health. Also, only the men found irrelevant some of the questions (C5, C10, C12, C20, and I3) and those questions was "saved" by women and in the same situation was questions S2 and Q5 found irrelevant by women and saved by men's votes.
The final situation for each domain is present in table 2.

Table 1: The six basic domain of foot health as evaluated by ESP

Domain	No. of items	Theoretical Construct	Meaning of lowest score	Meaning of highest score
Symptom	7	Self perception and evaluation of feet in terms of shapes appearance and perception	Self perception that the feet are in very good state of health	Self perception that the feet are in a poor state of health and identifies few symptoms
Pain	9	Evaluation of feet pain in terms of type of pain, intensity and frequency	No pain at all	Extreme pain that is acute in nature
Function 1	19	Evaluation of feet in condition of daily leaving activities in terms of impact on physical function	Can perform all type of activities without difficulties or complains	Extremely difficulties in normal function of feet can change the daily leaving activities
Function 2	6	Evaluation of feet in term of being active on a higher level as is sport and recreation function	Can perform all type of activities without difficulties or complains	Extremely difficulties in access to sport and recreation activities
Footwear	4	Life-style issues related to footweas and feet	No problem with choice of suitable footwear	Extremely limited options in access to suitable footwear
Quality of life	5	Impact of feet problem, in terms of activities and life-style limitation, to quality of life	The foot health have no impact of the life quality	The feet health and condition have a major impact to quality of life

To complete the questionnaire design is adopted the method of answer to the questions: using a Likert scale in 5 point, from meaning of lowest score to meaning of highest score. Each level on the scale is assigned a numeric value, starting at 0 and incremented by one for each level.

Interpretation of questionnaire result is linked by scoring value which can take a value between 0 and 100. Lower score, as close as possible to 0, indicates a very good foot heath status and a higher score, close to 100, indicates serious problems of foot health. Subscale calculations for each domain can offer information about the type of foot problems.

In conclusion, ESP questionnaire is an useful instrument in health evaluation of feet. Also, it was designed to be use for evaluation of footwear impact to feet health status. It can be use by specialists in orthopaedics and in footwear design and technology. The main objective is to help to increase the life quality for everyone.

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Scholarly communication paper

DIVERSIFICATION IN THE FOOTWEAR PRODUCTION COMPANY USING CAD / CAM SYSTEMS

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Abstract: *The most important tasks of the footwear companies are to meet the needs of people with quality footwear and items of interest to all ages. Being the first to bring a new style shelves is often the difference between success and failure in business. The paper analyzes the program CES 2000, which expands the possibilities automatic sewing machine CEM 350. With the help of automatic sewing machine CEM 350 was made 10 models of footwear. The case study was conducted within the enterprise shoe „Cristina Mold-Rom Simpex" SA in Chisinau. Conclusions drawn from the survey are: analyzed program does not require sophisticated computers and great effort from the user to himself mode; the implementation of automatic sewing machine in the production process to a considerable increase of labor productivity; sales; new patterns were obtained with a different appearance, improved the appearance of the products and high quality.*

Key words: *Footwear technology, shoes, diversification, CAD/CAM systems.*

INTRODUCTION

The main task is to ensure public light industry with quality manufacturing, production would increase the material and cultural level of people's lives. Relations between domestic operators, depending on their interests, competition is an economic system in which everyone has the freedom to produce and sell what suits the conditions it deems most favorable [5]. Therefore, the company intends to develop is very important to research the characteristics of potential consumers preferred product. Currently, the client is not forced to buy the first product that meets his needs, but can choose between pricing models and brands [3].

1. DIVERSIFICATION IN THE COMPANY OF FOOTWEAR PRODUCTION USING SYSTEMS CAD / CAM

Diversification of production in an enterprise is the result of concentrates several factors [1, 2, 4]: the diversification of raw and auxiliary materials, their production technologies, and technologies for manufacturing of products; existence of competitors; manifestation of the natural desire of every individual to distinguish themselves from others to put their personality through the style.

Diversification techniques involved in producing a number of models in the same families, models which are then subjected to an analysis aimed at defining the best solutions for both the consumer and the manufacturer. Product development through diversification idea starts from the premise that at the design stage of the basic model have been taken into account and respected general criteria: functional, aesthetic, socio-economic and technological.

Diversification can be applied to the entire assembly of the shoe, or only to certain parts of the shoe, resulting in products with a different appearance. In making the shoe upper assembly can adopt models that faces footwear consist of one part or several parts. Detailing faces is considering several objectives, namely:

- the use of natural leather under their physico-mechanical characteristics and demands faced landmarks both in the manufacturing process and in the conduct;
- economic use of natural leather surfaces;
- facilitating the process of forming the space, according to requirements of the technological process;
- creation of possibilities of combining different kinds of materials.

This diversity technique allows to obtain a very large number of types of shoe models costs are kept low due to the fact that the same design. The most common method of diversification is still changing in line and form. In a first phase, form parts is designed in a simple way, to highlight the figure last, so that, in the next phase, the upper assembly to undergo a series of changes by detailing what more pronounced. The process of diversification through restructuring the line parts used in its aspects: right, broken, curved, thin-thick, continuous, interrupted, etc. The models obtained can be classified in the same family, provided that they meet certain conditions:

- use a common structure for the upper assembly materials;
- keeping unchanged the composition and shape of the lower assembly;
- keeping embodiment upper assembly type.

The need for rapid introduction of high quality designs constantly pressuring all companies producing shoes. Be the first to bring a new style shelves is often the difference between success and failure in business. Therefore, the management company ICS "Cristina Mold-Rom Simpex" LLC purchased CES_2000 program and automatic sewing machine CEM 350.

CES_2000 program benefits are [6]:

- the possibility of writing the desired design level step stitch;
- compatible with any version of Windows;
- minimum power consumption;
- comprises a database stitch types, designs, markings.

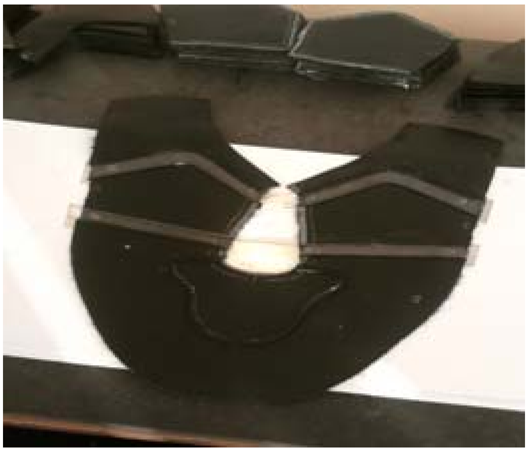
Automatic sewing machine CEM 350 has an area of 500 x 250 mm. Using the machine does not require special training and allows a single operator to 2-3 machines. Sewing operations on this machine consists of phases whose content is determined by the number and order of the calculation technology.

Workflow in the automatic machine CEM 350:

STEP 1 - sticking tape on the bottom of the tablet:

STEP 2 - arrangement of parts as contour cut board:

STEP 3 - preparation of blank sewing:



STEP 4 - sewing blank:

Step 5 - remove the blank from the board, cutting splint and cleaning adhesive.

With automatic machine CEM 350 was made 10 models of shoes (figure 1).

Figure 1. Footwear made by automatic machine CEM 350

Figure 1. Footwear made by automatic machine CEM 350 *(Continuation).*

2. CONCLUSIONS

Analyzing the possibilities offered by the CES_2000 work, we find that it is a system that does not require sophisticated computers and great effort from the user to work very way.
When implementing automatic sewing machine CEM 350 in production was noticed a considerable increase in labor productivity and sales analyzed enterprise; new patterns were obtained with a different appearance, has improved external appearance and high quality of these products.

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ASPECTS REGARDING THE FLAP BAG DEVELOPMENT

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Abstract: *Leather goods are products for which at least 80% of the surface area of the main body is leather (excluding internal dividers, pockets, pen holders etc.). The aim of a leather goods manufacturer is to use leather as economically as possible in order to avoid producing material wastes. The raw material wasted at pattern cutting influences significantly the consumption norm- the quantity of leather necessary for manufacturing a product- as small pieces of material cannot be usually used afterwards.*
The paper illustrates aspects concerning the development of a leather flap bag with a view to the specific consumption of material. The methodology implies developing the anterior and lateral parts of a flap bag model, six model types being obtained and then analysed. The results present interest as an input for future research on the economical usage of raw materials in the development of new leather goods products.

Keywords: *leather, handbag, development, nesting factor, specific consumption*

1. INTRODUCTION

The majority of patterns used in leather goods manufacturing are of irregular shape except in few cases. The pattern making of a bag starts with cutting the patterns from a hide, patterns being packed as tight as possible because any small gaps between two patterns are not usable. The gaps resulting from the spaces between and around the placed patterns are wasted materials. The nesting problems generally refer to placing a number of patterns within the bounds of the material, the most popular shape for nesting being the rectangle.

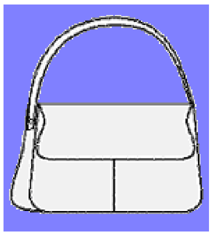
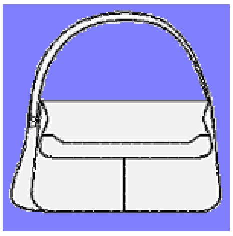
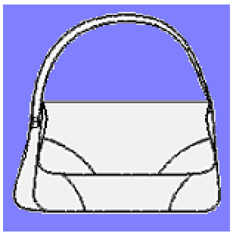
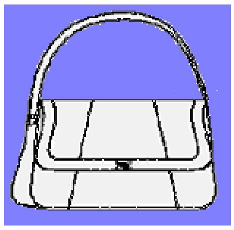
The product development is an important part of the design process meant for bringing a new product to market. Techniques for product development follow up obtaining a sufficient number of models in the same category, with a view to obtain models for both the consumer and the manufacturer. A series of criteria are used in leather goods development such as: combination of materials, changing the pattern's shape, ornamentation, the modality of detailing the master pattern of the exterior patterns, the manner of manufacturing-assembling and the closing system.

In the case of leather goods, the development process starts from the assumption that the functional, the esthetical, the socio-economic and the technological criteria are taken into consideration in the design phase of the product [2].
The model is defined as a sum of characteristics (such as material, shape and color), manner of assembling the patterns and decorative aspects.
The development of the exterior patterns through detailing the base sketch is highly used in leather goods industry. The paper describes several model types of a bag that are developed through detailing the anterior part and the flap.

2. PRODUCT DEVELOPMENT

In this paper we will use the term "master model" to refer to a bag that includes the following patterns: anterior part (1 item), posterior pattern (1 item), base+ lateral parts (1 item), shoulder strap (2 items) and piping (2 items).
In order to achieve results for this study there have been developed six model types, table 1. The new models vary as for the number of patterns; starting from the master pattern, the anterior and the lateral parts are developed. All these model types maintain the rectangular base and the two trapezoidal lateral parts; the width at the superior profile is smaller than the base width.

Table 1 The model types developed from the base mode

Nr.crt.	Number of patterns	The model types	Nr.crt.	Number of patterns	The model types
1.	ns=8 anterior side-1 posterior side-1 base + lateral side -1 flap-1 shoulder strap -2 piping-2	 The master model	2.	ns =9 anterior side -2 posterior side-1 lateral sides+ base-1 flap-1 piping-2 shoulder strap -2	 Model1
3.	ns = 11 anterior side-2 posterior side-1 lateral sides+ base-1 flap-3 piping-2 shoulder strap -2	 Model 2	4	ns = 11 anterior side -1 posterior side -1 lateral sides + base -1 flap -4 piping-2 shoulder strap -2	 Model 3
5.	ns = 13 anterior side -3 posterior side -1 lateral sides + base -1 flap -4 piping-2 shoulder strap -2	 Model 4	6.	ns =15 anterior side-3 posterior side-1 lateral sides+ base-1 flap-6 piping-2 shoulder strap -2	 Model 5

As function of the pattern's shape and area, several nesting problem can be identified:

- placing regular patterns on a regular area,
- placing irregular patterns on a regular area,
- placing regular patterns on an irregular area,
- placing irregular patterns on an irregular area.

For each component of a model type a theoretical nesting in parallelogram is done, figure 1. The most popular shape for nesting is the parallelogram. This type of nesting implies that patterns are placed and can be translated in a row.

After establishing the ways of nesting for each single pattern, the nesting factor is obtained as a proportion between the area of the patterns included in parallelogram and the area of the parallelogram that includes similar patterns. The nesting factor for each pattern is calculated with the next formula:

$$F_a = \frac{n_s \cdot A_r}{A_p} \cdot 100 \text{ , (\%)} \qquad (1)$$

where:
Ar –pattern's surface area, in dm^2;
ns –number of similar patterns included in parallelogram.
The average nesting factor is calculated with the formula:

$$\overline{F_a} = \frac{A_{set}}{A_{paralelogram}} \cdot 100 \text{ , (\%)} \qquad (2)$$

where:
A_{set} – sum of patterns area
$A_{parallelogram}$ –area sum of parallelograms that include the patterns
As the average nesting factor is higher, the normal wastes resulted at the cutting process are smaller.

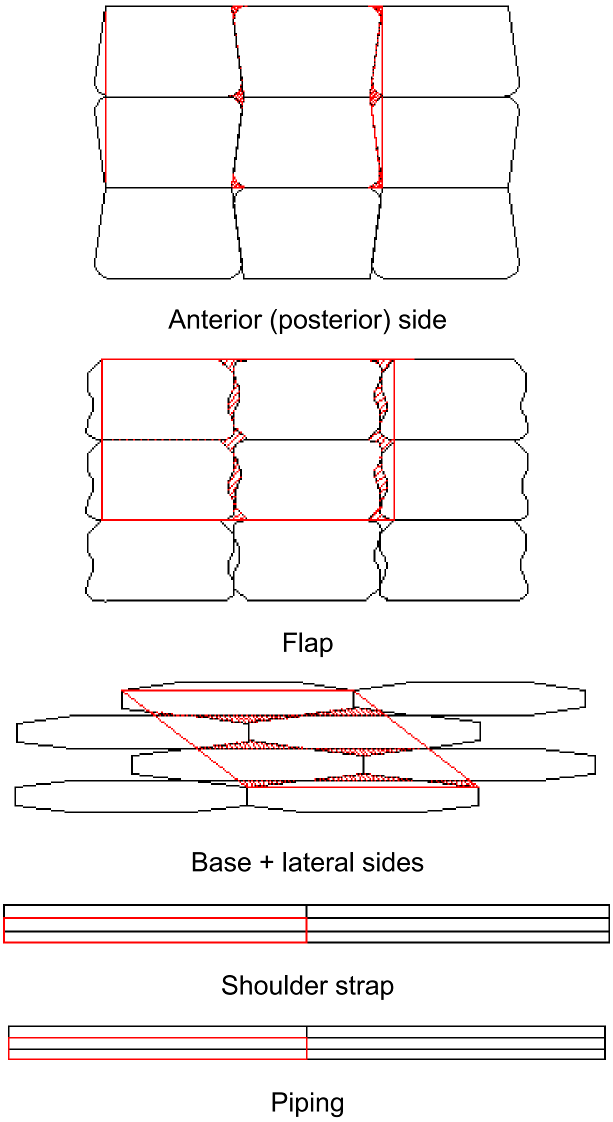


Figure1. Parallelogram nesting of patterns

The nesting factor is calculated for each model type, the number of patterns being comprised between 8 and 15. The values of the average nesting factor vary between 95.06% and 96.44%, table 2. There can be noticed that the best placing of patterns is obtained for the master model; from the developed model types, patterns are best disposed for type 1; this may be due to the patterns shape.

Table 2 The average nesting factor

Model	**n_S**	**A_{set}, (dm^2)**	**$A_{parallelogram}$, (dm^2)**	**$\overline{F_A}$, (%)**
M_b	8	29.449	30.537	96.44
M_1	9	29.578	30.872	95.81
M_2	11	29.749	31.294	95.06
M_3	11	29.582	31.112	95.08
M_4	13	30.505	31.898	95.63
M_5	15	30.679	32.195	95.29

Placing only one type of pattern helps to calculate the raw material requirements more accurately and as well it serves to generate fewer nesting errors.

The placement of patterns on the raw material has to be done easily in order to estimate the optimum nesting before cutting.
The normal wastes mean the amount of the wastes issued from the curved configuration of the similar parts, Dn. In order to calculate the normal wastes the following formula is used:

$$a_{DN} = 100 - \overline{F_A}, \quad (\%) \qquad (3)$$

The term "bridge wastes" (Dp) indicate two close patterns that cannot align tangentially due to the cutting tool; the following relation is used for the calcul:

$$a_{Dp} = \frac{P_S \cdot p}{2 \cdot A_S} \cdot 100, \ (\%) \qquad (4)$$

The term "marginal patterns" is used for the wasted area that is created when aligning patterns of different shapes and sizes.

$$a_{Dm+t} = \frac{a}{\sqrt[4]{f_A}}, \quad (\%) \qquad (5)$$

where:

P_s – set perimeter;
p – width of the between pattern;
a = 39, for flexible leathers;
f_A – area factor as a ratio between the average area of leather surface and the average area of set surface.

A hide of 160 dm^2 has been used for estimating D_n, D_p and D_{m+t} wastes, values are mentioned in table 3.

Table 3 Values of D_n, D_p and D_{m+t} wastes

Model	D_n (%)	D_p (%)	D_{m+t} (%)	D_t (%)
M_b	3.56	3.38	15.72	22.66
M_1	4.19	3.42	15.29	22.90
M_2	4.94	3.49	14.79	23.22
M_3	4.92	3.76	14.03	22.71
M_4	4.37	3.77	13.58	21.72
M_5	4.71	4.14	13.13	21.98

In leather goods manufacturing the cutting process implies a special attention as for the economic analysis of the raw materials used; at cutting an important objective is to maximize the utilization of the raw material. The theoretical nesting has been done for a leather of second quality.
The index of utilization at cutting is calculated using the following formula:

$$I_U = 100 - a_{Dt}, (\%) \qquad (6)$$

The consumption norm represents the quantity of raw material necessary for manufacturing a product and it is considered an important aspect showing the accurate design of a product. The consumption norm is calculated as the ratio between the set area and the leather utilization index, with the next formula:

$$N_C = \frac{A_s}{I_U} \cdot 100, \ (dm^2/pair) \qquad (7)$$

where:

A_s – set area (the area of the patterns from a bag), dm^2;
I_U – material's index of utilization, %.

According to Table 4, the results show that, for the model types analyzed, the consumption norm indexes vary between 76.78% and 78.28%. When developing the anterior part and the flap the consumption norm increases with 1.24dm^2.in comparison to the master model.

Table 4 The utilization index

Model	A_s (dm^2)	D_t (%)	I_U (%)	N_c (dm^2/pair)	Model	A_s (dm^2)	D_t (%)	I_U (%)	N_c (dm^2/pair)
M_b	29.449	22.66	77.34	38.08	**M_3**	29.582	22.71	77.29	38.27
M_1	29.578	22.90	77.10	38.36	**M_4**	30.505	21.72	78.28	38.97
M_2	29.749	23.22	76.78	38.75	**M_5**	30.679	21.98	78.02	39.32

3. RESULTS AND DISCUSSIONS

When placing irregular patterns on a regular area at most two types of patterns are used for the same material.
The master pattern has the biggest value of the nesting factor. As for the model types, they present proximate values of the nesting factor, figure 2.
The variation of the total wastes (%) is illustrated as the sum of D_n, Dp and D $_{m+t}$ wastes. The highest value corresponds to D_{m+t}, figure 3.

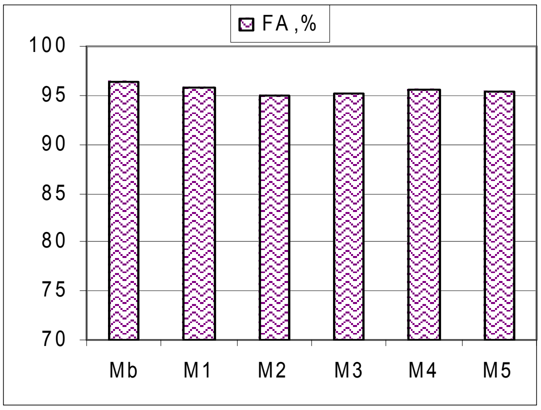


Figure 2 Variation of the nesting factor

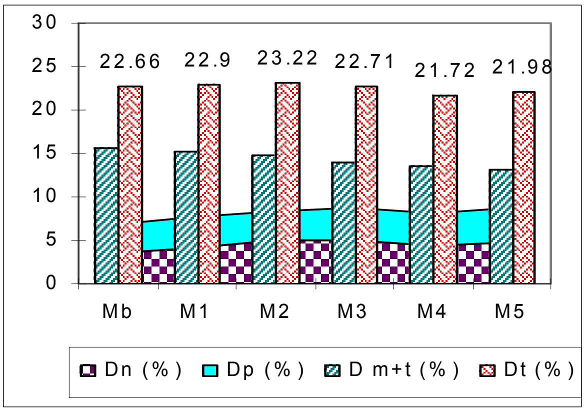


Figure 3 Variation of wastes, as function of the model type

Once the number of patterns increases, the value of D $_{m+t}$ wastes decreases.
The M2 model type, including 11 patterns shows the highest value of D_n wastes 4.94%.

The variation of the consumption norm is analyzed in comparison to the total technological wastes, figure 4.

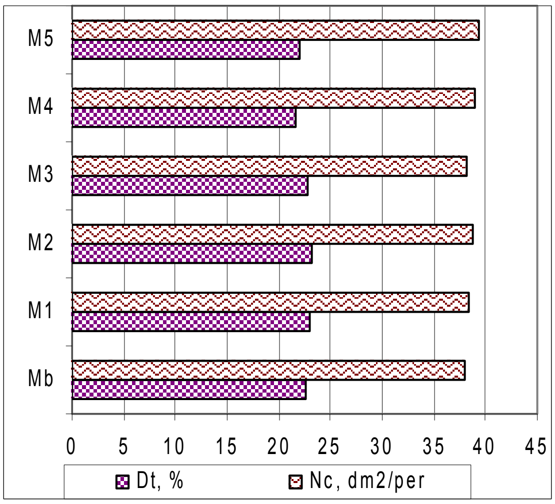


Figure 4 Variation of the theoretical consumption norm

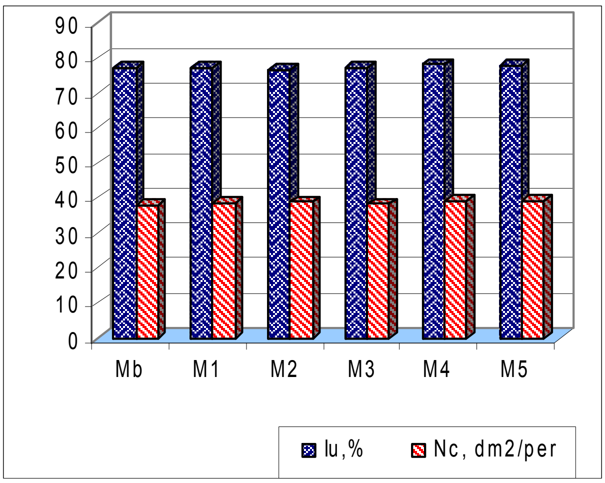


Figure 5 Variation of the index of utilization

The variation of the index of utilization, figure 5, indicates the highest value for M4 model type (78.28%). The model types obtained from the master pattern have proximate values of the index of utilization and of the consumption norm.

4. CONCLUSIONS

The aim of the present study was to determine the influence of pattern shape and configuration on the consumption norm. Product development has been done starting from a base model, a flap bag; developing the anterior and lateral patterns of the base model, six model types have been obtained and analyzed.
Leather goods development regards firstly obtaining optimal patterns as for the esthetical (aspect, shape) and functional (dimensions) requirements. The material used for manufacturing a leather good can be reduced in correlation to product development and the increase of the technical level of production.
The percentage of each type of waste is useful in leather goods manufacturing for minimizing the wasted materials. The development of models types with a high nesting factor allows a significant decrease of the normal wastes. It is recommended the use of those hides with a bigger surface, a combined interlock of small patterns for the leather goods.
The presented data are of interest as input for future research on the economical usage of raw materials at developing new leather goods products.
The analysis of the model types has led to highlighting the influence of the number of patterns on the size of wastes and respectively on the index of utilization at the cutting process.

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Section 11: Ecology in Textiles and Leather Processing

STUDY OF MICROWAVE INFLUENCE ON THE HYDROLYSIS YIELD OF HUMAN HAIR AND WOOL WASTE KERATINS

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Abstract: *The paper presents the influence that the presence of microwaves during alkaline hydrolysis of keratin from wool and human hair waste has on the reaction efficiency and on the products resulting from this process. It was studied the influence of different treatment mixtures on the process of hydrolysis and determined the keratin hydrolysis yield and the structural modifications induced by the microwave field by FTIR analysis performed. Microwaves enhance hydrolysis processes concurrent with the significant reduction of reaction time, facilitating fragmentation of the disulfide bridges due to the thermal effect and the inter- and intramolecular stirring induced by microwave from inside to outside of keratin structure. The obtained results show the possibilities of superior revaluation of human hair and wool waste with the aid of green chemistry.*

Keywords: *human hair wastes, wool wastes, green hydrolysis, microwave.*

1. INTRODUCTION

Recently, there has been an increasing demand for novel biocompatible materials with various properties and much attention is focused on protein materials [1]. One group of promising candidates is the wool and hair keratin materials, which have the biodegradability and biocompatibility to support cell growth [2]. Therefore, from an economic and environmental point of view, it is worthwhile developing a process to use and reuse these resources.

Keratin, which is the major component of hair, wool, feathers, nails and horns, is abundantly present in wastes from the textile industry, barberries and hair salons (keratin waste from hair salons is estimated at being approximately 300,000 tons per year worldwide), stock-farming and butchery, and it has been estimated that about 5 million tons per year is produced worldwide. In recent years, research on the reusing of such a large amount of renewable biomass has widely increased: keratin has been dissolved to produce films, porous membranes, powders or gels or hydrolyzed to find applications in the cosmetic and detergency industry and to produce foaming agents for fire extinguishers [3].

Keratin is extremely difficult to extract, because it is a hardly soluble high-molecular substance having a natural crosslinking structure. Keratins have been extracted by cleavage of the disulphide cystine bonds via reduction or oxidation treatments and regenerated into various forms for biotechnological application, such as films [4], orthopedic materials [5], hydrogels [6], fibres [7], sponges [8], alone or blended with other natural or synthetic polymers [9]. The hydrolysis of wool keratin to oligopeptides or amino-acids was also proposed as an alternative route to provide building blocks for the synthesis of novel polymers. Keratin hydrolysates can be used as a food supplement for animals, carrier for active compounds or fertilizer in agriculture [10,11]. In industry extracted keratin can be utilized as filler in plastics, as sorbent, for preparation biodegradable sheets or as a biodegradation agent [12–14].

Hydrolysis can be carried out in different process conditions, with different chemical agents. The traditional degradation is usually achieved by thermal hydrolysis in dilute acid or base, or by enzymatic hydrolysis. The decomposition products are almost entirely α-amino acids. Boiling in alkali media represents a common way to carry out a strong hydrolysis of keratin by cleavage of peptide bonds, primary amide bonds and cystine disulfide bonds.

Keratin can be extracted by cleavage of the cystine disulfide bonds with reducing agents, such as thiols, to form cysteine, or by sulfitolysis with sodium sulfite to form cysteine and cysteine-S sulfonate or using oxidizing agents, such as peracetic acid, to form sulfonic acid [15]. However, the reductive or oxidative agents used for S-S cleavage, namely sulfites, thiols or peroxides, are harmful, often toxic and difficult to handle. Besides, the treatments result in severe degradation of the protein structure of keratin with reduction of the molecular weight and loss of mechanical properties. More recently, green hydrolysis processes, such as treatments with superheated water and by steam explosion, have been proposed with the aim of avoiding the use of harmful, often toxic, agents. Wool fibres were submitted to green hydrolysis with superheated water in a microwave reactor, in view of potential valorisation of keratin-based wastes [16-20].

The microwave region of the electromagnetic spectrum is classified as that between 0.3 and 300 gigahertz (GHz). Household microwave ovens and scientific microwave apparatus typically operate at 2.45 GHz, with few exceptions. As a result, microwave irradiation does not break chemical bonds; it simply makes molecules rotate. Microwaves, like all electromagnetic radiation, comprise oscillating electric and magnetic fields. Microwave heating is based upon the ability of a particular substance to absorb microwave energy and convert the electromagnetic energy to heat (kinetic energy). Similarly, molecules with a dipole moment attempt to align themselves with the oscillating electric field of the microwave irradiation, leading to rotation. One water molecule excited rotationally by incident irradiation can strike a second molecule of water, converting rotational energy into translational energy. Under microwave irradiation, a large number of molecules are being rotationally excited and, as they strike other molecules, rotational energy is converted into translational energy (i.e., kinetic energy) and as a consequence heating is observed. Using microwave heating, reactions can often be performed in a matter of minutes. This is not because of anything special about microwave heating as compared to conventional heating but just that with a scientific microwave unit it is possible to access high temperatures in sealed vessels easily, quickly, and safely. Thus, a reaction that may take many hours to reach completion when performed at reflux using a hotplate or a steam, oil, or sand bath may be performed in five or ten minutes when heated in a sealed tube to a higher temperature using a microwave. An extension of this is application in the field of proteomics (the study of proteins and in particular their structure and function). Large complex proteins can be broken into smaller parts by using microwave heating. By knowing the constitution of these smaller parts, it is possible to piece together the sequence of the original protein [21].

In this paper it was aimed to perform alkaline hydrolysis of wool and hair waste (previously cleaned and degreased) in a microwave oven, in order to study the efficiency of the thermal treatment induced by this field on the reaction products, subsequently analyzed by specific methods. Thus by infrared spectral analysis were highlighted the main structural changes induced by the microwave field on keratin hydrolysates, compared with hydrolysates obtained under normal conditions, as well as some changes in the major reaction parameters (reaction time and yield).

2. EXPERIMENTAL

In order to conduct the laboratory experiments, the following substances have been used: HCl conc. (Merck), NaOH (grains), CH_3COOH, Na_2CO_3, NH_4OH, trichloroethylene, nonionic surfactant, isopropyl alcohol, ethyl alcohol, acetone, distilled water, pH indicator paper, coarse wool waste and human hair waste from barber shops.

The apparatus used consisted of: thermostatic controlled stove, 750 W microwave oven, reaction vessels, centrifuge, IR-ATR spectroscopy using a DIGILAB–SCIMITAR Series FTS 2000 spectrometer with ZnSe crystal, 750÷4000 cm^{-1} range, 4 cm^{-1} resolution. For wool and hair degreasing a classic Soxhlet installation was used.

In the first stage, wool and hair wastes were subjected to dirt cleaning, then the fibers were cleaned and degreased in a solution of 3% Na_2CO_3 followed by an additional treatment with 0.1% nonionic surfactant solution. Then, the material thus treated was subjected to a final scouring in a Soxhlet apparatus for 8 hours; the resulting fibers were dried in a thermostatic controlled stove at 30ºC, then washed with a mixture of water:ethanol (1:1, v/v) and dried again at 25ºC for 24 hours.

Subsequently, wool and hair fibers were cut to 1÷2 mm in length in order to subject them to alkaline hydrolysis in mixtures of hydroxide and isopropyl alcohol solutions. Then there were weighed 5 g of each fiber which have been held for 2 hours for prior swelling in 200 ml of the mixture for treatment. In these experiments two hydrolysis solutions were used: a) 0.5N NaOH:isopropyl alcohol (3:1, v/v); b) 0.5N NH_4OH: isopropyl alcohol (3:1, v/v). The use of isopropyl alcohol is meant to facilitate a more rapid swelling of the protein matrix of wool and hair.

In a first experimental variant, alkaline hydrolysis was performed with the two solutions at 50ºC for 16 hours; in the second, alkaline hydrolysis was conducted in a microwave oven (figure 1). Thus, a glass bowl with 5 g of sample in the treatment mixture was put in a crystallizer with 300 ml of distilled water, in order to maintain the work temperature at the prescribed value of 50ºC.

Figure 1. Reaction wessel inside of the microwave oven

The samples was treated under the following conditions: working cycles of 2 min with 1 min break, total time 60 min, power 750 Watts, frequency 2,45 GHz, temperature 50ºC. After 60 min treatment the contents of the flask became a yellowish molten solution that showed the hair and wool has been completely hydrolyzed.

After the completion of the alkali hydrolysis, the samples were allowed to cool to 25ºC; hydrolysates were then treated with a solution of HCl:distilled water (1:1, v/v) in order to precipitate the protein mixture, finding a wool pH_{iz} = 5, and a hair pH_{iz} = 5.5. After the separation of the precipitates by centrifuging for 20 minutes with a rotational speed of 8000 rpm, the resulting supernatants were washed three times with a mixture of acetone:ethanol (1:1, v/v) each of these followed by drying in a stove at 25ºC for 24 hours.
Each of the mentioned experiments was conducted on three parallel samples.

3. RESULTS AND DISCUSSIONS

The extraction yield was determined by the following equation:

$$Y = \frac{W_h}{W_i} 100$$

Where: *Y* is the extraction yield (%), W_h is the weight (mg) of the dried hydrolysated powder and W_i is the weight (mg) of the initial sample in the dry state. The results obtained for the extraction yield (average of three determinations) are shown in Table 1.

Table 1. Yield hydrolysis of sheep wool and hair waste normally heated and by microwaves at 50ºC.

Analysis	0,5N NaOH:isopropyl alcohol				0,5N NH_4OH:isopropyl alcohol			
	Wool sample		Hair sample		Wool sample		Hair sample	
	normal	MW	normal	MW	normal	MW	normal	MW
Sample used (g)	5	5	5	5	5	5	5	5
Solubilised matter (g)	4	4,8	4,3	4,9	3,2	3,8	3,8	4,1
Yield (%)	80	96	86	98	64	76	76	82
pH after hydrolysis	12,5	12,5	12,5	12,5	10	10	10	10

From Table 1 it can be seen that the best values in terms of hydrolysis efficiency were obtained for the samples treated with the mixture of NaOH:isopropyl alcohol, both for the normal hydrolysis treatment and for the hydrolysis carried out by means of microwaves, comparing to the samples hydrolysed in the same conditions but in alkaline medium using NH_4OH. This is due to increased swelling capacity of this mixture and also to pronounced disulfide bridges breaking in NaOH medium. NH_4OH has weaker basicity and lower swelling capacity and therefore lower access to the two areas (inner and outer) of the keratin matrix, but even in these conditions the yields obtained are satisfactory. Microwaves enhance hydrolysis processes concurrent with the significant reduction of reaction time regardless of the alkali agent in mixtures.

The results for structural characterization by Fourier transform infrared spectroscopy are shown in figures 2 and 3.

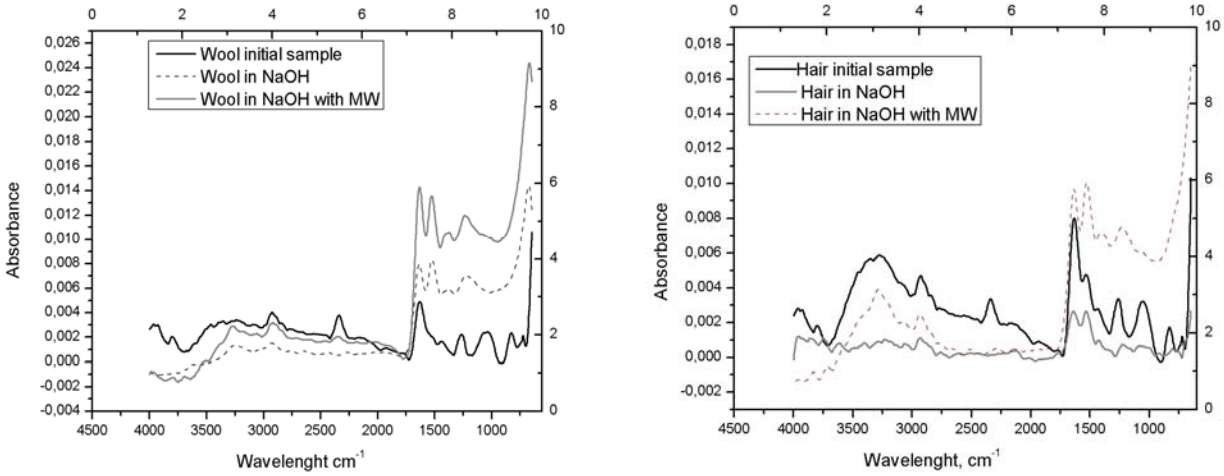

Figure 2. IR spectral analysis of wool and human hair treated in NaOH and in NaOH with microwave

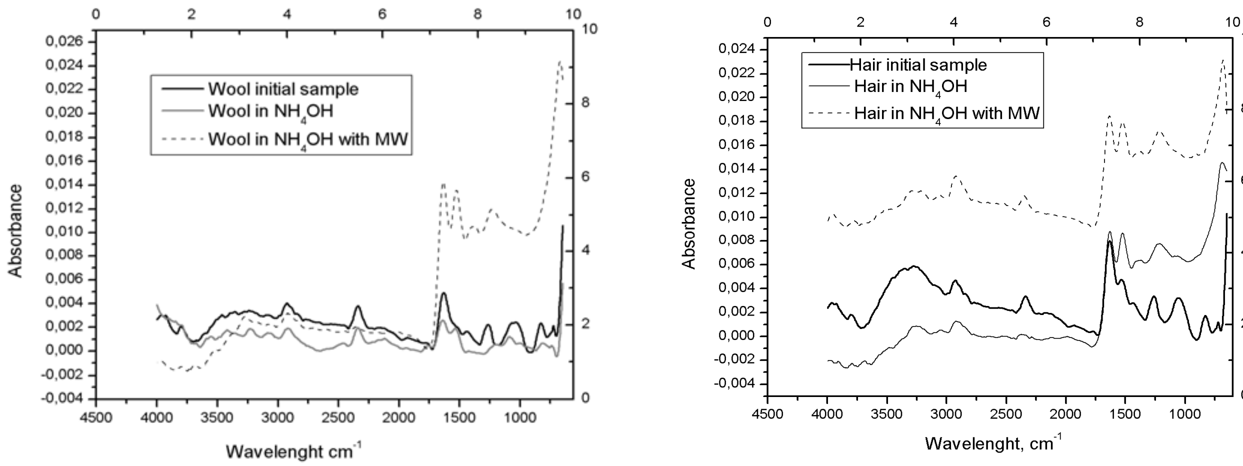

Figure 3. IR spectral analysis of wool and human hair treated in NH_4OH and in NH_4OH with microwave

All spectra were baseline corrected, smoothed with a sixteen points Savitsky–Golay function. Data for the characteristic peaks were processed using Origin Pro 8 software.

In the figures 2 and 3 the spectra of both initial samples of wool and hair respectively, show characteristic adsorption bands due mainly to the peptide bonds (-CO-NH-). Amide A and B are found at 3250–3300 cm^{-1}, connected with the N-H stretching vibrations and at ~ 2900 cm^{-1}, respectively, related to stretching modes of the C-H alkyl chains. The region between 1700-1500 cm^{-1} contains the most intense features in the IR spectrum, arising from the amide groups, predominantly from protein structures such as amide I band at ~1650 cm^{-1}, mainly due to the C=0 stretching vibration coupled to the in-plane bending of the N-H and stretching of C-N bonds; amide II band much weaker at ~ 1540 cm^{-1}, due to the coupled N-H in-plane bending and C-N stretching vibrations; and amide III which appears as a weak band at 1240-1260 cm^{-1} resulting from an in-phase combination of C-N stretching and N-H in-plane bending, with some contribution of C-C stretching and C=O bending vibrations.

In the spectra of all keratins extracted by hydrolysis, the signal strength in these areas decreases as well as its response surface, and both wool and hair treated normally in alkaline mixture shows the most attenuated signal, which is due to the strong degradation of hydrolyzed keratin; the hydrolysis carried out by means of microwaves leads to a lower degradation.

The amide I, II and III are the most sensitive probes for the conformational changes in the protein. The literature [22] suggests that every chemical interference within a keratin fibre leads to a decrease in the share of a-helix as compared with a raw, untreated sample. The amide I adsorption which is known to be sensitive to the secondary structure of polypeptides shows a lower signal intensity for all treated samples, much more attenuated for the normal treated samples; this could be atributted to conformational changes in secondary structure, with a decrease in the α-helix structure, possible accompanied by an increase in the random-coil structure. What is interesting to note is that unlike this attenuation of the vibration of amide I, the signal in the spectral region of the amide II reveals no decrease in hydrolysates samples, which could be determined by a reforming of the α-helix of the amide II after treatment. Amide III remains relatively stable during microwaves hydrolysis.
The intense peaks at ~ 1200 cm^{-1}, observed in the infrared spectrum of all keratin treated samples, are related, respectively, to the asymmetric and symmetric S-O stretching vibrations of the cysteine-S-sulfonate residues (bunte salts), formed through the reaction of cystine with sulfites during the hydrolysis of protein from wool. It can also be noted changes in the intensity of the characteristic peaks and of the surfaces in the area of the respective peaks at the wavelength 650 cm^{-1} which is characteristic for C–S bonds. Thus, it can clearly be seen the presence of this peak at all the control samples, both for wool and human hair. The alkali:alcohol mixtures treatment strongly affects the disulfide bridges, contributing to their partial dissolution or complete break during the treatment, highlighted on graphic by strong decrease of the peak intensity or even by its disappearance.

4. CONCLUSIONS

1. Hydrolysis yield of wool and hair samples shows that the best results are obtained for the samples hydrolysed in NaOH, both for the classic hydrolysis treatment and for the alkaline hydrolysis carried out by means of microwaves, comparing to the samples hydrolysed in the same conditions but in alkaline medium using NH_4OH.
2. Microwaves enhance hydrolysis yield concurrent with the significant reduction of reaction time regardless of the alkali agent in mixtures, as a result of disulfide bridges breaking due to the presence of alkaline environment combined with the effect of the microwave field, as it is obvious from the comparison of IR spectral analysis.
3. FTIR analysis performed highlight the structural modifications induced by hydrolysis conditions, the process carried out by means of microwaves leading to a lower degradation of hydrolysis products.
4. The use of NH_4OH for the microwave treatment of keratins lead to lower reaction yields yet satisfying, but on the other hand prevents contamination of resulting protein hydrolysates, thus eliminating additional purification steps used in the case of hydrolysates obtained by NaOH:alcoholic hydrolysis, aspect which is the subject of further experiments.

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STUDY ON THE INFLUENCE OF ELECTROLYSIS CONDITIONS ON THE HYDROLYSIS OF COLLAGEN FROM SHEEPSKIN WASTES

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Abstract: *This paper presents the research carried out in order to adapt the electrolytic deposition process of the protein components from the waste resulted from the polishing process of Chamois leather, to an electrolytic hydrolysis on an installation specially created for this experiment. At the same time, there was analysed the influence of the electrolysis conditions of upon certain possible structural changes caused by the new conditions of the electrolytic hydrolysis (highlighted through IR analysis), and also determined the efficiency of the extraction of the protein components from the waste powder. Morphological appearance of the protein compound surface was revealed by optical microscopy. The new method to getting collagen hydrolyzed from this waste by electrolysis (green hydrolysis) uses milder work conditions and smaller quantities of reactants comparable to conventional methods of hydrolysis.*

Keywords*: sheepskin wastes, green hydrolysis, electrolysis, electrolytic hydrolysis.*

1. INTRODUCTION

Leather industry provides a large amount of solid wastes as non tanned collagenous and tanned collagenous. In 2004, there were produced 1.601204 tons of sheepskin, of which, after processing, 60% represented the quantity of waste containing fat and proteins [1-3].

In this category, are included the wastes produced during the process of polishing Chamois leather which is used in the auto industry, and the wastes resulted in the leather goods industry, where 8-10 million leather pieces are processed every year [4]. Generically the hides and skins waste material consists mainly of proteins and lipids. The most important is the collagen component which is a fibrous protein that is found abundantly in all animals and is the main leather making protein. The molecule is characterized by a triple helical structure formed by three polypeptide chains. At least seven polypeptide chains have been identified, which mathematically enables the formation of hundreds of possible collagen molecules. So approximately twelve types have been identified.

Finding different methods to recover and use the waste represents a challenge for the researchers in this field. Significant research work has been carried out in development of newer methods of recovery and utilization of wastes. Nowadays, there are available different methods of recovery and usage of collagen both from skin, bones and from waste. The best known are those using enzyme processes, alkaline [5] or acid [6] treatments, resulting in different hydrolysed protein components.

In the case of enzymatic processes the methods that were developed have shown that the untanned leather waste can be successfully processed to the powder like leather flour, gelatin products and enzymically hydrolyzed protein powder products. The method that was developed has shown that leather waste can be subjected to moderate pretreatment temperatures and that the enzyme can be added at these temperatures, thus eliminating the need to cool reaction mixture, which is in the case of thermal treatment, a waste of energy [7]. The extraction of collagen from raw sheepskin trimmings was studied in a two step process. In the first step trypsin was used to perform an enzyme digestion. The temperature, pH and enzyme concentration were varied in the enzyme digestion step and their influence on this step's extract was examined [8]. Also a procedure for the extraction of protein from skin, bone and cartilage wastes by phosphoric acid hydrolysis was developed and analysed [4,9].

Various types industrial animal wastes convertible into a low cost high value biodegradable end product based on alkaline hydrolysis has been developed for use as a broad care soil conditioner [10].

Waste leather hydrolysates prove to be a valuable protein resource possible to be converted to added value commercial products as soil fertilizers, biodegradable polymers and additives for cosmetic industry, building materials etc. [11,12]. Also, collagen-based biomaterials have been used in a variety of clinical applications such as tissue adhesive, vascular grafts, aortic heart valves, drug delivery matrices, wound dressing, and tissue engineering scaffold [13].

Nevertheless, there are some disadvantages to the methods of obtaining acid or alkaline hydrolysates such as: protein distortion by exposure to acid or alkaline pH, high amount of ashed and the altered solubility of the protein components as a result of their rehydration. The enzyme method is limitted to protein components soluble to a neutral pH, also requiring special work conditions [14].

The use of electrodialysis using bipolar membranes represents an ecologic, environment-friendly alternative with a broad practicability potential. The protein recovery process reduces both the costs due to the use of chemicals necessary for the stages of neutralization and also the amount of residual waste related to the hydrolysis processes mentione earlier [14]. Another way to obtain protein components out of different wastes, including those with a collagen content, is the electrodeposition method, by electrophoresis on the surface of ion-shifting membranes [15], where the 2 electrodes, the anode and the cathode, are separated by 2 ion-shifting membranes. The positively charged protein components deposit on the cathode side, and the negatively charged protein components deposit on the anode side.

The phenomenon of the electrodeposition of the protein components on the surface of the electrodes depends on: the nature of the electrodes, their geometry, the distance between them, the applied voltage, the intensity of the current. The work voltage ranges between 16 - 35 V, the intensity of the current is of 0.5 – 0.9 A. The concentration of the protein mixture ranges between 16 – 30 % and the work temperature is of 20 - 60º C [16, 17].

Starting from the facts mentioned above, the experiments performed in this study aimed at adapting the electrolytic deposition process of the protein components from the waste resulted from the process of polishing Chamois leather, to an electrolytic hydrolysis on an installation specially created for this experiment. We used a stabilized source of direct current (DC) powered to 6 – 12 V, an intensity of 4,5 A, and a tank with stainless-steel electrodes, with a flat surface, covered with a semi-permeable mebrane, fluoropolymer-based.

At the same time, there was analysed the influence of some process parameters upon certain possible structural changes caused by the new conditions of the electrolytic hydrolysis (highlighted through IR analysis), and also determined the efficiency of the extraction of the protein components from the waste powder.

2. EXPERIMENTAL

2.1. Apparatus and materials

In order to conduct laboratory experiments, the following substances have been used: HCl conc. (Merck), CH_3COOH, NH_4OH, trichlorethylene, ethyl acohol, acetone, distilled water, pH indicator paper, Chamois powder waste. The necessary equipment was: a thermoregulated oven, an installation for the electrolytic hydrolysis specially created for this experiment (Figure 1), a centrifuge, IR-ATR spectroscopy using a DIGILAB – SCIMITAR Series FTS 2000 spectrometer with ZnSe crystal, 750 - 4000 cm^{-1} range, 4 cm^{-1} resolution, and optical microscopy using an Optical Microscope EUROMEX ME 2665 (Holland) with video digital camera. For Chamois powder waste degreasing a classic Soxhlet installation were used.

2.2. Working method

The first step was to degrease the Chamois powder waste on a Soxhlet installation, for 8h, the material being then dried in the thermoregulated oven at 30ºC, for 24h. The resulting samples were subjected to alkaline hydrolysis using a 1N NH_4OH solution, at a temperature of 50ºC, for 16h. Subsequently, the obtained hydrolysates were cooled to 25ºC, and then treated with a solution of HCl:distilled water (1:1, v/v), in order to precipitate the protein mixture. For the hydrolysed product it was found that pH_{iz}=4,8. The precipitates were centrifuged at a speed of 8000 rpm, for 20 min, the resulting supernatants being first washed with a mixture of acetone:etyl alcohol (1:1, v/v) and dried in the oven at 25ºC, for 24h. They were

then washed again 2 more times with acetone at 25ºC, for 24h. The solid phase was dried in a stove until a constant weight.
Another sample was prepared for electrolytic hydrolysis consisting in a paste with a concentration of 10% powder waste in 1N NH_4OH. This paste was allowed to expand at room temperature, for 24h and then, the mixture was introduced in the tank of the electrolytic hydrolysis installation, presented in figure 1. The working parameters were: time – 2h, voltage – 6V and 12 V respectively, intensity – 4,5 A, the distance between the electrodes – 2 cm, the nature of the electrodes – stainless steel. The anode area was separated from the cathode area by some semi-permeable fluoropolymer-based membranes which covered the 2 electrodes, in order to avoid gases from being released in the mixture and in order to direct the protein components through electrodeposition.

After the electrochemical process was finished, the resulting mixture was introduced in a glass column and washed with distilled water and then it was allowed to decant in order to separate the components. The liquid was collected and the remaining solid waste was removed. The liquid was then centrifuged at 8000 rpm for 20 min, the solid fraction being then collected. This component was introduced in a glass, diluted with distilled water and treated with HCl:distilled water (1:1, v/v). The resulting precipitate was resuspended and treated with CH_3COOH 0.1 N and it was brought to a neutral pH and centrifuged at 8000 rpm, for 20 min. The solid component was then mixed with alcohol and dried at 25ºC for 24h and then introduced in a desiccator with $CaCO_3$.

Each experiment was conducted on three parallel samples. The dry powders resulting from experiments were then subjected to microscopic and FTIR analysis in order to detect structural changes induced by the hydrolysis conditions.

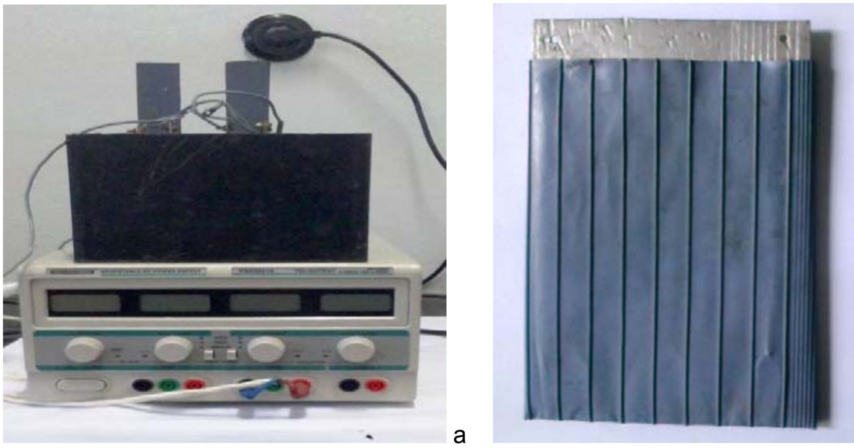
a b

Figure 1. Electrolytic hydrolysis instalation (a); electrode detail

3. RESULTS AND DISCUSSIONS

The extraction yield of dried powder was determined by the following equation:

$$Y = \frac{W_h}{W_i} 100$$

where *Y* is the extraction yield (%), W_h is the weight (mg) of the dried powder and W_i is the weight (mg) of the initial sample in the dry state. The results for the samples of the protein hydrolysates obtained through the experimental versions are presented in table 1 (average of three determinations):

Table 1. Characteristics of Chamois powder waste in 1N NH_4OH

Analysis	Sample Normal hydrolysis	Electrolytic powder hydrolysis at 6V, 4,5 A	Electrolytic powder hydrolysis at 12V, 4,5 A
Sample used (g)	5	35	35
Solubilised matter (g)	1	8	9,2
Yield (%)	20	22,85	26,28
Insoluble residue (g)	4	27	25,8
pH after hydrolysis	10	12	12
Time (h)	16	2	2

The analysis of the results presented in table 1 shows that the electrolytic hydrolysis treatment with stainless-steel, flat electrodes, covered with semi-permeable membranes, amplify the efficiency of the process, producing also an increase of the voltage applied between the anode and the cathode.

At the same time one can observe a significant reduction of the time required to obtain hydrolysis reaction product from 16 hours (during the hydrolysis performed with 1N NH4OH at 50ºC) to 2h for electrolytic hydrolysis. The highest yield was obtained when using a voltage of 12 V.

Depending on the construction and nature of a particular electrode, the protein charged, and the surface of the electrode may get tangled together during formation of an electro-deposited layer of the substance, or the layer may retain gases generated electrolytically. As a result, this not only reduces the amount of protein recovered but also makes the removal of the protein mixture from the electrode difficult and noticeably reduces the quality of the deposited material.

An important feature of this present work is that semi-permeable membranes are positioned on each electrodes to which the protein is attracted and the liquid containing the protein. In this study case where two membranes are used, the waste paste containing the protein is placed between these two membranes. However, OH^- ions in the aqueous alkaline solution in the common anode-cathode chamber can pass relatively easily through the semi-permeable membrane to neutralize the positively charged protein in the surface of the membrane. Consequently, it becomes possible to adjust the optimum conditions of operation relatively easily by controlling, for example, the concentration of the charged protein, pH of the aqueous dispersion of the charged protein and of the aqueous alkaline solution, the current intensity, planar electrode surface and distance between electrodes.

The morphological appearance of the protein hydrolysates revealed by optical microscopy is presented in Figure 2. The images in Figure 2 show a powdery aspect of hydrolysates obtained after precipitates drying, a greater tendency to agglomerate of hydrolysate obtained by normal hydrolysis and a slight tendency to cluster of hydrolysates obtained electrolytically.

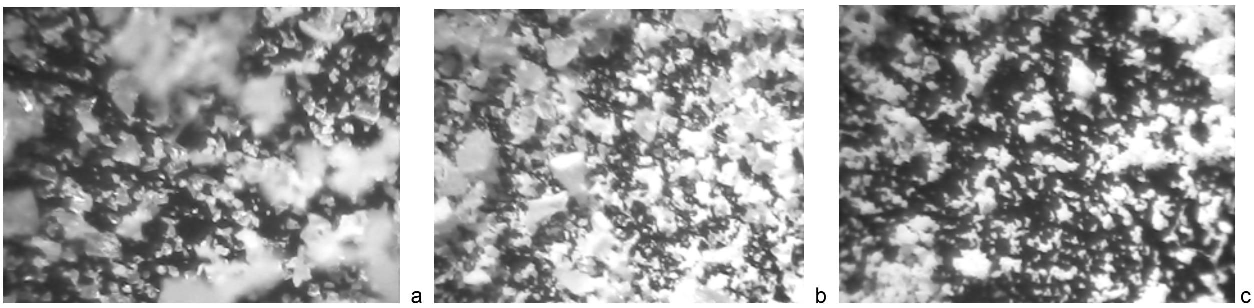

Figure 2. Microscopic images of dry hydrolysates: a) normal hydrolysis; b) electrolytic hydrolysis at 6 V; c) electrolytic hydrolysis at 6 V.

The spectral IR analysis, represented in figures 3, 4 also offers information regarding the structural changes produced by the experimental conditions used.

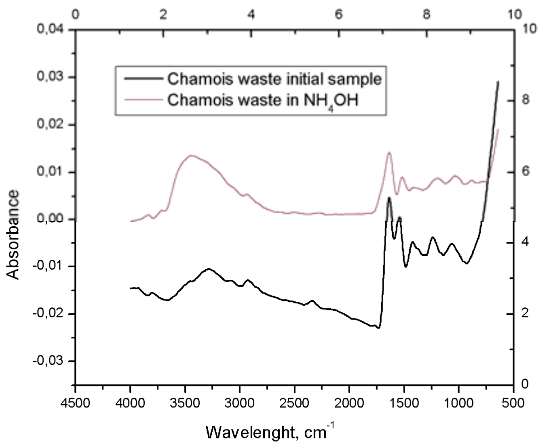

Figure 3. IR spectra of Chamois powder and his hydrolysate in NH_4OH

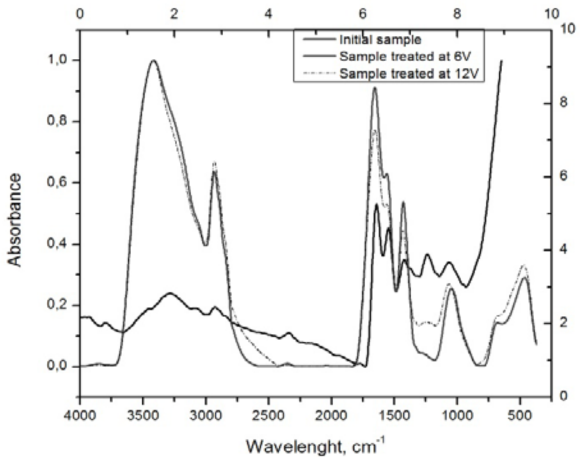

Figure 4. IR spectra of Chamois powder and his electrolytic hydrolysate in NH_4OH

From figures 3 and 4 we can observe the typical bands of collagen such as: the amide A band associated with the free N-H stretching vibration, in the range of 3400 to 3440 cm^{-1}, amide B related to the stretch of CH_2, was found at ~ 2900 cm^{-1}, amide I band with its characteristic frequencies 1600-1700 cm^{-1}, mainly associated with the stretching vibrations of the C=O group along the polypeptide backbone, amide II at 1500–1550 cm^{-1} corresponding to N-H bending vibrations, and amide III at 1200–1300 cm^{-1} related to C-H stretching. Normally, the amide I band is strong, the amide II band is weak and the amide III band is moderate.

The spectrum of initial sample shows a shift to lower frequencies of amide A band (at ~ 3300 cm^{-1}), suggesting that more NH groups were involved in the hydrogen bonding, in contrast to the hydrolysed samples where this band occurs at ~ 3400 cm^{-1}. This increase of intermolecular interactions is associated with broadening of the amide A band.

In the spectra of electrolytic hydrolysates (figure 4) the bands corresponding to amide A, amide B, amide I and III are very intensive, compared with the same bands of normal hydrolysed sample spectrum (figure 3). This can be attributed to a more pronounced denaturation of the sample obtained in normal conditions of hydrolysis.

4. CONCLUSIONS

1. Using the electrolytic hydrolysis method with a stabilized source of direct current and stainless-steel, flat electrodes, covered with semi-permeable membranes, allows both the reduction of the hydrolysis time and also leads to obtaining higher reaction efficiency than in the case of the hydrolysis conducted only in the presence of an ammonium hydroxide solution.
2. Increasing the voltage applied between the 2 electrodes leads to higher quantities of protein hydrolysates. We need to further expand the experiments in order to analyze the influence of the distance between the electrodes, the size of their surface, as well as their nature upon the efficiency of the electrolytic hydrolysis.
3. The new process of electrolytic hydrolysis applied to alkaline solutions of powder waste from Chamois leather contributes to obtain protein hydrolysates modified from those obtained by alkaline hydrolysis in normal conditions as evidenced by the structural changes revealed by infrared analysis performed.
4. NH_4OH used as a medium for the hydrolysis is preferably compared with strong basic medium, in order to avoid contamination of the hydrolysates as well as additional subsequent purification steps. Thus subsequent experiments aim at increasing efficiency of the extraction by optimizing the parameters of the recipe and technology.

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ECO-FRIENDLY DYEING PROCESS FOR DENIM FABRICS

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Abstract: *The desire to colour textiles is as old as spinning and weaving. Natural dyes were the first used [1]. The invention of synthetic dyes has limited the application of natural dyes, but the effluents generated by this processing heavy pollute the environment as 10 – 15 % of the dye is lost in the effluents [2]. The majority of the dyes used in the textile industry are resistant to biodegradation, photodegradation and even oxidising agents [3].*
Natural dyes still represent an essential part of the world ecological heritage to create permanent colours [4]. Application of natural dyes on cotton fibre involves the use of chemicals known as mordants to create affinity between the fibre and the dye molecule. The heavy metals detached from these traditional mordants, however, will contaminate the water and the environment, thereby jeopardising the original intention [5].
The work presents contributions in order to develop environmental sustainable dyeing techniques for cotton denim fabrics, without the use of mordant.

Keywords: *natural dyeing, denim, colour fastness, environmental friendly*

INTRODUCTION

People never stopped adding colour to their life, starting from the clothes they wear, the cosmetics they apply on their face and the way they dye their hair. Colour is a reflection of our mood, feelings and personality. Today, dyeing is a complex, specialized science. Nearly all dyestuffs are now produced from synthetic compounds. This means that costs have been greatly reduced and certain application and wear characteristics have been greatly enhanced. Synthetic dyes are being used in all commercial applications. Large amounts of water are used to flush conventional synthetic dyes from garments and then this waste water must be treated to remove the heavy metals and other toxic chemicals before they can be returned to water systems. [1]

European regulations are more stringent in terms of dye environmental impacts. Many countries are rich in natural and renewable resources and they often have expertise on how to produce and process these resources in a sustainable way. The economy should have only to realize that abundant dye sources are just around us and finding another valuable use for these plants coupled with appropriate technology can encourage more people to conserve these resources. Although the Earth possesses large plant resources, only little has been exploited so far. More detailed studies and scientific investigations are needed to assess the real potential and availability of natural dye-yielding resources. Almost all parts of the plants produce dyes. It is interesting to note that over 2000 molecules used for dyeing are synthesized by various parts of plants, of which only about 150 have been commercially exploited [2].

In developing countries with a textile tradition, natural dyeing is still practiced, but only as a handcraft. Recently, a number of commercial dyers have started looking at the possibilities to overcome environmental pollution caused by the synthetic dyes, by replacing them with natural dyes. Natural dyes produce soft shades as compared to synthetic dyes. In spite of the better performance at multiple washing, recently the potential use of natural dyes on textile materials has been attracting more and more scientist to study the natural alternative for dyeing due to the following reasons:

1. wide spread of natural dyes sources and huge potential
2. available experimental evidence for allergic and toxic effects of synthetic dyes
3. available information on different natural colorants, including methods for their extraction and purification.

For successful commercial use of natural dyes, appropriate scientific techniques need to be established by scientific studies on dyeing methods, dyeing kinetics and compatibility of selective natural dyes, in order to obtain shades with acceptable colour fastness behavior and reproducible colour yield [3].

In the last few decades, denim garments has gained popularity unimaginable for those who initially wore it for protection, rather than for fashion. Denim has become a wardrobe staple. Fit, comfort and price are the most important factors affecting the purchase of denim jeans. Due to longer life span of jeans, the denim industry continues to hold an advantageous position over other types of apparel [4]. In 2010, Greenpeace published a report denouncing the pollution caused by the denim industry [5]. Apart from conventional cotton production, which can be one of the most water-consuming industries, the report was also critical of jeans laundry, printing and dyeing processes, which involve high water usage and heavy toxic metals such as cadmium, lead, copper and mercury. A renewed international interest has arisen in natural dyes due to increased awareness of the environmental and health hazards associated with the synthesis, processing and use of synthetic dyes [6]. Most of the natural dyes have no substantivity for the fiber and are required to be used in conjunction with mordants. A mordant, usually a metallic salt, is regarded as a chemical, which will be fixed on the fiber and which will attach the dyestuff. A link is formed in this way between the fiber and the dye [7]. In general, textile fibres can allow the adherence of the dyes in their structures as a result of van der Waals forces, hydrogen bonds and hydrophobic interactions (physical adsorption). The uptake of the dye into the fibres depends on the nature of the dye and its chemical constituents [8].

The heavy metals detached from the traditional mordants, however, may contaminate the water and the environment, thereby jeopardising the original intention of using environmentally friendly dye for better protection of the environment [9].

Coloring components are derived from roots, barks, leaves, fruits and flowers of plant. All plants show a certain reaction to the increasing of toxic elements concentration in soil, depending upon their sensitivity and exposure intensity. Some species of plants disappear, while others are stimulated by these elements. On lands containing metals – some plant species have developed tolerance towards metals, and others are characterized by the capacity to accumulate metals in their tissues. Different plant parts contain different heavy metals quantities, the highest ones being contained in roots and leaves, and the smallest in flower buds and fruit [10].

EXPERIMENTAL

In recent years there has been a revival of the use of dyes and color of natural origin for coloring food, pharmaceutical, cosmetic and textile products. Colours obtained with vegetable dyes are warm and have particular nuances. Nevertheless they have two problems that are the same of the industry: color fastness and reproducibility. Colour fastness means the resistance of the colour when exposed to different procedures textiles may suffer during manufacture and use.

Considering the latest trends, MODAZEN Company started to gain interest on using natural dyes within their industrial denim garment production. For this reason MODAZEN INC initiated VEGDENIM project, financed through ERANET CROSSTEXNET Programme.

Vegetable materials of indigo (Indigofera tinctoria leaves powder), Punica granatum (pomegranate bark powder) and walnut shells (Juglans Species) were used to dye denim fabrics at optimized dyeing conditions and the resulted colour fastness of the dyed samples was evaluated through the following tests:

- color fastness to washing, according to SR EN ISO 105 C06: 2010
- color fastness to acid perspiration, according to SR EN ISO 105 E04: 2013
- color fastness to alkaline perspiration, according to SR EN ISO 105 E04: 2013
- color fastness to water, according to SR EN ISO 105 E01: 2013
- color fastness to artificial light, according to SR EN ISO 105 B02: 2003

Materials used:

- Denim naturally dyed samples, dyed with extracts of pomegranate, madder, walnut shells and indigo – supplied by MODAZEN INC (dyeing process is protected by a patent owned by the project coordinator)
- Adjacent multi-fiber, purchased from James Heal, England
- ECE Detergent with phosphate, without optical brighteners, purchased from James Heal, England

Testing equipments used during evaluation:

- Scourotester – for washing fastness
- Memmert oven – for water and perspiration fastness
- Hunterlab – used for measuring color change

RESULTS

A number of 9 denim samples dyed with vegetable natural dyes prepared by MODAZEN INC. were tested by INCDTP in order to evaluate their colour fastness properties. Preliminary chemical and physical–mechanical tests were performed in order to characterize the denim garments.

The change in color has been made by visual assessment, using the 9 grades grey scale from James Heal, and confirmed by instrumental analysis performed by using Hunterlab equipment. Grades according to ISO 105 A02 have been atributed to each tested sample. An interpretation of the attributed grades:
1 = Poor durability of the colour
2 = Moderate durability of the colour
3 = Good durability of the colour
4 = Very good durability of the colour
5 = Excellent durability of the colour
Intermediate grades were also attributed.

Determination of colour fastness properties

Table 1: Colour fastness test results

No. crt.	Color fastness test	**Walnut shells**			**Natural Indigo**			**Punica granatum**		
		B1	B2	B8	B5	B6	B7	B3	B4	B9
-	Washing	1-2	1-2	1-2	2	3-4	3	1-2	1	1
-	Acid perspiration	4-5	4	4-5	3	4-5	4-5	3	2-3	3
-	Alkaline perspiration	4-5	4	4-5	2-3	4-5	4-5	4	4	4
-	Water	4-5	4	5	2-3	4-5	4-5	3-4	4-5	4-5
-	Light	1	1	1	1	1	1	1	1	1

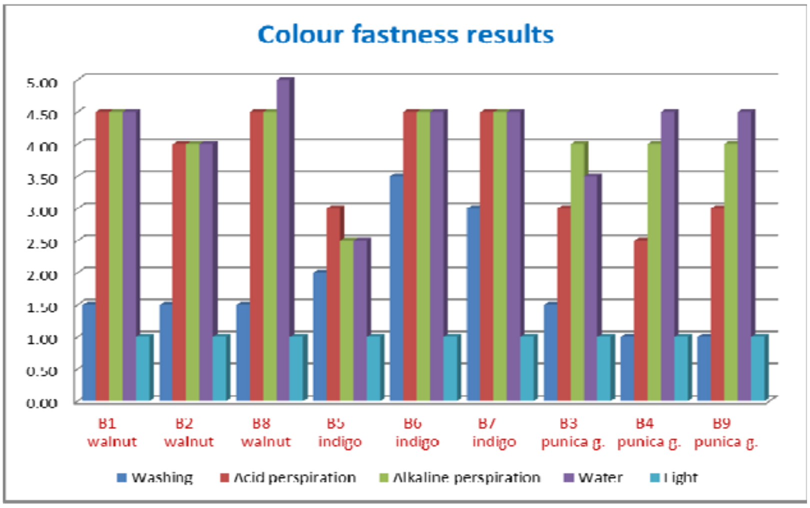

Figure 1: Graphic representation of colour fastness results

As it can be seen, the greatest modification of the colour has occured in the case of the following tests: colour fastness to light and colour fastness to washing. Acceptable results have been obtained for color fastness to water and perspiration in the case of using walnut shells and indigo dye.

Table 2: L*a*b* values obtained for naturally dyed denim samples

Sample:	**B1 - Walnut shells**			**B5 - Natural Indigo**			**B3 - Punica granatum**		
Parameter:	L*	a*	b*	L*	a*	b*	L*	a*	b*
Reference value:	55.07	1.11	7.34	69.99	-2.96	-11.16	65.34	17.98	4.35
Washing	62.90	-0.77	3.31	76.94	-2.46	-7.02	74.55	13.15	2.62
Acid perspiration	56.38	0.80	7.55	74.25	-2.84	-8.44	68.30	16.72	7.70
Alkaline perspiration	56.27	0.90	7.04	74.62	-2.60	-8.12	66.64	17.37	5.07
Water	55.52	0.94	6.58	75.02	-2.85	-7.12	67.18	17.10	4.25
Light	78.34	-0.43	4.57	88.71	-2.11	7.19	85.05	5.77	5.96

Sample:	**B2 - Walnut shells**			**B6 - Natural Indigo**			**B4 - Punica granatum**		
Parameter:	L*	a*	b*	L*	a*	b*	L*	a*	b*
Reference value:	54.84	0.87	6.89	70.00	-3.02	-11.38	64.19	18.48	4.96
Washing	63.63	-0.61	3.66	72.67	-2.56	-11.39	75.25	10.64	7.22
Acid perspiration	56.83	1.19	8.07	70.88	-2.70	-11.64	68.88	16.74	8.22
Alkaline perspiration	56.14	0.99	7.11	71.14	-2.72	-11.51	65.81	17.75	5.85
Water	55.98	1.00	6.68	69.56	-2.82	-11.95	64.24	18.03	5.32
Light	78.55	-0.32	4.54	88.12	-2.21	6.07	82.14	6.12	6.43

Sample:	**B8 - Walnut shells**			**B7 - Natural Indigo**			**B9 - Punica granatum**		
Parameter:	L*	a*	b*	L*	a*	b*	L*	a*	b*
Reference value:	58.52	3.22	17.29	71.38	-3.13	-11.04	55.09	21.84	8.89
Washing	65.18	2.22	16.74	73.59	-2.33	-11.03	66.10	19.37	8.59
Acid perspiration	59.15	3.66	17.88	71.03	-2.58	-11.44	58.55	19.37	8.59
Alkaline perspiration	58.08	3.87	18.58	71.01	-2.68	-11.67	57.80	20.14	6.98
Water	58.70	3.49	17.16	71.47	-2.56	-11.10	56.24	20.36	6.77
Light	70.52	1.03	13.64	88.22	-2.09	6.55	80.45	7.79	8.33

Analysing the data obtained it can be seen that all the samples have been losing saturation, samples luminosity has increased and the shade was altered. The data obtained through visual assessment was confirmed: the most significant fading was observed in the case of samples submitted to washing and to artificial light for denim garments dyed with natural indigo, followed by pomegranate. The best results obtained were noticed in the case of using walnut shells.
The colour degradation has reached the lower limit (grade 1) according to the 9 grade scale after 5 consecutive washings for the denim samples dyed with extracts of walnut shells and pomegranate and after 7 consecutive washings for the denim samples dyed with natural indigo.

Determination of the content of heavy metals in final products of naturally dyed denim fabrics

Sample	Zn conc. (mg/kg)	Cu conc. (mg/kg)	Cr conc. (mg/kg)	Ni conc. (mg/kg)	Pb conc. (mg/kg)	Co conc. (mg/kg)
B 1	6.57	2.53	2.69	3.01	7.38	4.62
B 2	7.64	2.44	2.54	2.94	7.40	5.02
B 3	9.74	2.64	0.40	1.82	7.50	2.36
B 4	8.95	2.60	3.08	3.16	7.40	4.80
B 5	9.03	2.43	2.78	3.21	7.28	2.53
B 6	8.68	2.74	2.43	3.30	7.32	2.44
B 7	7.72	2.52	3.16	3.28	7.60	2.66
B 8	5.34	2.98	2.92	3.20	7.80	4.74
B 9	10.06	2.66	3.28	3.30	7.80	5.10
Limits according to OEKOTEX 100	No limits established	50 mg/kg	2 mg/kg	4 mg/kg	1 mg/kg	4 mg/kg

The results have showed that Chrome, Lead and Cobalt were present on the final denim dyed samples. Having in mind that the method used by Modazen Inc. is not implying the use of mordants, therefore it can not be explained the presence of the heavy metals other than being brought in the process either from the water used to prepare the extract and the finishing treatments, or by the plants used to obtain the dyeing bath.
The exact source could not be attributed due to the lack of samples of water and plant extract. Further investigation will be continued.

CONCLUSION

Over the past few years natural textiles have been developed out of a growing awareness of the environmental, health-related and social problems caused by the conventional production of textiles. Meanwhile there are clothes, which are advertised using terms like 'natural', 'eco' or 'bio', but the labelling refers to rather different quality standards. Products may be labelled as 'sustainable' on condition that the raw materials come from organic farming and that manufacturing processes up to the finished garment comply with ecologically acceptable production methods.
From the sustainability point of view it is desirable to use natural dyes to a greater extent. An intensified use of renewable raw materials represents a substantial contribution to sustainable development, the environmental impact is reduced throughout the whole life cycle and agricultural land is preserved.
Presently cultivation of dye plants is mainly restricted to botanical gardens and museums for experiments and demonstration.There is clear evidence that opportunities exist for optimizing the use of natural resources, while simultaneously creating opportunities for cost savings and increased competitiveness.
As a conclusion generated from the information gathered so far: colour fastnesses of denim naturally dyed samples are generally moderate. Optimization of the dyeing procedure is necessary.

Acknowledgment: All the results presented here are part of the research performed so far within the project with the acronym VEGDENIM financed by ERANET CROSSTEXNET Programme.

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Project presentation

SUSTAINABLE ENERGY SAVING FOR THE EUROPEAN CLOTHING INDUSTRY

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Abstract: *Efficiency and competitiveness in textile and clothing manufacturing sector must take into account the current and future energy challenges.*
Energy efficiency is a subject of critical importance for the Textile & Clothing industry, for other sectors and for the society in general.
*EURATEX initiates **Energy Made-to-Measure,** an information campaign running until 2016 that will pursue Energy Efficiency in the T&C industry by promoting: synergies between European projects and organizations, the use of analytical tools, best practices, quality information delivered to managers, training of companies' staff.*
*Also, SESEC helps companies to understand their energy consumption and allows them to compare the sector benchmarks in different production processes. SESEC has developed the ESS, **Energy Saving Scheme,** a free of charge tool customized for clothing manufacturers. Designed specifically for small and medium enterprises (SMEs), the ESS enables the evaluation of energy consumption and recommends measures to reduce the consumption.*

Keywords: *Energy efficiency, clothing sector*

INTRODUCTION

Efficiency and competitiveness in textile and clothing manufacturing sector must take into account the current and future energy challenges.
SESEC (Sustainable Energy Saving for the European Clothing Industry) is a project co-funded within the European Programme Intelligent Energy Europe by EASME. The consortium, co-ordinated by EURATEX, includes CITEVE (Portugal), Gherzi (Germany), ENEA (Italy), INCDTP (Romania), DITF (Germany), BMS (Belgium), PIRIN-TEX (Bulgaria), BAATPE (Bulgaria) [1].
The goal of the SESEC project is to improve the Energy Efficiency in the clothing industry, with a special attention to small and medium enterprises, by developing specific tools and apply them throughout the European area.
INCDTP collaborates as partner in 2 projects co-financed by the European Programme Intelligent Energy Europe, the SESEC and the SET project.
The objective of INCDTP in these activities is to be the interface between the Romanian textile and clothing companies and the European partners in order to identify and apply viable solutions to reduce energy consumption in Romanian companies.
Energy efficiency is a subject of critical importance for the Textile & Clothing industry, for other sectors and for the society in general.
EURATEX initiates Energy Made-to-Measure, an information campaign running until 2016 that will pursue Energy Efficiency in the T&C industry by promoting: synergies between European projects and organizations, the use of analytical tools, best practices and quality information delivered to managers, training of companies' staff.
Also, SESEC helps companies to understand their energy consumption and allows them to compare the sector benchmarks in different production processes.

SESEC'S ENERGY SAVING SCHEME (ESS)

SESEC has developed the ESS, Energy Saving Scheme, a free of charge tool customized for clothing manufacturers. Designed specifically for small and medium enterprises (SMEs), the ESS enables the evaluation of energy consumption and recommends measures to reduce the consumption.
SESEC draws up energy efficiency benchmarks based on the analysis of the production patterns and of companies' data in 5 different EU countries and companies' data. This enables companies to assess the internal consumption and to compare it with the best performing values (benchmarks).
By introducing their relevant data into the ESS applications, developed under SESEC, companies can identify their consumption patterns and work autonomously on a set of proposed energy efficiency best practices.
The SESEC's support is complemented by 14 training modules on how to introduce energy efficiency measures in the company, considering the cost/benefit ratio.
SESEC promotes the use of best practices for the whole sector through project partners located in 5 European countries and through the members of EURATEX (the European Apparel and Textile Confederation). The project plans to involve over 150 companies in testing and using the ESS to improve their energy efficiency [1].
SESEC's Energy Saving Scheme (ESS) self-assessment tool implements a methodology that can be relatively easily applied by the internal work force within the clothing industry. The addressed clothing industry segments include [2,3]:

- T-shirts and related - knitted;
- Shirts and blouses - woven;
- Trousers and skirts (casual and denim) - woven;
- Suits & overall jackets - coats;
- Pullovers flat knitted;
- Underwear and bras; and
- Technical products.

Figure 1: The work approach of the SESEC's ESS

For each of these segments, the tool allows an analysis by process. The processes are:

- Weaving;
- Knitting;
- Spreading & Cutting;
- Embroidery;
- Printing;
- Sewing; and

Finishing.

The tool is result oriented, simple to understand and based on the intrinsic technical and production knowledge of the company's work force. The methodology requires commitment to energy management by top management and an "energy team", which is composed by employees that embody the plant knowledge on production flows and the technical and operational data for production machines and its auxiliaries.

The ESS is a support scheme made up of three applications with original algorithms; it includes benchmarks and guidelines to facilitate the uptake of energy efficiency measures. The applications are:

- EDST (Energy Distribution Support Tool) can be used where energy audit data is not available, the tool estimates energy distribution throughout the various processes and auxiliaries. It also allows constant monitoring of consumption.
- EMBT (Energy Management and Benchmark Tool) compares the energy consumption data with the production data. It generates energy efficiency indices and it reports on the dynamics of consumption [5].
- SAT (Self-Assessment Tool) is an instrument for self-evaluation which allows companies to identify the most promising Best Practices for energy saving in the company [6].

EDST it is possible to collect and calculate consumption data the machines in the company by production phase.

Process			Equipment/Machine	Quantity (un)	Tension (V)	Current (A)	Power (kW)	Cos ϕ	Apparent Power (kVA)
N°'	Designation	Observations							
1	Weaving		A	3					5
1	Weaving		B	3					5
2	Knitting		A	3					5
2	Knitting		B	3					5
[illegible]	[illegible]		[illegible]	[illegible]					[illegible]
3	Spreading & Cutting		B	3					5
4	Sewing		A	3					5
4	Sewing		B	3					5
5	Embroidery		A	3					5
6	Printing		A	3					5
7	Finishing		A	3					5
7	Finishing		B	3					5
8	Auxiliaries		Humidification	1					4
8	Auxiliaries		HVAC	1					8
8	Auxiliaries		Ventilation	1					5
9	Others		office	1					3

Figure 2: EDST sheet

The EMBT allows companies to compare on monthly basis the production with the energy consumption (in kWh and toe), green house gas emission and the energy cost (in €). It is also possible to analyze the dynamics of energy consumption on varying of production and to represent it through a regression line.

Some of the best practices proposed by the tools can deliver tangible results in short time:

- Heat recovery from fumes of steam and hot water thermal generators
- Heat recovery from dyeing and scouring water.

Both of these Best Practices allow companies to achieve savings from 5% up to 30% of thermal energy consumptions, with a payback time of two years.

After implementation, SESEC's ESS tools will provide the following outputs:

- List of energy saving measures with qualitative cost & payback data and implementation priority;
- Energy distribution by segment, both thermal and electrical;
- Energy distribution throughout the various production processes depending on segment, both thermal and electrical;
- Energy bookkeeping which collects and documents all energy relevant data systematically;
- Company's global and/or segment energy indicators on a monthly and annual basis. Indicators include the Specific Energy Consumption (SEC), the Specific Cost (SC) and the Carbon intensity (CI) where:
  - SEC = Energy / Production;

  - SC = Energy Cost / Production; and
  - CI = Greenhouse Gases (CO2) / Energy
- Company's global and/or segment graphical analysis of "Energy vs. Production" on a monthly and annual basis;
- Company's global and/or segment graphical analysis of "Energy Cost vs. Production" on a monthly and annual basis;
- Company's global and/or segment analytical calculation of energy consumption when production is 0, the calculation of energy required to produce one additional unit and calculation of the energy proportion that doesn't contribute to production;
- Benchmark position based on calculated indicators globally and by process in each segment.

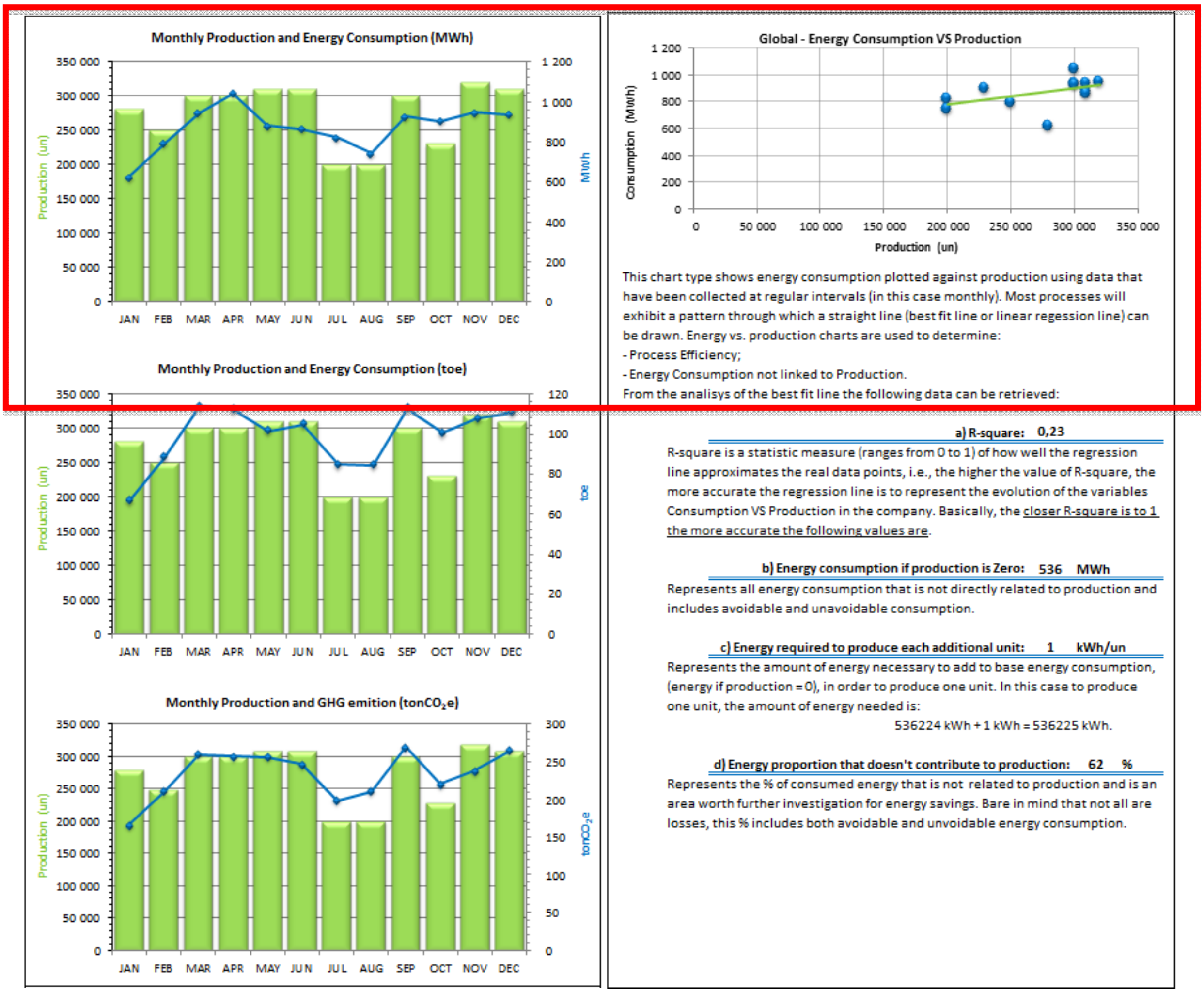

Figure 3: EMBT sheet

BEST EXEMPLES

Based on the results of 28 energy audits, performed on-site at the companies' premises, the SESEC teams analysed the structure of energy consumption and identified the best practices for investments on energy savings. This helped several companies across Europe to optimise their consumption, for instance:
Thanks to the SESEC approach, the Italian company CANALI spa has been able to identify opportunities to optimize its thermal and electric consumption to be addressed with innovative methods to gain significant energy savings.
In Bulgaria, thanks to SESEC, the producer Kris Fashion has identified a potential saving of 10-15% in its annual energy consumption.
Also the Romanian company SC Datsa Textil SRL has identified a series of actions which have already saved an average of 20% of the electricity costs.

The Portuguese company DAMEL, specialized in sportswear, identified savings in lighting, variable speed in production machine and insulation for up to 5% of their electricity consumption and for up to 3% in the consumption of thermal energy as result from the SESEC intervention.

CONCLUSIONS

SESEC brings to companies the following advances:
• Three ESS tools that can be applied by company staff, namely the Energy Distribution Support Tool, Energy Management and Benchmark Tool and Self Assessment Tool;
• Fourteen Training Modules that support application of best practices;
• Direct support delivered by SESEC teams in some EU countries to understand and operate the tools.
Tools and Training Modules are available free of charge via the SESEC website.
Direct support can be provided in cooperation with national partners (Single Entry Points) listed on the website.

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ADVANCED AND CLEAN TECHNOLOGIES FOR CHROMIUM TANNED LEATHER WASTE RECYCLING AND GREEN ENERGY PRODUCTION

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Abstract: *Chromium tanned leather wastes are difficult to valorise by chemical and biological processes due to the strong bonds established between collagen and chromium. Thus a one-step fast clean pressure-assisted alkaline hydrolysis method has been studied to disrupt recalcitrant bonds. The effects of calcium oxide, temperature, time, liquid to solid ratio and leather scrap size on organic matrix destruction, chromium dissolution and anaerobic biodegradability of hydrolyzates obtained were evaluated. The results show that pressure-assisted hydrolysis with CaO may be a good alternative to reduce leather waste volume, obtain biodegradable solutions with low Cr concentration and final residues usable as a chromium bearing resource. In the optimised conditions, about 50% to 55% of the leather is dissolved. The slurries obtained contain above 90% of the chromium. The hydrolyzates show good anaerobic biodegradability mostly in the range of 50% to 70 %, indicating them as a source of biogas.*

Keywords: *Waste, leather, chromium, alkaline de-chroming, anaerobic biodegradation.*

1. INTRODUCTION

The treatment of chromium-containing leather waste, mainly bovine shavings, by alkaline hydrolysis with calcium salts has been studied to obtain protein hydrolyzates with low chromium content and a chromium rich cake [1–3]. A lab scale study proposing a three-step process to treat pigskin chromium tanned leather waste and separate the protein and chromium fractions has also been reported [4]. Various alkali and enzymatic hydrolysis were compared and calcium oxide alone was found to be more effective for the purposes pursued over magnesium oxide, sodium hydroxide and enzymes plus magnesium oxide [4]. A study on leather wastes hydrolysis with CaO (temperatures ranging from 343 K to 371 K for up to six hours in one or two steps) and other study on alkaline CaO hydrolysis followed by enzymatic hydrolysis (temperatures ranging 310 K to 343 K up to four hours of holding time) have been reported, to obtain an hydrolyzate with average molecular mass below 10 kDa and low chromium content [5]. Some of these processes have been scaled-up [6–11].

Alkaline hydrolysis above atmospheric pressure has also been the object of some studies. Temperatures reported range 373 K to 573 K, pressures are till 15 MPa, and the alkaline agents used include calcium oxide, calcium hydroxide, magnesium oxide, magnesium hydroxide or sodium hydroxide [12–17].
Alkaline hydrolysis plants at industrial scale are in small number, however an excess of hydrolyzate production is reported [18, 19]. Therefore, research on more applications is needed and one is exploring hydrolyzate biodegradability through anaerobic digestion, thus contributing to use its potential for producing biogas.

The biodegradability of tanning chemicals, natural tannin extracts [20–24], fatliquors [25, 26], surfactants [27], tanning agents [28, 29] and finishing resins [27], has been studied. Biomethanization of tannery waste, especially wastewater treatment sludge and wastes from pretanning processes steps has also been the object of several successful reports [30–45]. The biodegradability of chromium tanned leather and vegetable tanned leather under anaerobic conditions has been addressed, too [46, 47]. In the studied conditions, it has been found that vegetable tanned leather leads to more gas production than chromium tanned leather and detanning tends to improve biodegradability of both types of leathers [46]. The study of biopolymers as tanning agents to develop biodegradable leathers is a global trend in leather industries [48–50]. The anaerobic biodegradability of protein hydrolyzates resulting from alkaline enzymatic hydrolysis has also been studied in the following conditions: i) modifying polyvinyl alcohol which had been processed into water-soluble films often employed in agriculture [51, 52]; ii) cross-linked with dialdehydes [53] ; iii) cross-linked with higher-molecular weight diepoxides, which have the potential to be biodegradable films [54]. The effect of anaerobic digestion at 323 K for 15 days on deproteination of chromium sludge resulting from a two-step alkaline enzymatic hydrolysis has also been reported [55]. In many of these works biodegradability reported is based in BOD/COD ratio.

The present work evaluates the application of one short time wet alkaline treatment at relatively mild temperature and pressure to the finished leather scrap from footwear manufacturing; it aims at recovering chromium with maximum organic matrix attack and minimum chromium dissolution, followed by organic biodegradation of the liquid phase obtained. The effect of temperature, time, CaO concentration and leather size on both chromium and organic matter recoveries was studied. Anaerobic biodegradability of the resulting liquid phases was assessed based on established standards and quantification approaches.

2. EXPERIMENTAL

2.1 Materials and reagents

Seven bovine finished chromium-tanned leathers presenting general properties usual in shoe manufacture were collected. Calcium oxide and other reagents used were of adequate analytical grade.

2.2 Sample preparation

For the pressure-assisted hydrolysis tests the leather samples were shredded to ≤ 1 and 2 mm using a Pegasil® – Zipor® mill with rotating knives or cut by hand to 1 cm x 1 cm pieces, thoroughly homogenized and conditioned in standard laboratory atmosphere at 296 K ± 2 K and 50 % ± 5% relative humidity. For chemical characterization the material was shredded to ≤ 4 mm.

2.3 Pressure-assisted alkaline hydrolysis tests

The pressure-assisted hydrolysis tests were done at least in triplicate using a titanium laboratory autoclave model 4842 from Parr® (Moline, Illinois, USA) with a 400 mL reaction vessel and no stirring action. The liquids were immediately characterized or frozen at 253 K ± 2 K and the residues were dried at 373 K ± 2 K and calcinated at 1173 K ± 5 K for characterization. The experimental plan followed is presented in Table 1.

Table 1: Experimental plan

Set series	Test	Tempe-rature, K	Leather size, mm	Liquid to solid ratio, mL:g	Holding time, min.	CaO, g
First	T1.1; T1.2; T1.3	373	≤ 2	6.67	45; 90; 180	0.75
	T1.4; T1.5; T1.6; T1.7			10	15; 45; 90; 180	0.38
Second	T2.1; T2.2; T2.3	403	≤ 2	6.67	45; 90; 180	0.75
	T2.4; T2.5; T2.6; T2.7; T2.7; T2.9				90	0.38; 0.75; 1.13; 1.50; 1.88; 2.26
Third	T3.1; T3.2; T3.3	423	≤ 2	6.67	45; 90; 180	0.75
	T3.4; T3.5; T3.6; T3.7; T3.8; T3.9		≤ 2		90	0.38; 0.75; 1.13; 1.50; 1.88; 2.26
	T3.10; T3.11; T3.12		≤ 1; ≤ 2 10 x 10		90	0.75
Fourth	T4.1; T4.2; T4.3	443	≤ 2	6.67	45; 90; 180	0.75
	T4.4; T4.5; T4.6; T4.7; T4.8; T4.9				90	0.38; 0.75; 1.13; 1.50; 1.88; 2.26

2.4 Anaerobic biodegradation tests of hydrolyzates

Liquid phases from selected leather hydrolysis tests, as well as gelatine and standard cellulose material Avicel® from Fluka® were subjected to anaerobic biodegradation tests using sludge from leather factory "Curtumes Aveneda" anaerobic wastewater treatment plant and following an internal method based in ISO 11734:1995 [56]. Measurement of biogas and calculations were done using the WTW OxiTop® Control measuring system according to Süßmuth et al., 1999 [57].
In this method, the total coefficient of degradation is calculated according to:

$$D_t = [(n_{CO2,g;CH4,g} + n_{CO2,l})/n_{C,theo}] \times 100\% \quad (1)$$

Where: D_t – coefficient of total biological degradation, in percentage; $n_{CO2,g;CH4,g}$ – number of moles of carbon dioxide and methane gases formed; $n_{CO2,l}$ – number of moles of carbon from carbon dioxide formed in the aqueous phase; and $n_{C,theo}$ – theoretical number of moles of carbon in the test solution or material.

2.5 Analytical procedures

The chromium tanned leather sample shredded to ≤ 4 mm, the alkaline hydrolysis liquids obtained and the dried residues were chemically characterized following standards listed in Table 2 [58–66].

Table 2: Chemical methods to characterize leather samples, hydrolysis solutions and residues [58–66]

Parameter	Method
pH	ISO 4045:2008
Volatile matter	ISO 4684:2005
Total ash at 1173 K	-
Total organic carbon	EN 13137:2001
Total Cr	Digestion US EPA 3050B:1996 and Atomic Absorption Spectroscopy
Calcium	Standard Methods for Examination of Waters and Waste-Water 2003
Hexavalent chromium	ISO 17075:2007
Azo colorants	ISO 17234-1:2010
Pentachlorophenol	ISO 17070:2006

3. RESULTS AND DISCUSSION

3.1 Sample chemical characteristics

The leather material used in the hydrolysis tests has pH of 3.5 ± 0.1, (4.0 ± 0.1) % of ash, (53.1 ± 0.5) % of total organic carbon (TOC), 2.0 % of Cr and 0.6 % of Ca. Hexavalent chromium, amines and pentachlorophenol are below threshold value (<3 mg/kg, <30 mg/kg and <5 mg/kg, respectively).

3.2 Alkaline hydrolysis tests results

Fig. 1 summarizes the results obtained in the first set of experiments (T1.1 to T1.7). Leather hydrolysis at 373 K for 15 to 180 minutes with liquid to solid ratio of 6.67 or 10, gave higher TOC recoveries for longer holding times and higher liquid to solid ratio. The hydrolyzates are brown liquids containing 7 g/L to 27 g/L of TOC and 5 mg/L to 20 mg/L of Cr. Approximately 10 % to 20 % of the initial TOC and below 1 % of chromium, respectively, were recovered in that liquid phase.

In these test conditions, resulted residues having 73 % to 93 % of the original leather weight which contain total chromium below 3 %. The ashes obtained after calcination of those residues at 1173 K for 2 hours present chromium expressed as Cr_2O_3 and calcium expressed as CaO in the range of 14 % to 24 % and 24 % to 29 %, respectively.

Globally, this first set of tests indicates poor mass waste reduction under these conditions. Other authors [1-5], as well as tests done in our laboratory, indicated much faster leather destruction using NaOH even though with higher chromium concentration in the solutions and more difficulties to filtrate them [67].

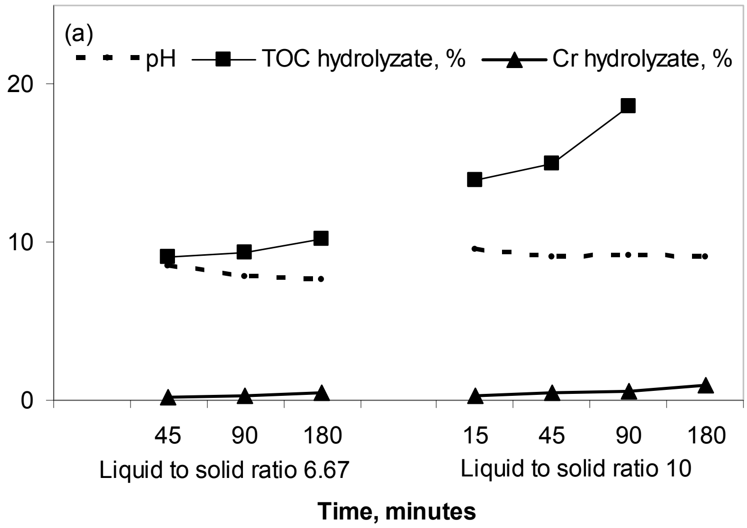

Figure 1: Results obtained in the first experimental tests T1.1 to T1.7

Fig. 2 shows the effects of temperature and holding time (T2.1 to T2.3, T3.1 to T3.3 and T4.1 to T4.3 tests) in the hydrolysis characteristics. Hydrolysis at 403 K promotes chromium dissolution that reaches 1 % to 3 % of the Cr available in the leather sample. TOC recovered reaches 30 % to 43 % of the available TOC, depending on the hydrolysis conditions. At 423 K leather matrix destruction is higher than at 403 K and reaches 50 % of the initial leather mass with only 4 % Cr dissolution. At 443 K, TOC concentration in the hydrolyzate ranges 50 % to 55 % and Cr concentration in it is always above 6 % reaching 11 % for the longer holding time.

In these tests, the mass of the residue obtained is in general 40 % to 60 % of the leather mass treated. The solid residues from most of the tests gave ashes with around 30 % Cr as Cr_2O_3 and 22 % to 25 % of CaO, thus are interesting as a source of Cr for some industrial applications, since they are in the normal range of common chromite concentrates.

The results of all these hydrolysis tests show that hydrolysis solutions final pH may be explained by effective CaO addition (CaO, g) and liquid to solid ratio (L/S, mL:g)) through the equation pH = 3.20 + 0.74 CaO + 0.45 L/S. The quality indicators of this regression are $R^2 = 0.81$, F = 53.19 with $p < 0.00000$, thus indicating that the equation that relates the variables has not only statistical significance but also high physical/experimental significance.

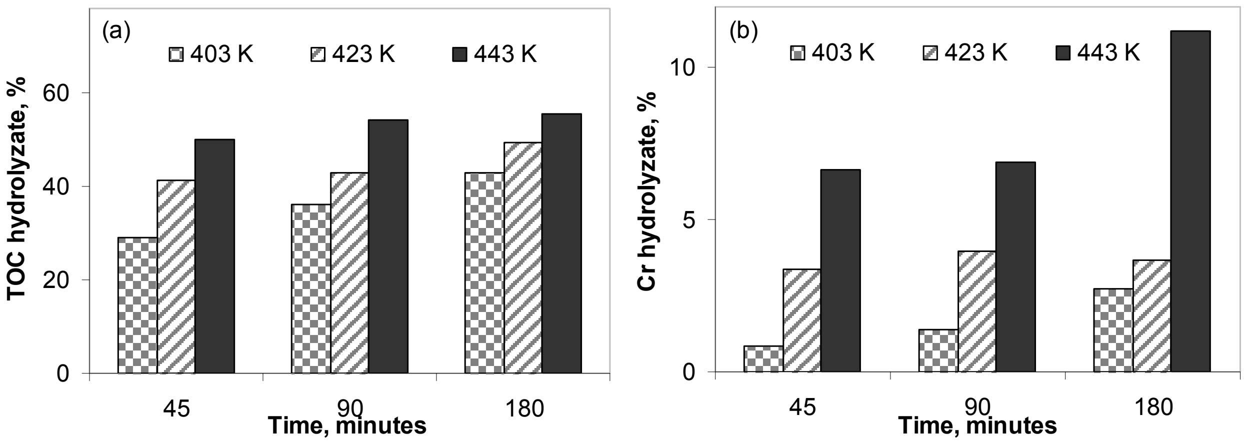

Figure 2: Comparing the effect of temperature and holding time for tests T2.3 to T2.5 at 403 K, T3.1 to T3.3 at 423 K and T4.1 to T4.3 at 443 K, respectively for 45, 90 and 180 minutes

Fig. 3 presents the effect of temperature and CaO concentration in tests with 90 minutes of holding time (T2.4 to T2.9, T3.4 to T3.9 and T4.4 to T4.9 tests). These results indicate that by increasing temperature and CaO addition leather dissolution increases, particularly till 1.50 g CaO per 100 mL solution. Above this concentration the effects are less pronounced. Fig. 3 (b) indicates temperature as having strong influence in chromium dissolution thus suggesting selection of lower temperature conditions for less chromium in solution. Adding above 1.13 g of CaO in the 423 K and 443 K hydrolysis tests had no relevant effect in residue reduction. Furthermore, addition of CaO above 0.75 g up to 1.13 g has a relative consumption decrease in the alkalis, therefore lowering Cr_2O_3 concentration in the ashes significantly below the 30 % target.

The most interesting results for the purpose of ensuring reasonable leather organic matrix destruction with relatively low chromium dissolution, generating calcinated residues having above 30 % Cr_2O_3, seems to be those obtainable under the following hydrolysis conditions: i) for 45 or 90 minutes at 423 K with 0.75 g CaO addition; ii) for 90 minutes at 423 K with 1.13 g CaO addition; iii) for 90 minutes at 443 K with 0.38 g CaO addition; and, iv) at 443 K with 0.75 g CaO addition and holding time of 45 minutes.

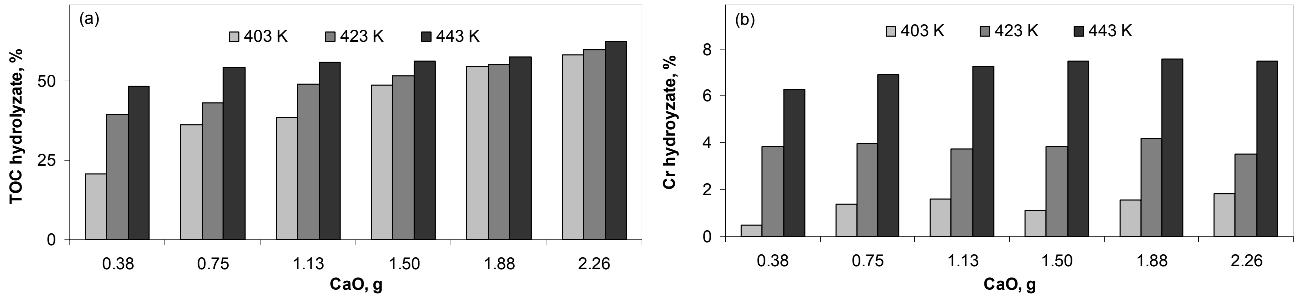

Figure 3: Comparing the effect of temperature and CaO concentration for 90 minutes holding time for tests T2.4 to T2.9 at 403 K, T3.4 to T3.9 at 423 K and T4.4 to T4.9 at 443 K, respectively for 0.38 g, 0.75 g, 1.13 g, 1.50 g, 1.88 g and 2.26 g of CaO addition

Leather wastes are generated in footwear industry as scraps presenting random shape and size. Due to its intrinsic fibrous nature leather grinding is a costly step that must be avoided if possible. Tests T3.10 to T3.12 evaluated the effect of leather size on leather dissolution at 423 K for 90 minutes with 0.75 g CaO addition. The preliminary results obtained indicate that 2 mm size may be a good compromise option for organic matrix destruction. However, this aspect needs to be explored in potential applications.

According the objectives established for this work globally the results obtained seem to indicate that the preferred options for hydrolysis treatment correspond to a ratio of 150 g of leather per 1000 mL water either at 423 K for 90 minutes with 11.3 g CaO addition (as T3.6) or at 443 K for 45 minutes with 7.5 g CaO (as T4.5). The solid residues obtained present lower volume than the original waste. Also, despite the relatively mild pressure and temperature used in these experiments, final solid residue has a mass of the same order of magnitude than the obtained by treatments at boiling temperature under longer times [1-5]. Fig. 4 presents images of initial grinded leather and the equivalent dehydrated sludge obtained for test T3.6.

Figure 4: Effect of CaO hydrolysis on leather volume for test T3.6: initial material and dehydrated sludge

The hydrolyzates and the solid residues obtained from the test T3.6 were characterized regarding Cr(VI), amines and pentachlorophenol. Amines and pentachlorophenol were neither detected in liquid samples nor in the solids. Cr(VI) in the solution was 0.4 mg/L ± 0.1 mg/L and in the solid 7.3 mg ± 0.4 mg of Cr(VI)/kg.

3.3 Biodegradability tests results

In the test conditions studied the coefficient of total anaerobic biological degradation, D_t, as defined by the expression (1), was above 70 % in 90 days for standard cellulose material and gelatine. Hydrolyzates from tests T3.3, T3.4 and T3.6 and T4.2, T4.3 and T4.5, obtained at 423 K or 453 K, gave D_t of 55 % to 65 %, 60 % to 70 %, 50 % to 60 % and 20 % to 30 %, 60 % to 70 %, 50 % to 60 %, respectively. Therefore, despite the variability of the results, the influence of the hydrolysis conditions on the anaerobic biodegradability of the resulting hydrolyzate is small. The D_t obtained ranged 20 % to 70 %.

4 CONCLUSIONS

Mild pressure-assisted alkaline hydrolysis with CaO may be an alternative to reduce the leather waste volume to manage, obtain biodegradable solutions with low Cr concentration and final residues usable as a chromium bearing resource.
Adequate conditions for this treatment are 150 g of leather in 1000 mL water heated for 45 minutes at: (i) 423 K with a 11.3 g CaO addition; or (ii) 443 K when 7.5 g CaO is added. In these conditions over 50 % of leather matrix and less than 6 % of total chromium were dissolved.
The hydrolysis temperature and conditions proposed are moderate and the alkaline hydrolysis reagent is common and relatively inexpensive. The hydrolysis process could be heated at the company level by using vapour as heating source or solar energy, since the temperature needed is relatively low.
The resulting hydrolyzates present good filterability and anaerobic biodegradability mostly in the range of 60 % ± 10 %, indicating them as a source of biogas as a feedstock of an anaerobic co-digestor preferably existing in the proximities.
The solid residues obtained after calcination may be attractive as a chromium resource.
Globally, CaO mild pressure-assisted hydrolysis contributes to reduce the leather waste volume to manage, obtain solutions with low Cr concentration that present reasonable anaerobic biodegradability and give value to the ultimate residue as a chromium bearing raw material.

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Scholarly communication paper

ECO-LABELING – A STEP TOWARDS A HEALTHIER LIFE

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Abstract: *Buyers concerns regarding the acquisition of products that won't harm the environment or health is continuously growing. As a result the EU has decided to give a helping hand in informing the clients of ecological products, by introducing eco-labeling. Eco-labeling can be regarding as a positive appreciation that a product or service is considered less harmful to the environment, compared to similar other products and services. As such the label allows the consumers a comparative analysis between products and services when it comes to making a choice. The purpose of this paper is presenting the most important aspects of eco-labeling percentage, its impact at this stage and the advantages brought by implementing it in the production process.*

Keywords: *products, labels, environment, ecology, textiles.*

INTRODUCTION

In this modern economy, the necessity to protect the consumer's health and the environment surfaced as a result of the continuous diversification in the offer of textile products, the advancement of informational system and development of commercial publicity.
The protection of the environment and the consumer in the textile products branch is a complex problem and must be approached from different directions, from which we may mention:

- ❖ using ecological fibers and yarn, biodegradable or recyclable, with antibacterial effects, auto-sterilization and auto-clean function, the capacity to absorb and remove moisture, permeable to air, thermal regulation capacity and ecological marking of them with the "ECO – TEX" label;
- ❖ making textile materials with improved characteristics, new or special, (biodegradable material, optical, perfumed, thermo-resistant, holographic etc.);
- ❖ reduction in using chemical substances in the manufacturing operations;
- ❖ respecting the marking and labeling conditions of these products.

Insuring the quality in the product usage step is also obtained by respecting the information contained by the label and emblems that accompany the product. Made out of washable materials or not, fixed or just attached to the product, the labels and emblems have the role to inform the user about:

- possibility to know the product (name, fibrous composition, type and size);
- possibility to know the provenance(producing or commercial company);
- maintenance conditions and the price of the product.

Through this information the product is being introduced to the potential user, helping him in making a decision in regarding to its acquisition.
In the world there are many inscription systems for textile labels, classified usually after the producing country. The first inscription scheme was used in Great Britain and was named HLCC (Home Laundry Consultative Council). Other label designation systems for textiles are: the International Inscription System, the American, the British and Japanese ones.
Romania is affiliated to the international textile labeling system, GINETEX (founded in 1975). It decided to inform the users to the product's maintenance, through an uniform and simple system, regardless of language, and to promote it on an international scale, thus avoiding misunderstandings in the component countries.

1. ECO-LABELING

Eco-labeling is the activity that has as purpose the establishment of a voluntary system to grant the ecological label to products with minimal impact over human health and environment, through the entirety of its life cycle.

1.1 The ecologic label

Romanian legislation defines **the ecologic label** as a “graphic symbol and/or descriptive text applied on the product or the package, in a brochure or other informative document that accompanies the product and that offers the necessary information in regard to ecological criteria of the marketed product”. [HG nr. 189/2002]
The ecological label is offered on demand for the groups of products that fulfill the following **conditions**:
- ✓ high protective potential of the environment, that explains the choice made by the consumer;
- ✓ competitive advantages for the producers;
- ✓ high consumer demand.

In Romania, for the implementation of the ecological labeling system, was founded the National Committee for Granting the Ecological Label, consultative organ with a role in decision making regarding the granting of the ecological label. The Romanian ecologic label (figure 1) is given to products that respect the aforementioned conditions and contains a series of information for the consumer: contains the logo of the Romanian ecologic label and the contract registration number as well as the motives for which this label was given, that must target at least three types of environment impact (for example: low air pollution, energy efficient, low toxicity).
European Union ecologic label (European flower – figure 2), created by the European Committee in 1992, is a unique certification scheme that allows the consumer to distinguish “green products and services”. Represented by a flower with petals in the shape of 12 stars, it targets 24 groups of products from different activity sectors.

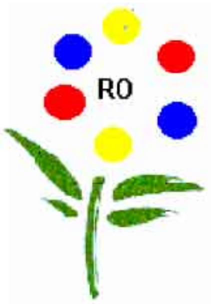

Figure 1 The symbol of the Romanian ecologic label (Romanian flower)

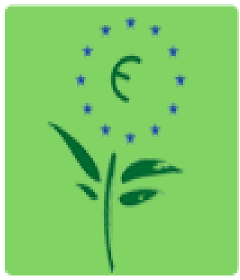

Figure 2 European flower

The European ecologic label is part of a larger strategy, orientated toward promoting rational consume and production.
There are **two types of ecologic labels**: government (sponsored) and made exclusively from the initiative of organizations or companies (voluntary). Voluntary eco-labels can be based on the statutory declaration of the producers, or can be imposed by a tertiary part (governmental or non-governmental organism). In table 1 some examples are presented.

Table 1: Types of ecological labels

Label type	Organization	Example
Governmental	National	EKO-Seal (Netherland)
	Multinational	EU-label, Nordic Eco-label
Voluntary (Private)	Non - Governmental	Good Environmental Choice (Sweden)
	Institution	Öko-Tex (Germany)
	Producers Association	AKN Trademark (Germany)
	Companies	Mark &Spencer Steilmann

Eco-labeling is fundamentally different from any other type of certificate, because of the fact that it awards environmental performance.

1.2 Main characteristics of eco-labeling

The general objective of eco-labeling is offering the consumer a trustworthy evaluation of the product in rapport to the environment and to promote conception, producing and using product with a low impact on the environment and human health.
The main characteristics of eco-labeling (presented in figure 3) are:

Figure 3 Caracteristics of eco-labelling

Is voluntary – offers the producer or merchant the possibility to decide if it will apply it or not. Does not create commercial barriers. Has a dynamic and evolving character.
Is selective – is granted only to those products with low environmental impact.
Is reliable and transparent – the granting criteria were established according to technical and scientific guides, with the large participation of independent and neutral organisms.
Function through a multi-criteria approach – conditions are not based on a single parameter but rely on studies that analyze the impact of the product on the environment all along its life cycle, this way offering advantages to the final beneficiary.
Has a European dimension – a producer or merchant that fulfills the criteria for a group of products and obtains the eco-label can sell on the European Union market. The ecologic label is normally granted to a group of products. Theoretically all groups of product are eligible for eco-labeling, with the exception of food products, beverages and medication.
The ecological performance criteria are specific to each category of products, being established based on the analysis of the entire life cycle, from the conception-design stage, up to the reintegration into nature or capitalization in the post-usage stage. In each of these stages is recommended to be taken into consideration the following ecological aspects: ambient impact of the resulted waste, pollution and degradation of the soil, air and water contamination, sound level, energy and natural resources consumption, effects on the ecosystems.
Granting criteria of the ecologic label for textile products targets the certification and promotion of a cleaner environment, the ecological symbol offering the conviction that:

- during manufacturing the use of substances with a harmful effect on the environment and health of the beneficiary is limited;
- air and water pollution is reduced;
- the risk of allergies is lower;
- the products have colours that resist to finishing treatment, repeated washings, friction and forced drying;
- the colours of the product will resist to perspiration, ironing and exposure to sunlight without fading;
- the product fulfils all the specific requirements in regard to the whole production process;
- the products have durability.

The ecological label can be offered for textile materials (yarns, knitted, weavings), destined to clothing products, accessories, or interior decoration products, that have at least 90% textile fibres weight content.

The necessity of using this label also on the confections branch stems from the increase in the desire of buyers to buy more "friendly" products. Four out of five European buyers wish to own products that don't harm the environment, as long as this certification is done by an independent organism.
Textile merchandise with the ECO-TEX label shows that the general and special conditions in the ecological domain are met, the ecological authorisation being granted by an institute pertaining to the International Association for Research and Testing in this field.

Benefits of eco-labeling:

- Increase in the producer's image and rise of export opportunities;
- Improvement in product quality and a rise in competitiveness as well as insuring consumers health;
- Product traceability;
- Financial efficiency – optimizing the production process, minimizing the water consumption, prime materials, chemical agents, energy, lower pollution taxes, possibility to establish a more advantageous price;
- Improvement of environment performance, protection and conservation – elimination of the toxic and dangerous substances, reduction of the polluting emissions etc..

2. ECOLOGICAL MARKING OF PRODUCTS

The mark is a distinctive sign with multiple roles:

differentiates the products and services from the competition, offering insurance of a superior and constant quality;

adds value, determining trust in regard to the quality level of the product and satisfying the psychological needs of the buyers;

forms in the conditions of the law, the object of an exclusive right protection wise, through enlistment by the national specialty organism (in Romania – OSIM).

The role of the mark is expressed through its functions (presented in table 2):

Table 2: Mark functions

Function type	Characteristics
Identification function	Offers the user the possibility of fast orientation towards the products that fulfil the conditions and have gained a good reputation
Insurance of a constant quality level function	Prestigious mark insure a superior quality
Competition function	The mark allows the producers to diversify and differentiate their products from those of other companies
Communication function	The mark delivers the user information about the product and its quality
Advertising function	Is determined by the mark dynamism and by publicity
Personalisation function	Offers the user the possibility to affirm his personality, by choosing certain marks of products

In order to accomplish its functions, the labelling must respond to certain **characteristics**, presented in figure 4.

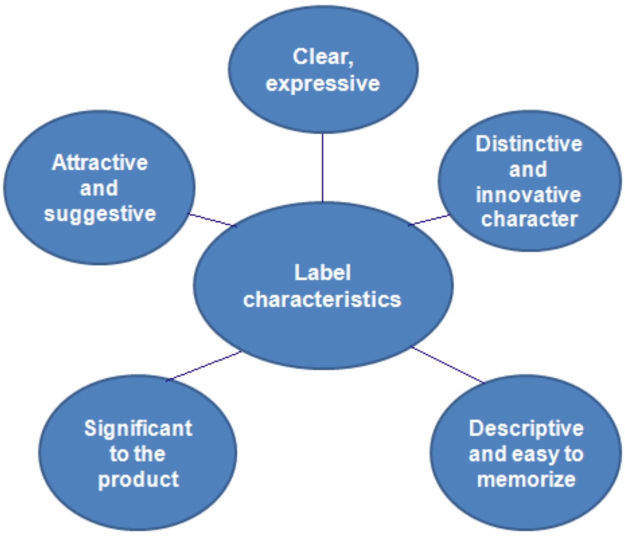

Figure 4 Mark characteristics

Ecological marking is a relatively new process, specific especially to evolved countries.
The mark attributed to the product gives it a certain individuality, and in time, the **eco-mark** will fulfill one of the classical functions of a label, that of insuring the quality, health and originality of the product.
Ecological marking is the object of international standard, adopted at the ISO recommendation, respectively the ISO 14000 standards family. The more intense preoccupations with reduction of the negative impact of technological processes and their result on the ambient environment are underlined, through time, in many countries, by the existence of national brands of ecologic labeling. The first initiative of this kind was Blue Angel – Germany (figure 4), that started functioning in 1978, as a response to the intensification of the buyers ecological preoccupation.

Figure 5 „Blue Angel'' ecologic mark

This system is under the patronage of the German Federal Environment Agency – FEA that decides if a product fulfils the established condition of ecological performance, so that it may be enlisted in the **''Blue Angel**'' catalogue. The product is first evaluated examined and evaluated by the Institute for Product Safety and Labelling-RAL in collaboration with FEA, being also subjected to an independent testing, realized by the Quality Test Organization – CQTO. During this analysis the possible implications of the product on the environment on its entire life cycle are taken into consideration.
Until present times the system established the ecological performance criteria for about 3600 products, grouped into 80 categories.
The German system for ecological labelling of products has been adopted lately by a series of countries, each of them establishing their own ecological brand. Through them we can mention: **Canada (Environmental Choice Program), Finland, Denmark (Nordic Swan), USA (Green Seal), Japan (Eco-Mark), France (NF Environnement), Austria, Netherlands (Miljomarkt), Great Britain**, etc (table 2).
In table 2, some of the characteristics of the marks are presented.

Table 2: Types of ecological marks

Country	Ecologic brand name	Formation year	Specific characteristics	Common characteristics
Canada	**Environmental Choice Program**	1988	Presently the ecological branding system is applied to 20 product categories. The eco mark is granted based upon strict criteria, taking into consideration the entire life cycle of the product and buyers opinions. The coordination of the ecological branding system is insured by the Environmental Choice Board. The Canadian Standardization Association (CSA) is responsible with testing the ecological adequacy of products.	➢Are voluntary systems; ➢The determination of ecological criteria is made based upon the product's entire life cycle; ➢Granting criteria are established such as to encourage the development of low environment impact products; ➢Systems are legally protected by a symbol or logo; ➢Are periodically revised, taking into consideration technological developments and
USA	**Green Seal**	1989		

Country	Ecologic brand name	Formation year	Specific characteristics	Common characteristics
Norway, Finland, Denmark, Iceland	**Nordic Swan Ecolabel**	1989	Branding system coordinated by the Nordic Council. The decision regarding the right to grant the ecologic label is taken on a national level.	market position; ➢ The ecological product brand stimulates the consumers ecologic consciousness and exerts on the industry a considerable pressure meant to determine the creation of „clean" unpolluted products.
Japan	**Eco-Mark**	1989	The ecologic branding system for products is coordinated by the Eco-Mark department from the Environment Agency of Japan. The right to grant the "Eco-Mark" label is granted to companies based on a **2 year** contract. Presently the eco brand is given for 22 product categories.	
France	**NF Environnement**	1991	The ecologic branding system for products based on the most advanced techniques for life cycle analysis. The right to use the ecologic label is granted to companies based on a **3 year** contract, insuring a strict surveillance so conditions are respected, by the team of experts created for this purpose.	
Austria	**Chenumweltze**	1991	The Austrian system of ecologic branding is giving now the "green" label for 32 product categories. The ecologic label is granted by the environment ministry basing on a set of standards realized by an expert committee and **is valid only one year.**	
Great Britain		1992	For the granting of the eco mark the UK Eco- labelling Board was constituted.	

The UE's efforts concerning the unity of the ecological labeling system
Given the fact that each country has developed a national tagging system for all their ecological products, the creation of a law system which establishes a unifying set of labeling criteria for the whole European community has become mandatory. The first step in this direction has been made through the 880 C.E.E. Regulation of the UE Council in the 23-rd of March 1992 that concerns the promotion of products that have a low environment impact during their whole life cycle, the protection of life and health of the UE beneficiaries and the correct informing of all citizens concerning the ecological properties of products. The labeling system established by the European Community is conceived as a voluntary, decentralized organism, the rights to eco label the product being granted by a specialized national committee that exists in every EU country. The performance criteria superimposed on each product are specific to each product category and are established after the analysis of the product's life cycle from the stage of conception and projection, to the

reintegration in nature or the partial recovery of the product in the post-use stage. In each of these stages the following ecological aspects is recommended: the environmental impact of the resulting waste, pollution and soil degradation, water and air contamination, noise levels, energy and natural resources consumption, the general effect on local ecosystems. The analysis should include the impact that the packaging can also have upon the environment.
The process of establishing the ecological criteria set, specific to each product category, is carried out by the national committees that are responsible for the labeling with the „ecological product" print, the consultative forum in Brussels that consists of industry representatives, commerce, consumer organizations, ecological organizations and a regulations committee made from EU representatives. The criteria are then translated into technical terminology and then adopted by the regulations Committee. Among the products that have been labeled as such are: detergents, soil fertilizing products and part of the textiles on the market. Twenty new types of products are in the process of being regulated as such.
The ISO 14000 standards referring to the ecological labeling of products have as a goal the offering of a way to evaluate the ecological characteristics of all products in an internationally acknowledged manner and to inform consumers in this respect. Through these standards we distinguish three types of ecological marking:

- ✓ *Type I marking* – it has been granted by a third party (a governmental or a nongovernmental organism) that establishes the evaluation criteria.
- ✓ *Type II marking* – the one that is a result of an affidavit on the part of the producers, importers, distributors or other interested parties.
- ✓ *Type III marking* – that includes quantifiable information about the product based on predetermined indices.

The principles that stand at the base of the implementation of the ecological marking system are:

- ❖ the ensuring of the transparency behind the products characteristics;
- ❖ ecological information used for marking is based on product life cycle analysis;
- ❖ the use of scientific methods that are reproducible to assess the environmental impact of all products;
- ❖ the use of recognized test methods and transparency in the methodologies and processes used;
- ❖ the guarantee of equal access of all interested parties;
- ❖ the establishing of an user information system;
- ❖ the non-discriminatory treatment of products from domestic production and those from other countries;
- ❖ the periodical review of criteria for ecological labeling, in order to improve their progress in terms of knowledge.

The project for the standard referring to ***type I ecological marking*** defines a set of practices which aims to ensure the marking by a third party in a credible and non-discriminatory manner. They considered the following elements:

respect for the basic principles established for all organic marking schemes;
defining categories and ecological criteria for each category so as to avoid the exclusion of products deemed environmentally acceptable in the country of origin;
consideration of environmental requirements in the country of origin;
the establishing of verification procedures for marking ecological products in a non-discriminatory way.

In the case of the ecological marking of the second type it is provided that the affidavit given by the manufacturers, traders and other stakeholders can take different forms - graphic symbols mentioned on the product or packaging, a document to accompany the product. Such a statement will be made also in the case of advertisements on the product.
The type III environmental marking standard is still in the drafting phase.

CONCLUSIONS

The increase in desire to reduce the negative impact of technological processes and their results on the human health and ambient environment imposed the formation and implementation in more countries, of the eco-labeling process. **Eco-labeling** is a complex activity that has as purpose the establishment of a voluntary system of granting the ecological label for products with minimal impact on the human health and environment during their entire life cycle.
European Union ecologic label (European flower) is a unique certification scheme that allows the consumer to distinguish "green products and services" and is part of a larger strategy orientated to promote rational consumption and production.
The ecologic marking is a complex process meant to facilitate the differentiation of products and services, offering insurance of a superior and constant quality, adding value and determining trust in regard to the quality level of the product by satisfying the psychological needs of the buyers.

The ecological product brand stimulates the consumer's ecologic consciousness and exerts on the industry a considerable pressure meant to determine the creation of „clean" unpolluted products.
Taking into consideration the benefits implied (improvement of product quality and increased competitiveness, insurance of consumer health, financial efficiency, improvement of environment performance, product traceability and increase of export opportunities as well as improvement of the producer's image) the processes of eco-labeling and ecological branding emerge as a necessity of the modern life.
This paper presents the most important aspects of eco-labeling and ecological branding, their impact at this stage and the advantages brought by implementing them in the production process.

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Section 12: Marketing and Management

RCM APPLYING METHODOLOGY IN TEXTILES FIRMS' ACTIVITY

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Abstract. *Considered as a basic strategy in the maintenance management, Reliability Centred Maintenance (RCM) guides the attempt for a continuing improvement of resource assigning optimization process in the critical points of a functioning production system. The applying principles are based on an operating participative management, on an arborescent approach and on a logic and proper study limitation to what is truly essential for the continuing improvement.*
The main research' objective is to adapt the RCM methodology to the textiles industry specific, in which the equipment maintenance is considered to be an expenses "chapter" that can be forgotten if the works gone well. The usage of this method leads to a strategic development of the assigning process of the maintenance resources – which are always in a limited amount – towards the critical points of a functioning production system. In another words, as a final outcome, the present research is proposing an optimizing methodology for the maintenance technical plans, methodology that can analyze and solve the eventual malfunctions of the so-named "critical parts of the critical subassembly of the critical equipment of the critical production line of the critical production unit of the textiles firm".

Keywords: *Management, Maintenance, Reliability Centred Maintenance*

1. BRIEF PRESENTATION OF RCM METHOD

Since its debut, it has been recognised that the RCM (Reliability Centred Maintenance) is not a new method, but a way to federalize into a single action already established methods. As a general definition, RCM is a comprehensive maintenance strategy of a technical system, using a structural analysis method and, at the same time, ensuring the inherent reliability of its functioning [1].

The transfer of this method in the industry field and, particularly, in the area of small and medium size enterprises (SMEs), has led to a modification of the basic principles of the method by the fact that in most cases availability is more important than the inherent reliability of the equipment. As a result, it seeks an optimum ratio between reliability and cost, determined on scientific basis [2]. Therefore, the RCM is an optimization method in economic and organizational terms of the technical maintenance plans [2].

As overall objective, primarily RCM was designed for the development of an optimized preventive maintenance program, in order to ensure the safety functioning of production means by taken into account the economic aspects as well [3].
Under these conditions, the implications of RCM are included on the following:

- Using the method as the main vector of maintenance organization improvement, in terms of a lack of resources, generally noticed in many companies [3];
- Preserving the maintenance information and organizing the feedback loop, in order to ensure a continuous improvement of maintenance;
- Reaching an optimal level for the preventive maintenance program;
- Minimizing the risk of failure by preserving the highest production capacity of the production means;
- Diminishing the maintenance costs yet preserving the earn factors [3].

All these items can come together under a more general objective, bounded to the efficiency increasing of maintenance and production activities, aspect which can be monitor by a specific assessment in this area [3].

2. FUNDAMENTALS OF RCM METHOD

The advantages of technical, economic or organisational aspects of the RCM method are achieved by following three basic principles [2]:

Arborescent analysis: during the different stages of the method it will be necessary to shift from general to particular. The problem is to split the considered system into levels increasingly smaller, to reach the critical element that we want to analyze/improve.

Participative action: improvements can be achieved only through mutual cooperation among the different hierarchical levels of the company, in respect with the practice of participative management of the various groups of employees directly involved on the RCM actions.

Study's confinement: it seems that the first principle implies that MBF would be an exhaustive action of deductive type. It would greatly complicate the analyses carried out, especially in the case of complex systems (for example, for an entire company), whose arborescence involves a large number of levels. Applying that principle asks to define the performance criteria for each level of the arborescence, by keeping only of truly critical elements into analysis.

3. METHODOLOGY FOR APPLYING RCM IN THE PRACTICE OF A TEXTILES FIRM

In a traditional approach, the RCM method needs to follow four stages (Figure 1) [2]:

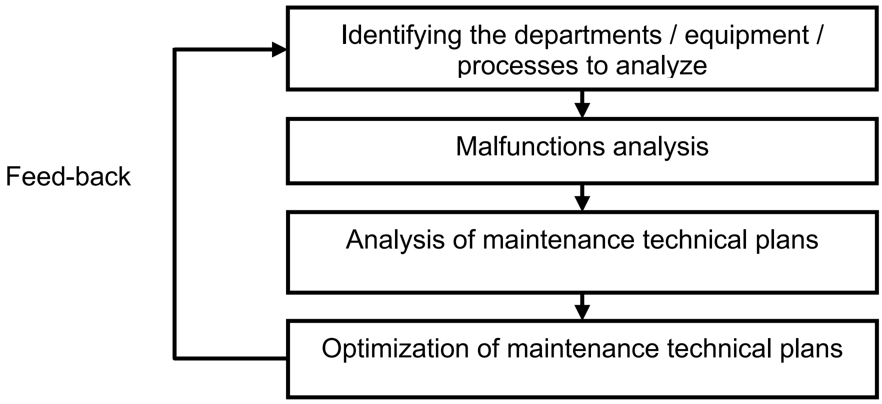

Figure 1: RCM method stages

In order to achieve RCM, specific analysis methods and techniques are applied during each of these stages. Next, we will try to customize them, by defining a methodology especially designated for applying this method in a textiles company practice.

3.1 Stage 1: Determining the departments / equipment / processes to analyze

The starting point of the analysis is an arborescent, topographical and functional approach of the company, as the model in Figure 2 shows:

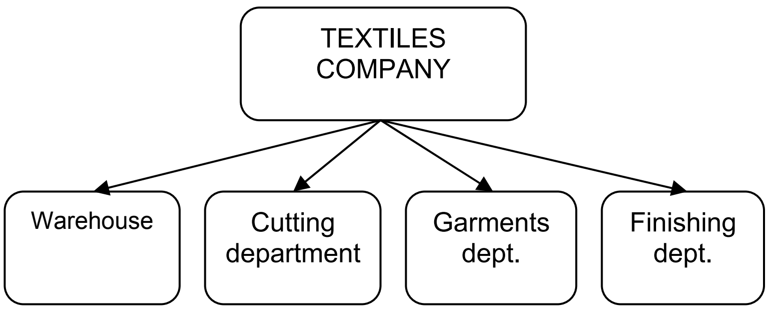

Figure 2: Topographic arborescence of a textiles company

Criteria used to assess the performance may be the type of "safety (S), availability (D) or reliability (A)" by integrating the arborescent items in a sort of "SDA" criticality matrix (Figure 3):

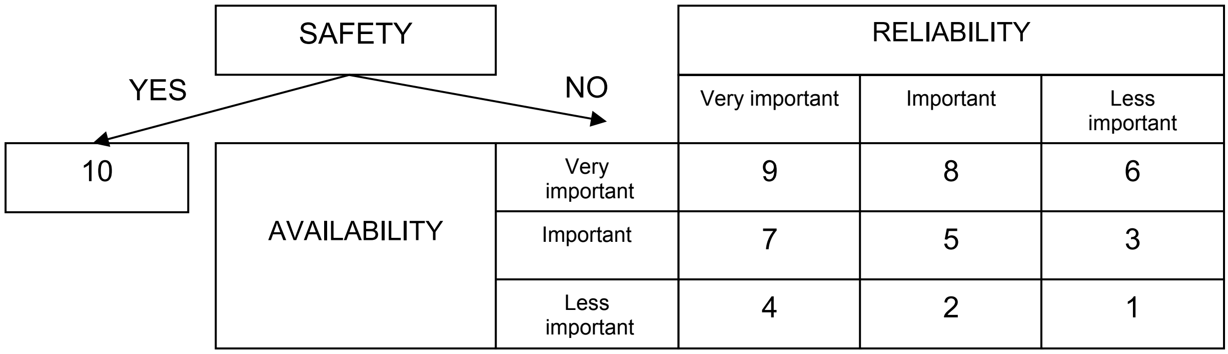

Figure 3: SDA Matrix

Availability is associated with a production strategy of „physical productivity / volume of production" type, while the quality is a "reliability" one. In any and every case, safety is a priority.
Consequently, the four elements of topographical arborescence are inserted into one of the matrix cells and the analysis is limited by taking into account only the item with the maximum score. For example, in most textiles companies, the cutting department (typically, fully automated) involves either a maximum safety of employees or an availability and reliability of utmost importance, thus becoming "critical".

The analysis continues by developing the functional arborescence for the critical element previously identified. For example, if the cutting department would be considered critical, the identified functions could be the following (Figure 4):

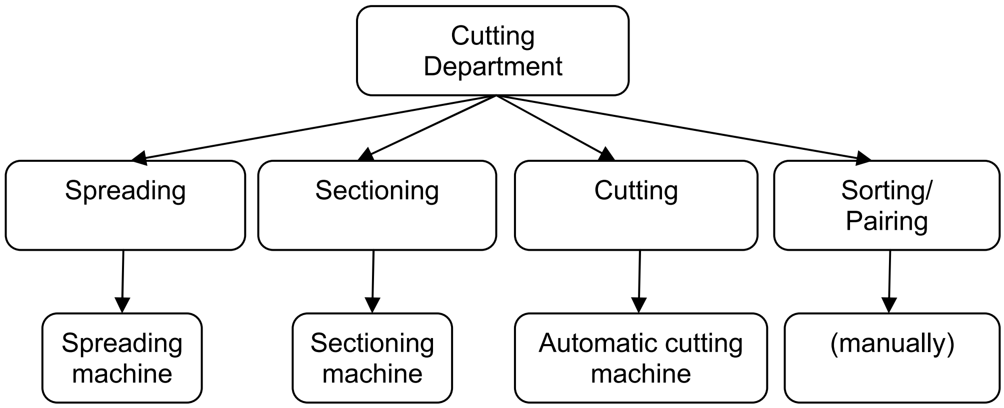

Figure 4: Functional arborescence of a department

Obviously, the arborescence presents particularities for each company. However, what is really very important is to place the equipments on level 3 in the SDA, according to their own importance for the production process. For instance, a spreading machine requires with priority "Safety and Availability", while the requirement for automatic cutting machines are "Safety and Reliability". For the next RCM study' stage the critical equipment is kept.

3.2 Stage 2: Malfunctions analysis

The first step in malfunctions analysis lies in the development of a functional and organic arborescence of critical equipment. Basically, we need a representation of equipment functions, followed by the identification of the main working parts. Without attempting to be comprehensive in our approach, an arborescent pattern for the chosen equipment as a critical one might be the one presented in Figure 5.

The strategic decision that managers should take at this stage is related to the level of analysis [4] and, hence, the involved level of maintenance:

A level 2 approach involves replacing the entire device in an emergency case (for example, if the cutting head is damaged, it is changed entirely!). The consequence is the high price of the function replacement.
A level 3 approach involves changing a working part in case of function' damage. In this case, replacing the working part is less expensive but, in return, it requires maintenance operators with a high level of qualification (that can be available or not!).

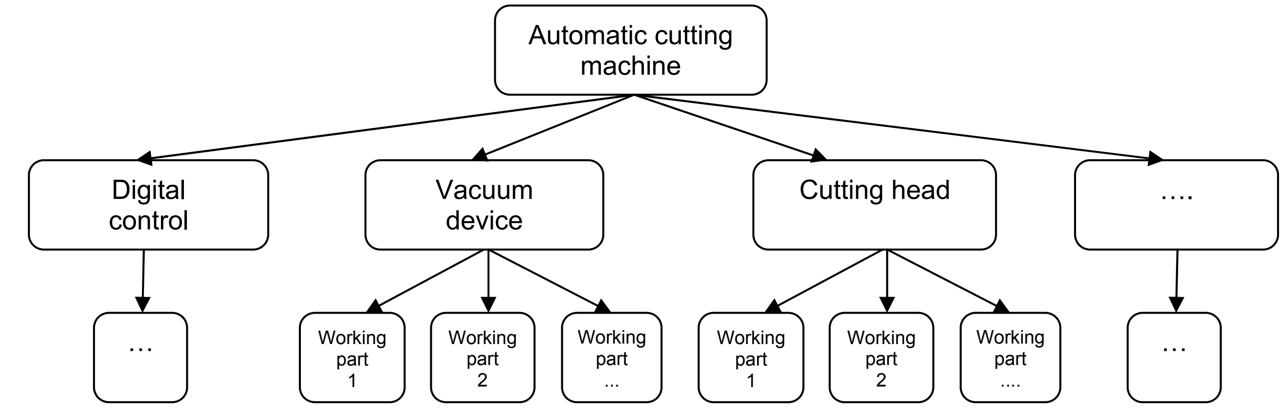

Figure 5: Functional and organic arborescence of an equipment

Once the level of analysis is chosen, the next step is to define the criteria for malfunctions assessment [4]. They can be of different types such as "frequency", "severity", "detectability", "safety" etc., and they will be prior used, in a simplified form, in the application of FMECA method. Basically, the frequency and severity are considered foremost in assessing the criticality. An example could be the following:

Table 1: Determining the F coefficients

Description of the criteria	Assessment coefficient (F)
Malfunction comes out after more than 200 hours of functioning	1
150 < Fixing time ≤ 200 h	2
100 < Fixing time ≤ 150 h	3
50 < Well functioning time ≤ 100 h	4
Malfunction comes out after less than 50 hours of functioning	5

Table 2: Determining the G coefficients

Description of the criteria	Assessment coefficient (G)
Malfunction fixing time ≤ 1h	1
1h < Fixing time ≤ 4h	2
4h < Fixing time ≤ 8h	3
8h < Fixing time ≤ 16h	4
Malfunction fixing time >16h	5

Based on these criteria, the malfunctions analysis is performed through a simplified FMECA sheet (Table 3):

Table 3: Simplified FMECA sheet

<table>
<tr><td colspan="8">FMECA Sheet No. ...</td></tr>
<tr><td colspan="8">Company : Department : Equipment: Automatic cutting machine</td></tr>
<tr><td colspan="8">Analysis goal : Improving the plan of technical maintenance</td></tr>
<tr><td>Working part</td><td>Malfunction way</td><td>Cause</td><td>Effect</td><td>F</td><td>G</td><td>C
(F x G)</td><td>Corrective actions</td></tr>
<tr><td>Cutting slide</td><td>Intensive wear</td><td>Defective sharpening device</td><td>Out of order cutting head</td><td>4</td><td>4</td><td>16</td><td>Revising the plan of technical maintenance</td></tr>
<tr><td>…</td><td>…</td><td>…</td><td>…</td><td></td><td></td><td></td><td>…</td></tr>
</table>

On the FMECA sheet, all malfunctions - corresponding to the chosen level of analysis - must be considered. The expertise of production and maintenance operators is very important at this stage: some malfunctions currently occur, other occurred in the past, and the future can bring other potentially problems in the machine functioning. Items with the highest criticality of malfunctions will be used in the next stage of PTM analysis and review. Therefore, this plan will consider critical working parts of critical equipment of critical technologic flow of the company' critical department. This is the best example of prioritization of resource assignment into the production system' maintenance.

3.3 Stage 3: Analysis of maintenance technical plans

The maintenance technical plans (MTP) present a series of maintenance activities, revision and replacement-type working (spear) parts, in order to reduce and to keep low the failure probability value within a satisfaction range for the user. The plans are drawn up by the equipment producer, based on the statistics carried out during long-term intervals, in various conditions and different operating procedures, on the basis of the compilation of the Mean Time before Failure - MTBF [5]. The productive context of a company (by using, more or less, excessively the equipment, the specific working environmental conditions, the operators' qualifications, the types of working materials etc.) can lead to deviations from the standardized technical plan recommended to the user. For this reason, a review of this document is quite necessary in order to adapt it to the specific production activities.

MTP improvement is achieved through critical analysis of existing situation [2], by using the logical approach showed below (Table 4):

Table 4: Logical approach of critical malfunctions in order to improve MTP

Does malfunction exists?	Does malfunction occurs other times too?	Is there any plan to remove this malfunction?	**Strategy**
Yes	Yes	Yes	Review/ improve existing MTP
Yes	Yes	No	Quick adding on MTP of a measure designed to remove this malfunction
Yes	No	Yes	Simplifying the existing MTP
Yes	No	No	Estimating consequences if malfunction occurs
No	Yes	Yes	Reviewing the criticality and maintaining the existing MTP
No	Yes	No	Reviewing the criticality and the opportunity assessment of modifying MTP
No	No	Yes	MTP simplifying
No	No	No	Existing situation confirmation

When the analysis is under run MTP does not exist, MTP could be conceived by using the logic of analysis above-described, in which case the criticality level of the malfunctions is considerably revised in a decreasing way.

3.4 Optimization of maintenance technical plans

The impact of a change in the MTP is difficult to be assessed at the time of analysis. Therefore, it is necessary that the plan would be applied for a period of time long enough to demonstrate its usefulness.

Analysis by RCM is a continuously improvement process, which leads to the necessity of periodical reconsidering of malfunctions' criticality level, as well as to the development of evolution strategies both for the entire production system and, consequently, for the level of maintenance as well [2]. Accordingly, the authors propose to optimize MTP by using the logical analysis shown in Figure 6.

The logic of the suggested optimization approach allows to changing the MTP until to the very limit of assigned resources to maintenance activity. If the budget is low, all that can be done is just to optimize the plans by defining new maintenance activities. Yet, the existence of a long term strategy for this task, based on the right allocation of funds, allows an evolution by modernization or definition of new investments in the production system.

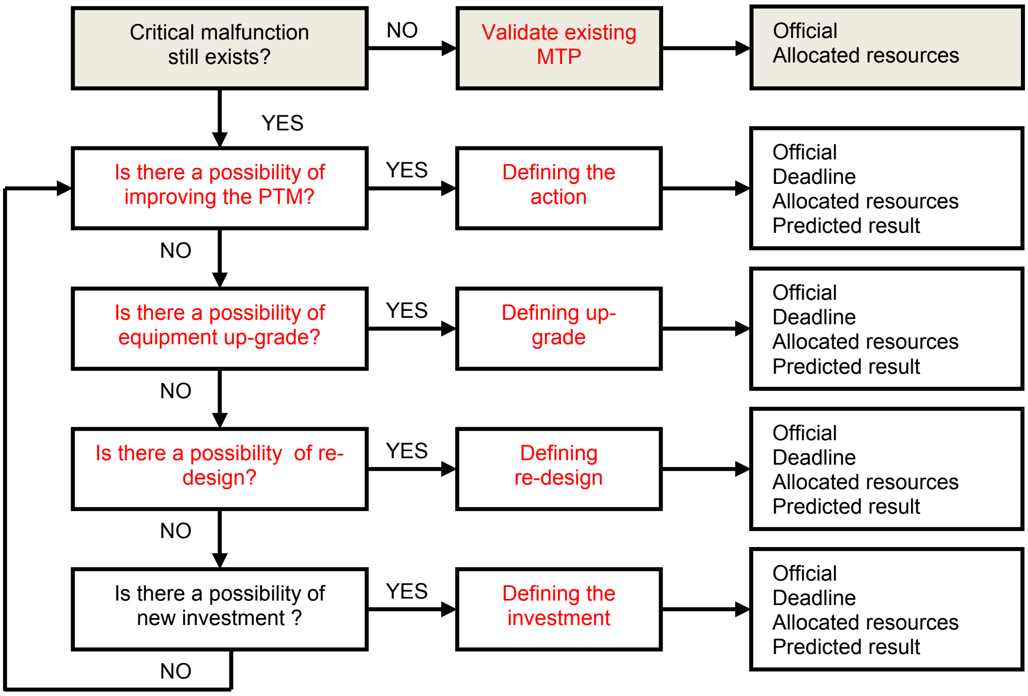

Figure 6: Logic of maintenance technical plans optimization

4. CONCLUSIONS

The described research has led to the definition of a methodology of continuously improvement of maintenance by using RCM. Based on specific performance criteria, the topographic, functional and organic arborescence, allow elements´ classification accordingly to their importance for the proper functioning of the production system, by limiting the study just to the critical points. Application of FMECA identifies the points where existing maintenance technical plans must be modified. So, the genuine proposed methodology for maintenance improvement was applied as a simulation based the example of a company in the textiles industry. The final practical purpose of this approach is an optimized Maintenance Technical Plan.

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PRODUCTION COSTS ASSESSMENT IN THE CLOTHING INDUSTRY BY USING THE CONVENTIONAL WORK UNITS

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Abstract.*The difficulty of the production costs assessment before the manufacturing process launching, remains a real challenge in the textiles industry. The more and more small volume lots, the impossibility of a quick and proper rate-setting of the labor under the manufacturing conditions of the unique products, and the fluctuation of direct productive personnel number, make impossible the unit costs assessment when is needed, more precisely, at the direct negotiation moment with the clients of the price tags or of the unit labor cost. Practically, at this present moment the firms are using repartition keys for the indirect costs in correlation to the material cost or to the direct wages.*
The present research objective is to find out a brand new way to assess the production costs in relationship with the labor volume provided by the direct productive operators, despite the production lot size. To this purpose, it is proposed a genuine computation methodology of unit cost, based on the repartition keys of the indirect costs that, at their turn, are determined accordingly to the direct labor volume.

Keywords: *costs assessment, work productivity, repartition keys, direct and indirect costs*.

1. INTRODUCTION

One challenge of the production systems management in the textile industry is to evaluate with accuracy – as high as possible – the labor rate-settings even from the technical documentation elaboration stage. From economical point of view, these technical manufacturing items have to be accompanied by – as much as possible – a proper assessment of the production costs, under the efficient use condition of the human, material and financial resources [1].

Product series in a more and more lower volumes of production and the deadlines asked by client, under the condition of a industrial flexibility which has a numberless technological limits, make more and more difficult the production costs assessment before launching the product manufacturing process. Just here arises a major difficulty for a right negotiation process of the products’ selling prices, under the condition that the production breakeven is losing significance once the production is shifting from the small volumes to unique products [2].

The general direction noticed by us is that the labor productivity must be reconsidered by passing from the items which are manly bond to the achieved production volume towards, both, the production value, and the efficient use of human resources and, also, of the available working time. In other words, the idea is to bond properly the working potential of the employees to the production cost, equally for a rightful wage system setting, as well as, for a real warranty that the production is done in a profitable manner for the company [3].

Under these circumstances, our research purpose is to develop a production cost’ assessment methodology, in direct accord to the labor volume required by one or by many product lots, methodology possible to be successfully used before contract a new order, or before a new product manufacture launching process.

2. CONSIDERATIONS OF THE PRODUCTION COSTS’ CLASSICAL ANTE-CALCULATION OF IN TEXTILE INDUSTRY

In direct relation to the assigning possibility on each and every product, the production costs can be put in two main categories [4]:

- Direct costs, possible to be “directly” assigned on a product, and
- Indirect costs, related to the overall company organization and functioning.

The identification of the cost items (components) associated to each cost category can be done accordingly to the following figure (Figure 1):

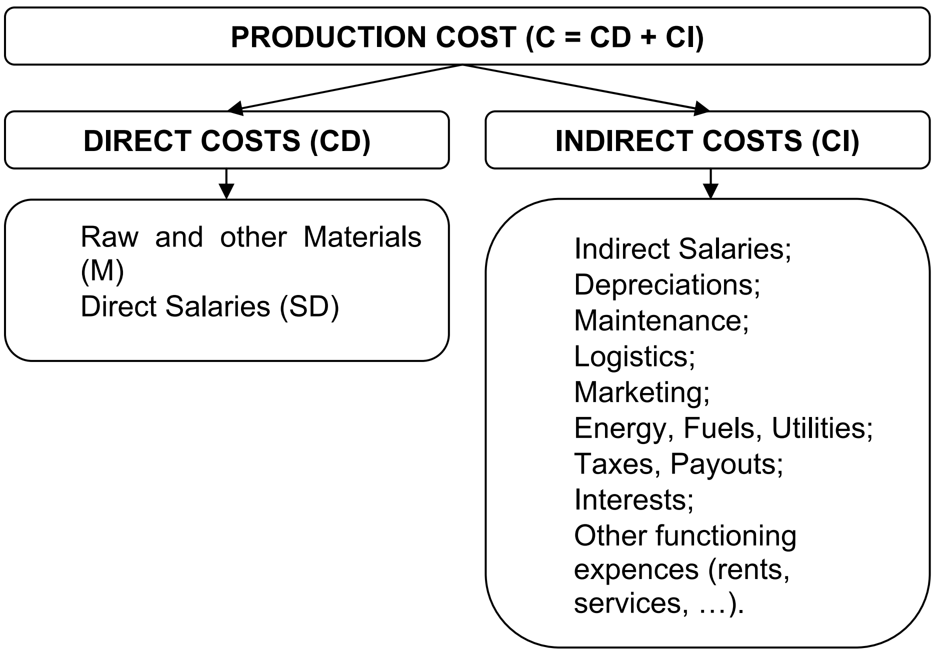

Figure 1: Production Costs Structure

The direct costs are related to the variable costs, since they are varied accordingly to the performed production volume, meanwhile the direct cost are (theoretically) considered fixed in relationship to the production volume.

2.1 Classical ante-calculation of the unit direct cost in the garment industry

As the Figure 1 shows, the direct costs are made by the material costs and those with the direct salaries. Their calculation is performed per single product unit (u.p) as follows [5]:

m_i = the unit material cost of each product i (lei/buc that means Romanian currency units / pieces):

$$m_i = \sum_{j,k} cs_{ijk} \times p_{jk} \ , \tag{1}$$

where:
cs_{ij} = specific cost recorded for the product *i*, in technological phase *j,* from raw material of type *k* (*lei/u.p.*);
p_{jk} = unit price of raw material o type *k, that was used in the technological phase j (lei/u.p.)*.

sd_i = unit direct salary *(lei/u.p.):*

$$sd_i = \sum_j top_{ij} \times To_j \tag{2}$$

Where:
top_{ij} = operation time recorded for the product *i*, in technological phase *j* (*ore x om /u.p.*) that means (*hours x worker/u.p.*), respectively the standard time (the time rate-setting);
To_j = the cost per hour assigned to the technological phase *j* (*lei /oră x om*) that means (Romanian currency/hours x worker):
Consequently, for each and every unit product the unit direct cost cd_i is computing by using the formula (3):

$$cd_i = mi + sd_i \tag{3}$$

In the garment industry, the following circumstances can be occurred:
In case of lohn system production the cost of material is 0 (or negligible), what makes $cd_i = sd_i$;

Although the variable cost is calculated on the basis of fulfillment of the standard time/production, *sdi* acquires a fixed component, linked to the national minimum wage;
There are various interpretations of what it means to "direct/indirect labor (employment jobs)". For example, the workers of a garment equipped with automatic machines, are considered in many factories as "directly productive." In reality, however, the result of their work depends on the fullest measure of the parameters of the station for garment, thus becoming "indirect productive". The fact that spreading, cut off or mate landmarks do their work but to direct components. Also, the fact that a fabric board can contain one or more layers of material relating to a cluster of products are again debatable normalization of direct/indirect labor. The same type of problem arises in the case of shaking feeders of the technological line.

2.2 Classical ante-calculation of the unit indirect cost in the garment industry

Whereas indirect costs are fixed costs associated with the enterprise, the indirect costs are calculated using the repartition keys. The thinking is:

• A company that produces consumes raw materials (if production is performed after its own designs). Since the company produces more goods, the more you consume the raw materials, then the value of "M" is directly proportional to the indirect costs. Therefore, the repartition key for indirect costs depending on the raw material cost "K^M" becomes a constant of a company, calculated with relation (4):

$$K^M = \frac{CI}{M} \tag{4}$$

Since a good portion of the indirect costs are known accurately after the end of the financial year, the values of CI and M are determined for the last operational year of the company. If the repartition key is valid for all company products and if there are no major changes in the structure of production system, then - for any product unit in the current production - the unit indirect cost ci_i can be calculated with relation (5):

$$ci_i = K^M \text{ x } m_i \tag{5}$$

A company that produces in lohn system pays direct salaries, while the consumption of raw materials is of little value. When company produces more goods, more direct wages will have to be charged, the value of "SD" being directly proportional to the indirect costs. Therefore, the repartition key of indirect costs related to the direct salaries "K^{SD}" becomes a constant of a company, calculated with relation (6):

$$K^{SD} = \frac{CI}{SD} \tag{6}$$

As in the previous case, it is considered the values *CI* and SD for the last operation year of the company. If the repartition key is valid for all company products and if there are no major changes in the structure of production system, then - for any single product that will enter the current production – the unit indirect cost ci_i can be calculated with relation (7):

$$ci_i = K^{SD} \text{ x } sd_i \tag{7}$$

In a negotiation process of prices and tariffs, a specialist in the field can easily assess the sd and m. On the contrary, the repartition keys constitute a "secret" of each company, which it uses to obtain higher prices than the cost of production, in terms of obtaining a convenient profit margin.

2.3 Criticism of the ante-calculation classical method of unit costs

The classical method of the costs ante-calculation presents certain limitations, such as:
• If the firm produces both, in lohn system and according its own designs as well, it can't be used both repartition keys at the same time key. Therefore, the method of calculation is becoming less effective for companies in the garment industry;

• The repartition key K^M begins to give errors whenever significant changes are taken place in the raw material prices;
• Both repartition keys standardize production cost without taking into account the seasonal effect of textile production;
• Simultaneously manufacturing programming on the same technologic line of several product types, some in the lohn system, others after their own projects and with variable size of lots, make difficult - or even impossible – the ante-calculation of the unit production costs.

As a result of these shortcomings, we try below to propose a new calculation method of unit production costs.

3. Ante-calculation methodology of the unit production costs

Ante-calculation principle of unit production costs will be based on the use of a new type of repartition key of the indirect costs, depending on the direct productive work volume [6]. In this regard, next, it will be presented a genuine calculation reasoning, which takes into account the direct productive workload.
The direct workload needed to perform a specific product quantity Q of i type (marked by Quc_i), it can be expressed by using the conventional unit of work (u.c.), according to the relation (8):

$$Quc_i = Nt_i \times Q_i \,, \tag{8}$$

where:
Nt = standard time (h x people / pieces);
Q_i = quantity of product of *i* type.

For instance, if a product with a standard time of Nt = 2 (h x people / pieces) has to be made in a 200 pieces quantity, is required a workload Q_{uc} = 400 u.c. Whereas, in a company, there is an inhomogeneous production, for a certain period of time (for example, for the last completed financial year) the normal workload $O^N{}_{uc}$ can be calculated with relation (9):

$$Q^N uc_i = \sum_i Nt_i \times Q_i \tag{9}$$

This is the standard workload for employees who manufactured the products quantity Q.
The direct workload Q_{uc} - which should be performed by a direct productive employee in an hour - is 1 people x 1 hour = 1 c.u. Follows from here that in one working day an employee should work 8 c.u. Whereas over a period of time the number of working days per employee may vary (due to sick leave, new hires, layoffs, ...), the total working time of an employee TM_j can be calculated with relation (10):

$$TM_j = 8 \times Nzl_j \,, \tag{10}$$

where:
Nzl_j = number of working days checked in for an employee j during the calculation period of time.

For the same period of time (for example, for the same last completed financial year, where every person j, had available working time TM_j), and for the entire direct productive staff Ndp_j, the actual volume of work $Q^E uc$ can be calculated with relation (11):

$$Q^E uc = \sum_j Ndp_j \times TM_j \tag{11}$$

As an extension of our research, from relations (9) and (10) follows the yield of the direct productive staff Rdp obtained for that period of time (12):

$$Rdp = \frac{O^N uc}{Q^E uc} x100 \tag{12}$$

Under the condition of exceeding the labor rate-settings, the obtained yield can be greater than 100%. In this case, it is possible the existence of a rate-setting error, caused, for example, by misfit labor standardization

to the technological level of the equipment, to the non-fully use of work time for reasons of discipline or of people qualification.
Based on these observations and calculation relations, further, it will be defined the repartition key of indirect costs K^{uc} accordingly to the actual workload, by using the relation (13):

$$K^{uc} = \frac{CI}{Q^E uc}\left[\frac{lei}{om.h}\right] \quad (13)$$

This relation is valid for a production season before the present one, and for an entire workload. Therefore, if we want to evaluate the indirect cost for a product – which will be launched into production - then the indirect cost per unit will be (14):

$$ci_i = K^{uc} \ x \ Nt_i \ \text{(lei/buc.)} \quad (14)$$

For instance, for a product with Nt = 2 h x people /pieces and a repartition key of 0,5 lei / people x hour, the unit indirect cost will be 0,5 x 2 = 1.00 lei / pieces.

For an entire product order of i type, the total indirect cost CI can be calculate by using the relation (15):

$$CI = Q_i \ x \ ci_i \quad (15)$$

For example, for Q = 200 pieces, the related indirect cost should be 200 x 1 = 200 lei. If the production is inhomogeneous, it becomes obviously that we could calculate the indirect total cost by using the relation (16):

$$CI = \sum_i Q_i \times ci_i \ \text{(lei)} \quad (16)$$

The formula (15) is adding the indirect costs for all products placed in the ante-calculation stage. So, the assessment of indirect costs is simplified and, in particular, it is earned an important asset for the negotiation process of prices and/or tariffs.

In these circumstances, the total cost (C) can be calculated as shown in Figure 1, by adding the direct cost.
Also, the relationship (12) allows the periodical calculation of the direct productive staff' yield, an indicator that enables human resource development for the purposes of meeting the labor rate-settings.

In order to increase the effectiveness of the production cost calculation, we also recommend a seasonal assessment of the repartition key, which leads to a dynamic calculation series of indirect costs.

3. CONCLUSIONS

Starting from the existing realities in ante-calculation production cost in textile garment industry, our research has led to the definition of new methodology for calculating indirect costs.
The starting point was the assessment workload associated with an entire product quantity. Based on this, the first result was a calculating mean of the directly productive workers efficiency for a period of time to review at the choice of managers. Next, a logical reasoning led to the determination of a new type of key distribution to serve both indirect costs related to the evaluation of inhomogeneous production, as well as the possibility of dynamic evaluation of the efficiency of the employees. As prospects of our research, we consider integrating this calculation in the profitability of production.

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BRANDING PROCESS AN IMPORTANT FACTOR IN GUIDING THE COMPANY TOWARDS SUCCESS

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Abstract: *One of the important processes of an organization being tightly connected and interdependent with other organizational processes is the process of branding. In the literature, there are few researchers addressing the branding process.*
The objective of the paper is to emphasize the relationship and interconnection between these organizational processes in textile and leather industries.
Starting with the analysis of a company's brand, using modelling process, the authors propose an effective model to improve brand directed side of strategic management.
In organizations that use the process approach, branding has become a process integrator whose influence on other processes, but also depending on other processes, it may be a determinant of success or failures of an organization.
The proposed model of the branding process allows a more accurate understanding of the activities underlying this process, of the implications that it has both inside the company and in the market in which it operates.

Keywords: *Process approach, branding process, modelling process, textile and leather companies*

1. CONTEXT

Textile and leather industry in Romania has a long tradition and experience in production, but also a good international recognition. In the Romanian economy, textile and leather industry has a significant contribution. In the past years, the industry brought 2.33% of GDP, achieved 3.63% of industrial production. Another important factor to be noted is that this industry occupies an important part of the labour force that is 13.8%.Textile and leather industry sector faces a number of threats, but there are opportunities that run through proper management can ensure and enhance the future of the sector. To cope with the competitive environment and to overcome problems faced by organizations is necessary for textile and leather industry to make changes that allow them to become competitive and to ensure their long-term added value elements. Acquiring recognition and a good reputation are key elements of an upward trend over a long period of time. These objectives are part of a branding process which not only creates a positive image and differentiate, but allows, in time, maintaining a high standard of quality.
Brand and branding process - as it will be defined in this paper, may become key factors necessary for changes which this industry needs, for stability and sustainable development.

2. RESEARCH METHODOLOGY

The authors have conducted a study – bibliographical research -- in an attempt to investigate what brand approach can determine the sustainable development and obtaining long-term competitive advantage of industrial organizations, in the textile and leather industry.
Under these circumstances, the empirical research has addressed the following objectives:

to investigate the brand concept as it is definited in scientific papers.
to define a brand approach capable to determine an organization's long-term sustainable development

to develop recommendations for organizations in textile and lather industry, regarding the branding process.

3. DATA ANALYSIS

3.1 Brand – definition, importance

American Marketing Association (AMA) defines brand as: "name, term, sign, symbol or a combination of these, in order to identify products or services of a company or group of companies and to differentiate them from competition products or services"
The accepted definition of the American Marketing Association did not make any reference to the contribution value, the consumer awareness of the brand or to the reputation it has in the market. AMA definition is restricted to what can be called generic "brand image elements" ie, those elements which distinguish the products name, logo, design, package [1].
In the acceptance of Keller [1], a specialized branding researcher, the brand is defined as "based a product, but one that brings another dimension that distinguishes it from other products that meet the same needs". Keller emphasizes that what distinguishes a brand and differentiates it from the product is the sum of consumer perception and feelings that he has towards product attributes and how it performs.
Economic developments in recent years, financial crisis, further strengthens the idea that the most valuable asset of an organization is not in the products, equipment, real estate values, but in intangible assets and the most valuable of these is the brand.
Brand, in essence, has several functions which are essential for the development of an organization. The first of these is the distinguishing function, marking the company's distinctive elements. For customers, brand simplifies choice, promises a certain quality, reduce risks and generate trust [2]. The brand has an important role in determining how marketing efforts, such as advertising and distribution, are justified or not. This is possible due to its construction which is based on product and its attributes; this is why consumer perception of the brand reflects the perception of the product.
Long time the idea that in business-to-business relations, predominant choice is based on rational criteria, efficiency targets and therefore the brand is a less important factor. Practice has proved the contrary. As Naurus Anderson (1998) and Blakett (1998) quoted by Kotler [3]: "[Brands] ... facilitate identification of products, services and companies differentiate them from competition, becoming an effectively and persuasively means to communicate the value and benefits that a product can provide, represent a guarantee of quality, enhancing perceived customer value."
An important feature of business-to-business brands is that they not only get to the client but also to all stakeholders: investors, employees, suppliers, competitors, government officials, therefore leading to knowledge and better coverage the economic and social environment in which it operates.
According to Kotler and Pfoertsch [3] we can assert that:

- A brand is a promise.
- A brand is the sum of perceptions about a product, service or company.
- A brand holds a distinctive position in the minds of customers, based on previous experience and expectations of future ventures.
- A brand is a collection of attributes, benefits, beliefs and values that differentiate, reduce complexity and simplify the decision making process.

3.2 Brand – proposed model

The author's conception, on brand - as a generic concept - consists of (Figure 1) [4]:

- Realization process product/organization - name, logo, slogan, packaging, font, colors etc.. - Creating visual identity.
- The brand itself - perception, attitude, knowledge of the consumer product / organization.
- Brand Equity - is a series of associations and contributions to the awareness of consumers in the market, the company's financial results

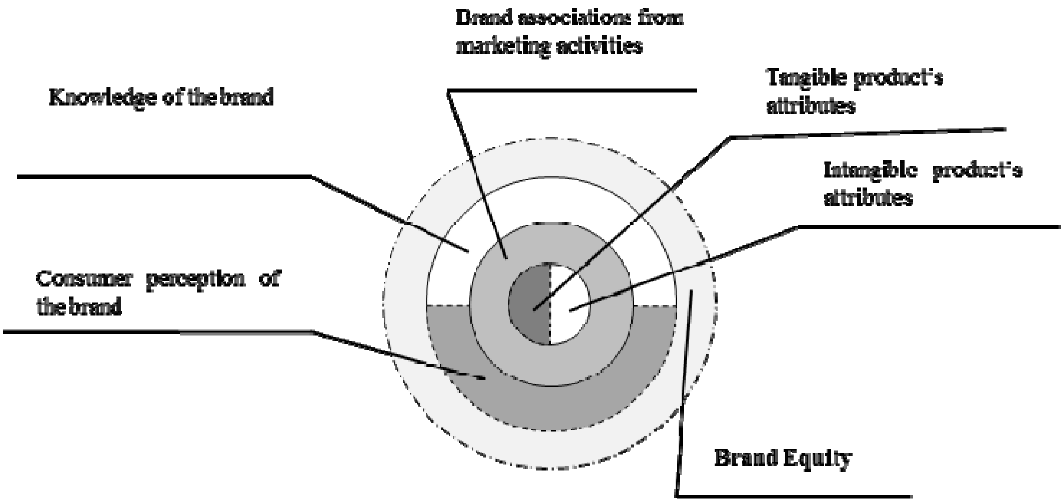

Figure 1: Representation of a brand – brand components

4. RESEARCH FINDINGS – BRANDING PROCESS

From bibliographic research carried out has been observed that few researchers have focused explicitly on the branding process, most often focusing only on certain aspects of it.

4.1 The process of brand building by Philip Kotler

In Kotler and Pfoertsch'model [3] are depicted the main activities required in order to efficiently build, bearing in mind that, according to the aforementioned the "brand building begins with understanding key product attributes and understanding and anticipating customer needs." (Figure 2).

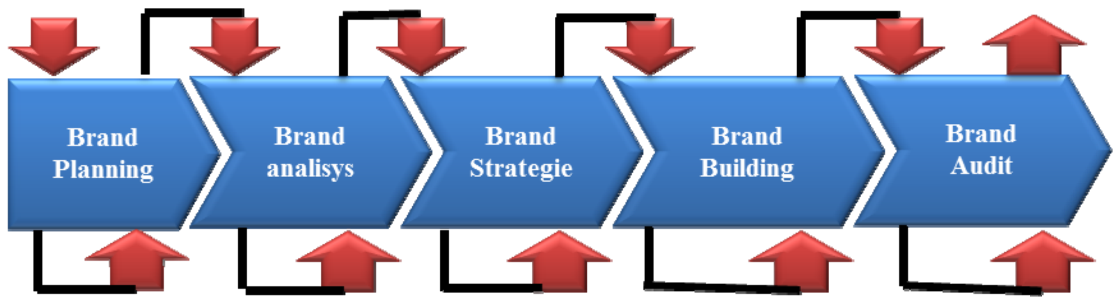

Figure 2: The brand building process by Kotler and Pfoertsch

Therefore, the brand building process involves resource allocation from planning stage to brand audit, as it follows:

Brand planning involves creating a climate in the organization's management to develop a brand strategy, i.e. development of a branding program.
Analysis is based on the brand market research - customer and competition analysis - but includes a process of self-analysis. .
Brand strategy is based on core brand values and its associations is described by Kotler as "the arrangement and ordering number and nature of common and distinctive brand elements that a company applies everywhere in the organization." .
Brand building is a continuous process and refers to the design of the logo, slogan and so on, which is what is meant by product brand. .
Brand audit is a process of identifying strengths and weaknesses of a brand. It enables to determine finally a brand's scorecard, measuring its performance in relation to customer preferences. .

2.2 The strategic brand management process by Keller

Strategic brand management process developed by Keller [1], shown in Figure 3, involves four stages in its development:

- Identifying and establishing brand positioning and values.
- Planning and implementation of marketing programs.
- Measuring and interpreting brand performance.
- Increasing and sustaining brand equity.

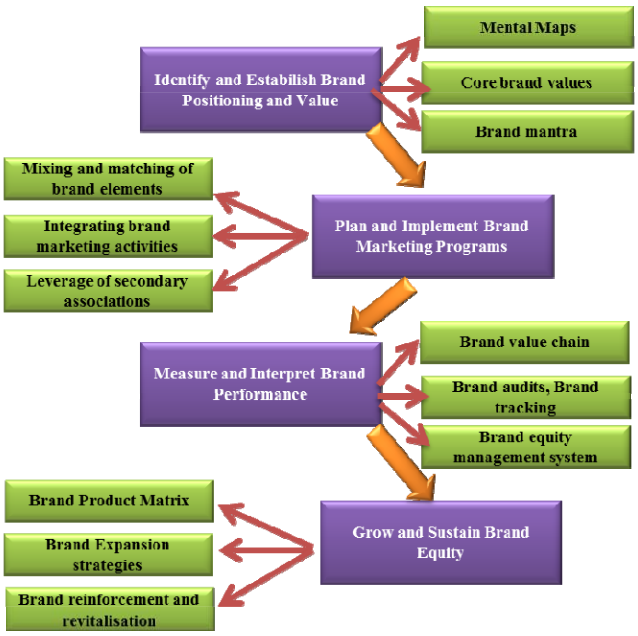

Figure 3: The strategic brand management process by Keller

4.3 The branding process by authors

It is superficial and lacks vision the idea that the successful achievement of the brand is limited to creating only its constituents. A brand is much more. The elimination of phases not only shortens the life expectancy of a brand, but could also lead to losses for the company.
Realization processes and strategic management process of the brand are fundamental processes in the activity of an organization. The two processes are closely linked, and therefore we present them as one. The branding process is constantly recreating the brand and aligns it with the external and internal conditions. To be performing a brand must be continuously adapted to the realities of the organization's external and internal environment, consumer needs and financial realities of the moment. In present paper, the authors have proposed a branding process model which is based on their experience in managerial achievement of Romanian brands. The model integrates two independent processes: the realization of the brand and the strategic management of the brand. The branding process interacts with other organizational processes as shown in Figure 4.

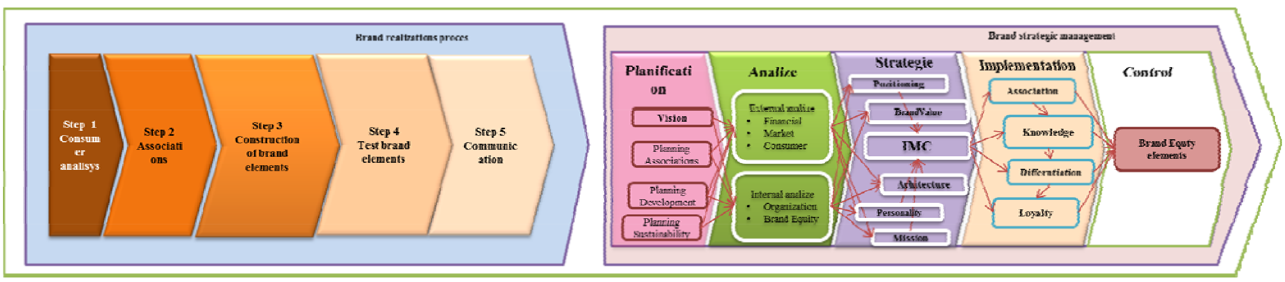

Figure 4: Branding Process

Authors considered that the implementation of the brand is based on both the art and science of designer, going far beyond the creation of logo types, a slogan etc, and include a process that has the power to influence consumer perception and attitude towards the product or company (brand creation process itself). (Figure 5)

Step 1 - analysis of consumer behaviour in the target market for the product that builds the brand. Understanding the needs and expectations of target, mode of action -- are the objectives of this stage. In practice that means builds "portrait" target consumer and builds "bulls eyes target" -- describes a day in targets' life. It penetrates the mind of the consumer as trying to determine the reality that he perceives.

Step 2 – involves the determining associations for both product features and those combinations that allow the connection between company values with product added value and consumer values. Because the attitude is learned not instinctive, joint role is to guide consumers toward a favourable attitude.

Step 3 – involves the construction of brand elements which include: Name, Logo, USP (Unique Selling Proposition) = slogan, Packaging, Font, Colours. All these are created based on the target customer profile and suggested pairings.

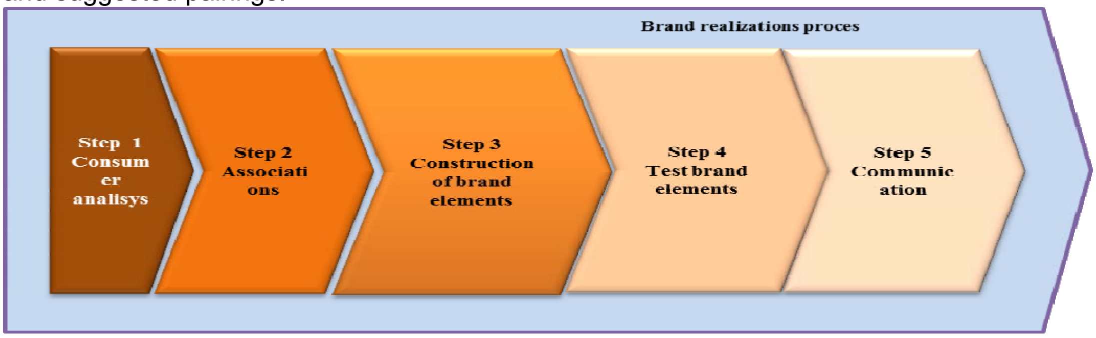

Figure 5: Brand Realizations Process

Step 4 - Test brand items.

It is the stage of analysis, stage of presentation to the ideal consumer the new brand as it will be thrown into the market. It is an important step because the brand comes before the one for which it was created. Focus group is the most common method for testing such a "product" and the most effective of them.

Step 5 - construction of consumer perception. Stage is based on a focused action integrated marketing communication to transmit consumer brand elements and its associations.

Strategic brand management process is a holistic process across the organization. The entire organization, participates in this process and is directly influenced by the deployment process. For an organization to be long term successful it is necessary to continuously identify opportunities for value - value exploration, promising new proposals embodied in value - value creation and not least to send offers value - value transmission.

Thus, strategic brand management process becomes a process that can provide long-term competitive advantage of the organization by creating brand equity that brings lasting value to the branding triangle: client, company, employees [3], as it is shown in Figure 6.

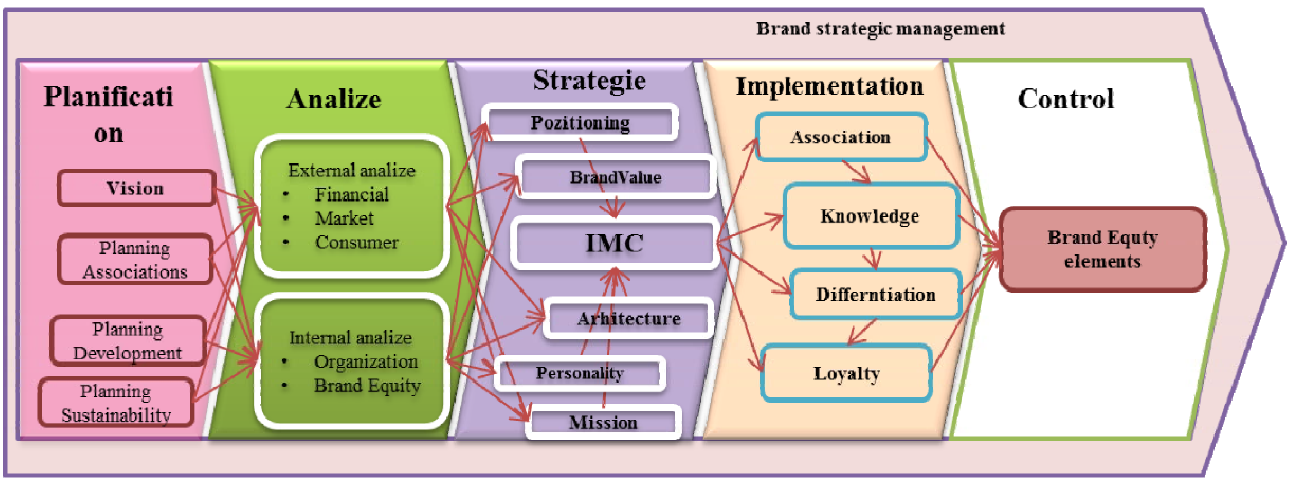

Figure 6: Strategic Brand Management Process

An organization that treats its brands as strategic devices must conduct a comprehensive review process of marketing, brand planning to succeed in its efforts to support and continuous development of its brands.

Continuous improvement of strategic brand management process is a long process, which is strongly correlated with the development strategy of the organization and involve the whole company.[5]
Brand planning activity within the strategic brand management process is an essential step in this process, that managers often neglected. Brand planning should provide the whole picture of what is currently the brand, what you can become and where can you get with a proper plan (view on the evolution of the brand). There is a sales planning marketing planning, there is a financial plan, planning of production and so on, each related to planning objectives that lead to the brand.
One of the key stages of the strategic brand management process is the analysis of the external environment and the internal environment of the organization. A thorough analysis of the market in which the brand will be present is primarily a source of information that could become the core brand values. Industrial organizations from textiles and leather industry can obtain through such analysis relevant views of customers, suppliers, which can then be solved by product attributes or brand associations.
Juck Peddis quoted by Kotler and Pfoertsch [3] says that the essence of increasing company value lies in the ability to have competitive brand in market.
Brand strategy is built based on a few items that will bring added value to the consumer perception:

- Brand Positioning
- Brand Mission
- Brand personality
- Brand Promise
- Brand Architecture

The implementation of brand strategy is achieved through the following steps:

- Establishing unique brand associations, meaning to strengthen the brand in the consumer's mind.
- Achieving brand differentiation from competition
- Increasing brand awareness
- Creating brand loyalty - by strengthening relations with customers

Each of the brand strategy implementation stages is the creation of marketing programs. These stages need a require time and ongoing attention and constant correction to maintain the brand's mission and values associated with it.

5. CONCLUSIONS

Dynamic environment in which they operate, phenomena such as globalization, labor dynamics, all these issues, rapid change has led to an approach to organization that is in the foreground -- organizational process. Due to the multitude of parameters and the difficulty of analyzing the processes based on the data, we have designed models which can simulate behaviours and identify main phases. Modeling helps managers in decision making and simulation scenarios described through the impact they can have on organizational performance.
Branding has become, in organizations that use process approach, a holistic process whose influence other processes, and depending on other processes may be an important determinant of success or failure of an organization. Increasing economic development, globalization, have increased the value that brands bring to companies. The brand has become an intangible asset of the company that far exceeds the value of tangible assets. Brands are traded, brands are those that establish the price of a company. Long time, brands from industrial organizations and brand from textile and leather industries are included, operating in the B2B sector has been regarded as insignificant judging from their target group. Experience has shown that large companies' brands both operating in B2B markets and the B2C markets, have an increasingly roll for creating long-term competitive advantage.
The conclusion reached is that branding is a process and not just any, but a process of organization related to activities in all sectors of the organization, touches all the important processes of the organization and is an essential element of progress.
The proposed model of the branding process allows more accurate understanding of the activities underlying this process; it may have implications both inside the company and the market in which they operate.
Continuous measurement of market indicators, of financial indicators and consumer perception and behavior, should be permanent concern of a dedicated team for branding process. Kotler in "B2B Brand Management" recalled Jim Collins's principle "is not an end to be the best is not a strategy to be the best, no intention to be the best and is not a plan in itself to be the best. It's all about understanding the domain where you can be the best "is the principle that underlies the performance of a brand. Understanding the industry in which the brand operates, understanding the close links between the branding process and other processes of the organization is the way to corporate success.

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HUMAN RESOURCES MOTIVATION: AN INTEGRATIVE MODEL

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Abstract: *Achieving organizational success requires motivated employees who act in the best interest of the company fostering the organizational performance. The current paper aims to develop a conceptual model integrating essential theories of motivation in order to identify the level of employees' motivation working in industrial firms. The study emphasizes that an integrative model for determining the level of employees' motivation should investigate employees' needs, values, motives, goals, expectations, satisfaction, rewards and performance. Identifying the most important motivational factors will provide a complete framework on the dimensions managers should focus on in order to foster the level of employees' work performance. The results of the model will indicate different dimensions of employees' motivation with a direct influence on increasing human resources performance. In conclusion, the current study investigates some key motivation theories in developing an integrative model of identifying the level of employees' motivation and the influence on the organizational performance.*

Keywords: *HR motivation, motivational factors, conceptual model, organizational performance.*

INTRODUCTION

Nowadays companies seek to obtain high organizational performance following human resources strategies in order to motivate their employees to better performing their daily work activities. This article highlights the most important motivational factors, according to relevant theories of motivation, which enable employees to engage proactive in work activities in order to obtain high organizational outcomes. The current study focuses on literature review, developing a conceptual model which integrates motivational variables prevalent in industrial companies. Accordingly, in the light of this research, it is necessary to achieve an approach more concise of the most important motivational factors which contribute to maintaining a high level of employees' motivation in organizations, fostering the overall organizational performance and creating value for the company. The novelty of the scientific research consists of developing an integrative framework including key motivational factors according to the most relevant theories of motivation in the literature.

Starting from Goal-setting Theory developments extended in order to join together with other motivation theories, we developed a model comprising classic motivational factors and also new relevant directions of research within the field. The aim of the research is to develop a research model, attempting to achieve a degree of integration within motivation field. Also, our attempt is to provide the conceptual framework including an integrative motivation scheme in relation to contextual variables which influence human resources motivation and performance at the workplace. Accordingly, there will be established the relevant correlations between categories of variables, proposing relevant motivational research items in correspondence with the new integrative research model developed.

EXPERIMENTAL

The framework of this study is based on a set of research papers in the field of human resources management, with a focus on identifying relevant motivational factors which determine a high level of employees' work motivation, which influences the level of work performance achieved by employees. The literature indicates that motivation, as a psychological concept, has a great impact in initiating "work performance, worker's overall output and firm's profit maximization" [1], acting like "an inner force in each of us that drives us towards the determined goal" [1]. Thus, it is of outmost importance to identify the level of employees' motivation working in industrial firms, taking into account motivational variables proposed by the most relevant classic content and process motivational theories. Also, identifying the relationship established between contextual variables influencing employees' motivation with a direct influence on work performance provides relevant findings for managers to fostering the overall organizational performance.

Work motivation

In the literature, motivation has been defined as "the willingness to do something and it is conditioned by this action's ability to satisfy some need for the individual" [2]. Referring to motivation at the workplace, researchers state that individuals can motivate themselves by seeking and carrying out work that satisfies their needs and conducts to achieving their goals, but also can be motivated by management through methods such as pay, promotion, praise, etc. [3].

Theories of work motivation

Various theories of motivation were elaborated over the years, ranging from content theories (such as Maslow's Need Hierarchy Theory, ERG theory, Herzberg's two factor theory, the Need for Achievement Theory) to process theories (The Reinforcement Theory, Goal-setting Theory, Vroom's Expectancy Theory, Equity Theory), to Hackman and Oldham's Job Characteristics Theory, Attribution Theory, Social-Cognitive Theory and latest approaches in the field (Self-Determination Theory, the 3 C heuristic model of motivation, etc.). Also, recent studies mention the importance of contextual variables [4], [5], such as feedback from managers and co-workers, rewards, decision-making processes, leadership (vision, support), interpersonal climate and social processes (co-worker support), job enrichment and job stressors, as influencing employees' proactive motivational states, identified as "can do", "reason to" and "energized to" motivational states [5].

The motivational theories of content and process will be analyzed briefly in this paper due to the limited space and the aim of this study. In the first place, Maslow's Need Hierarchy Theory states that all humans have five basic sets of needs which could be arranged hierarchically from the lowest level (basic needs-physiological and safety needs) to the highest level (social, esteem and self-actualization needs). According to Maslow, the needs are fulfilled from the bottom to the top and one set of needs should be fulfilled as the next set of high level needs can be activated [2].

Revising Maslow's five categories of needs into three broader ones, Clayton Alderfer's ERG theory emphasizes that existence (basic physiological needs), relatedness (social and affiliation needs) and growth (the need to develop individual's potential) are categories of needs which could be fulfilled progressively. Once the lower level of needs is satisfied, the individual focuses his attention on relatedness and growth needs. Also, the individual shifts his attention on fulfillment of lower level needs as the higher order needs are less satisfied [6].

Moreover, according to Herzberg's two factor theory, there are two categories of factors (motivators and hygiene factors) which influence the individual while performing work activities. Thus, Herzberg states that intrinsic motivation factors determines work satisfaction for employees in their work activities, whereas extrinsic factors (hygiene factors) do not produce satisfaction for employees, but only prevent dissatisfaction to appear [6]. Motivator factors include the work itself, promotions, recognition, autonomy and responsibility, and the category of hygiene factors encapsulates the working conditions, salary, company policy, technical supervision, job security and interpersonal relations [7].

David McClelland proposed a learned needs model, also known as the Need for Achievement Theory, arguing that individuals have three important needs culturally-bounded, as following: need for achievement (the behavior toward competition), need for power (the desire to influence the others) and affiliation (the desire to maintain close relationships with others). His model of motivation highlights that individuals are motivated "according to the strength of their desire either to perform in terms of a standard of excellence or to succeed in competitive situations" [7].

Regarding the process theories of motivation, the Reinforcement Theory of B. F. Skinner underlines that the behavior of the individual could be directed by its consequences, which act as positive or negative reinforcement which is able to influence the behavior. Also, Skinner introduced the term "operant conditioning" referring to a process by which individuals learn behaviors from their consequences [7].

According to Goal-setting Theory (Edwin Locke and Gary Latham), setting goals energizes performance achieved by motivating people to exert effort in line with the difficulty or demands of that goal/task, to persist in activities through time and to direct people's attention to relevant behaviors or outcomes [8]. The model of goal setting includes the challenge (goal difficulty, goal clarity and self-efficacy), the mediators (join challenge and performance), moderators (ability, goal commitment, feedback and task complexity), performance, rewards, satisfaction and consequences [7].

Vroom's Expectancy Theory emphasizes that motivation and performance are influenced by the perceived link between effort and performance, the perceived link between performance and outcomes and the valence of the outcome to the person [3]. According to Vroom's model, the rewards should be worthwhile and achievable in order to establish a link between effort (motivation) and reward.

Equity Theory involves the perceptions people have about how they are treated in comparison with others. According to Stacy Adams' theory, employees will be better motivated if they are treated equitably at the workplace and their level of motivation will decrease if they are treated inequitably.

Hackman and Oldham's Job Characteristics Theory states that there are critical psychological states, such as meaningfulness, responsibility for work outcomes and knowledge about work activities results, which determine desired outcomes at the workplace as worker satisfaction and high-quality performance [6]. Also, according to Hackman and Oldham's Job Characteristics Model there are five essential job characteristics which determine critical psychological states and work outcomes to occur: skill variety, task identity, task significance, autonomy and feedback from job [6].

Attribution Theory (Terence Mitchell and Stephen Green, 1979) highlights the role of the manager in determining the causes of (making attributions regarding) the ineffective performance of subordinates. The attributions that managers and employees made about success and failure can be internal (attributions regarding effort and ability) and external (attributions regarding luck, task difficulty), reflecting differences in self-esteem and locus of control. Accordingly, an individual with high self-esteem and high internal locus of control is likely to assess his own work performance positively and to attribute his good performance to internal causes, increasing also the level of work motivation [7].

Social-Cognitive Theory states that the human behavior represents an interaction between cognitive, behavioral and environmental variables. Thus, according to theory, Albert Bandura demonstrated that people can learn new behavior watching the others performing an activity. Knowledge is acquired through the mental processing of information by observing and imitating others The dimensions which are included in the social-cognitive theory are the following: symbolizing, forethought, vicarious learning, self-control and self-efficacy [7]. Although, the social-cognitive theory propose by Albert Bandura refers to social learning, it also highlights the motivational process and performance achievement.

Also, Self-Determination Theory, elaborated by Deci and Ryan, suggests that the need for competence, autonomy and relatedness are the three main psychological needs that drive human behavior and are key to intrinsic motivation [9]. The authors conceptualize a motivation model identifying amotivation, extrinsic motivation, and intrinsic motivation. Accordingly, the extrinsic motivation refers to "doing something because it leads to a separable outcome", whereas, intrinsic motivation refers to "doing something because it is inherently interesting or enjoyable" [10]. Moreover, amotivation represents the state of lacking an intention to act, and just to the right to amotivation, the authors identify the least autonomous forms of extrinsic motivation, *external regulation* (behaviors are performed to satisfy and external demand), followed by *introjected regulation* (people perform actions with the feeling of pressure in order to avoid guilt or anxiety), *identification* (people identify with personal importance of a behavior) and the most autonomous form of extrinsic motivation, *integrated regulation*, which means that identified regulations have been fully assimilated to the self [10].

The 3 C heuristic model of motivation described by Kanfer, Chen and Pritchard emphasizes the role of motivation as function of context, highlighting the impact of different personal characteristics (content) and situational conditions (context) on motivational processes and their outcomes. The heuristic model of work motivation underlines the role of context (socio-technical context, the cultural/non-work context), content, translated into different personal characteristics and change, which characterize a globalizing work environment [4]. The researchers mention that basic motivation processes still remain to be discovered and applied issues regarding motivation in a context of an increasingly diverse workforce should be reconsidered. Thus, there should be incorporated diversity dimensions, such as employee gender, age, sexual orientation, cultural background, nationality and other contextual dimensions which will advance knowledge of work motivation field in the future research projects [4].

RESULTS

The review of the most important content and process motivation theories realized in the current paper provides the basis for developing a conceptual integrative model for investigating human resources motivation. Thus, the literature review regarding the core of the most relevant theories enabled the research of the motivational variables which should be included in a questionnaire applied to employees in order to identify the level of their motivation at the workplace, with implications in fostering the overall companies' performance.

Research model

The integrative model which resulted from our study contributed to developing a research framework regarding the motivational sources which drive employees to perform better, fostering the proactivity, engagement and performance at the workplace. Taking into account the extended developments of Goal-setting Theory elaborated by Edwin Locke and Gary Latham and Locke's model of the motivation sequence

[8], we developed an integrative model of motivation which comprises employees' needs, according to Maslow's Need Hierarchy Theory, Self-Determination Theory, their values and motives, emphasizing only McClelland's Need for Achievement Theory, Vroom's Expectancy Theory and Equity Theory, from Locke's framework, their goals and intentions (Goal-setting Theory), performance (Attribution Theory, Vroom's Expectancy Theory, Hackman and Oldham's Job Characteristics Theory), self-efficacy and expectancy (Social-Cognitive Theory, Vroom's Expectancy Theory), the rewards they receive (Equity Theory, Reinforcement Theory and Self-Determination Theory) and satisfaction (Herzberg's two factor theory, Hackman and Oldham's Job Characteristics Theory, Social-Cognitive Theory, Maslow's Need Hierarchy Theory), adding the influence of the contextual factors and the relationship with the work performance.
The figure below highlights the most important motivational elements that influence employees' activities at the workplace, illustrating also the influences of contextual factors on employees' motivation and the relationship established with the work performance they achieve.

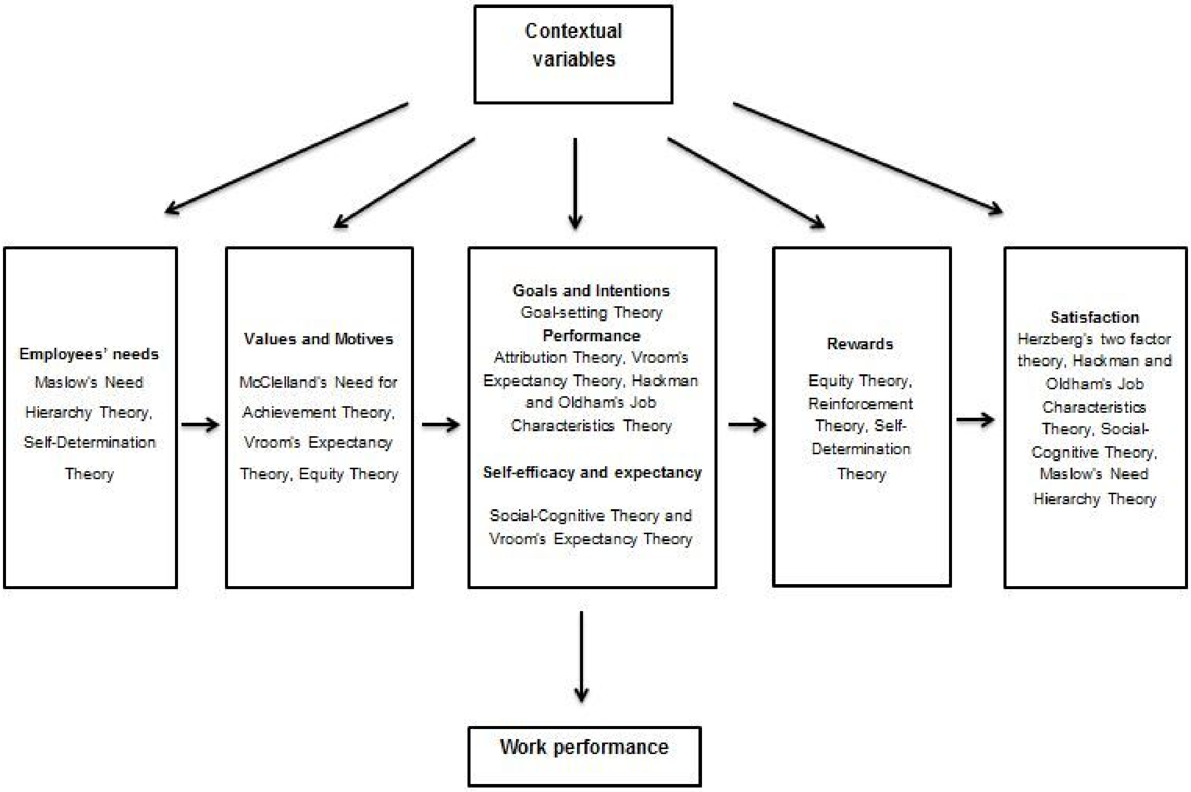

Figure 1: An integrative model of human resources motivation (adapted from Edwin A. Locke's model of the motivation sequence [8]

The present research framework will be extended in quantitative instrument, establishing relevant motivational dimensions for each motivational theory which was discussed in the current research paper. Thus, regarding Maslow's Need Hierarchy Theory, the motivational variables we proposed for the research are the following: work conditions, financial rewards, meal tickets for satisfying food needs, union contracts, property titles (physiological needs), safety and protection in work, job security, work organization, work discipline and control, programs and private and social insurances (safety needs), teamwork, affective relatedness within the work groups, the relationship with managers, organizational climate, friendship and membership (affiliation needs), the possibility to obtain performance, recognition for the obtained performance, the appreciation of colleagues and managers, promotions, recognition, public rewards for professional success (esteem needs), the possibility of creativity development, the possibility to do a challenging work, the possibility of personal and professional development, professional fulfillment, achieving individual potential (self-actualization needs).
In relation to ERG theory, the motivational variables are similar to those identified for Maslow's Need Hierarchy Theory: financial rewards, discounts for medical insurances for employees embracing healthy life styles, life insurances (needs of existence), rules based on teamwork, company parties, cultural and sports programs, volunteering programs, the opportunity to establish warm interpersonal relationships (relatedness needs), autonomy for planning work, tasks for employees with unique abilities, self-realization through designing work by employees (growth needs).

According to Herzberg's two factor theory, we developed the following research items, according to previous research papers [11, 12]: intrinsic motivation variables (the value of work, appreciation and recognition, responsibility, personal development opportunities, promotion possibilities) and extrinsic motivation variables (manager's competence, work conditions, salary, job security, company policy).

The variables we chose according to the Need for Achievement Theory elaborated by David McClelland are the following: the need to help the other colleagues in performing work activities, maintaining close relationships/ friendship, participating in group activities (needs of affiliation), the need to help the others to feel more capable and powerful, the need to be powerful and to influence the others, need to make the others feel weak, accomplishing important activities, control, influencing, persuading and impressing people, reputation (needs of power), improving individual performance, achieving and exceeding personal growth standards, the need to accomplish new tasks, long-term planning regarding promotions, the need to overcome a self-imposed standard (need of achievement).

Referring to process theories of motivation, we took into consideration items according to The Reinforcement Theory, Goal-setting Theory, Vroom's Expectancy Theory and Equity Theory. Regarding Reinforcement Theory, the most important variables which should be included in our research model are: the feeling that obtained performance produces value in the organization the individual works, positive reinforcement for good working to a successful project, receiving rewards according to a schedule for behaving appropriately at the workplace, praise, recognition and immediate feedback for employee's performance, payment every week, bonus and leisure (positive reinforcements) and punishment and efficient discipline, salary cuts for being late at work, benefits cuts as punishment for absenteeism (negative reinforcements).

To identify the level of employees' motivation according to Goal-setting Theory (Locke and Latham), the research items which should be included in the developed questionnaire are the following: the need to achieve a difficult goal, the necessity of a specific goal in order to produce effort to accomplish it, employees' acceptance of the goals, employees' participation to setting goals in the organization, setting important goals for meaningful tasks which increase performance (challenge). Mentioning the mediators and moderators, according to Goal-setting Theory, the proposed variables are the following: attention on accomplishing goals and steering activities irrelevant to achieving the goals, imposed challenge for goal achievement, persistence in achieving the goal, individual strategy for accomplishing the tasks (mediators), permanently seeking challenging tasks and new methods to accomplish them, total commitment to achieving a goal, willingness to expend effort to achieve goals, the improvement of commitment to a goal as a result of the feedback received for the obtained performance, goal achieving satisfaction.

Highlighting Vroom's Expectancy Theory, the expectancy regarding the performance comprises satisfaction of security needs, expectancies regarding the correspondence between the level of effort and the level of performance obtained, the need to be sure that employee's effort will conduct to results and rewards (expectancy), the existence of a relationship between the level of performance obtained and the received rewards (instrumentality), the positive or negative value (valence) associated with the results expected by the employee (external results – payment, salary, bonus; and internal results – feedback for achievement, the achievement of a task).

The variables proposed in our model regarding the Equity Theory refer to: equitable relationships between employees, the equity regarding received rewards, the importance of equitable appraisal of employees' performance, the perception of the employees regarding the rewards they received according to their work, the variety of tasks according to employees' educational level.

Regarding the core job characteristics at the workplace which involve the appearance of critical psychological states and work outcomes, according to Hackman and Oldham's Job Characteristics Theory, in our integrative model of human resources motivation were included the following variables: job variety, different job responsibilities, task variety, competencies variety for performing work activities (skill variety), the opportunity to accomplish work activity, the opportunity to fully realize the tasks, the opportunity to visualize the result of the performed work activities (task identity), the perception about employees' work, the impact of a good performance on the organization (task significance), the possibility to work individually on a task, independence and liberty in accomplishing tasks, the opportunity to think and to action independently, empowerment for establishing the schedule for performing tasks (autonomy), feedback regarding the work while it is being accomplished, feedback on work performance, the possibility to receive directly information regarding the work performance (feedback from job).

Taking into account the Attribution Theory, we can identify the level of employees' motivation referring to the following research variables in our research model: the failure or success it is attributed to competencies to realize the task (ability attributions), the results at the workplace are attributed to the effort of the employees in performing work activities (internal attributions), attributing success or failure at the workplace to task difficulty, attributions about luck or the circumstances surrounding the tasks (external attributions regarding work performance).

Investigating the five dimensions included in Social-Cognitive Theory, we identified the following motivational variables: learning the positive behaviors of colleagues/managers, directing behavior according to work

experiences (symbolizing), planning work activities according to desired level of performance, anticipating the consequences of the future activities (forethought), imitating work colleagues behavior in order to obtain performance at the workplace, the right perception of colleagues' behaviors (vicarious learning), using leisure time to learn new techniques and programs, taking responsibility for learning and accomplishing desired behaviors, authority, ability and self-control in performing activities (self-control), the confidence in performing well at the workplace, learning the factors which enhance the work performance, the capacity to accomplish the work tasks (self-efficacy).
The motivational variables selected in the current research model according to Self-Determination Theory are the following: interesting and challenging work activities, feeling competent, perceived autonomy, positive feedback, secure relatedness (intrinsic motivation), received rewards for adequate behavior, good evaluations, perceived value of the work activities, feeling guilty for not realizing tasks in time, the importance of work activities for the self (extrinsic motivation).
In the end of our scientific research, we find it necessary to sum up our results configuring a figure integrating key motivational variables we identified according to the theories we discussed in the paper. Thus, the figure below emphasizes the most relevant motivational dimensions according to the conceptual model developed, excluding those variables which are redundant in the motivational theories we analyzed.

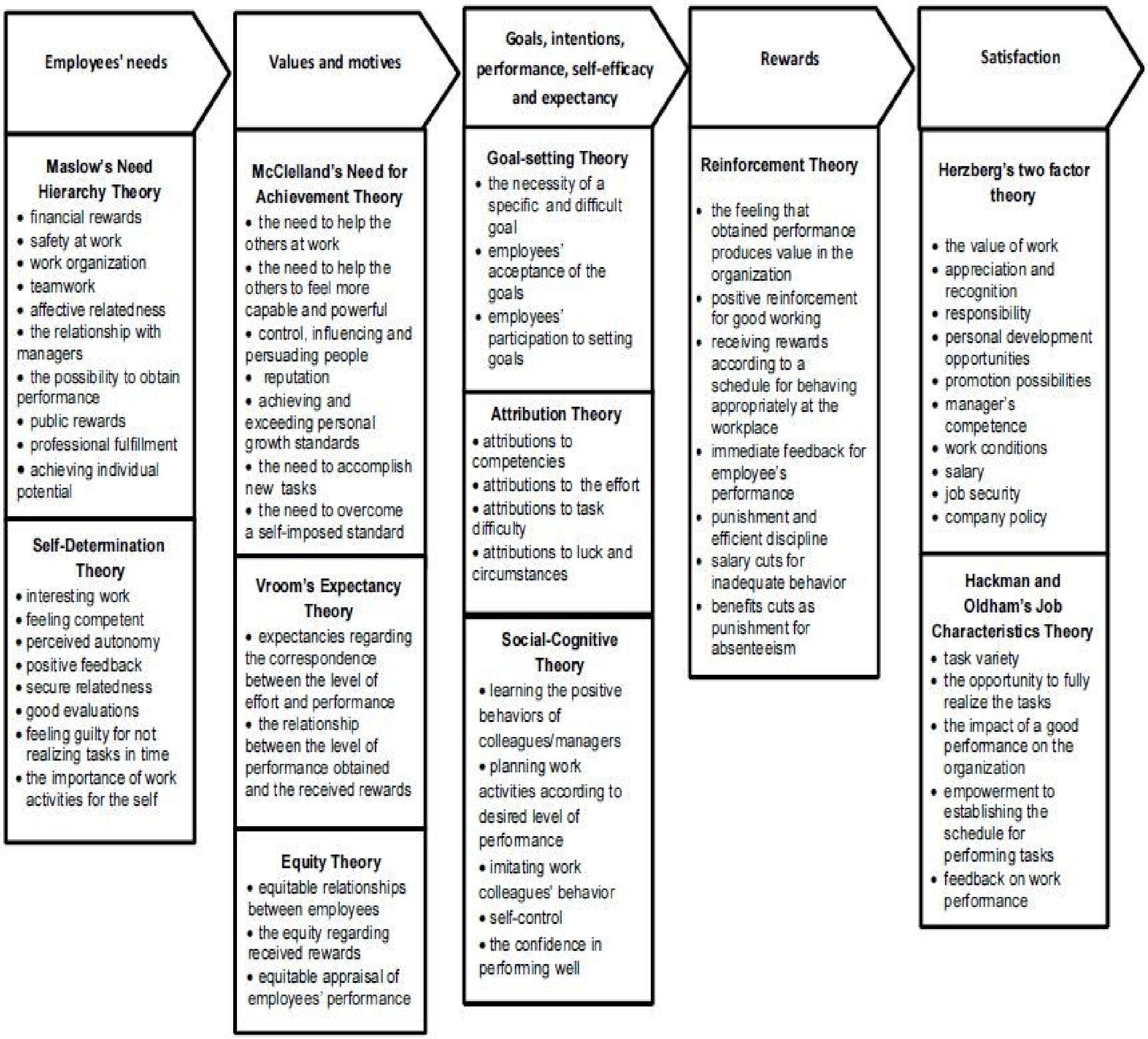

Figure 2: Integrating key motivational variables

In the figure above, we included only the most important motivational variables identified in our current paper, the variables corresponding to each theory being mentioned only once for each motivational source (employees' needs, values and motives, goal and intentions, etc.).

In the first place, although we mentioned ERG Theory in the literature review of the motivational theories, we did not mention it in our research model due to constraints of redundancy, as we highlighted the fact that Clayton Alderfer's ERG theory revises Maslow's five categories of needs into three broader ones.
Moreover, only few of the variables representing physiological needs, esteem needs and self-actualization needs in Maslow's Need Hierarchy Theory were included in the research framework, as most of them are also analyzed in Herzberg's two factor theory, representing hygiene factors and motivators.
Also, taking into account the Need for Achievement Theory elaborated by David McClelland, we also included into our research framework key motivational variables, highlighting the role of the variables which refer to the needs of power and achievement, and less those representing the needs of affiliation, as social and affiliation needs are also identified in the other content motivation theories.
Regarding Goal-setting Theory, we included in the research framework the variables of the outmost importance, referring to the four elements of the theory elaborated by Locke and Latham: challenge, mediators, moderators and satisfaction.
For the Self-Determination Theory, we excluded variables referring to received rewards at the workplace and the perceived value of the work activities, as these dimensions are also verified through the other theories of motivation.
However, we also selected, from the proposed list in the current scientific paper, the most relevant variables for the theories we mentioned in the research model, in order to emphasize the core elements which determine employees' motivation at the workplace.
Therefore, it can be concluded that the quantitative research instrument which will be developed according to the current integrative research model will represent a useful tool investigating employees' level of motivation at the workplace. Comprising the most relevant motivational sources, according to the literature and taking into account Lockes' model of the motivation sequence, we find it necessary to underline the fact that our scientific approach provides the most important variables identifying the level of employees' motivation.
Also, of outmost importance for future research is the influence of contextual variables on employees' motivation and performance. Identifying also relevant contextual variables influencing employees' motivation and performance at the workplace will provide for managers the instruments of identifying the strategies for increasing employees' motivation and performance, focusing on organizational context influences.

DISCUSSION

The paper aims to provide the conceptual model of human resources motivation integrating the most important theories of motivation, according to the literature. Also, the novelty of the current research consists of an approach emphasizing also the role of contextual dimensions influencing employees' level of work motivation and the level of the overall organizational performance.
Joining together motivational factors from various theories of motivation in the literature creates the premises for integrating all the motivational sources relevant for increasing the level of employees' motivation at the workplace.
Moreover, the current research framework, which will be extended in a quantitative research instrument, will provide important conclusions regarding the most important motivational factors and sources which determine employees to get involved in work activities and to obtain performance. Identifying the most important motivational factors, which influence to a very large extent employees' motivation, provides for managers relevant insights of the issues which they should focus on in order to increase the level of employees' motivation, job commitment, engagement, involvement in work activities and performance obtained at the workplace.

CONCLUSIONS

In conclusion, according to the current integrative model of human resources motivation, it is highlighted the role of organizational context variables (cultural context and socio-technical context), according to the 3 C heuristic model of motivation. Also, taking into account employees' needs, values, motives, goals, expectations, satisfaction, rewards and performance, according to the most relevant theories of motivation, creates the premises for integrating the most important motivational dimensions in order to investigate the level of employees' motivation and the influence on their work performance.
Therefore, it can be concluded that the current research model including essential dimensions of motivation according to the literature review of essential motivation theories, highlights some key ideas in identifying the level of employees' motivation and performance in relation to organizational context influence.

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COLLABORATION VERSUS COOPETITION

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Abstract: *Business ecosystem concept emerged and gained acknowledgement as new way of business network structuring. It is important to understand business ecosystem architecture and to identify specific relations between the elements. The purpose of business ecosystem is to align all elements to the single strategy and to create a common process of value creation by establishing the relations of collaboration and coopetition. Thus this paper aims to redefine what collaboration and coopetition means for business ecosystem and to identify at which level they emerge in analysed architecture. In order to highlight the dual character of these relations there will be conducted a comparative analysis whose main outcome is to specify the key features involved from elements point of view. The foreseen results are to show the importance of collaboration and coopetition in business ecosystem's activities as mechanism of co-evolution*.

Keywords: *Business ecosystems, architecture, collaboration, coopetition, value creation*

INTRODUCTION

The emergence of new business structures has an important influence for the development of new concepts. The late debates in management domain have shown the importance of development of new mechanisms and procedures as an integrative part of business growth. From this point of view the business ecosystem approach provides the most valuable features by including an organisation as a collaborative economic entity. However, the main concern is still concentrated on facing the customer driven challenges and provided solutions.

As customers became the key of organizational growth, there have been traced various changes in economic processes. The manufacturers and service providers, along with their clients, became value creators, as value production was transformed into value creation. This approach was generated by increasing necessity to engage the clients and customers into major processes through collaboration. The main outcome of this type of relations was creation of personalized products and services complied with customers' vision and needs.

Going further, the perception of business owners changed as result of the multiple transitions from supply chain to value chain [1], from value chain to value network and value network to business ecosystem approach (figure 1). These transitions have extended the meaning of produced value, identified in case of manufacturers networks, and extended it to the created or co-created value, characteristic to collaborative networks of business entities.

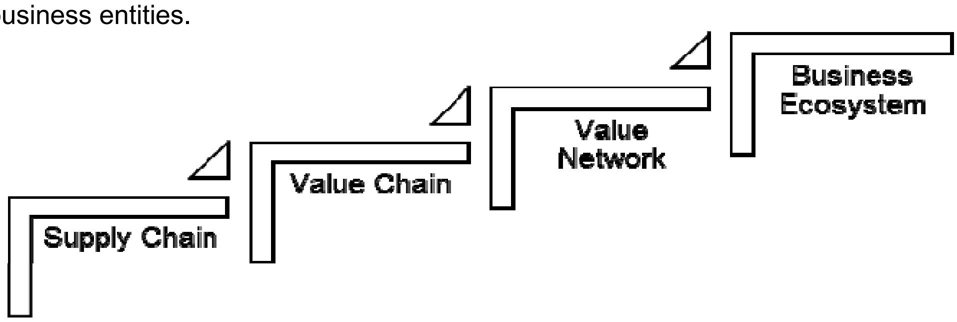

Figure 1. The Evolution of Business Structures

This evolution was influenced by new technological changes and the need for innovation, where customers or clients became triggers for development of new products and services in terms of the design produce and promote.

BUSINESS ECOSYSTEM: THE EVOLUTIONARY VIEW

The ecology theory and biological domain provided the most important features for understanding of business ecosystem concept. From this point of view the main challenge for the scientists was to reveal the multidisciplinary understanding of this concept. Moore assessed the necessity of analogy with biological ecosystem as a challenge in order to understand the behaviour of economic entities, an entire community of different type of agents aligned to a single strategy [2]. Pointed by Moore and sustained by other contributors is the fact that business ecosystem concept denies the limitation to a single industry or geographic zone, such as in case of clusters, opposite this concept extends the limits by occupying several niches from different industries [2, 3, 4]. Therefor the author coined together different types of actors into a single interrelated, self-emergent and self-organised community [2]. However his past research pointed the importance of leadership and strategy [2, 3, 5], business ecosystem became an important concept for strategic assessment [6].

The classical view of business ecosystem as a community was altered by new research approaches. As technology involvement became an important research issue, there was considered that business ecosystem can be formed around new technology development, as Hartigh stated: "…business ecosystem is determined by an anchor point…" [4, p. 106]. However, Moore considered that the core of such structure should be expressed through the organisation itself [7]. From this point of view, the leadership plays a special role in business ecosystem dynamics [8]. Gueguen, Pellegrin – Boucher and Torres stated that the dynamics of this structure depends on leadership function, on the presence of keystone players [8]. Also they defined the main conditions for business ecosystem's development:

Respects the principle of co-evolution
Established relations of coopetition
All involved parties share the same fate or are aligned to a single strategy [3,8]
The principle of diversity.

1.1. Business Ecosystem Structure

As it was mentioned before a business ecosystem represents a community of different actors, who must respect the principle of co-evolution and share the same fate [2, 5, 8]. Although the definition, given by Moore, is very generous, there are still controversial discussions about its structure.

According to Moore this type of community should be structured in several levels: core business, extended enterprise and business ecosystem, as it is shown in figure 2 [3].

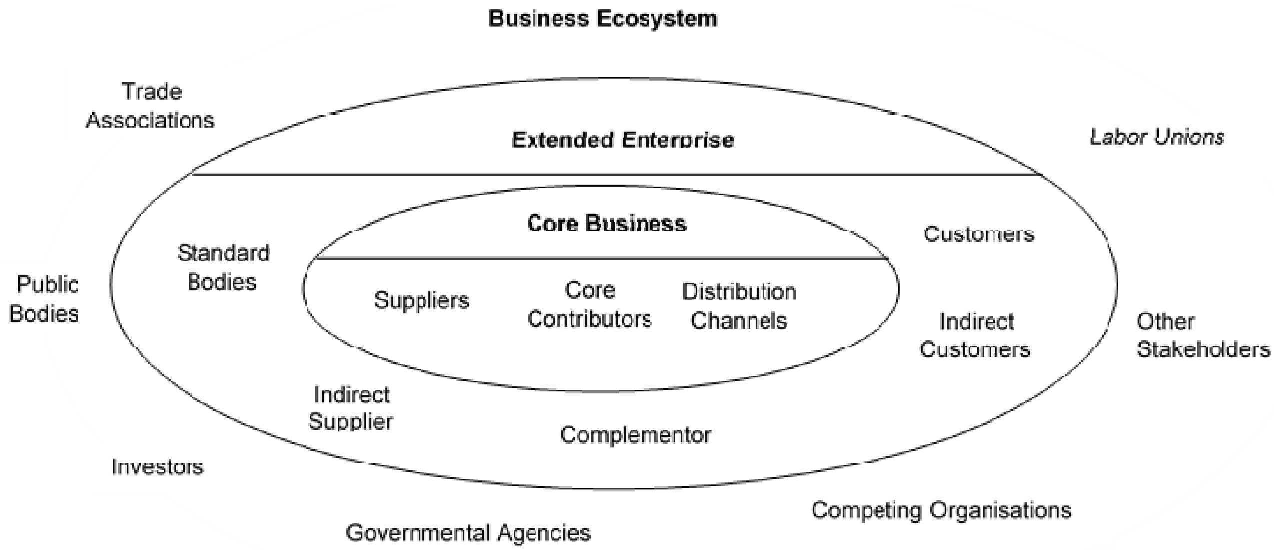

Figure 2. Basic Business Ecosystem's Structure (source J. Moore) [3]

However the current research of this concept, shown the need of new actors' identification and disclosure. From this point of view, the authors of this paper developed a new structure of business ecosystem (figure 3), based on Moore's theory and by taking in consideration following assumption:

1. Adopting the modularity approach from complexity theory
2. Business ecosystem should have an anchor point (the core element) [7]
3. Business ecosystem should achieve a special recognition and international disclosure
4. In order to co-evolve there should exist collaboration and coopetition
5. The dynamics of business ecosystem depends on the engagement of its actors, especially the competition.

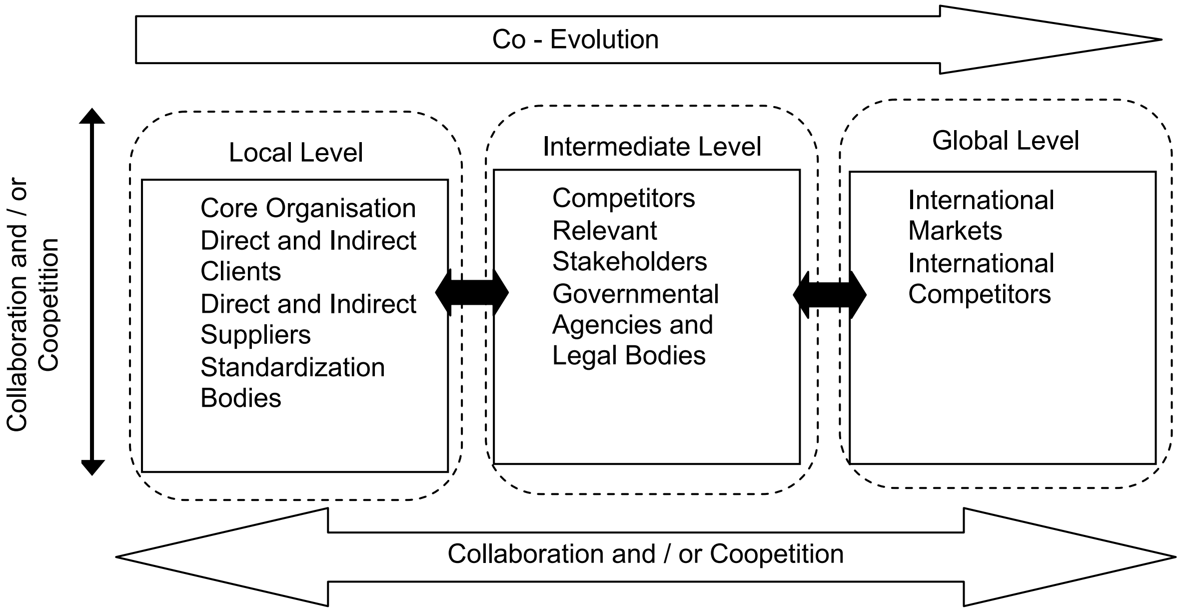

Figure 3. Redefined Business Ecosystem Structure [5]

Relevant findings of development of this structure are that a special attention should be paid to the markets where the core company activates (Business – to – Business, Business – to – Consumers, etc.) [9]. From this point of view there can be traced various categories of clients (individuals or professionals).

COLLABORATION AND COOPERATION: A BUSINESS ECOSYSTEM PERSPECTIVE

The transition from supply chain to value chain brought together not only the need for clients' feedback about the products, but also the need for new type of relations, such as collaboration. The emergence of value creation process indeed demonstrated the utility of this type of relations in order to achieve highly innovative goods or services and not at last competitive advantage. However this first transition was limited, from involved parties' point of view. The change from chain to network derived as necessity to engage also, into value creation process, other types of actors. Ultimately it is not only about the size of network, but also it is about mutual assistance.

2.1. Collaboration

As it was mentioned before, the transition from supply chain to value network was coined to the development and engagement process into collaboration relations. However the transition from value network to business ecosystem is more valuable for defining the collaboration. Muegge pointed in his paper "Platform, Community and Business Ecosystem", published by TIM Review, that in a complex community collaboration is more likely to be successful rather than on classic markets [10]. As diversity characteristic is a must for business ecosystem, collaboration can be established between different types of actors, at different levels. From strategic point of view, this concept is more about overcoming competition and achieving competitive advantage [11]. The authors' approach is based more on gaining power and sharing costs [11], illustrated through:

"To increase selling power
To increase buying power
To build barriers against substitution" [11, p.262].
To achieve competitive advantage
Value co – production
To growth and to entry new markets

Another approach to assessment of collaboration is innovation point of view. As Adrian Cho stated it is difficult for one individual to create an innovative idea [12]. Still of the major importance is the collective effort. From this point of view the existence of developed collaborative mechanisms has a greater impact if they are implemented in collaborative communities [13]. The increasing influence of virtual environments and open source movement [14] brought in front the collaboration between virtual social communities [13]. Thus, the technology development is the most important anchor point in establishing collaboration between agents. Creating specific infrastructure, exchange of tangible and intangible assets and generate value became collaborative mechanisms in order to enable the community of economic entities to co-evolve and to exploit the new opportunities [15].

The main purpose of collaboration is to create a common ground for business ecosystem's actors and to anchor them to a unique purpose. However this type of alignment does not necessary respond to actor's need [16]. In essence the collaboration can be seen also as "an emergent process" [17, p.219] which recognise each actor's identity and seek to find a unique governance system or procedure [17]

2.2. Coopetition

The second type of relations existing in the business ecosystem architecture is the coopetition. As a common definition it can be considered as a collaboration with competitor. Still this concept extended the means of simple collaboration. The current trend in coopetition research revealed that the need to collaborate with competitors is increasing.

From strategic point of view, the coopetition has an arbitrary meaning between the collaboration and the competition. The actors engaged in this type of relations should be capable to alternate the collective strategies with those competitive. The key aspect in this case is vigilance, the actors should be aware and prepared to confront and accept the failures or other negative results of their own adopted strategy [18].

Although in its essence the meaning of coopetition is close to collaboration, it is common used to describe the interactions between the competitors [19]. Yami and Nemeh sustained the idea that coopetition is more likely to be visible in the Information Technology or other high-tech industries and their approach is based on perception of the coopetition as an innovation strategy. Thus it is important to understand the actors' prior motives to engage into this type of relations or strategies.

As it was mentioned before the need of coopetition derive from the prior motives of the engaged actors. In the business ecosystem framework, the main condition is to create a common background for actors' development. From this point of view there are identified the most important consideration for coopetition adoption:

1. *Technology and Innovation* – the positive impact of the coopetition can be visualised in case of technology leaders on the market. As Yami and Nemeh pointed, the leader can choose to engage into this type of symbiosis when technology challenge is increasing [19]. According to Ritala et.al the recognition of new technologies and adopting of virtual instruments (example Amazon) can be seen as the main motive to coopetition [20].

2. *Actors Experience and Opportunities* – the main distinction can be seen in case of highly or low developed companies. In the first case we are referring to the leaders of the market. According to Yami and Nemeh findings their successful prior experience will lead to the engagement into the coopetition inside their business ecosystem. Opposite the experience of low developed companies could be seen as a trigger to engagement into coopetition outside their business ecosystem. Both cases still provide opportunities for both partners, such as value co-creation, new market entrance, and new development opportunities.

CONCLUSIONS

Business ecosystem and the analogy with biological one provides the most valuable insights for the research of new developed business structures. Based on previously developed architecture there were defined the concepts of collaboration and coopetition. As it can be observed the main objective of business ecosystem framework is to bring together different types of actors, linked through specific relations.

Although collaboration and coopetition are similar from their destination point of view, still there can be observed significant differences and similarities.

Both concepts have known an increasing attention and their utility were demonstrated in various researches. These relations are established as a necessity to gain new opportunities from strategic point of view. Technology and innovation became an important anchor point for further development of economic agents within business ecosystem framework.

However the collaboration does not ensure the positive outcome. From this point of view this type of relations in some cases can be seen as a negative influence. Opposite is the coopetition, as a continuous collaboration with competitors can ensure the alignment with the market leader.

From this point of view, both collaboration and coopetition, complies with the main objective of the business ecosystem that is to share the common fate, strategy, development. Also the foreseen outcome that of co-evolution can be achieved by alternating the collaboration and coopetition strategies

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COMPARATIVE ANALYSIS OF ENTREPRENEURSHIP PERFORMANCE MEASUREMENT INITIATIVES

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Abstract: *The topic proposed for this study is research in entrepreneurship performance. It starts from the analysis of Global Entrepreneurship Monitor, Eurostat and the Organisation for Economic Cooperation and Development, which have established a series of performance indicators for entrepreneurship measurement. GEM contribute since 1999 to increase knowledge in the field of entrepreneurship. It has its own perspective of analysing entrepreneurship. The key indicator for GEM is TEA - "Total Early Stage Entrepreneurial Activity". Also, OECD and Eurostat launched the Entrepreneurship Indicators Programme (EIP) in 2006, which develops internationally comparable entrepreneurship indicators.*
The aim of this study is to find the similarities and differences between these data bases.

Keywords: *Entrepreneurship, performance, performance indicators, GEM, OECD, Eurostat.*

INTRODUCTION

Entrepreneurship is a very old notion, but more and more present in our lives, with implications in every state’s economy. Entrepreneurship has its origins in the XVIII century, when Richard Cantillon first defined it as the risk assumption for beginning a new business venture.
Since then, many researchers tried to find various ways of defining and measuring it. It is not easy to measure something that depends on human performance and also on human errors. The main reason of measuring entrepreneurship is to reach a certain level of performance. So, for measuring the entrepreneurship there are necessary some indicators.
In this research, the author gathers the performance indicators for entrepreneurship measurement of three international data bases – OECD, Eurostat and GEM. The aim of this paper is to find out which data base is the most accurate in measuring entrepreneurship.
OECD (Organisation for Economic Co-operation and Development), from French – Organisation de coopération et de développement économique, represents an international economic organisation of 34 countries founded in 30.09.1961 to stimulate economic progress and world trade. The official languages of this organisation are French and English and the leader is Secretary-general José Ángel Gurría. OECD has its origins in 16.04.1948 as the Organisation for European Economic Co-operation (OEEC). [1]
Eurostat was established in 1953 to meet the requirements of the Coal and Steel Community. Over the years its task has broadened and when the European Community was founded in 1958 it became a Directorate-General (DG) of the European Union. It is located in Luxemburg and has the role to supply statistics to other DGs and supply the Commission and other European Institutions with data so they can define, implement and analyse Community policies. [2]
In 2006, from the collaboration of OECD with Eurostat resulted Entrepreneurship Indicators Programme (EIP), which, in the beginning, produced methodological tools to structure the development and a collection of entrepreneurship indicators.
GEM (Global Entrepreneurship Monitor) is a global study conducted by a consortium of universities. It has the beginnings in 1999, as a partnership between London Business School and Babson College, when the first study covered 10 countries. GEM aims to analyse the level of entrepreneurship occurring in a wide basket of nearly 100 countries. So the main activity is to annually assess the entrepreneurial activity, aspirations and attitudes of individuals across this wide range of countries. This report has achieved a very important role in the scientific research about entrepreneurship. [3]

EXPERIMENTAL

The method used in this research is comparative analysis of bibliographical research. The comparison is made between OECD, Eurostat and GEM indicators for entrepreneurship measurement.

The indicators for entrepreneurial performance from EIP are structured in three categories: firm-based, employment-based and business wealth.
The first category, firms, include the following indicators:

- employer enterprise birth rates;
- employer enterprise death rates;
- business churn;
- net business population growth;
- survival rates at 3 and 5 years;
- proportion of 3 and 5 year old firms.

The second category, employment, is formed from the following indicators:

- high growth firm rates by employment;
- gazelle rates by employment ("gazelles are the subset of high-growth enterprises which are up to five years old" [4]);
- business ownership start-up rates;
- business ownership rates;
- employment in 3 and 5 years;
- average firm size after 3 and 5 years.

The third category of entrepreneurship indicators, the business wealth, includes:

- high growth firm rates by turnover;
- gazelle rates by turnover;
- value-added by young or small firms;
- productivity contribution, young or small firms;
- innovation performance, young or small firms;
- expert performance, young or small firms.

Eurostat and OECD are registering data from new companies. The Global Entrepreneurship Monitor, in comparison with the other two data bases, it measures the entrepreneurial activity in general and concentrates on the role of individual persons in entrepreneurial process and on the behaviour of individual persons which are beginning and administrating businesses. [5] It measures individual perceptions about opportunities, capabilities, fear of failure, and intent to start a business. [6] The main indicators used by GEM are described in Table 1, Table 2 and Table 3.

Table 1: Entrepreneurial activity rate of adult population [7]

Indicator name	Indicator definition
Nascent Entrepreneurship Rate	Percentage of 18-64 population who are currently a nascent entrepreneur, i.e., actively involved in setting up a business they will own or co-own; this business has not paid salaries, wages, or any other payments to the owners for more than three months
New Business Ownership Rate	Percentage of 18-64 population who are currently a owner-manager of a new business, i.e., owning and managing a running business that has paid salaries, wages, or any other payments to the owners for more than three months, but not more than 42 months
Total early-stage Entrepreneurial Activity (TEA)	Percentage of 18-64 population who are either a nascent entrepreneur or owner-manager of a new business (as defined above)
Established Business Ownership Rate	Percentage of 18-64 population who are currently owner-manager of an established business, i.e., owning and managing a running business that has paid salaries, wages, or any other payments to the owners for more than 42 months
Improvement-Driven Opportunity Entrepreneurial Activity: Relative Prevalence	Percentage of those involved in TEA who (i) claim to be driven by opportunity as opposed to finding no other option for work; and (ii) who indicate the main driver for being involved in this opportunity is being independent or increasing their income, rather than just maintaining their income
Informal Investors Rate	Percentage of 18-64 population who have personally provided funds for a new business, started by someone else, in the past three years
Necessity-Driven Entrepreneurial Activity: Relative Prevalence	Percentage of those involved in TEA who are involved in entrepreneurship because they had no other option for work

Table 2: Entrepreneurial aspirations [7]

Indicator name	Indicator definition
Growth Expectation early-stage Entrepreneurial Activity: Relative Prevalence	Percentage of TEA who expect to employ at least five employees five years from now
New Product early-stage Entrepreneurial Activity	Percentage of TEA who indicate that their product or service is new to at least some customers
International Orientation early-stage Entrepreneurial Activity	Percentage of TEA who indicate that at least 25% of the customers come from other countries

Table 3: Entrepreneurial attitudes [7]

Indicator name	Indicator definition
Entrepreneurial Intention	Percentage of 18-64 population (individuals involved in any stage of entrepreneurial activity excluded) who intend to start a business within three years
Entrepreneurship as Desirable Career Choice	Percentage of 18-64 population who agree with the statement that in their country, most people consider starting a business as a desirable career choice
Fear of Failure Rate	Percentage of 18-64 population with positive perceived opportunities who indicate that fear of failure would prevent them from setting up a business
High Status Successful Entrepreneurship	Percentage of 18-64 population who agree with the statement that in their country, successful entrepreneurs receive high status
Know Start-up Entrepreneur Rate	Percentage of 18-64 population who personally know someone who started a business in the past two years
Media Attention for Entrepreneurship	Percentage of 18-64 population who agree with the statement that in their country, you will often see stories in the public media about successful new businesses
Perceived Capabilities	Percentage of 18-64 population who believe to have the required skills and knowledge to start a business
Perceived Opportunities	Percentage of 18-64 who see good opportunities to start a firm in the area where they live.

RESULTS

After the comparison of OECD and Eurostat entrepreneurship indicators with GEM indicators resulted a series of similarities and differences (**Table 4**) between them.

Table 4: Differences between OECD, Eurostat and GEM

Differences		
OECD	**Eurostat**	**GEM**
OECD and Eurostat, together, are gathering data from the firms points of view		GEM gathers data from the entrepreneur point of view
OECD and Eurostat can gather information for data bases only from certain countries		GEM can apply its indicators in every state
OECD and Eurostat are providing data only about companies, about the result of the entrepreneurial process		GEM measures entrepreneurship as a process, with its different stages.
Established in 1961	Established in 1953	Initiated in 1999
34 countries members	–	100 countries
Budget of 357 million euro	Budget of 91,2 million euro in 2012	Nearly 9$ millions
2500 secretariat staff	850 posts of staff	Over 400 specialists in the field

The similarities between OECD, Eurostat and GEM are few:

All three data bases are using entrepreneurship indicators
All three data bases are realising this statistics for the improvement and growth of some countries

CONCLUSIONS

Analysing this data bases, the author concludes that it is very important to have accurate statistical data, that cam be operated and used to know the reality from a country. From the accuracy point of view, Eurostat is in the first place, among the data bases, because it's applying the same set of concepts, methods, structures and technical standards to all countries.
From another point of view, according to the author research, the most important data base is GEM, because it gathers information about entrepreneurship as a process and focusses on the entrepreneur as the main actor of the process – entrepreneurship. The entrepreneurship measurement realised by this data base is made at certain levels of entrepreneurial development in this ample process.
The present paper shows the main performance indicators from entrepreneurial contexts used in international data bases for comparing different states between them. In the author's opinion, a mix between all the entrepreneurship measures presented in this research would cover all stages of entrepreneurship, from idea to business older than 3 years.

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PROSPECTING INNOVATION THROUGH PATENTING IN THE TEXTILE INDUSTRY AND RELATED RISK FACTORS IN THE CONTEXT OF ECONOMIC CRISIS

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Abstract: *The protection of intellectual property and the valorisation of innovation in the textile, clothing and leather industry are essential for the purpose of reducing risks in the innovation process, aiming at ensuring a competitive advantage by employing intellectual property as a strategic instrument of market survival and of overcoming the economic crisis. To this end, the specific aim of the present paper is to holistically identify the main risk factors related to innovation in the textile, clothing and leather industry in the context of the economic crisis and to correlate the attitude towards said risk factors with the number of pending patent applications in the timeframe of the research. The methodology employs tools of secondary research and consists of a comparative analysis which is performed to determine the approach to innovation through patenting before and after the start of the economic crisis, as survival and sustainable development tool.*

Keywords: *innovation, intellectual property, risk factors, patent.*

INTRODUCTION

The textile, clothing and leather (T&C&L) industry represents an important sector in the economy of the European Union, having a sustainable growth potential through its capacity to adapt to changes of economic, social or ecological nature. According to the European Commission [1], following a study on the European T&C&L industry concluded in December 2012, the T&C&L industry represents a small and medium enterprises (SMEs) based sector, considering that companies of less than 50 employees account for more than 90% of the workforce and produce almost 60% of the value added. The T&C&L industry in Romania has a significant role in the total T&C&L production at EU level considering that currently, according to Eurostat, the added value per employee costs exceeds the EU average, while the value added per employee positions Romania next to last of the EU countries. The discrepancy between the value added per employee costs and the value added per employee is due to low salaries in the Romanian T&C&L industry and to an incomplete chain of value added. In order to insure a long term development of the industry in Romania, the competitive advantage based on low salaries needs to be replaced with a sustainable innovation capacity and valorisation of the unexploited potential.

The economic crisis started in 2008 and out of which the European Union and most of the world seeks to pull through even five years later has had both predictable and unpredictable effects, while opening up multiple directions to take in the immediate future in order for industries, such as the T&C&L industry, to survive or to have a sustainable development.

Even though there are various definitions to approach it, the T&C&L industry can be holistically represented as a value chain of activities, extending from processing raw materials, e.g. cotton, wool, silk, artificial fibres/yarns, fur and animal skins to the market use and consumption of textiles, clothing and leather products, including but not limited to activities of distribution and retail of such products. Other supporting activities can be included in the value chain, such as supplying of processing and production machinery, supplying of information and communication equipment and the chemical industry [2]. The structure of the T&C&L industry can be comprehensively established in subsectors following a specific classification provided by NACE codes (Nomenclature of economic Activities in the European Community), harmonised at national (e.g. Romania) and international level. Accordingly, there are three separate sectors within the industry: the textile sector, the clothing sector and the leather sector, each having their own specific sub-classifications. Considering the complex value chain of activities, inputs, outputs and diverse applications,

the aforementioned sectors are intertwined and interdependent, all extending links in numerous other industries.
The T&C&L industry, especially in the EU, is continuously restructuring and modernising under the pressure of consumer developments, technological advances, the changes in different production costs, the retailers' purchasing power, environmental issues on chemical use and wastewater discharge and important international competitors [3]. For the purpose of comprehending the dynamics of innovation in the T&C&L industry, it needs to be specified that textiles, clothing and leather do not represent a discipline in itself but a cluster of knowledge from different domains, coming together in a technological platform aiming at processing and structuring various row materials into products for specific applications. Still, for the purpose of efficiently defining innovation as a concept in present paper, the Oslo Manual (3th Edition) [4] allows for approaching innovation as representing the market uptake of: a) a new or significantly improved product (good or service) in terms of technical and functional specifications, components, materials and incorporated software; b) a new or significantly improved process in terms of production or delivery methods; c) a new marketing method in terms of changing the product design or packaging, product placement, product promoting or pricing. Changing functional and/or user characteristics of a product represents marketing innovation and not product innovation if the changes are significant yet not essential, e.g. changing the product's sensory perception and aesthetic appearance represents marketing innovation); d) a new organizational method in terms of business practices, workplace organisation or external relationships.

In order to characterise the innovation in the T&C&L industry, the following classification [5], based also on definitions provided by Oslo Manual (3th Edition), is relevant for the purpose of present paper: technological innovation and non-technological innovation. Technological innovation covers new or significantly improved products and processes, while non-technological innovation covers marketing and organisational methods, both being interlinked in the innovation process. The technological innovation is slightly more focused on product innovation than on process innovation, as it is considered to be more important for the development of the T&C&L industry. To this end, strategies of product placement, promoting or pricing are conceived as non-technical innovations to enhance the market uptake of new products which fall under technological innovations. On the other hand, product differentiation through product design represents a well-established non-technological toll in the T&C&L industry, being particularly specific to the clothing sector. With respect to introducing a new or significantly improved process as technological innovation, it constitutes a solid base for modernizing the industry and it further requires a concentration of research and development efforts. It also establishes another link between technological and non-technological innovation, in the sense that introducing new technologies (i.e. technological innovation) in production or distribution often requires a reorganisation of the business, respectively the intake of new business practices or new organisational models (i.e. non-technological innovation) [6].

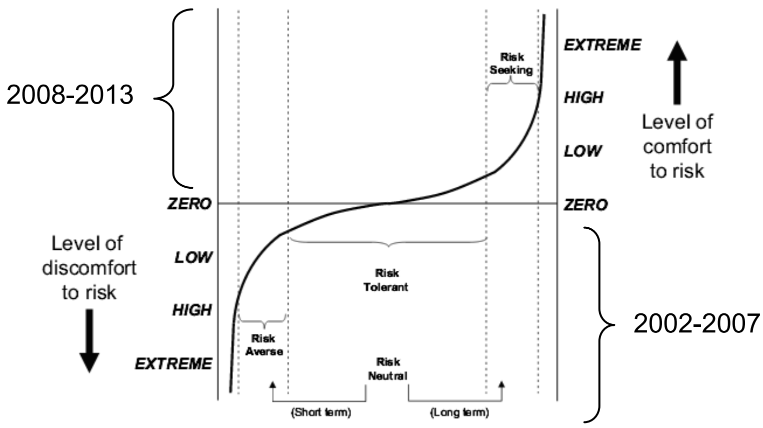
Numerous researches have shown that technological innovation is more specific to the textiles and leather sectors, while non-technological innovation characterises primarily the clothing sector. Non-technological innovation is perceived by the T&C&L industry as being able to produce a significant variety of outputs, in a relatively short time, while requiring lower costs than in the case of technological innovations. The T&C&L industry invests heavily in non-technological innovation [7], while the technological innovation still takes a back sit in the innovation process of organisations. As the case with other industries, the major trends influencing the technological innovation in the T&C&L industry "Rosendo *op. cit.*" were productivity, during the years 80s and 90s, while after 2000, the direction was shifted towards flexibility, sustainability and environmentally friendly production.

The T&C&L industry is generally considered as being a "low tech" industry. Still, when compared with other industries in terms of own research and development intensity and innovations placed on the market, it is considered that the T&C&L industry underperforms. Nevertheless, the textiles and leather sectors stand out, being fundamentally modernised as a result of developments in IT technology, engineering, automation and electronics applied in the T&C&L industry.

When referring to Intellectual Property Rights (IPRs) in the T&C&L industry, the technological innovation is mainly protected by patents, while non-technological innovation is be mainly protected by trademarks and industrial designs. It is a well-known fact that IPRs encourage and support innovation by providing temporary protection and control over the benefits of the innovations. Trademarks protect the right to use a distinctive mark or name making a product, service or company easily identifiable, without representing the creation of additional knowledge. Trademarks are unlikely to directly raise innovation and to encourage technology transfer, yet they can lower research costs, protect against fraud and secure commercial reputation for quality, while encouraging companies to improve quality over time and generating product differentiation. Industrial designs protect the aesthetics, design, ergonomics and usability of products, while encouraging product's marketability and production to a certain extent. Industrial designs encourage technology diffusion and to some degree the innovation. Patents protect inventions which provide an inventive step, novelty and industrial applicability, being considered the most important tool to protect industrial innovations while strongly encouraging technology diffusion and to some extent the innovation itself [8].

While IPRs represent a tool in the approach to ensure the full benefits of innovation, there are also risks associated with the innovation process, having impact in its development. In terms of protecting the innovation from its specific associated risks, the relation between IPRs and innovation in the T&C&L industry is very complex as IPRs are not fully embraced by the industry. Furthermore, it is the patenting of innovation in the T&C&L industry which is less employed by innovative entities, patents being regarded as complex and expensive tools which are yet to be fully comprehended by the industry as far as registration procedure and potential in the valorisation of innovation [5]. Still, considering that the risk factors with impact on the innovation in the T&C&L industry should be analysed and evaluated also in relation to the economic situation in which the innovative entity unfolds and that in the particular case of the T&C&L industry, the economic crisis that started in 2008 had an important impact on the industry [9], a hypothesis can be formulated as such: in the context of economic crisis, the innovation in the T&C&L industry can be prospected through patenting and related risk factors, especially considering the perception of the T&C&L industry regarding patenting of the innovations, as indicated above. As shown in **Table 1**, the main risk factors with impact on the innovation in the T&C&L industry are the same before and after the beginning of the economic crisis, however the major change taking place was in the perception of risk by entities in the industry. As aforementioned, the relation between risk factors and the attitude towards them in the context of innovation activity is linked to the particular economic situation in which an organisation is running.

Table 1: Main risk factors related to the innovation in the T&C&L industry and the risk attitude spectrum [2][10]

Main Risk Factors	Risk Attitude Spectrum – before and during the economic crisis
Distribution, use, copy without owner approval	
Storage for sale without owner approval	
Lack of information on technology	
Lack of qualified personnel	
Lack of information on markets	
Uncertain demand for innovative goods	
Budget overrun	
Information leak due to co-operation partners	
Difficulty in finding co-operation partners	
Lack of external finance sources	
Mistaken the innovative product with an already existing one	

EXPERIMENTAL

The methodology employs tools of secondary research and consists of a comparative analysis which is performed to determine the approach to innovation through patenting before and after the start of the economic crisis. The Official Industrial Property Bulletin (BOPI) – Published Patent Applications Section issued by the Romanian Office for Inventions and Trademarks (OSIM) was researched as a secondary source with the purpose of determining the distribution of patent applications between 2002 and 2013, respectively 6 years before and after the start of the economic crisis in 2008. BOPI allowed for a formal search according to the International Patent Classification which positions the T&C&L industry in the generic Section D – Textiles and paper, covering textiles, clothing and leather in terms of products, processes and equipment. Excluded from the search were the subsections covering paper related inventions. Still, secondary sources (i.e. literature and previously conducted research studies) were researched to identify the risks related to the innovation in the T&C&L industry in the attempt of correlating said risks with the patent applications evolution in the timeframe of the study.

RESULTS and DISCUSSION

Before 2008, the dominant attitude of managers was of risk aversion, which included reluctance in undertaking innovative projects, while at the opposite end, the economic crisis starting from 2008 has become an actual trigger to increase the organisation' tolerance level towards accepting risk. The difference of the twofold risk appetite in the T&C&L industry is quantified in the number of patent application recorded before and after 2008, which has increased by 35%, as it is emphasised in **Table 2.**

Table 2: Number of patent applications in the T&C&L industry, 2002-2013

Number of patent application in the T&C&L industry											
2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
44						**68**					
5	10	9	7	3	10	16	7	13	7	15	16

In a growing economic situation, managers are reluctant regarding employing resources in projects highly exposed to risks, whose unpredictable outcome, e.g. unsatisfactory sales expectations, unsuccessful prototype or even, impossibility of obtaining the patent, might end in anything but gain. When this particular economic circumstance has changed, a new proactive and risk-seeking attitude has replaced the latter one, as competition has become more aggressive and sustainable development has turned into a top priority. In this respect, assuming risk by developing new products came up to be the prerequisites to organisation' survival in the global crisis situation, where the need to protect the idea has become crucial, from the moment it is set in development motion until the first commercial transaction is finally performed.

Since aversion has been until 2008 the dominant attitude when undertaking innovative projects, as described in **Figure 1**, it has influenced the number of patent applications recorded in all industries nationwide.
Undertaking an innovative project within this twofold economical context implies the following:

- Growing economic situation (2002-2007): the level of accepting risk decreases with the chance of recording a loss or an unsatisfactory gain (risk aversion); as such, a decrease in patent applications nationwide was registered before 2008;
- Situation of economic crisis (2008-2013): the level of accepting risk increases with the chance of recording higher gain (risk preference); an increasing number of patent applications nationwide can be observed since the beginning of the crisis.

Regarding the T&C&L industry, the results have ranged between 0.29% and 1.08% before 2008, and 0.48% and 1.55% after 2008 including.
It can be observed that there is a low share of T&C&L industry patent applications in the total number of patent applications filed in Romania, providing an indication that there are other industries which show more interest in the valorisation of innovation through patents. Furthermore, the observation confirms the general attitude of the European Union T&C&L industry towards patenting, which represents a tool yet to be fully developed and employed by the innovators [5].

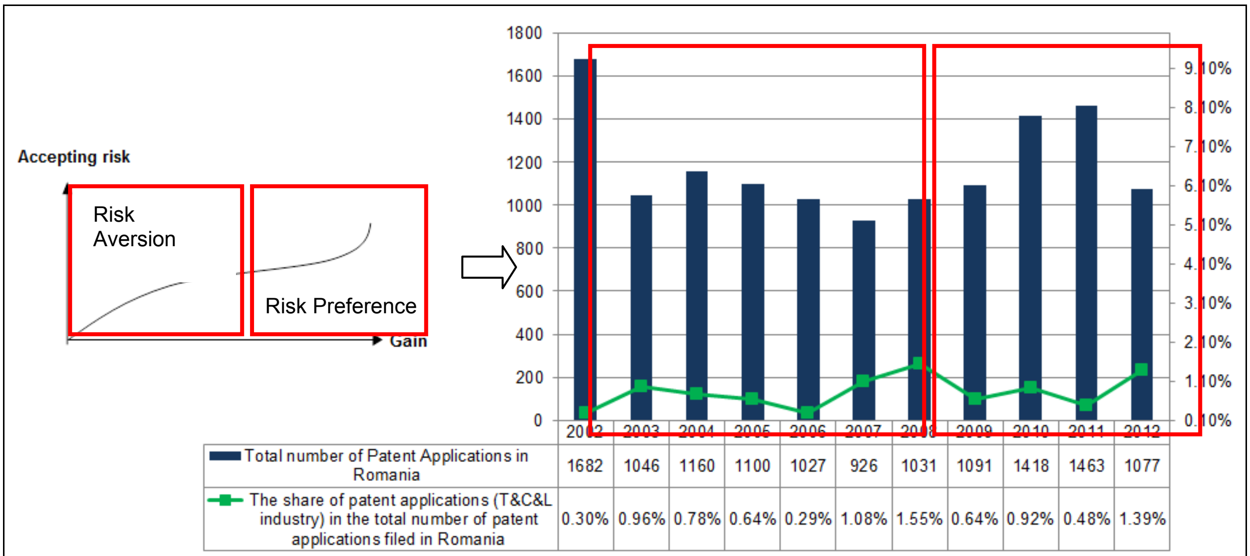


Figure 1: The share of patent applications (T&C&L industry) in the total number of patent applications filed in Romania

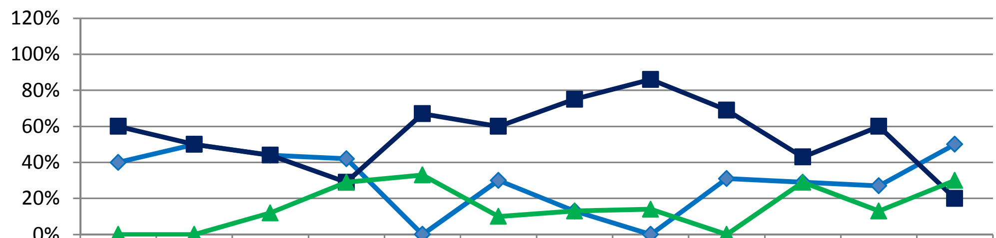
In line with the patent filing requirements and with some of the main activities in its value chain of activities, the Romanian T&C&L industry has filed patent applications to cover the following:

Equipment: new or significantly improved production machinery, systems, devices etc with use in T&C&L industry

Product: obtaining new materials (materials with new functions, which can be used in different industries and domains, not only in the T&C&L sector)

Process: processing raw materials, e.g. cotton, wool, silk, artificial fibres/yarns, fur and animal skins employing new or significantly improved methods

As seen in the graph below (**Figure 2**), product innovation has been the main aim for innovative entities, reaching in 2009 a maximum value of 86% share in total number of T&C&L patent application. The equipment and process categories have recorded both a similar uptrend after 2008.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Equipment	40%	50%	44%	42%	0%	30%	13%	0%	31%	29%	27%	50%
Product	60%	50%	44%	29%	67%	60%	75%	86%	69%	43%	60%	20%
Process	0%	0%	12%	29%	33%	10%	13%	14%	0%	29%	13%	30%
Object of patent application	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Figure 2. Object of patent applications, 2002-2013

The T&C&L industry is a heterogeneous and versatile industry, producing outputs comprising of simple or complex synthetic or natural fibres and fabrics which can be used in multiple applications in various fields, e.g. high-tech and technical garments, household, furniture, civil engineering (construction, automobiles and aircrafts) and medical textiles. The BOPI search allowed for semi-empirically categorizing the T&C&L outputs as "low-tech" and high-tech" according to the novelty and complexity of the scientific approach employed in the creation of either the equipment, product or process. As it is depicted in **Figure 2**, the share of high-tech products has significantly increased after 2008 compared to previous six years, however it still remains a small contribution in the total number of patent applications having product as object. The "high-tech" equipment and "high-tech" process do not show same or constant interest from the innovators. Nevertheless, a clear interest for "high-tech" process innovation is emerging starting from 2007; similarly, the "high-tech" equipment shows an increase from 2007. On the other hand, the "low-tech" T&C&L innovation exhibits a significant increase during the economic crisis.

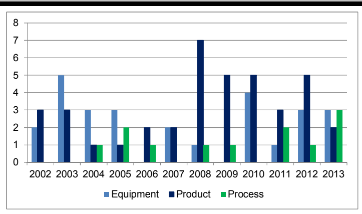
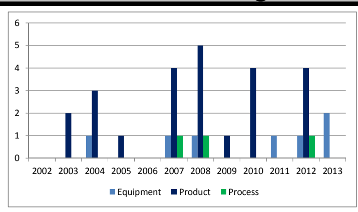
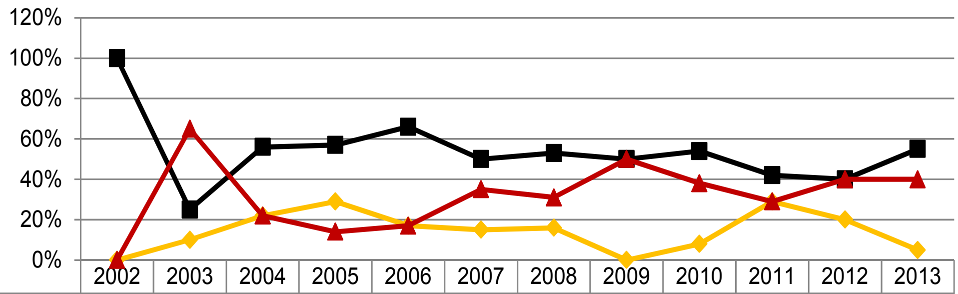
Low-Tech	High-Tech
	

Figure 2. Low Tech vs High Tech T&C&L inventions according to the object of patent application, 2002-2013

As the expectation in business outcomes has significantly transformed from gain to loss starting from 2008, the economic crisis become a trigger for motivating managers to come up with new ideas and for researchers to increase their research and development activities, regardless of the legal status of their organisation. Private or public institutions and other legal entities have acknowledged that despite the rationalization of financial resources, the innovation and the protection of the innovative encounters have to become a top priority. Prospecting innovation through patenting in present paper provides indications to this end. The general trend in Romania was that legal entities other than companies and national institutes (i.e. natural persons) have had a sustained patent filing activity. However, most of their filings were as co-applicants and co-inventors collaborating with national research institutes. The national research institutes accounted for a significant share in the total number of innovating entities (i.e. applicants), likely due to their sphere of activity and access to funding. An important evolution is in the case of companies, showing a dramatic drop in patent-pending innovation activities in 2009, at the beginning of the economic crisis. Nevertheless, companies have made a comeback and their share in all innovating entities increased significantly in the following years yet manifested a notable drop in 2013, as described in **Figure 3**.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Companies	0%	10%	22%	29%	17%	15%	16%	0%	8%	29%	20%	5%
Natural Persons	100%	25%	56%	57%	66%	50%	53%	50%	54%	42%	40%	55%
National Research Institute	0%	65%	22%	14%	17%	35%	31%	50%	38%	29%	40%	40%
Innovating entities	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Figure 3. Innovative entities in the T&C&L industry, 2002-2013

CONCLUSIONS

Considering that the development through innovation in all key sectors, both in micro and macroeconomics, represents the main priority of all medium and long term policies of the EU for sustainable development, Romanian companies in the T&C&L industry have a strong chance of survival and sustainable development if they can concentrate their efforts in research and innovation, focusing particularly on intellectual property protection, while identifying the main risks concerning the innovation and it is valorisation. The overall market positioning and business growth strategies of companies in the textile industry should first of all rely on technological innovation, i.e. inventive products, inventive processes and inventive equipment, and not only on non-technological innovation.

When prospecting innovation through patenting and related risks factors in the context of economic crisis, the impact of the economic crisis on the T&C&L industry in Romania can be summarized as follows:

- Increased innovation activities and increased innovation results protected by patents as IPRs;
- Increased market competition;
- Increased risk taking in direct correlation with the search for new ways of profiting (i.e. valorisation of innovation through IPRs, respectively patents).
- increased collaboration in the T&C&L industry between research entities;
- Change in business strategy of companies by embracing the western world view on IRPs and the related benefits;
- Increased focus on high-tech research of products, processes and equipment;
- Development of new abilities of marketing and communication due to the increased embracing of research cooperation between research entities;

The approach to innovation through intellectual rights such as patents and control of related risks ensures the competitive advantage in the textile T&C&L industry, while facilitating continuity in achieving the company's objectives. There is thus a huge potential for change, growth and innovation in the T&C&L industry as such factors represent both influences and impacts from and on other connected industries.

As future direction of research, a holistic analysis model allowing for systematically correlating the IPRs protected innovation with its risk factors in various economic environments should provide a tool for sustaining the valorisation of innovation.

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MODELING THE MARKETING RESEARCH WORKFLOW – A KEY IMPROVEMENT FOR STAKEHOLDERS SATISFACTION IN APPAREL INDUSTRY

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Abstract: *The enterprises acting in apparel industry are facing with an acerb competition and their competitiveness is wined and maintained by flexibility, fast reaction and conformation to the changing customers' needs and expectations with the aid of the continuous improvement of the fashion-items, related-services, and internal processes.*
The aim of the paper is to design and model the marketing research activities that gain more complex bonds in the case of enterprises operating in the apparel industry. The methodological framework was firstly consisted of a literature review on the current knowledge on topics related to business processes management. Consequently, it has been modelled the marketing research workflow based on the utilization of the business process management notation methodology – BPMN.
The findings highlight the benefits of modeling and simulating the marketing research workflow that enhances the value of the market information while reducing the cost of obtaining it, in a coherently way.

Keywords: *business process management, marketing research, process modeling, continuous improvement*

INTRODUCTION

The textile and clothing sector, an important globally market, is facing with a significant pace of changes determined by the five major drivers as industrial and consumer markets, globalization of markets, knowledge and technology, regulation and policy, and, also the financial crisis.

According to the specialty literature, textile and clothing sector encompass two different market systems: consumer markets mainly characterized by retailing activities, and industrial markets predominately served based on downward industries. As studies argued, the consumer market that represents almost 60% of total textile and clothing market is nearly stable in mature segment whilst industrial market that represents 40% of the total is growing slightly above the rate of economic growth 1 .

Another key driver for changes in textile and clothing industry is referring to the globalization of the value chain with impacts on massively disinvesting on manufacturing, subcontracting and outsourcing related activities from developed countries. These relocations were accomplished with a substantial knowledge transfer, reinforced by the weak protection of intellectual property that creates the new product development and innovation as a means of facing global competitive pressures. Indeed, over the last ten years, more than 85% of patents field in the EU to the European Patent Office were technical textile.

As far as the regulation and policy driver, the growing sensitive of the key governmental bodies to environmental issues has determined the SMEs from the textile and clothing industry to cope with environmental protection regulation. Undoubtedly, the textile and apparel industry has one of the longest and most complex industrial chains within the manufacturing industry, being fragmented by three end-uses: clothing, home and technical textiles. The apparel and textile industry encompasses a wide number of sub-sectors that covers all the production life cycle from manufacturing raw materials to semi processed and final products.

Overall, the apparel and textile industry account for 75% to 95% of the total environmental impact that mainly arisen from the use of electricity to heat water, run laundry and drying processes. Thus, the main environmental concerns in textile and clothing industry are referring to the amount of water discharged and the chemical load it carries as well as the energy consumption, air emission, solid waste, noise and odors.

According to the study Assessment of the way research and innovation outcomes are transformed into marketable products/processes , the most important attention for SMEs from apparel industry appears to be the initiative for raising the productivity, followed by investments in technology and process development. Over the last decade, approximately the half of textile and clothing enterprises at EU level increased their investments in innovation the operating activities related to market development and new product development, followed by process improvement. These realities are related to the industrial markets were enterprises had to adopt innovation roadmaps and technical specification concerning materials, manufacturing technologies and system integration of their beneficiaries in medical devices, automotive or construction sectors 2 .

The improvement of internal processes and the workings are possible with the aid of process thinking, a key enabler for enterprises to survive on the long term through the holistic understanding of any system. The emergence of process management is supported by significant developments in the field which defined the value chain concept with a clear distinction between core processes such as research and development, production, marketing and selling, and support processes as procurement, human resources, IT, etc . The value chain is closely related to the value proposition concept that allows a thoroughly understanding and modeling the enterprise in a way in which the processes and activities with no value added should be eliminated 3,4 .

The advent of IT has allowed modelling the internal processes based on automated processes that facilitate radically new business models. Emerging digital technologies presents an innovative vehicle for modeling the enterprise environment that change the way decisional factors make decisions to solve enterprise problems. Using the powerful IT instruments for knowledge processing, the decisional factors is moving from making decisions based on shallow analysis and weak resources planning to deeply informed, accurate and opportune decisions [5].

As researches in the textile and clothing industry highlighted, the use of ITC in the business processes such as marketing, design, logistics, supply chain management, production planning and customer relationship management have been strongly increasing over the last years 1 . Moreover, the innovation of work as well as the use of customer and market innovation and organizational innovation require designing end-to-end enterprise processes based on the conceptualization of any work as a process, identifying its beginning, end, intermediate steps, clarifying the process's customer, measuring the progress, and ultimately improving it.

Lastly, globalization of markets, the high rate of consumption, and the fast changes in the customers' attitudes and preferences have affected the apparel industry in terms of the compression of the product life cycle, for the whole range of clothing items and equipment. These realities contribute to the increased demand for good marketing research endeavors as a means for capturing customers' perceptions and attitudes, and for analyzing the apparel buying behavior towards a boarder understanding of stakeholders' satisfactions 6, 7 .

EXPERIMENTAL

The scope of the research was consisted of applying the Business Process Modeling Notation (BPMN) for modelling business processes in the context of the enterprises acting in the apparel industry. As marketing research process is a sub-process of marketing process, embedded in the core processes of enterprise it was supposed that an effective marketing research model would enable enterprises to market their clothing products in a straightforward and cost-effective manner, according to the seasonal influences and fashions trend.

Modeling the marketing research workflow has drown valuable insights from the APQC s Process Classification Framework developed by the world-wide leading organization in business practices, business benchmarking and knowledge management research. These frameworks enable researchers and practitioners to make objective comparison of organizational performance within and among organizations through an out-of-box thinking and searching for insights not typically found within intra-industry paradigms. [8].

The Process Classification Framework enables enterprises to properly understand the inner workings from a horizontal process viewpoint rather than a vertical functional viewpoint. In this way, it is possible to make a clear distinction between the operating processes encapsulated in the enterprise s value chain that creates added value to the stakeholders, and supporting processes that enable a coherent functioning of the previous ones. In this regard, table 1 shows a synopsis of the high level process framework.

Table 1: The synoptic view of enterprise s process classification

Process category	**Processes types**					**The goal**
Operating processes	Develop vision and strategy	Design and develop products and services	Market and sell products and services	Deliver products and services	Manage customer service	To create and deliver added value to the stakeholders
Support processes	Develop and manage human capital					To ensure a coherent functioning of enterprise, as a system
	Manage information technology					
	Manage financial resources					
	Acquire and construct property					
	Manage environmental health and safety					
	Manage external relationships					
	Manage knowledge, improvements and change					

It is worthy to emphasize that the role of the marketing research is mainly cross-functional since the corresponding flow transcends the boundaries of different internal processes and encompasses a wide range of information depending on the key decision makers and other stakeholders [9].

Thus, analyzing the coordination on resources allocation depends on the stage in which the marketing research is performed, as table 2 reveals.

Table 2: The cross-functional role of marketing research flow

Process category	**Processes types**					**Goal**
Operating processes	Develop vision and strategy	Design and develop products and services	Market and sell products and services	Deliver products and services	Manage customer service	Creating added value
Marketing research related processes	Survey market and determine customer needs and wants	Analyze market segment, portfolios and technologies Test market for new/revised products and services	Understand markets, customer and capabilities	Procure materials and services	Measure and evaluate consumer satisfaction	Delivering added value
Marketing research workflow	Wide range of marketing research information					Improved stakeholders satisfaction

Performing an effective and efficient marketing research project within the apparel industry so that the stakeholders involved accomplish a high level satisfaction, it is necessary to accurately design and model the marketing research workflow. The hierarchical decomposition of inner workings emphasizes the role of marketing research flow in performing the related processes embedded in the value chain processes, starting with the process survey market and determine customer needs and wants and finishing with the process measure and evaluate consumer satisfaction .

One of the most valuable methods for process modeling is the Event-drive Process Chain (EPC) that use the business process management notation – BPMN for creating graphical models for process operations, named flowcharts [10]. According to specialists, the process flowcharts are seen as easily understandable by all users starting with the business analyst that design the process to the technical person responsible for implementing, managing and monitoring those processes. The method allows modeling the flow diagram using: activities, events, and logical connectors as syntax elements which enable the conceptual integration of the information system design [11].

The process flow diagram using EPC answers to the question what should be done? , enabling to define and design the required activities, the corresponding events, and also the possibility to create a modular framework based on the process interfaces [12]. Generally speaking, the Event-driven Process Chain (EPC) technique is a modeling language for representing the logical and temporal dependencies of activities encompassed within any type of process. In this regard, table 2 presents the syntax and semantic aspects for designing and modeling the marketing research workflow with the aid of EPC that enable the conceptual integration of the information design.

Table 2: The syntax and semantic aspects of the EPC

<table>
<tr><th>The syntax</th><th colspan="3">The semantic aspects</th></tr>
<tr><td>Activity</td><td colspan="3">Describes clearly and concisely the action is performed</td></tr>
<tr><td>Event</td><td colspan="3">Describes pre-conditions and post-conditions of functions
Do not consume resources of any kind</td></tr>
<tr><td>Process interface</td><td colspan="3">Marks the necessity of executing the process in question between the flowchart's predecessor element and the flowchart's successor element.
May indicate an input from another process, an output for other process, or an output for another process with feedback loop after the execution of that process.</td></tr>
<tr><td rowspan="4">Connectors</td><td rowspan="4">Describes the precedency relationship between the activities/ process interfaces</td><td rowspan="3">SPLIT connectors</td><td>AND-split (A) - triggers the execution of all subsequent branches in concurrency</td></tr>
<tr><td>OR-split (O) - triggers the execution of any combination of the multiple subsequent branches, based on the condition of at least one branch execution;</td></tr>
<tr><td>XOR-split (X) - represents a choice between one of several alternative branches and requires the execution of the selected branch.</td></tr>
<tr><td>JOINT (J) connectors</td><td>Have multiple incoming arcs with one outgoing arc</td></tr>
</table>

RESULTS AND DISSCUSION

The result of modeling the marketing research workflow, represented by the process diagram in fig. 1, designates the major role of accurately define and analyze the business need that trigger the market survey. Thus, if the business need is not well defined, it will be triggered the execution of the process interface aimed at documenting all high-level information about the context of the research, research objectives, high-level requirements and assumptions, targets to research, a roughly description of the decision makers, time and cost constraints, key milestones, the budget estimates, key stakeholders, and the person in charge with the marketing research endeavor. Consequently, the marketing research brief, formally authorized by the stakeholders, triggers the execution of activities related to elaborating marketing research proposal.

The marketing research proposal is obtained by performing a set of activities aiming at documenting in details the following aspects: I) background – context of the research, assumptions, risks etc.; II) problem definition – diagnosing the problem and identifying specific components for marketing research problem; III) research objectives – research questions or hypotheses that may be tested; IV) research design - exploratory descriptive, or casual. Methods of collecting data, justification, and a sampling plan with details of sample size; V) data collection – what techniques are to be used, the extent to which the result will be interpreted in the light of the set marketing objectives; VI) reporting – the framework and the form of the final report; VII) timetable – project schedule, broken by phase and the critical path; VIII) Budget – the estimated budget by phase or major deliverables; IX) stakeholders – research organization, key researchers working on the project, and other experts or decision-makers. All of these activities are tracked and reviewed on ongoing basis, followed by the identification and initiation of the corresponding changes.

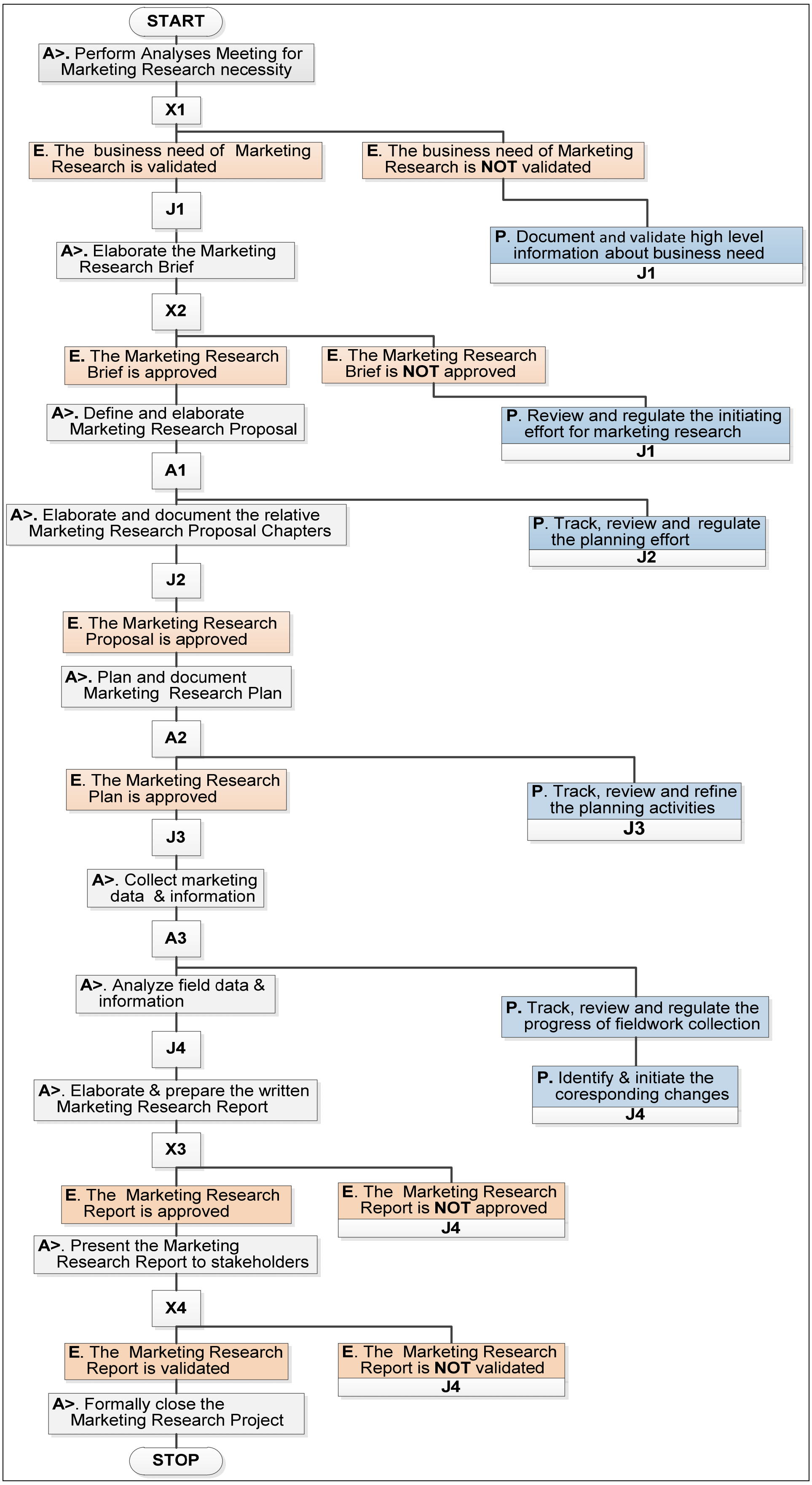

Figure 1: The marketing research process diagram

Executing the process involves collecting data and information from the markets, analyzing data, and reporting findings of the marketing research. Likewise, the tracking and reviewing activities are performed on ongoing bases to assess measurements and trends and to manage the changes. Finally, formally close the marketing research requires obtaining the financial, legal, and administrative closure, colleting lessons learned and transferring the ownership to the key decision makers.

CONCLUSIONS

Any enterprise acting in apparel industry striving to improve the stakeholders' satisfaction will adopt and leverage the process framework to organize workflows and facilitate interactions among work groups. With a strong focus on innovation, the initiative of modeling the marketing research workflow ensures the ongoing improvements of enterprise operations because it enhances the value of the marketing information whilst decreasing the corresponding costs.

The findings highlight the benefits of modeling and simulating the marketing research workflow by taking advantage of the rigorous discipline in related workings, with high impact on stakeholders' satisfaction. Regardless of the process in which is accomplished, the marketing research workflow aims to define, gather, and assess information needs and to provide relevant and effective information to stakeholders. Thus, enhancing the chances of success and improving the stakeholders' satisfaction are possible with the aid of systematic and objective marketing research activities that would satisfy the requirements in terms of accurate, actual, opportune, relevant and exhaustive information about the customer perception and attitudes, and market trends.

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SPECIFIC APPROACHES FOR COMPETITIVE POTENTIAL GROWTH OF THE GARMENT MANUFACTURING COMPANIES IN THE CURRENT PROFILE MARKET EVOLUTION CONDITIONS

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Abstract: *In the context of the textile market volatility, the flexibility to adapt to change becomes the key factor of business competitiveness for these companies.. Today’s enterprise is no longer a singular organization, centred on the business process level competencies. The globalization and externalization of some competencies have created an environment in which the supply chains include a number of participants which share the need for prompt and correct information. The garment manufacturer’s position at the highest level in the textile industry in what concerns the materials processing, with the direct impact to the individual consumer, determines the need for accentuated client focus and mass customization.. The case study mainly focuses on the analysis and evaluation of the primary base processes while also taking into account the secondary activities with indirect contributions towards the increase of the added value.*

Keywords: *garment industry, globalization, supply chain, competitivity, strategies & approaches*

1. PAPER’S OPORTUNITY

Romanian textile and garment industry is economically important, with approximately 9,200 manufacturing companies, being quite well represented in global competition.
From the products exported in 2009, 10% are represented by textiles, which represent the third type of the exported merchandise [1].

The East-European market has modified dramatically after 2010, as post crisis the companies have been compelled to freeze their activities, and together with the partial market come-back an acute need was felt to extend the production and the logistic network [1]..

In the market economy, the competitive potential is given by the capacity to sell products and services at a profit in competitive landscape conditions - a combined result of both quality and productivity [2].
Both productivity and quality are conditioned by the quality and cost of the involved `resources in the manufacturing processes of garment products.

Given the dynamics of fashion reinvention and relocation / the geographical mobility of suppliers and customers, the secure delivery to term “just in time” becomes a significant factor of supporting the potential competitive potential of garment company.
In this context the modern enterprise is facing a complex external environment factors: global market competition, strict delivery terms demanded by customers, quality and price exigencies, the need for diversity and customized products.
The key to survival and development through competitiveness in such a tough demanding and challenging environment is flexibility of adaptation/ adjustment and innovation.

Taking into account the specificity of garment industry in the world, among the action directives of Romanian garments companies related to the increase of the competitive potential it is recommended [3]:

- flexible and computerization of manufacturing systems
- restructuring and modernization of garment companies in adopting new technologies, new ways of work organization to increase work productivity.
- development of new brands and promoting their image.
- adapt quickly to market challenges, to meet customer‘s requirements
- specialization of human resources through professional training to meet customer’s quality requirements of garments companies.

• shortening the manufacturing cycle.

In the context of the textile market volatility, the flexibility to adapt to change becomes the key factor of business competitiveness for these companies.
The current paper deals with the issue flexibility of development and adaptation at the internal logistic level, as a support resource for the competitive potential of the textile manufacturing companies..

2. TECHNIQUES AND INSTRUMENTS WITH INDEPENDENT ACTIONS FOR THE GROWTH OF THE COMPETITIVE POTENTIAL OF THE GARMENT COMPANIES

A business process consists of all the activities involved in producing the projected output which is handed over to internal or external customers and for whom it represents a value. The business processes must also lead to an increase in the value of the product and an increase in value creation within the enterprise.

The core competency of a manufacturing system is to optimally bring together the employees know-how with the capacitive potential of the company.
We are often tempted to believe that only the production ensures the creation of "added value" to the company, by transforming raw materials, into products needed by the customer. However, the success of the production activity, in significant proportion depends on a good logistic, internal and external company support. As a result, "logistics" at its turn is a source of profit. The integrated logistic system by defining the three flows (material, information and financial), supposes the treatment of logistical problems from the product design to after-sales services

The ensurance of a stable environment for garments companies is essential to find new markets, to integrate value chains (SC) able to rapidly and on long term develop. The basis of the success for market place is numerous, but a simple model sits around the triangular relationship between the company, customers and its competitors "Three C".

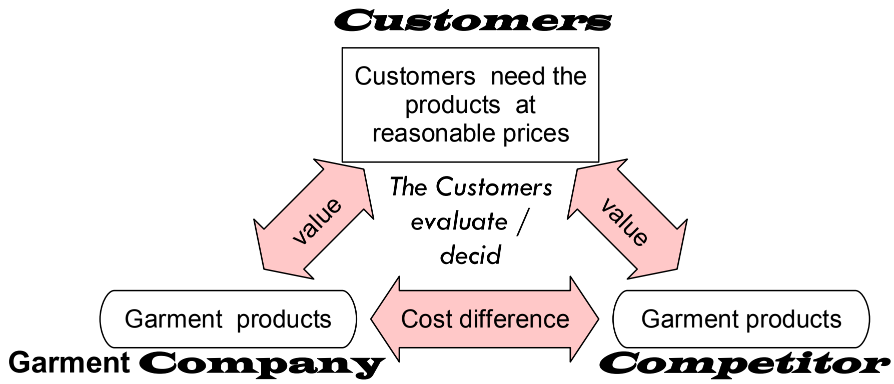

Figure 1. The competitive advantage and the 3 *C*

The primary source of the competitive advantage is first of all the company ability to differentiate its competitor, in customer's point of view**,** and secondly by functioning / operating at a lower cost having thus a higher profit.

2.1. The integration of garment company in supply chain structure

Today's enterprise is no longer a singular organization, centred on the business process level competencies. Those companies which will learn how to create and participate to powerful supply chains will have a competitive advantage, important on their markets.
Among the multiple definitions of the term "logistics", we consider it to be the most suggestive one: all activities which have as aim to provide at minimum cost a certain amount of products in the place and when it is demanded, managing and optimizing the physical flows from suppliers to customers/clients.
The enterprise supply chains concept includes all suppliers, production capacities, distribution centres, warehouses and clients, together with the raw materials, semi-fabricated and finished product stocks, and all the resources and information involved in meeting the customers

requirements [4].
In **garments** business field, a series of **international practices of cooperation between partners from a supply chain structure is operating.** The Companies in Romania develop their business mainly through the following systems:

- **CM (cutting-making)**, known as **lohn** which includes **the production cycle** comprising: cutting, sewing, umido-heat treatment, amn their packaging markets.
- **CMT (cutting-making-trims)** or " **semilohn** " which includes **the production cycle plus accessories and packing supplies** (buttons, thread, cardboard boxes, labels, bags, plastic, etc.)
- **FOB (Free on Board),** where the client is absolved from any risk, and requires the manufacturer liquidity to finance the production.

In the currently, Lohn - **CM** holds a significant share in the Romanian garments production. Globalization, highly competitive markets, and the fast pace of technological change is the key to "supply chain" development, of the value chains in which several companies are working together, each focusing on activities they do best.

For most cases, a company will focus on its core business competences in administering the supply chain, and will outsource the rest
Therefore, under the globalization of world economy, of the increase of production costs in Europe more and more brand owners adopt FOB system to simplify the logistics of purchasing raw materials and accessories and to receive the finished product.

The functional integration of garment company in the "supply chain" structure, through the material, financial and informational flows cooperation is dependent on the adopted cooperation system (Figure 2).

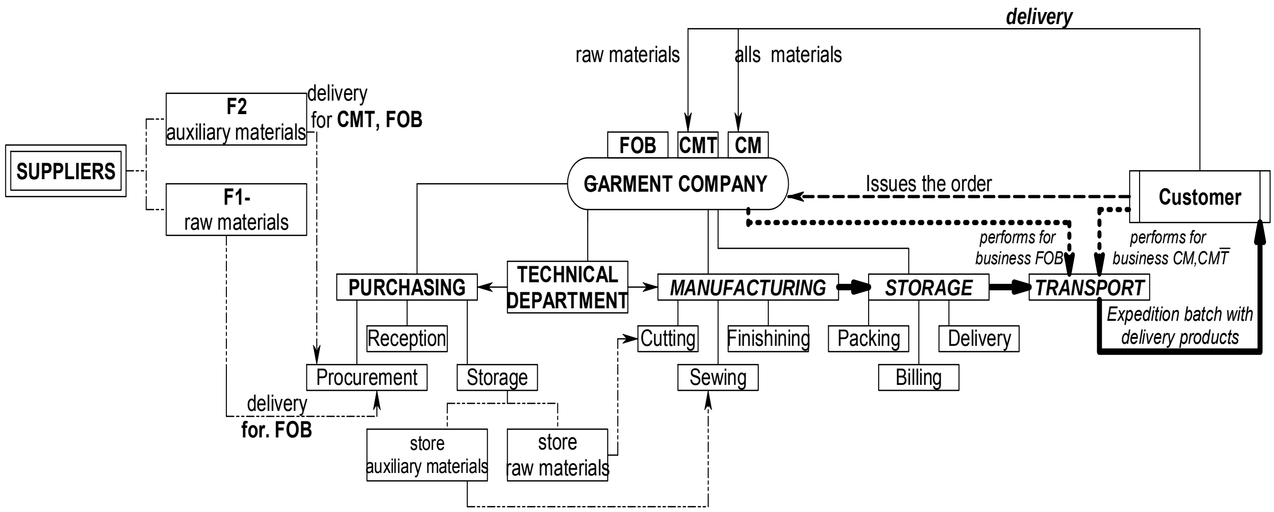

Figure. 2. Configuration of supply chain for a garment company

2.2. Focus on customer, a competitive potential improvement tool for garment company

The garment manufacturer's position at the highest level in the textile industry in what concerns the materials processing, with the direct impact to the individual consumer, determines the need for accentuated client focus and mass customization.

For the entire process, more important is that at the creative chain extremities there is "someone" who wants to hear more and more and who claims the right to get what he wants - the final consumer. The customer does not ruin us, he asks us, encourages us, changes us. He establishes the requirements that must be fulfilled if we want to remain competitive. By "mass customization" the customers are given the opportunity to create and choose the product within certain specifications.

Under the growing trend of individualisation of the end users' requirements of garments products, a way of gaining the competitive advantage is the mass customization system. The focus is on the development of customized products, adapting the garments to world fashion trends dictated by fashion, a new design, new technologies of product manufacturing, integrated quality and new modern concepts of management of the life cycle of a product.

Mass customization is a strategy in supply chain, which aims to meet market changing and increasing environment, trying to utilize mass production benefits. Mass customization (MC) is a marketing and manufacturing technique that combines the flexibility and personalization of "custom-made" with the low unit costs associated with mass production.
The end of the era of textile garments mass production marks the transition to a new industrial era of adaptation to the customer and personalization of products, simultaneously with the application of the concepts of production, logistics, distribution and smart services [6].
Mass Customization"uses flexible manufacturing systems assisted by computer to produce customized items in the three business variants: CM, CMT and FOB.

The technological and organizational requirements necessary to implement MC technologies involve advanced manufacturing technologies and ITC technologies.
A garment "made to measure" made to fit to each customer individually in terms of dimensional mail correspondence with the attire and lifestyle of the customer also ensures / provides competitive advantage, a new market niche for the garment manufacturer.

The concept of "Made to measure" refers to garments made by existing patterns based on standard sizes, through customized adaptation to specific customer's measurements.
The production process involves the inclusion of specific additional steps: taking customer's sizes (directly or online), drafting the customer's personal characterization, setting up the date for delivery, adapting patterns selected from the database, organizing specialized manufacturing production lines, customizing technical documentation, workers' training, making fittings on the customer, making changes if necessary after fitting site and prepare for delivery.
Using modern technology and efficient work systems generally support the competitive potential of garment companies. Only the creative, effective and motivated employees can help the company to gain a competitive advantage

The globalization and externalization of some competencies have created an environment in which the supply chains include a number of participants which share the need for prompt and correct information**.**
The **IT** technologies in the supply chains management through dedicated software solutions, integrated into a common platform for enterprise resource management, provide practical and concise, and more efficient in terms of time, accuracy and cost, communication between the company, customers and suppliers.

3. WORK METHODOLOGY

The systematic approach of the impact factors on the competitive potential of garment companies, defines the purpose of the paper.

The specific objectives are considering:

- ways of valuing the logistics system resources in terms of company competitiveness
- specific approach of flexible core processes (primary and secondary) of the company as a potential competitive growth factor
- assess the capacity to react promptly and effectively to changes generated by market challenges

The research methodology aims to address the garment company as a functional entity with direct input in creating added value in the structure of the value chain called "supply chain" of making textiles.

Procedural approach revaluates the case studies, which have been the subject of research within the dissertation papers, specialization SIPC within FTPMI .

The topics of case studies aimed at analyzing the flexibility of the internal logistic system components and their impact on the competitive potential of garment companies. Factors and resources to improve the competitive potential of define the subject of study.

Deliberately, the case studies mainly define the analysis and impact assessment processes for manufacturing flexibility in connection with the supply and delivery logistics activities, with indirect contributions to the creation of the added value.

Documentation was performed within garment companies with fields of activity and practices of international contractual cooperation in different businesses:

- Small / medium companies which are working in lohn system (CM), mass products for women as subcontractor. The business process is limited to cutting + sewing manufacturing only, the other components of the value chain, being borne by contractors company
- Large and medium companies specialized on product (casual and classic products for men) which are working in CMT and FOB systems.
- Large companies specialized to produce luxury garments, fashion products, casual, classic, mass products and even "made-to-measure", having concluded agreements preponderantly in CMT and FOB with production system. In particular situations to produce "made-to-measure" on personalization considerations in meeting customer's requirements CM system is used.

4. RESULTS AND INTERPRETATION

In light of the defined objectives, the research approach is based on:

- General assessment of variability of the capacitive factors (Table 1) in the context of the particularities of the companies under study
- Evaluation of controls variability in terms of technology, considering the tasks arising from orders (table no.2)
- Assessment of the need of flexibility for capacitive factors of the internal value chain.
- Identifying and formulating ways to improve the competitive potential, appropriate to the type of company.

4.1. Primary Data

Table.no.1. Characterization of working capacity at manufacturing lines level

Type of company		Pcs/year	Types of business	Structure of production	Ways of delivery	Nr. of technological lines	Nr. of operators per /line	Equipment level
1.Subcontracting companies		100000	CM	Blouses, dresses for women	The Order is entirely at contractor	1	50	Classic Universal Machines
2.Companies specialized on product	2a.	700000	CM, CMT	Jackets for men	The Order is entirely at customer	5	50-90	Medium level of specialization
	2.b.	200000	CMT, FOB	Trousers for men	The Order is entirely at customer	2	40-50	Performant Specialized Machines
3.Companies for fashion products		600000-800000	CM, CMT, FOB	Products/ garments for women and men	Weekly, composed batches*	23	12-25	Performant Universal Machines

** The delivery batch may include models, articles from different orders adapted to customer's planning*

Working capacity (number of technological lines, number of executants, equipment level), type of business (way of working with customers and suppliers) are important factors in the competitive potential of garment company.

For small subcontracting companies, the preponderance of the contracting system CM (lohn) limits the possibility to increase working capital from its own resources to develop advanced technical resources and production forecasting structure plan on long term. Limiting the business process competences only to the manufacturing processes, and taking the full production by the contracting company, simplify the logistic system of the company.

The relatively large size of manufacturing lines (50 workers), makes it difficult to assimilate new models with productivity losses. The minimal technical equipment with a normalization of work often empirical leads to develop activities focusing on labour intensity with great efforts for quality assurance.
The model relative stability (the coefficient of the technological uniformity with values generally above 80% [5] *capitalization of typing the benefits of standardization*, makes for the companies specialized on product

become feasible the support of competitive potential by automatic machinery equipment, specialized on operations. The stability of the type of product supposes the inclusion of a number restrains / stable suppliers in value chain structure. So, the advantages of supply might brings a positive impact on the competitive potential, especially for CMT and FOB business systems.
Small lines with a reduced number of executants make available the fragmentation of orders, meeting customers with deliveries in composed batches composed within the companies oriented on fashion products. A larger number of production lines favour their dedication on customers or groups of customers. This thing reduces the assimilation times of the new models, a better stability of quality requirements from customers is ensured with a greater impact on the competitive potential of the company is ensured as well. The increased frequency of deliveries leads on one hand to the diminishing of the storage space, but on the other hand requires a very rigorous production planning, supply and delivery coordination. A plausible solution in this case is the implementation of dedicated information systems (e.g. AS 400)
But, given the trend of personalization of finished products delivery to a larger number of (final or intermediate) customers, a systematic allocation of space for preparing batches of delivery is required.

4.2. Flexibility, factor of impact in competitive potential growth

Table 2. Assessment of orders variability considering the criteria of flexibility

Crt No.	Parameters of variability	Dimensions of parameters/ on types of company (tab.1)			
		1*	2		3*
			2a	2b	
1.	Quantities on model, *(buc)*	1000-2000	900 -1500	10-6000	1 -1400
2.	Production on shift, *(buc)*	350-450	200 - 400	400-500	40-95
3.	Times of execution / model (*min)*	50-60	100-140	40-50	90 -140
4.	Technological Complexity – number of phases per model	35-40	90-120	80-90	60-75
5.	Technological Flexibility, *number of operation /(%)executants*	1/88 % ; 2-3 / 12%	1/58%; 2/40% 3/2%	1/27%; 2/39% 3/19%;4-5/15%;	1/8%; 3-4 42/%;6-9/50%;
6.	Technical Flexibility, executants *no. of equipments / (%)executants*	1/100%	1/89%; 2/8%; 3/3%	1/39%; 2/37%; 3/18%; 6-7/6%;	1/42%; 2/50%; 5/8%;
7.	Flexibility of the equipments; *number of operation / % equipments*	1/90%; 2/8%; 3/2%	1/82%; 2/15%; 3-4/3 %	1/68%; 2/25%; 7/3%	1-2/48%; 3-4/28%; 5-8/24%

** - for Case 1 and 3, data are reported to the product named blouse, holding a significant share in the structure of production*

The Interpretation of the parameters of variability of the production plan within the coordinates of the capacitive flexibility factors of the analysed manufacturing systems highlights the need for specific approaches, to increase the competitive potential.

Drawing up coherent and viable strategies to improve continuously the competitive potential, supposes approaches adapted to the particularities that define each type of company related to the undertaken competences within the value chain structure.

The diversity of orders in terms of number of models, quantities and model complexity characteristics, generates tasks for system variables in general, and for the capacitive factors as well.
The low level of technical and technological flexibility of executants and means of work for small subcontracting companies (Table 2, column 2), generates difficulties in the fluency of technological flows and hence difficulties in compliance with the delivery deadlines implicitely . Such measures to improve the competitive potential will focus on:

- technological flexibility of workers, *motivational stimulation to increase the flexibility of workers*,
- improvement of working methods, *with direct effects on work productivity* ,
- supplying with easily replaceable technological devices, *with direct effects on work productivity and quality stability*
- employment qualified staff to perform activities of maintenance for equipment, even in part-time schedule, with significant impact on the delivery deadlines safety.

In the case of companies specialized on complex products (jackets for men, column 3, table 2), the universality of machinery/ equipment, shortage of technological devices,relatively high times to perform the technological steps assume their assignment to more executants, by means of the indicator of technical flexibility of the executant (1/89%) or technological flexibility of the equipment (1/82%) respectively. This thing adversely affects the uniformity of quality, labor productivity and delivery deadlines safety implicitely .
Among the resources to improve the competitive potential there are highlightened:

- the increasement of machines equiping with technological devices,
- the supply with specialized machines on operations,
- the flexible lines by structuring on groups,
- defining some groups focussed on automatic machines which should serve multiple lines.

The increased flexibility of the capacitive factors from the manufacturing system of companies specialized on product (column 4, table 2), promotes the efficient uptake of new models. The Development of the competitive potential assumes :

- the exploitation of flexibility resources of specialized equipment (full use of the adjustment areas)
- the improvement of maintenance services, by specializing the staff who are responsible of
- the implementation of informational systems assigned to process design, management and production tracking and standardization of work (eg SPD, GPD, SSD ..).

Assigning a large number of technological stages for executants (6-9 / 50%, column 5, table 2) from companies of type 3, raise problems to productivity and to the achievement of the planned production.
The data analysis of the effectiveness of 23 lines for a period of six months, results in achieving the physical production in percents of 64 -82% in terms of planning for 80% of working time. This situation is explained by prioritizing the focus mainly on customer in the detriment of the process. However the maintenances and development of the competitive potential requires a balanced approach to the two issues. In this respect, let's consider the following actions as appropriate:

- to redesign the work methods defined on individual operations, the operations comprising 3-9 phases (table 2, column 5).
- to reconfigure work places for multiple tasks (3-4 / 28% 8.5 / 24% tab.2.)
- to consider the workers ' performance rating on each operation, while dimensioning the time norms used in planning
- to reassess the allowance times dimensioning from the time norms structure, taking into account the perturbing factors to the interference between the components of the internal supply chain (supply-cutting - manufacture)
- to organize training courses related to working methods for workers,
- to motivate the employees by using the flexibility index in flexibilizing the payment system
- to provide equipments with providing specialized devices which are easily replaceable / adjustable.

The complexity of value chains this type of companies being integrated in (large number of production lines, structural diversity of manufacturing programs - types, models, different quality standards), a large number of customers and suppliers, assume strategic approaches for the development of the competitive potential. The large number of customers (about 40) implies the existence of a specialized staff. responsible for logistics at the level of each the client.

The effective articulation of inter-organizational and intra-organizational interfaces between the components of value chain with minimal disruption requires the support of a specialized computer system. By means of the component modules, the system optimizes the communication, providing information about planning and managing the supply and movement of the supplied goods to carry out orders, and information on the movement of procurement documents, deliveries and payments.

The permanent adaptation to customers' requirements in a constantly changing industry, such as garment industry, can be materialized only through continuous investment strategy, in technic technology and human resources. The main objective of software development is to strengthen the position on the national and international markets, primarily qualitatively and then quantitatively and to comply with the shortest delivery deadlines.

5. CONCLUSIONS

The way a society defines the core competencies and the way they are positioned within the supply chains they are serving is one of the most important decisions. The Romanian business in garments are moving

nowadays from **CM** to **CMT**, from **CMT** to **FOB** system, and in the case of medium and large companies working with a larger number of customers, all the three systems coexist.
Given the diversity of the way of integration / positioning Romanian garment companies in the "supply chain", it is required to avoid patterned approaches on improving their competitive potential. In order to remain competitive the core competencies needed to focus on three strategic areas, focussing on customer, focussing on employees, focussing on process. Each organization tries to maximize its performance through a combination of outsourcing, partnership and expertise.

An efficient management of the value chain requires simultaneous improvements both at the level of services for customers and at the level of the operation internal efficiency, levels which seem to be contradictory sometimes. For example, the requirement to maintain a high level of quality in terms of fluency in customer's service (frequent deliveries at short intervals of several models, types, items), lead to the maintenance of a high level of stocks and that of storage capacity inclusively. Therefore, the condition to operate efficiently needs to reduce stock levels, frequency of deliveries, storage capacity, minimum delivery time.

The dual approach of competitive potential in terms of meeting customer's requirements (the quality and the delivery deadlines safety) the efficient producer's efficiency implicitly, assumes that the solutions for improvement should target balanced and weighted components in the value chain.

Small companies which are subcontractors of orders, focus their resources on the main basic processes, face difficulties in compliance with the delivery deadlines, make great efforts in assuring products of high quality and depend to a great extend on the subjective factor.

In the structure of the organisation chart of large and medium companies with financial potential, we find specialized logistics departments with qualified staff and adequate facilities, dedicated software designed to manage the entire of supply chain. The transformation of the supply department from a centre assigned to materials acquisition into a centre of profit which competitively sells its services is an important factor in sustaining the competitive potential of the company.

The manufacturing process experience has confirmed that the build-out of an agile supply chain, adapted to the CM, CMT and FOB production systems, is very well suited in improving the competitive potential. Agility defines the capacity of forecasting the market challenges, of quick and efficient response to change, of smooth absorption of external disruptions, for quick adaptation.

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ASPECTS REGARDING SOME IMPORTANT REQUIREMENTS TO REACH SUCCESS IN PROJECT MANAGEMENT

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Abstract: *Today, the projects complexity is growing up because of the diversity of environment, great number of constraints, and a deeply involvement of stakeholders. As a tool of change a lot of project fails to reach their target not because technical reasons but because the human resource were not addressed. Thus, some of the critical success factors in project management refer to have a good project manager and team in the same time. To develop a project manager and to build and manage a project team is a very hard challenge. But, there are no successful projects without successful project managers and teams based on the both personal skills and a strong education in project management, too. This paper is based on the both documentary research and author's experience in the project management field.*
Keywords: *project management, success, requirements, project manager, project team, training.*

INTRODUCTION

The project management is today a modern way for the worldwide business development. To realize many activities and more work with fewer resources, to increase quality and efficiency, to find the better solutions for planning, to make good decisions, to be more creative, and to response more quickly to the customer demand, there are some characteristics of a project.

Each company which implements projects or programs can be defined as a **p**roject-**o**riented **o**rganization (POO), with specific strategies, structures and culture. Many firms develop the management by projects (MBP) as a *modus-vivendi* and as a new relative concept in order to conducting the business and improving the internal operations, in a decentralized network organizational atmosphere, and to satisfy the both categories of internal and external clients [1].

The military and aerospace projects have characterized the 1st stage of the modern MBP. The 2nd stage of the MBP has been characterized by the major projects with technical objectives and the support received from some important stakeholders as the World Bank, United Nations of International Development Organization, etc. The International Project Management Association (IPMA) developed the 3rd stage of the MBP since 1990 by the implementation of it as a new organizational strategy [1].
A question is coming: which are of the most important requirements in order to reach success in project management? Of course, the answer is very complex because it refers to a lot of factors with a strong influence on the project performance. But, in this paper the author presents some aspects regarding only three of the most important factors namely the project manager, project team and education in project management. This paper is designed on two directions:

A documentary research in order to find more and new information and best practices regarding the critical factors and their main features of projects success.

The author's expertise in the last years as a teacher of project management and as participant in different internal and international projects, too.

PROJECT MANAGER: THE NUMBER ONE FACTOR OF PROJECT SUCCESS

MBP as a concept is not a substitute for a weak management of an organization! The project manager is the person who must take the overall responsibility for coordinating a project, to make sure the results come in on time and within the budget [2].
That's why the project manager is the most critical factor to get success in every project, and he(she) has to be a manager and a leader in the same time because of the next reasons at least:

Management is the science and art of getting people just to do something 'the chief of project' is convinced that should be done. The management controls people by pushing toward the right direction.

Leadership is the art and science of getting people to want to do something the chief of project is convinced that should be done. The leadership motivates people by satisfying the basics human needs.

As *a manager* the project manager usually has to have a short/medium term vision, and he(she) establishes how and when has to do something, plans, solves, maintains, controls, accepts, and imposes.

As *a leader* the project manager usually has to have a long-term vision, and he(she) establishes the project direction, and what and why has to do something. The project leader inspires, develops, motivates, changes, and convinces. The project manager has to be in the same time a transformational leader who applies a charismatic leadership (the leader inspires and challenges deep feelings) and a transactional leader who applies a managerial leadership (the leader motivates, convinces, and rewards).

The leadership can affect the state of mind, productivity and quality, so that the project success is directly dependent of a good leadership. The shared leadership is very important because it means the involvement of all the team members in decision-making, problem solving, and to accept a real responsibility. By example, each key phase or task could be owned by one of the team members who accept the role of *key stage owner.* This responsibility is very important to make sure the work is done on time and also give the feeling of ownership [3].

The project manager has to apply different leadership tactics to influence the members of project team, stakeholders and even top-management in order to get their support, as the logical persuasion, inspired appeals, involvement, attraction, personal favours, changes, coalitions, stress, and legitimate requirements. The US Army Handbook, Military Leadership section recommends certain principles and key points in order to reach performance in leadership which could be used in project management [4].
The negotiation is one of the critical skills required of the project manager, and it may be the most important. There are conflicts over schedule, priorities, labour, technical opinions, procedures, cost and personality throughout all the phases of the project life cycle.

The most important qualities of an efficient project manager such as a manager and leader are shown in the figure 1. It is synthetic author's point of view based on the both theoretic recommendations [5], [6] and personal expertise of project managers.

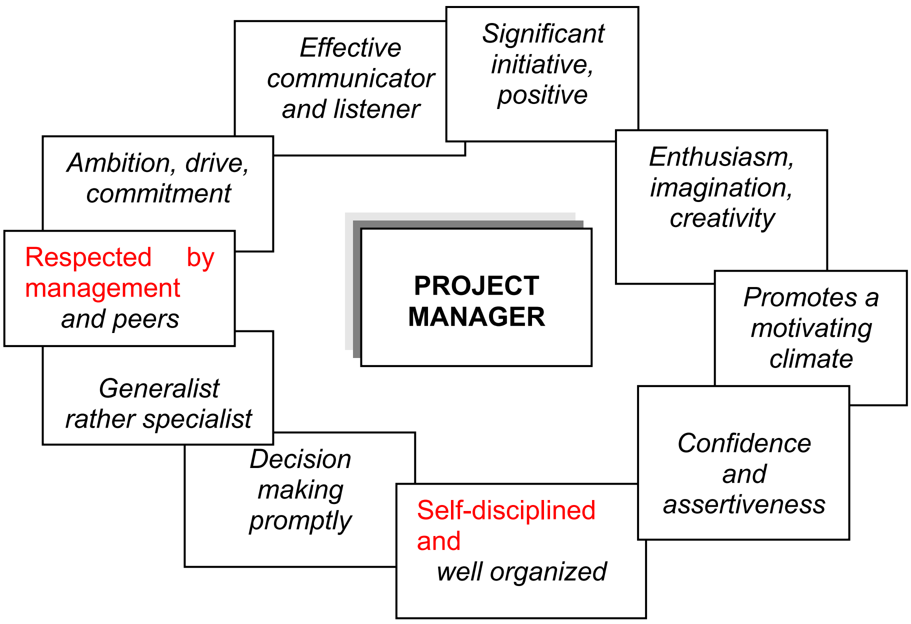

Figure 1: Qualities of an efficient project manager.

In addition, there are presented in [2] some traits of good project managers as practical rules for working, as follows:

Enthusiasm for the project.
The ability to manage change effectively
A tolerant attitude toward ambiguity.
Team building and negotiating skills.

A customer first orientation.
Adherence to the priorities of business.
Knowledge of the industry or technology.

PROJECT TEAM: A KEY FACTOR OF PROJECT SUCCESS

The building of a project team is a complex process because there are a lot of characteristics distinguishing it from the traditional team working. The project team is not a group of people who don't enough interact with each other, and each project needs an organizational structure [7]. The project team has a life cycle that has to be very well known in order to manage the performance of individuals and of the entire team to reach the synergy. The project team has to perform the right things and to perform the things right, in the same time!

According the Belbin's opinion relating on team roles the project team has to include a number of shyntetical and analytical roles, as follows [8]:
plant – a creative person with imagination and able to solve critical problems;
coordinator – a member with a clear thinking to define objectives and promote the empowerment;
monitor-evaluator – a good supervisor and evaluator;
resource investigator – a person who can easily identify the right resource, at the right moment;
shaper – a courageous person who works well under pressure and likes challenges;
specialist – the professional number one of the team with valuable skills;
completer – the most analitical member who wants with obstination to reach the perfection;
implementer – a real practitioner who turns in practice a lot of knowledge to obtain performance;
team worker – the conscious person, disciplined, a very good worker.

On the other hand, a project can be associated with a kingdom according its definisions and characteristics. This idea promotes the following roles in order to build an organizational culture, an attitude positive and opened mind to project management [9]:
king – the leader of kingdome;
hero – a very good solver and treasure seeker;
warrior – the person of action who plans the battles and conquers the unknown;
guide – a process facilitator, coach on the field;
guardian – he(she) builds the control system and keeps the flame of the team spirit;
craftsman – makes good work, provides good services;
bard – a person who has to frequently tale about the project in order to promote it.

There are presented in the table 1 some relationships between the previous different but complementary visions on the project team roles, as an author's opinion based on his experience in this area. The project manager or certain team members frequently play one or more roles according the real requirements of the project environment (or, one or more team members play the same role), as the following:

Project manager can play in the same time the roles of plant, coordinator, monitor and shaper (♣) and the the almost roles of the kingdom. Each role is played with a different intensity according its importance.

Other one can play the roles of resource-investigator and shaper (■) and he(she) could be associated with the hero, warrior, guide and bard, too.

Other one can play the roles of specialist and implementer (▲) or, implementer, completer and team-worker (▼) associated with others different kingdom roles.

Table 1: Relationships between different visions on the project team roles

	PROJECT MANAGER	PL ♣	CO ♣	R – I ♣ ■	M – E	SH ♣ ■	SP ▲	IM ▲ ▼	COM ▼	T–W ▼
KING	♣									
Hero	♣	●	●	●		●	●			
Warrior	♣			●		●	●	●		
Guide	♣	●	●	●	●			●		
Guardian	♣	●	●		●		●	●		
Craftsman								●	●	●
Bard	♣		●		●	●				

PL - plant; CO - coordinator; R–I – resource-investigator; M–E – monitor-evaluator; SH – shaper; IM – implementer; COM – completer; T–W – team-worker.

The intensity of each relationship can be evaluate on a relative scale (b. e. from 1 to 5, etc.) according the requirements from each role that are determined by the project features. This action facilitates very much the work of the project manager and project team.

SPECIFIC EDUCATION IN PROJECT MANAGEMENT

International Certified Training in Project Management

The specific training and professional certification have become important requirements to get professionals in MBP. One of the most important and accessed system of training and certification in project management is designed by the International Project Management Association. The specific standard is based on the International Competence Baseline Version 3.0 (ICB-IPMA) which specifies four levels of certification in project management and its main requirements, as follows [10]:

Level A - Project Director:

expert knowledge in the project management and management of POO;
experience as a project manager or manager of a PM Office in the last three years;
Project Manager certified-level B;
scientific publications in this domain.

Level B – Senior Project Manager:

expert knowledge in the project management and management of POO;
ability to manage a complex project;
experience in project management in the last five years and as a project manager in the last three years;
specific training in project management

Level C - Project Manager:

ability to manage non-complex projects or assist the project manager;
specific knowledge in project management;
experience in projects in the last three years and as a project manager in the last two years;
specific training in project management.

Level D - Practitioner

base knowledge of project management;
ability to apply knowledge of project management;
experience in the last year as a member of a project team;

The certification process offers a means to gain a formal recognition of qualification in project management. There is a trend away from the knowledge based examination which assesses the individual's theoretical knowledge, towards competence based on the practical ability to perform.

Personal Experience in Project Management Training

Obviously, the project management is one of the key factors of success in Romanian business environment, and the training in project management has become an important discipline in the curricula of Romanian higher education. According his experience in the last years as a teacher in Project Management the author considers the training on management-by-projects according the project life cycle as one of the best systems of training. The coordinates of training are learning-by-learning, learning-by-doing and learning-by-interacting. The training modules are the following:

a) *Introduction in Management-by-Projects.*
The aim of this stage is to offer access to the basics of project management.
The project life cycle, relationship with project line management and project environment analysis there are some of the important elements of this stage of training.

b) *Project Initiation, Definition and Design*
The aim of this stage is to design the project.
The design of project object, to select the project organization and sponsors, project manager and team, to establish the project informational system are some of the main points of this stage
.

c) *Project Planning and Budgeting.*

The aim of this stage is to build a realistic plane for the project implementation.

The identification of project work breakdown structure, activities, resources, milestones, ownership, and approach of project communication are the important elements of this stage. I insist on the necessity of using the software systems for an effective planning and tracking of projects.

d) *Project Execution and Closure.*

The aim of this stage is to simulate the project implementation.

The project launching and tracking, cost control, conflicts management, changes management, analysis of final perturbations, project hand-over and final evaluation are the main elements of this stage.

The author especially insists during this module of training on reliability (responsibility, confidence, robustness and fair-play), openness, creativity, self-control and leadership as very necessary competences throughout the project life. Expertise and best practices are presented, too.

The training in management of financing projects is also an important component of training system. In addition with the management-by-projects there are some specific stages as the following:

a) Project necessity

The aim of this stage is to define the project object in order to satisfy a specific necessity from different areas.

The information will be distributed to each other for review and the project team will finally establish the project object based on the SWOT analyses.

b) Necessary funds

The aim of this stage is identify the appropriate internal or external financing source(s).

The students have to undertake a documentation regarding on the Romanian, European Union and others international financing programs which are designed according the specific policies.

c) Project charter

The aim of this stage is to develop the project scope, general objectives, specific objective, deliverables, timeframe, review points, etc.

d) Interested parties

The aim of this stage is to identify the main actors because the success of each project is strongly determinate by the support of stakeholders.

There are stakeholders who will support or oppose the project because they could be positively or negatively affected by the project.

g) Project sustainability

The aim of this stage is to define the vision concerning the future of project results.

The project sustainability will be developed regarding on the sources of later financing after the non-returnable funds, institutional support, and future policies.

According the experience in the last years the author has identified the following main categories of outcomes:

a) Individual outcomes:

After this training each participant will be able:

To design, plan, and implement a project, and to manage or work in a project team.

To identify the appropriate financial fund, and to design the financing request.

To develop the future personal carrier.

b) Organizational outcomes:

The main organizational outcomes are the following:

Increasing of the organization good-will based on the individual results.

Improvement of the organization management.

CONCLUSIONS

Many project-oriented organizations develop the MBP as a *modus vivendi.* This is as a new relative concept in order to conducting the business in a decentralized manner. The performance in project management and the project success are determined by a lot of critical factors such as the project manager, project team and education in this field.

The project manager has to be a manager and leader in the same time. The management and leadership are two complementary processes, which have to be applied simultaneously and continuously in every project. The project manager has to apply a charismatic and managerial leadership in order to get success.

To build a project team is a complex process because there are a lot of different characteristics against the traditional team working. Today, there are different but complementary visions regarding on the project team roles based on different experiences. The paper author's presents a relashionship between two such of visions as a personal contribution according his experience in different projects.

The training in project management is becoming a strong necessity and it is addressed to any person interested in this field as the entrepreneurs, top managers and middle managers, engineers, economists, and students. The paper author's presents some personal opinions regarding the training in MBP based on his expertise as a teacher in project management in addition with IPMA certified training.

Of course, this paper will be continued by other researches concerning the important requirements because to reach success in project management is a balance among resources (people, time and money), results and customer satisfaction.

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ENVIRONMENTAL MANAGEMENT AND COMPETITIVITY IN EUROPEAN TEXTILE INDUSTRY

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Abstract: *The examination of the possible link between environmental protection and firm competitive advantages in the literature has produced mixed results. The present paper contributes to the literature by answering two questions: 1. What is the effect of internal and external drivers on the environmental strategy of textile firms? and 2. Does a proactive environmental strategy influence firm's performance by increased competitive advantages? This study draws on the resource-based view for the internal drivers' perspective and on the institutional theory for the external drivers' perspective. We develop a new model of strategic responses to internal and external drivers and of the dynamic capabilities that lead to competitive advantage in the textile European industry.*

Keywords: *environmental management, competitive advantages, textile industry*

INTRODUCTION

A proactive environmental strategy is driven by external pressures, the companies facing social and environmental demands from a variety of stakeholders groups (government authorities, industry associations, NGOs). In general, institutional pressures are understood as "social, legal and cultural forces outside the firm that exert influence on how managers perceive the environment and eventually shape and determine strategic actions". A wide range of new labels, certifications, guidelines and multi-stakeholder initiatives has created the infrastructure for environmental protection that puts pressure on companies to address the societal impacts of their operations [1].To date institutional theory has proven to be inadequate in explaining the heterogeneity found in organisations confronted with similar institutional pressures. Our research contributes to the literature by proposing a conceptual model that includes heterogeneity of responses to institutional pressures and proposes the underlying determinants of these responses. Further, we focus on the relationship between the proactive environmental strategy and the generation of competitive advantages for the textile firms. The relationship is mediated by some dynamic capabilities (stakeholder integration, high-order learning, and innovative capacity).

1. INTERNAL AND EXTERNAL DRIVERS OF ENVIRONMENTAL MANAGEMENT. COMPETITIVITY AS STRATEGIC CONCEPT

1.1. Institutional pressures as external drivers of proactive environmental management

The institutional pressures play an important role in explaining the proliferation of environmental concerns in companies that confront with requirements from many stakeholders. In general, institutional pressures are seen as: social, legal, cultural forces from outside the firm that exert an influence on the way managers perceive the environment and then model and determine strategic actions. For example, there are pressures of the clients on the suppliers, and pressures of the investors that want to invest in industries with high societal responsibility. In the same time, a wide variety of new labels, action guides and multi-stakeholder initiatives created an infrastructure for corporate responsibility that pressure on the companies to approach the societal impacts of their operations. The governments also launched a large number of policies that have as goal promoting the environmental responsibility, beginning with campaigns to increase awareness and raising competencies to encouraging schemes and legislation [2].

In general, institutions could be seen as resilient social structures that assure stability and sense for the social life. Traditionally, institutional studies on CSR highlighted the trends to a homogenization process through which companies assumedly conform to the changes in their institutional environment. Few studies had as object the multiple ways in which companies can respond to institutional pressures; for example, some companies can adapt the new requirements of the stakeholders in a more or less conscious manner, while others will try to hide non-conformity behind ostensive CSR politics. Even companies that operate in the same institutional framework could respond in a discrete manner to the sustainable development pressures.

The intensity of the pressures is likely to have a positive effect on the pro-activity of the environmental strategy. For example, some ONGs had success in modeling the organizational policies and behaviors. Also, firms will be more predisposed to adopt a non-compliance behavior when stakeholders give different priorities to environmental protection. The probability that non-compliance strategies emerge is higher when there is no consensus about the importance of societal responsibility in the interior of a stakeholder group (consumers, shareholders or employees). In other words, heterogenic institutional pressures are expected to lead to heterogenic organizational responses [3].

Our analysis differs from the existing studies through the approach beyond passive compliance of all types of resistance behavior. Accordingly to other streams of CSR literature, the analysis adds *opportunity seeking* as a category of strategic responses that cover the pro-active attempts to use CSR initiatives in order to translate institutional pressures in benefits for that business and in competitive advantages. Including of opportunity seeking as well as compliance, and resistance, offer a more complete image of the strategic responses scope that are available for companies that confront institutional pressures [4]. The variety of the strategic responses in a certain sector has received by now very little attention.

We propose a new scale of strategic responses to the institutional pressures that differentiates between three large groups of responses: 1*) resistance* (attempts to avoid compliance with the institutional pressures); 2) *compliance* (adapting to the requirements of the institutional environment); 3) *opportunity seeking* (behaviour beyond compliance, which exceeds the external expectances). Therefore, the model evolves beyond the anterior classifications of strategic responses in the institutional theory that tend to cover only the compliance and resistance strategies. This classification is according to the categories established in the literature. These three categories could be then sub-divided in a number of more specific strategies: rejection (non-compliance), negotiation (partial compliance), compliance, anticipation (anticipated compliance), and defining (innovative management). The grouping of the responses does not try to underestimate the effective complexity of the behaviours. It is important to assert that the same company can adopt multiple strategies as a response to institutional pressures of different stakeholders [5]. Some companies can adopt a negotiation strategy regarding a stakeholder and a compliance strategy relating other stakeholder.

1.2. The effect of the entrepreneurial orientation on the proactive environmental strategy

There is a small probability that firms follow a proactive environmental strategy, except the situation in which their top managers promote the entrepreneurial activity (for example, innovation, proactive attitude, risk acceptance). The receptivity of top management towards pollution prevention will increase when firms poses a higher entrepreneurial orientation. Proactive strategies as pollution prevention approaches must be integrated in the administrative, entrepreneurial and technical dimensions of a firm.

When there is an entrepreneurial culture established in the organization, top management is more predisposed to assume risks, to tolerate ambiguity and uncertainty, and to involve in domains with high, also risky, potential benefits. The managers have a higher propensity to interpret new markets as opportunities rather than threats [6]. The higher the degree of interpretation of environmental aspects as opportunities rather than threats, the higher will be the probability to adopt a proactive environmental strategy. These bold and proactive attitudes have a higher probability to transform in adopting and implementing more innovative and creative products and processes, which are unique and difficult to imitate. More, the highest the entrepreneurial orientation, the more present are organizational capabilities like learning, continuous innovation, experimentation, that enable the adoption of a proactive strategy [7].

1.3. Dynamic capabilities as mediators between proactive environmental management and competitive advantages

The dynamic capabilities are the ability to build, integrate and reconfigure the internal and external competences in order to react to changing environments. They derive from the collective learning of an organization, especially in relation with the coordination of manufacturing techniques and technologies, based on intangible assets, especially on the organizational and technological knowledge of the company. According to this perspective, the competitive advantages of a firm consists in its organizational and managerial processes, called "procedures", determined by its intangible assets, technology, industrial property, relations with suppliers and clients, and the strategic alternatives that they dispose of. Although

this vision is different from the resource based vision of the firm because of the inclusion of dynamism in the model, they both show the importance of internal resources of the business, especially those that are intangible, among which there is the environmental capital of the firm. More, some studies based on these two visions find the existence of a positive relation between the environmental practices and the generation or the reinforcement of organizational capabilities that eventually favor enhanced results [8].
There are three organizational capabilities related to the environment:
1. The capability to interact with the organizations and institutions that constitute the environment of the firm and that affect its development (for example regulation or environmental organizations), fostering better relations and a weaker opposition to development;
2. The capability to promote learning processes and to grow the level of knowledge, while the company explores new alternatives and creates new interpretations of existing information;
3. The capacity to continuously innovate, understanding that a higher diversity of perspectives and the analysis of the learning process contribute to the continuous generation of technological, organizational and operational innovations [9].

Table 1: Sources and forms of competitive advantage

The environmental management orientation, sources and forms of competitive advantages		
Environmental management system	**Sources of competitive advantages**	**Forms of advantage**
Compliance model	Environmental expenses are seen only as costs and not as investments in competitive advantages	Potential advantage based on costs, but typically not sustainable because this model suggests the accomplishment only of minimum environmental standards.
Strategic model	Environmental expenses are seen as investments in firm's ability to create value for the owners, clients and other stakeholders, trough the development of superior competences or through the addition of basic resources, building o strategy based on basic competencies	Competitive advantages based on costs through economies resulted from continuous improvement, "pollution prevention" programs, life cycle analysis, and lower potential expenses for litigations, insurance, energy. And/or layered with A specialization/differentiation position that aims the consumers sensitive to the environmental issues or discover/create market performance as a mobility barrier. Enhancing the company image can be a benefit of this positioning advantage.

The dynamic capabilities are organizational and strategic antecedent procedures that managers use to transform basic resources and to develop new valuable strategies. In non-linear and non predictable environments, the capabilities of the managers to integrate, build and reconfigure internal and external competences are sources of sustainable competitive advantages.
The contribution of proactive environmental management to the competitive advantage is materialized in terms of cost and differentiation [10]. The cost advantages generally derive from the adoption of practices that improve the productive process, enhancing its efficiency and reducing the input and wastes costs. Decisions as that of purchasing new non-polluting technologies, taking into consideration environmentally friendly distribution and transport systems or the eco-design of products and processes will allow the firm to gain competitive advantages that derive from cost reduction. A higher level of innovation of the firm regarding proactive technologies that limit pollution will lead to a higher competitive advantage from the environmental strategies. The differentiation strategies usually derive from the perception of clients that the product is more valuable. Hence, the differentiation advantages usually depend on the matching of the product's features and the market needs with the firm's ability to promote the environmental features of its products and services [11].
The compliance model describes the environmental management system as a cost of business operating, but in the same time as a potential means to create competitive advantage based on costs by continuous upgrading but also by using inputs more completely, through the adoption of "pollution costs" programs. Firms that activate on the commodities markets where the primary competitive mean is the price usually adopt this model. *The strategic model* of environmental management suggests that firm's investments in environmental capabilities create a structure of low cost or/and a competitive advantage based on differentiation. The firms that adopt a strategic perspective of environmental management propose to compete mainly by the other variables of marketing mix: product, distribution, promotion.

2. COMPETITIVENESS IN EUROPEAN TEXTILE INDUSTRY

The textile European industry has been passing over a period of decline through the last five decades, with an increased competition and relocation to low income countries. It is often mentioned the fact that the industry is heavily transforming - moving to niche markets and to the sector of industrial textiles. This fact is highlighted by the European Commission initiative, The European Technological Platform for the future of textiles and clothing, which identifies some priorities:
- the transition from commodity fibres to specialty products that imply flexible manufacturing processes and high technology;
- establishing of textiles as raw materials in many industrial sectors and new application domains;
- ending the mass production era and moving to a new paradigm, that of mass customization, of intelligent production, logistics and distribution [12].

Compared to China and India, the European textile industry is disadvantaged because of the high costs of human resources and higher environmental standards. Thereby, a strategy of leadership through costs is not possible. In order to resist in such difficult conditions, the manufacturers in textile industry specialised in hi-tech industrial textiles or in high-end fashion products,

For the sub-sector of industrial textiles, the energy efficient production process and recycling are two important types of eco-innovation. Recycling of textile products, dangerous substances minimization, alternatives to present raw materials, reduction of wastes, reduction of energy consumption, renewable energy and life cycle analysis could be examples. In the relationship between environmental protection and competitiveness, in the industrial textiles sector, innovation is strategic success factor. In order to gain competitive advantages, there are necessary investments in research & development, which require financial resources and qualified employees. As a result, production costs should decrease the products quality should improve, and the environmental impact decrease [13].

For high-end brands, a few producers play a central role by establishing trends and substantial investments in PR and communication. These have economic potential and the credibility to communicate the CSR activity to the consumers, to create and stabilize niche markets for manufacturers, and to integrate environmental aspects in the common practice of the sector. In this respect, eco-label can play a crucial role.

A study on the success factors for the competitiveness of European textile sector - performed with the participation of some experts from the European commission, the textile industry employers' associations - determined the success factors for the competitiveness of textile European sector. These six factors are considered to be the most important and are strongly interconnected, and their importance level differs for sub-sectors, and along the supply chain:
-high quality of products;
-niche markets/differentiation strategies;
-efficient processes;
-research & development activity;
-flexibility and quick response to market changes;
-human resources and organisational culture [14].

Table 2: Effects of eco-innovation and environmental protection on the competitiveness of textile sector

Success factors	Expected effects of environmental activities on the success factors	
Research & development activity	Very positive	Research and development is the basis for eco-innovation and for the environmental protection measures. Research leads to the development of **new products and/or lower production costs**.
Market niches/differentiation strategies	Very positive or positive	Eco products and especially eco-innovation can be a good opportunity for differentiating products/niche strategies, because these can gain competitive advantages compared to non-european competitors. however, there is still uncertainty if **mass markets** create eco products, as their production yet implies **high costs**
High quality of products	Positive or neutral	Only if eco features are relevant to clients, it can be considered as part of the **perceived quality of products**
Flexibility and quick response to market changes	Positive or neutral	The market requires more products that protect the environment, thus eco-innovations could have a positive effect on the **ability** of the industry to **respond** these requests
Efficient processes	Positive or neutral	More efficient processes require **investments** that could be beneficial, as the energy prices are growing.

The opinions of the experts regarding the effects of eco-innovation and the measures of environmental protection on the competitiveness of the textile European industry are presented in table 2. Recycling of textile products and eco-efficient production are two important types of eco-innovation. Environmental protection measures are, for example: minimizing of toxic substances, cleaning the water, alternatives for raw materials, reduction of wastes and energy quantity, renewable energy, life cycle analysis.

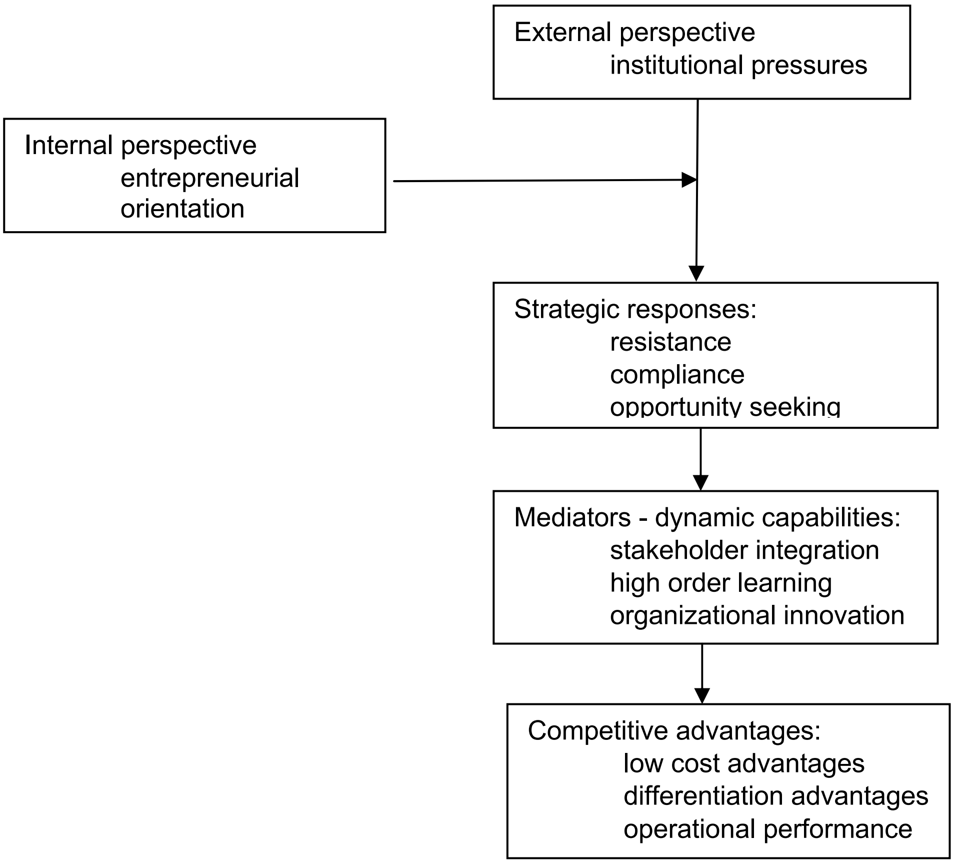

Figure 1: The conceptual model of the environmental strategy

An exhaustive representation of the relations between institutional pressures, entrepreneurial orientation, strategic responses and competitive advantages appears in the figure 1.

CONCLUSIONS

Our study contributes to the natural environment literature by conceptualizing an integrated model of the antecedents and consequences of a proactive environmental strategy. Our model suggests that institutional pressures have a positive effect on a proactive environmental strategy and that this effect is stronger when these pressures are homogeneous and their intensity is higher. The entrepreneurial orientation is a contingent factor for the adoption of an opportunity seeking strategy. Under the right combination of internal and external factors, a proactive environmental strategy can bring competitive advantages for the European textile industry, which is going through a transformation process, under the influence of producers from low income countries.

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THE ENTREPRENEUR AND BUSINESS MANAGEMENT IN CREATIVE INDUSTRIES

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Abstract: *Creative businesses can save the economy of a city, where the traditional economies, based on agriculture, industry or trade, have failed. They represent the happy combination of two qualities, that of the "artist", and that of the "business man". They are those sectors of creation and technological development that generate profit and rethink the culture as a driver of regional and national development.*
The aim of this paper is to explore and identify the characteristics of entrepreneurs in the Creative Industries in Romania, in order to draw a preliminary profile of the creative entrepreneur in Romania.
The foreseen result is to provide a "best practice" example through the "Entrepreneur in Creative Industries" case study.

Keywords: *creative industries, creative entrepreneurship, entrepreneurship, innovation.*

INTRODUCTION

The International community has experienced a great variety of studies and measurements, according to the particular definitions, regarding the concept of cultural industries, creative industries and creative economies. However, regardless of the term used, they are becoming more interesting as strategic components in the development and welfare of countries.
At European Union level, the concept of creative industries used is similar to the concept given by United Nations Conference on Trade and Development (UNCTAD) that combine creativity with the goods giving rise to a new class of products known as "creative goods and services" and the "cultural goods and services" are a subset of them, being composed of artistic and cultural content products as an addition to the creative ones. Thus, the definition of "cultural and creative industries" results from here, to better identify them as industries that produce creative and cultural goods.[1]
Nowadays, the most frequently mentioned and used definition is that the Department for Culture, Media and Sport in England (DCMS) has developed in 1998. DCMS defines the creative industries as those activities which have their origin in individual creativity, skill and talent and which have a potential for wealth and job creation through the generation and exploitation of intellectual property.[2]
Since its inception, the definition given by DCMS to Creative Industries in 1998 had a significant echo, although generating controversy. As the creative industries were presented as something great, able to encompass a set of heterogeneous industries and practices, controversies were related so whether arts might influence a country's economy or even if it really exists what Richard Florida has called "creative class."[3]
As for how to apply in Romania the definition of Creative Industries given by DCMS, it requires it's correlation with how the classification of economic activities in Romania is organized, namely the classification of the National Classification of Economic Activities (NCEA).[4]
Since the emergence of the Creative Industries, and once with the attempts to define them, a strong emphasis was also placed on the classification of the Creative Industries. Therefore, within the Creative Industries Mapping Document from UK, DCMS has best identified 13 sectors of creative industries.

Table 1: DCSM's Creative Industries sectors in UK, 1998

Advertising	Interactive leisure software (electronic games)
Architecture	Music
Arts and manufacturing	Performing arts
Crafts	Publishing
Design	Software and computer services
Designer fashion	Television and radio
Film and video	

Entrepreneurship seeks to perceive opportunities and bring them to reality, in order to capture a part of the value created. While this conventional plays in the markets, there are still four areas outside entrepreneurship producer: consumer, cultural, social and political. Each of this intersects Creative Industries.[5]
Entrepreneurship in the Creative Industries, as well as data related to the development of entrepreneurial skills are not very well known or rather fully known. The term of creative entrepreneurship has become a term that refers to the activity of entrepreneurs with businesses within creative industries.
Entrepreneurship in the Creative Industries represents a new way of thinking, a new attitude, namely to seek opportunities in the environment of cultural organizations, regarding the cultural mission as the starting point.[6]
Creative businesses are more active than other types of businesses in promoting innovation, and the real challenge that must cope with those who dare to engage in creative entrepreneurship is the need to find a balance between the artistic, the financial, and the development sides.
From the entrepreneurship in creative industries term (creative entrepreneurship/culture) derives the term of entrepreneur in the creative industries (creative entrepreneur), which deals with strategy making, organizational design and leadership in cultural context. This notion characterizes those talented and successful entrepreneurs, able to turn their ideas into products or services for society.[6]
According to Wikipedia, a creative entrepreneur differs from typical or social entrepreneur in that the former is more concerned with the creation and exploitation of creative and intellectual capital. Essentially, creative entrepreneurs are investors in talent – his own or other people's talent. The most famous entrepreneurs have combined creative flair with entrepreneurial talent to build business empires of billion dollars. Among them, we mention Rupert Murdoch, Madonna and Richard Branson.[7]
In other words, the entrepreneur in the creative industries is a person who uses his/hers creativity, ideas and passion to achieve economic activities, most often as an individual.
An important aspect that a creative entrepreneur must consider, on a personal level, is whether, if he wants a long-term career in the creative industries, this is sustainable, given that these industries are dominated by fashion, taste and young people.[8]
John Howkins has proposed a list of 10 rules for successful creative entrepreneurs. Therefore they must to: [9] 1. invent himself, 2. prioritize ideas, not data, 3. be nomadic, 4. be defined by their activities, way of thinking, seeing things, and not by the position/job somebody else has given them, 5. be the adept for life to study, to borrow, to innovate, 6. exploit fame and celebrity, 7. treat what is virtual as real and vice versa 8. be good, because goodness is a success factor, 9. openly admire success, 10. be ambitious and courageous, 11. have fun.
As shown, in fact there are 11 rules, and Howkins suggests not to panic if outnumbered 11. It is actually his way, creative of course, to draw our attention to the first rule, namely that a creative entrepreneur must *invent himself/herself*, whenever so requested.

2. RESEARCH METHODOLOGY

The identified **research problem** refers to the particularities of the entrepreneurship in Creative Industries in Romania.
As a result, **the major research question** generated is:

- ✓ *Which are the particularities of the entrepreneurship in Creative Industries in Romania?*

Thus, **the general objective** of the research is:

- ✓ *To identify and exploit the features of the entrepreneurship in Creative Industries in Romania.*

The specific objective of the research:

- ✓ To identify the particularities of the Entrepreneurship in Creative Industries in Iasi county;
- ✓ The identification of environmental factors that positively or negatively influenced the business in Creative Industries domain, in Iasi county.

The relevance of the research problem:
The Creative Industries are among the main drivers of renewal and innovation. Organizations in all industries turn to creative skills to develop user-centered products and services in an economy increasingly based more on collaboration.
The research strategy was driven by the purpose of research: exploratory and descriptive. These combinations allow answers to the questions *which?*, and *how?*
The research project contained the following main steps:

- ✓ preliminary documentation, familiarity with the studied domain, and the defining of the research domain: *Creative Industries domain*;
- ✓ development of the semi-structured questionnaire to conduct the interview;
- ✓ firm selection within the Creative Industries domain, as the unit of analysis for the case study;

- ✓ fieldwork: conducting the interview, field observations and documents study regarding the participating company;
- ✓ data structuring and analysis;
- ✓ interpretation of research results;
- ✓ discussions and conclusions drawing.

As the main instrument for data collection, a semi-structured questionnaire was used to conduct the interview with an entrepreneur in the Creative Industries.
The questionnaire resulted from the literature research and has been divided into the following sections:

I. General data regarding the entrepreneur's business/businesses
In this first section of the questionnaire we aimed to obtain general data on respondent's business. The goal to obtain such data was to familiarize with both the type of business that is the subject of this research, and the entrepreneur leading this business.

II. Entrepreneurial characteristics in creative industries
This section includes 23 questions, of which 22 are open questions, and one, the identification of the influence of external environment factors of the firm, close character. The framing of the questions was based on the assumption that the entrepreneur to be interviewed is aware that his/her business belongs to the Creative Industries, knows the Creative Industries domains, knows what happens in the world, including in Romania, related to them. Through these questions is intended:

- ✓ to identify the preliminary particularities/characteristics of an entrepreneur in Creative Industries;
- ✓ to identify the environmental factors that positively or negatively influenced the business in Creative Industries domain.

In the first case, the questions were formulated based on literature review. We took into account the 10 rules an entrepreneur in Creative Industries must follow, rules formulated by Howkins, as well other characteristics of entrepreneurship in the Creative Industries proposed by various experts, including the creative entrepreneurs.
In the second case, starting from the PEST analysis, it was intended to study how environmental factors influence the business through the five categories of environmental factors: 1. Political and legislative factors, 2. Economic factors, 3. Socio-cultural factors, 4. Technological factors, and 5. Environmental factors. For each of these, we proposed 5 other factors, and respondent’s possibility to give us more others that they consider relevant from the point of view of the business he runs. A Likert scale in five points was used, with the following meanings: 1-very little extent, 2-little extent, 3-some extent, 4-great extent, 5-very great extent.

III. Demographic data on the entrepreneur in creative industries (“the life story”)
This last section, as shown in the title, provides to the interviewed entrepreneurs the opportunity to freely present his/hers life story. It is envisaged to find out the professional path, and not only, of his/hers prior decision to become an entrepreneur. The aim is to achieve a correlation with the answers to the questions in Part II and finding/screening additional information related to the characteristics of an entrepreneur in the creative industries.
The qualitative research has resulted in a case study. For its realization, the elements identified as necessary to achieve *a preliminary profile of the entrepreneurial spirit of an entrepreneur in the creative industries* were preponderant followed.

3. CASE STUDY: ARHIPELAGO INTERACTIVE Ltd.

The following is a summary of the “**Entrepreneur in Creative Industries**” case study, namely the interview with Lidia Alexa, one of the two entrepreneurs of ARHIPELAGO INTERACTIVE Ltd, based in Iasi, with the object of activity: *online publishing*, and their first site of this kind: www.finantare.ro
“Since 2001 our company has provided quality service in web and business consulting. Currently, our main activities are:

developing and managing web portals and electronic journals;
providing services in online B2B promotion;
special business events;
organizing training courses.”

Since 2003, Arhipelago Interactive Ltd expanded, adding a new activity: *the organization of business events*, and in 2013 recorded a turnover of 120,000 euros. Currently, the Arhipelago team consists of 10 full time employees and 5 external collaborators.

The stage of development in relation to the life cycle, in the *online* area “we are in a phase of maturity, growth-maturity, because we have experience, most sites have years, already being in the second, even third redesign.” ...
“In the *event* area we are at an early stage, in a launch-growth phase, more growth. This area was launched last year when we had events in three cities, and this year, I think, there were over 20 ... I lost count.” ...
The company's vision is linked to the company's values, namely:

customer orientation,
dedication,
leadership,
integrity,
collaboration.

“We believe that Romania needs entrepreneurs in all social spheres, and the entrepreneurs must be endorsed with qualititative information and educational products.”
ARHIPELAGO INTERACTIVE Ltd.’s mission: „We are an online publishing company that provides practical information and support for Romanian entrepreneurs, acting with integrity and dedication to provide quality services to our clients.
Objectives and general strategic directions: *Online publishing*, with the focus on the business area, and *Business Event*.
“These two directions are correlated. Together they are trying to do the same thing: to educate the market, develop entrepreneurship in Romania by providing information, namely quality services. We hit the road with some sites, but after we have improved them, somehow, we offered other things besides them, respectively consultancy, guides, that we want to sell, all kinds of books, and the list is long. Basically, we try to offer the whole package!”...
The business positioning in Creative Industries
“It was clearly known from the beginning that our business was part of the Creative Industries, but without having the notion of what exactly a creative industry is, and to what extent we are creative or not.
Considering the fact that at the moment the business was launched, in 2001, there was nothing of the kind on the market, more creative than that ... To follow a thing that you even do not know what exactly is, but to do it because you feel that the market needs it, it is SUPER CREATIVE.”...
“As for the fact that our vision has changed from the moment we learned of this classification of our business, I do not know if something has changed! Basic things remained, even now, those things that we hit the road with. We want to bring on the market products of quality, we want to be different by both the product that we deliver and the attitude that we have towards the market, and the way we internally manage our company and how we work/collaborate with people.
Therefore, the vision itself has not changed, what changed was the process, *the polish* of it, given the fact that, at one time, others have also appeared on the market, we have learned more about what entrepreneurship is, about what to grow a business implies, and to make some products. Somehow we have also grown with our company and our products, because it is natural ... you need to change something.
Even at the formal level I had to *polish* mission and vision, because we realized that in some way, the market has also helped us. Receiving feedback from the market you refine your products, you refine the way in which you develop products, afterwards.” ...
Business initiating and development in Creative Industries
“From our perspective, the most important things in a business running in Creative Industries are the same as in all types of industries. What you might need in Creative Industries is to have a more “out of the box” way of thinking … that would be! You must not follow the market, but somehow you must force the market to follow you, to be a step ahead of it. Very important in doing business are the majority of things, like reliability, responsibility, respect for the customer and not just in words, but when I think the product the customer is in my mind. It exists everywhere, but yes, you are forced to come up with something new, always be aware of what is happening outside, because we are still waaaay back to what exists outside the country, in U.S. for example, or in West in general. Therefore, it forces you, it always *puts you in socket* with what is there, to see to what extent trends can apply here. Can you get ideas from there to here and implement them? Or can you come up with something new? For this reason, many in the creative industries, but truly creative industries, go abroad. Because abroad there is a lot more educated market, a market that understands the concept of creative industry. Therefore, it is easier for you to sell, and easier to talk to a customer who knows what is about, than to come with a very good product, but first be forced to explain to the customer what your product is, after to see if the customer is willing to buy it ... it's complicated! We have recently launched a website in English on the business area and want to get abroad with the online part as well.” ...
“What motivates me is to creat something different and to create something that brings value on the market, generally thinking, because we are motivated my people that send us emails saying: *yes, ok, I have used a lot this thing, I could not manage without what I have found there* ... *it is great that you found me a consultant and that he/she made my project and now my business is running*. ” ...

"The main reson we did not left Romania, both of us, even though we had the chance, is because we can make things here as well. But lets make them! Because we want our child to grow up in a country in which there is an entrepreneurial culture, in which people have the courage to develop things, and so to make our little part from which we get profit, because we must also live from something!
We have decided to become entreprenerus because where we worked before, and it applies to both, we have and have not adapted. " ...

The creative entrepreneur

"If the creativity is innate or acquired? I think it's a combination. You can be a *brick* and have no creative mind, but such cases are rare. I think it is a thing that is educated and self-educated. Because somehow we are born absolutely perfect ... and we are born with all the creative capacity of the universe, but somehow our society *polishes* us to turn into something that fits into a pattern, at which point you assume that you are not creative and you have to go on some directions that are made by others.
I think that nothing is set in stone, like you were born with it or not born with it. You can be very creative, and at a given time not to create anything because you self-educated in this way and follow some things ... or you simply can develop this to yourself." ...
"I do not feel creative and I assumed that somehow, because where I have been working on I became very procedural because that was the situation. But there are development training courses on this side as well. So I enrolled in an online course at Stanford, on Venture Lab, entitled Creativity Lab, taught by Tina Seelig, with a duration of 6 months. I rode the course from one end to the other, having to make videos, do mind mapping with people from all over the world until 2am. So I realized that when you let your mind free and tell to your mind: *you know, come out of there a little, let's see what is there, is there something there*? There is no such thing, and through a process of opening and how to listen more to your intuition, to be more aware of what is around you, creativity can be educated.
We give priority to creative ideas, but a creative idea without collected data is only an idea that does not produce. When you are in a company and the idea is thought of as something that must produce and make a profit, the data are relevant. But that does not necessarily mean to change your idea, but you need to adapt to the market and see to what extent it is feasible." ...
"Yes, we have confidence in us, but that applies more to Marius. Self-confidence can be educated, it is not something we are born with." ...
"Important is, I think, that self-confidence to be combined with authenticity, with the fact that ideas are coming from you, and are authentically part of you, and then it is easier for you to understand them, to explain them to others, and it is easier to convince. It is not enough to trust in you, somehow you must to convince others to trust you. So, it is a combination. Almost all the time!
It happens that when we are in a process of creation, in both cases, our attention to be easily distracted by surrounding factors. But is distracted because, somehow, the idea comes in a combination with what happens in the universe and on the market, and so have something else to check back, can see, go, have another new idea. The creative creation process is not a linear process. You are not here and know that you will get there. In fact you are here and it is so, and you go ... and so, somehow, you refine the idea, from the market, from questions." ...
"Even though we are quite known, we are not fascinated by the success/fame/celebrity. This is a reason why we do not promote the company, because I think they should not be an end in itself. If it is an end in itself the creative process is being missed." ...
"Three success factors of a creative entrepreneur, in my/our view are:

1. The fact that he/she listens to its instinct and is connected to what he/she thinks;
2. The fact that he/she can see those opportunities on the market where people only see ordinary things;
3. The fact that he/she believes in his/hers ideas and is trying to convince others till they say that it is ok.

As a way of working, we work as a team, but also individually. Basically, we make a combination of both, because when you get your ideas, they usually come when alone, you do not work in team for this. But we, for example, have cases where we do not know what to do with the idea, and then is when we are working with the team, especially because we have people covering different areas. For example, technical man knows how it should be, marketing man knows how can be sold or not on the market, the sales agent knows what customers we have, that would march on this thing. But the first part of the process I think is a matter of solitude: you just get the idea! I do not think we can say: *boys, let's see if today, between 4 and 8, we get any ideas!* Complicated! ... Can be, but I do not think so... maybe if we do a brainstorming, but it must be on a given topic ... But what is clearly a teamwork is the effective implementation."

The entrepreneur and business management in creative industries

"For the way we do and run the business, the more and the best we learn through real interactions, directly from the field. There are very few, I believe, that sit down and read and learn ... The part of interaction is very important because it also keeps you connected, all the time, to things that are happening around.

We are, without any doubt, the adherents of a flexible schedule. Well, usually people stay in the company and work from 9 am to 5 pm, but we are in front of the laptop even at 2 am, especially if an idea has occurred us. ... Basically, we never completely disconnect from the company." ...
"We are running our businesses with responsibility to all stakeholders (customers, employees, suppliers, the environment, so on), simply because for a small business that is all you have. At least, this is the way we see things and if you lose someone's trust, be it employee, whether a customer, but maliciously ... because it does not mean that we do not make mistakes sometimes, we all know misfire, no matter how well intentioned we are, but when a maliciously interferes, that is a thing that you can no longer recover. I do not know what credibility you have, because the market is very small, I refer to the online one." ...
"From the domain's perspective in which we practice, entrepreneurship means that we leave something behind, that we do not go through life *carefree/airy fairy/easy breezy* ... and we get some money ... and we go on some vacations.
We really believe that we have the role to leave something behind, to create something of value, more or less, how we perceive, because none of us is building the Cernavoda bridge. I mean we do something, on our piece and I think this also motivates us to leave our trade in something, and help grow a field, an industry as it is for events as well. To do something different and bring together people who normally would not get together."

CONCLUSIONS

The qualitative research study was conducted in the North-East of Romania, in Iasi city, aiming to identify those features/characteristics essential for the "entrepreneurial spirit" of an entrepreneur in Creative Industries, and so to achieve a preliminary profile of it.
Following the interview, based on the semi-structured questionnaire, in addition to being able to identify a number of features to draw a preliminary profile of the creative entrepreneur, a check of the characteristics presented in the literature was also performed.
Among the identified features, are remembered: *super creative; grants interest in practicing field, namely the creative industries*; *identifies/recognizes and seeks business opportunities*; *sees opportunities in the market where people only see ordinary things*; *learn from failures/mistakes*; *innovative offering novelty*, *interest to create something new unprecedented*; *to be different*, *to be also different through the product they deliver and the attitude they have towards the market and the way they internally manage each company and how they work with people*; *respect for the client "and not just in words, but you think the product having the customer in mind"*; *believes in his/hers ideas and even tries to persuade the others when they all say that it is not ok*; *desire for independence, to be his own master*; *"out of the box" thinking*; *desire for continuous improvement, "to polish"*; "*to be one step ahead*"; *concerned about leaving something behind*.

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Section 13: Engineering Education

RESEARCH ON THE CHALLENGES OF EDUCATION PROCESS IN BUSINESS ENGINEERING FIELD IN THE CONTEXT OF A TECHNICAL UNIVERSITY IN ROMANIA

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Abstract: *Today, the business engineering education has to go beyond the technical knowledge by preparing students with the attitude and skills needed to act in an entrepreneurial way. The aim of the study was to decipher the complexity of business engineering education process, as an interdisciplinary field of engineering, based on a proper understanding of students' expectations. A pilot study was conducted among the undergraduate students from a technical university.*

The methodological approach was firstly consisted of a secondary literature research on business engineering concepts and, secondarily, the authors have performed a descriptive research aims at assessing the students' expectations and opinions concerning the professional competences, the professional track, and academic resources used in learning activities.

The results are useful aids in bridging the gap between the enhancement and evolution of business engineering profession and the expectations of undergraduate students, as well as base for further research work.

Keywords: *business engineering education, entrepreneurial attitude, innovation*

INTRODUCTION

The evolving nature of business engineering profession requires educators to prepare students for the future challenges emerging from IT advance and globalization. The education process viewed from the entrepreneurial perspective has evolved into a new concept for both the content and methods of teaching and learning, as a theme that can be embedded in all subjects at every level of education 1 .

According to the survey of European Commission revealed in the *Rethinking Education: Investing in skills for better socio-economic outcomes* , the ability to think critically, take initiative, problem solving and working collaboratively are the skills which count for the 21st century. All of these are seen as entrepreneurial skills since they not only help individuals to achieve concrete entrepreneurial activity, but also enhance the employability of young people 2 .

Likewise, the annual work programme for the implementation of "Erasmus+" in 2014 states the importance of entrepreneurial skills for young people to enhance their employability and business creation within the context of achieving the Europe 2020 strategy for economic growth and jobs. Indeed, preparing young students for modern social and working life, it is particularly important for education process to create added value by improving the acquaintance of a wide range of transversal skills, generally named as entrepreneurial skills or thinking 3 .

Although, the meaning of entrepreneurship education has created much debate surrounding it, newly researches have highlighted that a narrow definition around preparing students for the world of business may place limitations on both learners and the educators community. Therefore, it has been built a broader definition that qualifies the entrepreneurship education as a key process with the goal of ensuring learners to acquire a broader set of competences that can bring individual, economic and social benefits 4 .

The entrepreneurship education process gains more complex bonds in the case of business engineering education because the competences acquired lend students to application in every aspects of their s life. In this context, the business engineering education has acquired a particularly importance since it has to go beyond the technical knowledge by preparing students with the attitude and skills needed to act in an entrepreneurial way.

Worthy to be mentioned is the view of European Parliament for the entrepreneurial thinking, as the individual s ability to turns ideas into actions. It includes creativity, innovation and networking, as well as the ability to plan and manage projects to accomplish objectives 5 . From this view, table 1 depicts the key drivers of entrepreneurial thinking.

Table 1: The framework of entrepreneurial thinking

The core	Key drivers	Description
Entrepreneurial thinking: turning ideas into actions	Knowledge	Ability to identify available opportunities for personal, professional and/or business development
	Skills	Ability to analyze, plan, organize, manage, delegate, debrief, evaluate and records
		Ability to communicate and negotiate, to work both as individual and collaboratively in teams
		Ability to judge, assess and take risks as when warranted
	Attitude	Characterized by initiative, pro-activity, independence and innovation in personal, professional and social life

Within this sphere, the major role of business engineering education process is to satisfy with high professional responsibility both parties involved: the students' expectations and the forthcoming marketplace requirements, in terms of entrepreneurial thinking: knowledge, skills and attitude needed to turn ideas into actions, and a board understanding of business engineering profession s role in the modern economies and societies 6 .

EXPERIMENTAL

The study undertaken by authors was focused on investigating the undergraduate students' mind-set in terms of the self-perception of the key entrepreneurial attitude, skills, and opinion about their professional track, and the preference regarding the sources of information, documentation, and learning 7, 8 . Although by no means exhaustive, these factors yield valuable clues about professional credentials required for becoming success entrepreneurs.

The pilot study was comprised of 58 undergraduate students involved in the business engineering and management program from the Faculty of Entrepreneurship, Business Engineering and Management, in University "Politehnica" of Bucharest. Since they are educated to become future entrepreneurs in a wide range of market sectors, it was supposed that these undergraduate students and their perspectives would provide a reliable sample for a pilot study.

According to these circumstances, the research objectives were as follows:
O1. Investigating to what extent students properly understand the new market requirements in terms of entrepreneurial thinking.
O2. Analyzing the students' opinion with respect to their professional track.
O3. Investigating to what extent students use different types of academic resources in learning activities.

The research methodology was consisted of establishing the research variables linked to operational ones, the scales of measurements and the scaling techniques. The nominal scale variables were consisted of demographic characteristics of the respondents and the employment preferences of students. As far as the entrepreneurial attitude and skills, and the preference for different types of academic resources, it has been used the ordinal scale variables to measure the opinion. As a summary, table 2 shows the structure of the research including the scaling techniques used to yield the highest level of information feasible.

The process of developing the content of research items with respect to research variables assessment has drown relevant knowledge from the scientific literature in the field [9].

Table 2: The research roadmap

Research objectives	Research variables	Operational variables	Scale of measurement	Scaling techniques
O1. Identifying the self-perception with respect to entrepreneurial thinking	Attitudes that help individuals to take actions	Sense of initiative	Ordinal scale	Comparative scaling technique based on rank order correlation
		Risk propensity		
		Self-efficacy		
		Need for achievement		
		Structural behavior		
	Skills needed to turn ideas into actions	Creativity	Ordinal scale	Comparative scaling technique based on rank order correlation
		Analysis capacity		
		Networking capacity		
		Adaptability		
O2. Analyzing the students opinion with respect to their professional track	Intention towards employment sector	Budgetary sector, business sector, ONG sector	Nominal scale	Frequency distribution
	Intention after the graduate level	Country job, outside job, master level in the same specialty, master level in another specialty, start-up own business	Nominal scale	Frequency distribution
O3. Investigating the use of different types of academic resources in learning activities	Preference of sources of information, documentation and learning	Classic library with hard copy books, e-library with specialty books, e-library with specialty articles, Wikipedia, teachers courses	Ordinal scale	Comparative scaling technique based on rank order correlation
	Preferred teaching style	Traditional style, modern style, e-learning	Interval scale	Non-comparative scaling technique based on Likert scale
Demographic characteristics of the respondents	Gender	Feminine, masculine	Nominal scale	Frequency distribution
	Study year	Third year, fourth year		
	Previously grade level	≤ 7, 7 – 8, 9 - 10		

The entrepreneurial thinking was measured by asking respondents to express their opinion regarding the key factors that assure the success in professional life. It has been taken into consideration the attitude that helps individuals to take actions such as: sense of initiative, risk propensity, self-efficacy, need for achievement, and structural behavior in terms of tenacity and perseveres. Also, the respondents were asked to rank the skills needed for success in terms of creativity, analysis capacity, networking, and adaptability to the environment.

Developing the items aiming at assessing the opinion about the professional track were consisted of asking respondents to nominate the intention towards employment sector (budgetary, business or ONG sector), and also the intention after the graduate (to find a job in the country or outside, to enroll in a master program in the same specialty or other, or to start-up own business).

Investigating the different types of academic resources used in learning activities was based on asking respondents to rank the preference concerning the sources of information, documentation and learning as follows: classic library with hard copy books, e-library with specialty books, e-library with specialty articles, Wikipedia, and teachers' courses.

As the resources used in learning activities depend on the teaching style, the respondents were asked to express the opinion regarding the preferred teaching style. The scaling techniques was consisted of a five-point Likert scale that measure the extent to which respondents are more likely to prefer traditional courses (downward communication from the teacher, as the expert, to student, as the apprentice), modern courses (two ways communication between parties involved, and teacher is only a knowledge facilitator), or e-learning courses (virtual communication between teacher and student based on the novelty of IT advance in education).

RESULTS

As there are several measurements on each element/research variables it has been applied the univariate statistical techniques for data analysis. The research was questionnaire based with an adequate pattern starting with questions for identifying the self-perception with respect to entrepreneurial thinking, and finishing with questions for respondents' personal characteristics. The questionnaire was distributed to 125 students enrolled in the third and fourth year of the study program and only the 58 business engineering students have filled the questionnaires.

Overall, the gender structure of the respondents was rather unbalanced (74% feminine and 26% masculine). The pattern of the sample in terms of the study year was as follows: 48% from students were enrolled in the third year of studies and 52 % of them were enrolled in the fourth year of studies. As far as the previous grade level, 60% of the students were excellent graded (between 9 and 10 mark), 29% of them were well graded (between 8 and 9 mark), and 11% of students were graded as satisfactory (less than 8 mark).

Business engineering students were asked to judge and assign points for the attitudes which will help them to succeed in the professional life from 1 point for an unimportant skill to 5 points for those extremely important. Moreover, the students were asked to rank the skills that enable them to turn ideas into actions, starting with 1 point for unimportant skill and finishing with 4 points for very important ones. In this context, assessing the self-perception regarding the entrepreneurial thinking was based on calculating the central tendency considering the way in which the variables were measured, as shown in tables 3 and 4.

Table 3: Attitudes that help individuals to take actions

Attitudes	**1 points**	**2 points**	**3 points**	**4 points**	**5 points**	**Arithmetic mean**
Sense of initiative	17	10	10	10	11	3.21
Risk propensity	11	11	14	12	10	3.02
Self - efficacy	25	14	8	9	2	3.88
Need for achievement	19	10	6	12	11	3.24
Structural behavior	9	13	13	7	16	2.86
TOTAL						5.00

Table 4: Skills needed to turn ideas into actions

Skills	**1 points**	**2 points**	**3 points**	**4 points**	**Arithmetic mean**
Creativity	17	10	13	18	2.45
Analysis capacity	22	14	16	6	2.90
Networking	21	12	18	7	2.81
Adaptability	12	21	6	19	2.45
TOTAL					4.00

As far as the students' opinion with respect to their professional track, the results reveal that 80% of the students prefer to find a job in the business sector, 10% of them are likely to work in the budgetary sector, and 10% of them in other sectors. Also, the results highlight that the students intentions after the graduate level are currently going towards finding a job in the country (32% of respondents), and only 10% of them are likely to find a job outside the Romanian borders; 29% of the students state that intend to apply for a master program in the same specialty (business engineering and management) whereas another 29% of them intend to go beyond to start their own business. In the matter of assessing different types of academic resources used in learning activities, the results were obtained by calculating the central tendency considering the way in which the variables were measured, as shown in tables 5 and 6 [10].

Table 5: The frequency of academic resources used in learning activities

Academic resources	Never	Seldom	Frequently	Always	Arithmetic mean
classic library with hard copy books	6	34	12	6	2.31
e-library with specialty books	12	15	24	7	2.45
e-library with specialty articles	16	11	25	6	2.36
Wikipedia	1	7	30	20	3.19
teachers' courses	0	7	22	29	3.38
TOTAL					4.00

Table 6: Respondents' opinion regarding the preferred teaching style

Teaching style	Strongly disagree 1 points	Disagree 2 points	Indifferent 3 points	Agree 4 points	Strongly agree 5 points	Arithmetic mean
traditional courses	15	17	7	16	3	2.57
modern courses	1	0	2	20	35	4.52
e-learning courses	1	9	10	22	16	3.74
TOTAL						5.00

DISCUSSION

The business engineering education is a highly complex process because it has to overcome the challenges arisen from the interdisciplinary character, going beyond the technical knowledge and preparing students for the future business market requirements.

The results of data analysis show that students place great emphasis on self-efficacy (3.88), need for achievement (3.24), and sense of initiative (3.21), as data reveal in table 3. The students scored the self-efficacy as very important because attitudes such as self-belief, self-assurance and self-awareness are essential for both social learning and social confidence. Indeed, acquiring appropriate positive attitudes and believing in one's idea are important prerequisites for entrepreneurial actions.

The research underlines that the students have a strong need for achievement being aware of the concern for personal capacity to set high personal achievable goals and, also, the concern for striving adequately for performance and when necessary, for competing. Interestingly, the business engineering students averagely weigh the sense of initiative (3.21) although the studies in the field pointed as a key driver for turning idea into actions. However, these seem to be a perception bias as the students have not been yet sufficiently exposed to the real working environment. The job experience with the challenges arisen from putting in practice the ideas would be beneficial for students' attitude. In this way, they would be aware of the significance of the sense on initiative for achieving their professional or personal goals.

One of the main goals of business engineering education is to develop students' skills and mindsets for future business market challenges. The data analysis reveals two important skills perceived by the students: analysis capacity (2.90) and networking (2.81), as shown in table 4. Indeed, the future business engineers are aware of the critical skills in making decisions: analyzing problems, separating main and side issues, seeking opportunities, and planning the solutions. This ability to analyze suggests that future entrepreneurial engineers will be able to carefully weigh up the pros and cons, to recognize the patterns and consequences, and to think about alternatives. Moreover, the students have the awareness of the benefits of networking as it is seen as the activity by which they recognize, create, or act upon opportunities.

In regard to the academic resources used in learning activities, the research shows the students place great emphasis on using teachers' courses (3.88), followed by Wikipedia sources (3.19), and e-library with specialty books (2.45), according to table 5.

The preferred teaching style is characterized by two key tendencies: modern courses (4.52) and e-learning courses (3.74), as it is shown in table 6. These results pay attention to the key role of teachers as regards both contents and teaching and learning methods. Since the entrepreneurial thinking is a transversal competence that should be available to all students, regardless of the area of engineering study, the traditional teaching practices in which the learner tend to be more passive recipient is no longer useful. The teacher has to take advantage of IT by using e-learning courses which provide the opportunity for students to engage into self-directed learning, taking the initiative and the responsibility for their own learning.

CONCLUSIONS

Based on the research results, the authors have placed great emphasis on curriculum development that focuses on the challenges of engineers as future entrepreneurs by promoting creativity, innovation and self-employment, as well as the acquisition of hand-on, operative capabilities. However, the curriculum improvement has to be part of the new established entrepreneurial education framework that should support a blend of activities for preparing students for the future business market requirements. This framework should facilitate the structured involvement of the community – teachers, students, alumni, local bodies, businesses and social enterprises – for networking and mutual exchange of best practices.

That's way, teachers have a critical role to play in developing entrepreneurial thinking because they are facilitators of learning and multiplying of ideas. They shape learning process and can help students to achieve entrepreneurial learning outcomes – concrete knowledge, skills and attitudes. Guiding students through the learning process rather than communicating knowledge and information, mainly through traditional methods, will place the students at the center of the business engineering education process.

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INTERACTIVE APPLICATION FOR THE SIMULATION OF THE SEWING MACHINE MECHANISMS

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Abstract: *The paper presents an interactive application regarding the construction and the functioning of the needle mechanism in a sewing machine. This mechanism is based on a rod crank mechanism that is widely used in textile industry. It converts the rotation of the cam into the sliding movement of the needle, placed in the needle bar.*
After discussing the 3D drawing of the mechanism, its movement is simulated. The simulation has been carried out using the SketchUp application and the Sketchy Physics plug-in.
The application can be used for teaching 3D drawing techniques and explaining the mechanisms of a sewing machine. The first group of students can learn how to create technical drawings and they become familiarized with textile mechanisms from an early stage of their education. Later, the students learn how the needle movement takes place and is controlled. Because Sketch Up creates 3D models, the students can view the sewing needles from different angles and can understand how the system is built.

Keywords: *engineering education, connecting rod crank mechanism, needle movement, simulation*

INTRODUCTION

Sewing machines are one of the most common type of machinery used in the textile industry. There are many types of sewing machines in the market, used to create different stitches, but their main functions and mechanisms are similar. In the learning process, the textile students must understand these mechanisms. how they work and how to identify them on a machine. Developing the 3D view in relation to the geometry of these mechanism is therefore of maximum importance in the learning process.
The loop stitching mechanism is one of the most important components of a sewing machine. It consists of needle, presser foot and looping or shuttle hook. The needle is fixed onto a needle bar and is driven up and down by the motor via a series of gears, cams, cranks and belts, as illustrated in Figure 1 [1, 2, 3].

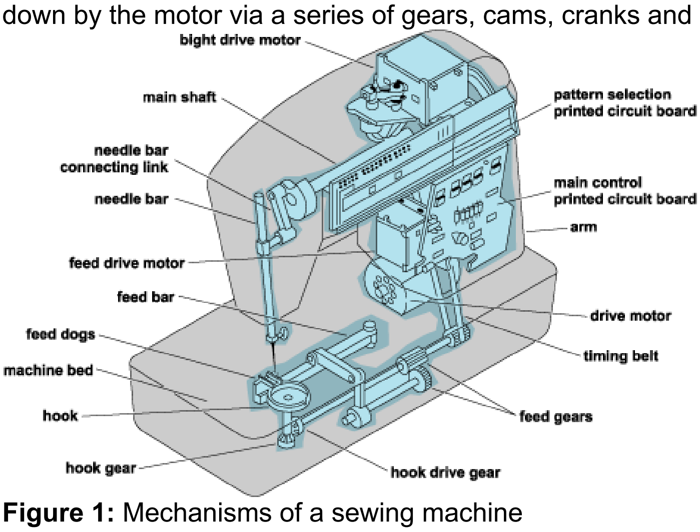


Figure 1: Mechanisms of a sewing machine

The paper presents the needle mechanism of a sewing machine and aims combining 3D drawing and 3D animations with specific issues of textile E-learning. The static model has been developed using a Google SketchUp application [4] while the dynamic simulation has been implemented using the Sketchy Physics plug-in [5]. Google SketchUp is a free and flexible CAD modelling application with great potential for 3D modelling that is easily applicable to the specifics of the textile industry, so that virtual models for the mechanisms of a sewing machine can be created.

The application can be used at two levels: for the students learning computer aided graphic and for the students learning about sewing technology. The application is easy to use and offers the possibility of understanding 3D drawing applied to textile machinery. It facilitates the advanced training of textile students, because they can use the models outside the laboratories and the 3D orbiting option helps them view such mechanisms from all perspectives, which is sometimes difficult on a real machine.

DEVELOPMENT OF THE MODEL

The a variant of the needle mechanism is presented in Figure 2. Basically, it is a rod-crank mechanism. The model will develop only the active part of the mechanism, that is circled in the figure, but further work can be carried out to draw and simulate the entire mechanism.

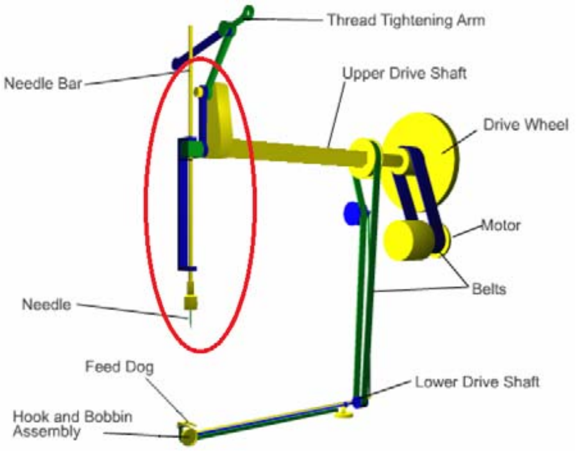


Figure 2: Needle mechanism

The drawing of the mechanism is relatively simple and can be used to teach the students how to create complex forms with Sketchup. It requires to define the initial surface of each element, extrude them to 3D forms and make them solids (so that they maintain unity and can be used to simulate the movement). The parts are then positioned in space according to their position in the mechanism. Figure 3 illustrates the resulting model. The mechanism has three parts: the driving part (circular shape), connected to the driving shaft, the arm and the needle bar (with the needle at the lower end).

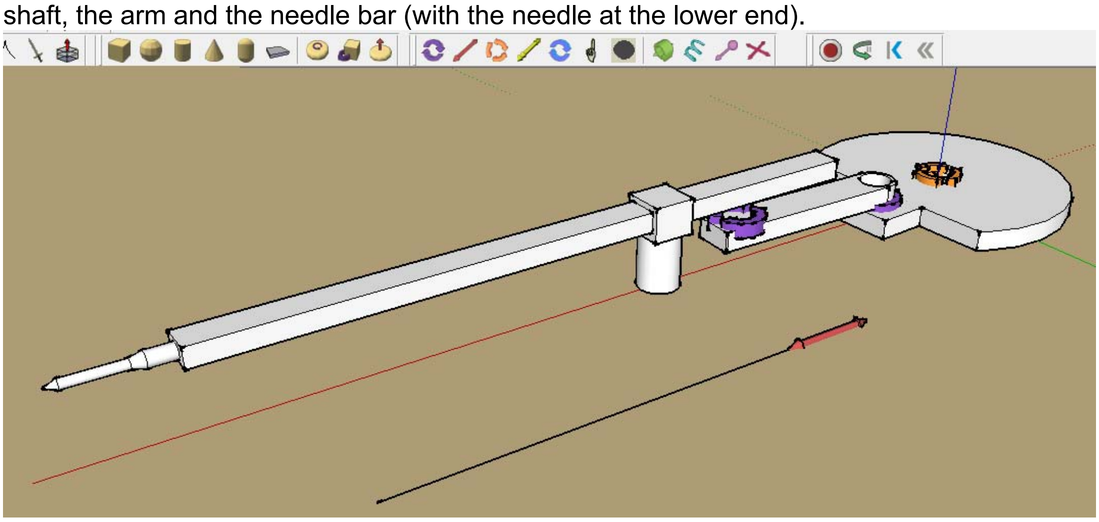


Figure 3: 3D model of the needle mechanism

After drawing the model and positioning the parts accordingly, the movement of the needle must be simulated. The Sketchy Physics plug-in must be used in order to simulate the needle movement. One of the biggest advantages offered by this plug-in is that the model respect both mechanical and physical characteristics of solid shapes. The components of the needle rod-crank mechanism were connected using the standard tools from the menu. The mechanism requires two types of displacement, rotation and sliding, therefore two types of joints are necessary - a hinge connector to ensure the rotation and a slide connector to ensure the sliding, as illustrated in figure 3. All the parts of the rod-crank mechanism are connected using hinge connectors while the needle and the needle bar are connected to a piston.

The hinge properties must then be defined, in order to control the movement of the mechanism (acceleration and damp), as illustrated in figure 4. Different values for the acceleration and damp can be used, so that the velocity of the movement during animation varies.

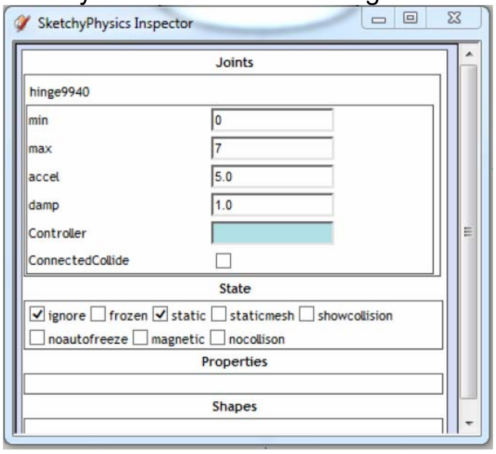
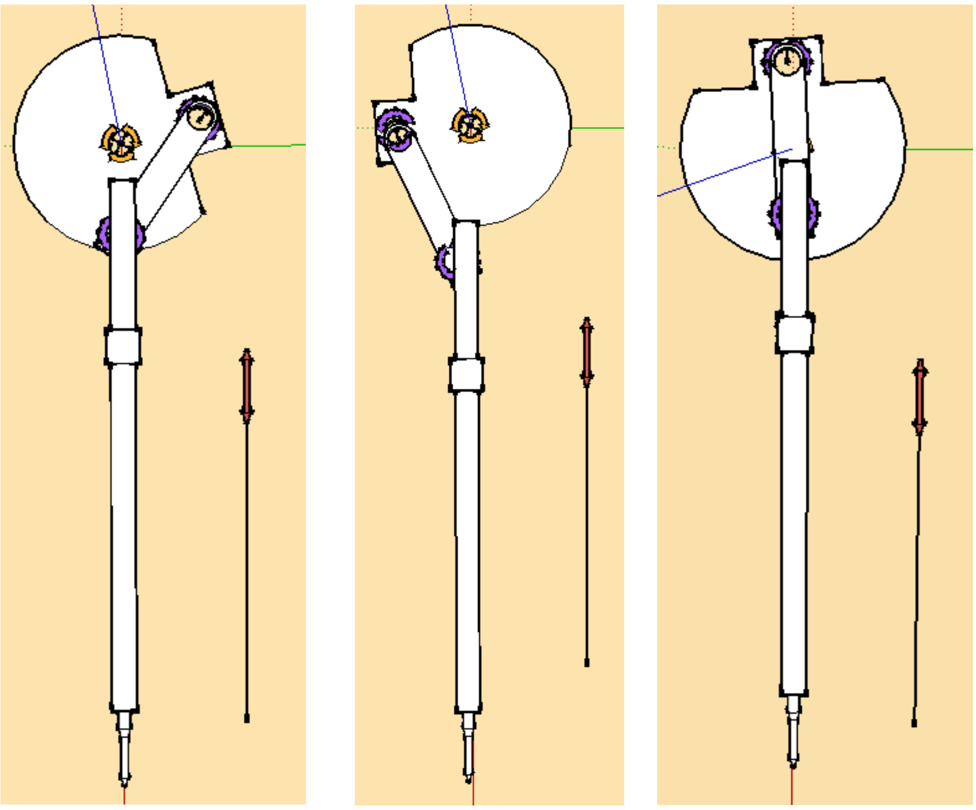


Figure 4: Definition of the hinge properties

The simulation shows the vertical sliding of the needle, determined by the rotation of the circular part (connected to the driving shaft). Figure 5 presents three position for the mechanism during the cycle of movement.



Position a Position b Position c

Figure 5: Simulation of the movement of the needle mechanism

In order to facilitate the understanding of the movement, a servo joint can be used for the driving part. The servo allows to rotate the part within a certain angle and it is controlled during the animation (see Figure 6). It makes it easy for the students to position the mechanism in whatever position they want. In order to obtain a complete rotation of the driving part, the rotation interval of the servo joint is set at -180^0 to +180^0. Figure 7 illustrates the setting of these values using the SketchyPhysics Inspector.

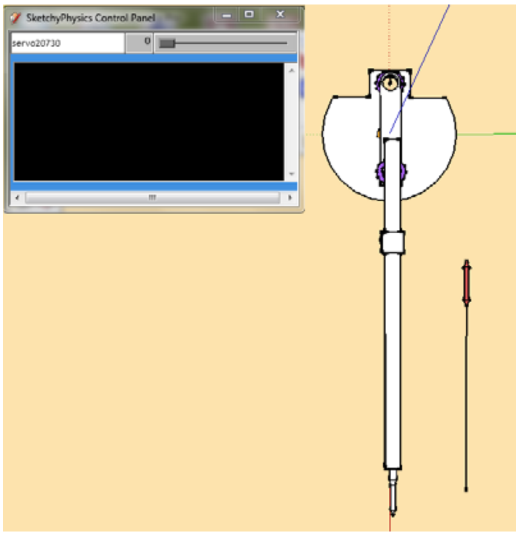


Figure 6: Controlling the rotation of the driving part using the servo joint

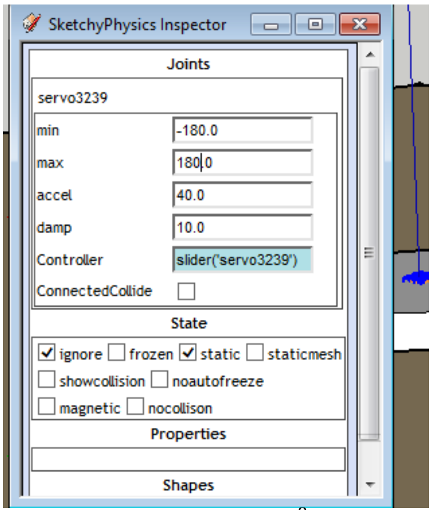


Figure 7: Defining a 360^0 rotation for the driving part using the servo joint

CONCLUSIONS

Google SketchUp is an efficient instrument in creating 3D mechanisms specific to textile machinery. One of the main problems in the training of textile specialists is the need to develop skills in understanding the components of the equipment they will work with. This means that the students must identify and visualise all types of textile mechanisms, from simple to complex. Sewing machines are such an example. The modelling of sewing mechanisms allows the students to see their parts not only directly on the machine, as it is possible during laboratory activities, but also during the time the students work somewhere else.
In this case, the paper presents an e-learning application referring to the design and simulation of the needle mechanism of a sewing machine. The students improve their skills in 3D geometry applied to textile mechanisms, their understanding of how these mechanisms function and they develop skills in simulating movement. These skills are useful in their further training when they study sewing machines.
The paper considers only the rod-crank mechanism (the final part of the needle mechanism) that actually drives the needle. Further work can consider the entire mechanism and its positioning in the sewing machine.

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IS MOOCs A SOLUTION FOR LEARNING TEXTILE ENGINEERING ONLINE?

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Abstract: *The MOOCs is a free Web-based distance learning program that is designed for the participation of large numbers of geographically dispersed students. The word MOOC was coined in 2008 by Dave Cormier, from the University of Prince Edward Island for a course offered by the University of Manitoba. In 2011, the Massachusetts Institute of Technology (MIT) OpenCourseWare (OCW) became the first large collections of MOOC resources made available from a university. Engineering is best learned the traditional way — with excellent teachers, problem sets, tests and project work. Some of the best engineering classes are available online in all areas of engineering, including mechanical, chemical, electrical and even nuclear. The list of engineering courses will provide from well-respected institutions such as Yale, MIT, Stanford and Harvard. They currently offer the best possible experience for taking an online course. In this paper is presented a solution for creating an open course for textile engineering education.*

Keywords: *eLearning, MOOCs, textile, engineering, course.*

1. INTRODUCTION

A massive open online course (MOOC) is a free Web-based distance learning program that is designed for the participation of large numbers of geographically dispersed students. A MOOC may be patterned on a college or university course or may be less structured. Although MOOCs don't always offer academic credits, they provide education that may enable certification, employment or further studies [1]. The idea is to provide free academic knowledge online is not recent. It's been now almost 15 years, for example, since the American university The Massachusetts Institute of Technology began its OpenCourseWare project, giving more people access to university lectures and other tools to enhance e-learning. Computers connected to the Internet started to multiply in offices, libraries, schools and, most importantly, in homes in many parts of the world. Nowadays, mobile devices such as smart phones or tablets have a growing role in learning within networks, and you're likely to start hearing a lot more about mobile learning or mobile MOOCs in the news soon [3].

The promise of MOOCs is that they will provide free to access, cutting edge courses that could drive down the cost of university-level education and potentially disrupt the existing models of higher education (HE). This has encouraged elite universities to put their courses online by setting up open learning platforms, such as edX. New commercial start-ups such as Coursera and Udacity have also been launched in collaboration with prestigious universities, offering online courses for free or charging a small fee for certification that is not part of credit for awards. Larger corporations such as Pearson and Google are also planning to move into the HE sector as global players and are likely to adopt a MOOC-based approach as a part of their plans. A new company, Futurelearn, has been launched by the Open University (OU) in the UK, to bring together a range of free, open, online courses from leading UK universities for learners around the world [4].

2. THE DEVELOPMENT OF OPEN COURSES

Distance learning is not a new phenomenon. With the development of the postal service in the 19th century, commercial correspondence colleges provided distance education to students across the country (in 1892, the University of Chicago creates the first college-level distance learning program, students exchange assignments and lessons through the U.S. Postal Service).

This trend continued well into the 20th century with the advent of radio, television, and other media that allowed for learning at a distance. In 1921 Colleges begin delivering education through live radio shows. The

Federal Communications Commission grants the first educational radio licenses to the University of Salt Lake City, University of Wisconsin, and University of Minnesota. The FCC grants these licenses to some 200 colleges between 1918 and 1946. In 1963 The FCC creates the Instructional Television Fixed Service (ITFS). The ITFS is a low-cost, subscriber-based-system that makes it possible for educational institutions to broadcast courses over TV. The California State University system is the first to apply for an ITFS license.

In 1970 Coastline Community College becomes the first college without a physical campus. The college creates, licenses, and implements the first fully televised college courses, and broadcasts them via KOCE-TV to other educational institutions in California. Learn/Alaska is created in 1980, becoming the first state educational satellite system. Students in 100 villages can watch six hours of instructional television daily. Another example is the National Technological University offers online degree courses using satellite transmissions. The university accesses course materials from other universities and broadcasts them to adult learners. Students can call their professors during broadcasts and participate in discussions.

In 1991 Tim Berners-Lee creates the World Wide Web. It catalyzes online education over the information superhighway, which later is renamed the Internet. For example, in 1993, Jones International University becomes the first fully online university accredited by the Higher Learning Commission. The university offers five online bachelor's degree programs and 24 online master's degree programs. Another step was made in 1996 by John Bourne establishes the Asynchronous Learning Network (ALN) Web. The Alfred P. Sloan-C Foundation supports development efforts. "Asynchronous learning networks" refer to the ability to deliver education anytime, anywhere through the Internet. The year 1997 marks the appearance of e-Learning system by creating of WebCT 1.0 LMS, an e-learning system which is considered the predecessor of BlackBoard.

The **Blackboard Learning System** is a virtual learning environment and course management system developed by Blackboard Inc. It is a Web-based server software which features course management, customizable open architecture, and scalable design that allows integration with student information systems and authentication protocols. It may be installed on local servers or hosted by Blackboard ASP Solutions. Its main purposes are to add online elements to courses traditionally delivered face-to-face and to develop completely online courses with few or no face-to-face meetings. This system was introduced in 1999.

2.1 Evolution of MOOC

The development of MOOCs is rooted within the ideals of openness in education, that knowledge should be shared freely, and the desire to learn should be met without demographic, economic, and geographical constraints [4].

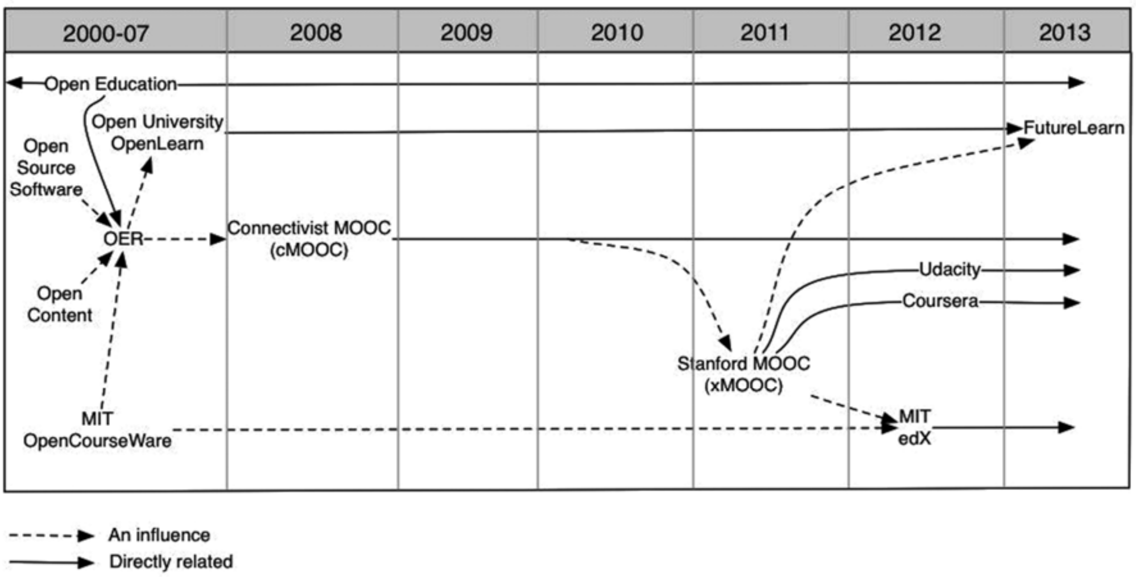


Figure 1: MOOCs and Open Education Timeline [5]

As figure 1 shows, since 2000 the concept of openness in education has been evolving rapidly, although it has its origins in the early 20th century (Peters, 2008). Massachusetts Institute of Technology (MIT) established OpenCourseWare in 2002 and the Open University set up OpenLearn in 2006, representing an ongoing development of the open education movement. Influenced by the early development of MOOCs, various open learning platforms have been set up by elite institutions; examples from 2012 include MIT edX and OU's Futurelearn. A key message that emerges is that the evolution of MOOCs is leading to more players in the market as HEI and private organisations seek to take advantage of these innovations in online learning.

A number of MOOC platforms have been developed and offer courses independent of or in collaboration with universities. The best known of these are:

edX (https://www.edX.org/) is a non-profit MOOCs platform founded by Massachusetts Institute of Technology and Harvard University with $60 million of resources contributed by the two institutions to support the project;

Coursera (https://www.coursera.org/) is a for-profit company, which started with $22 million total investment from venture capitalists, including New Enterprise Associates and Kleiner, Perkins, Caufield & Byers Education;

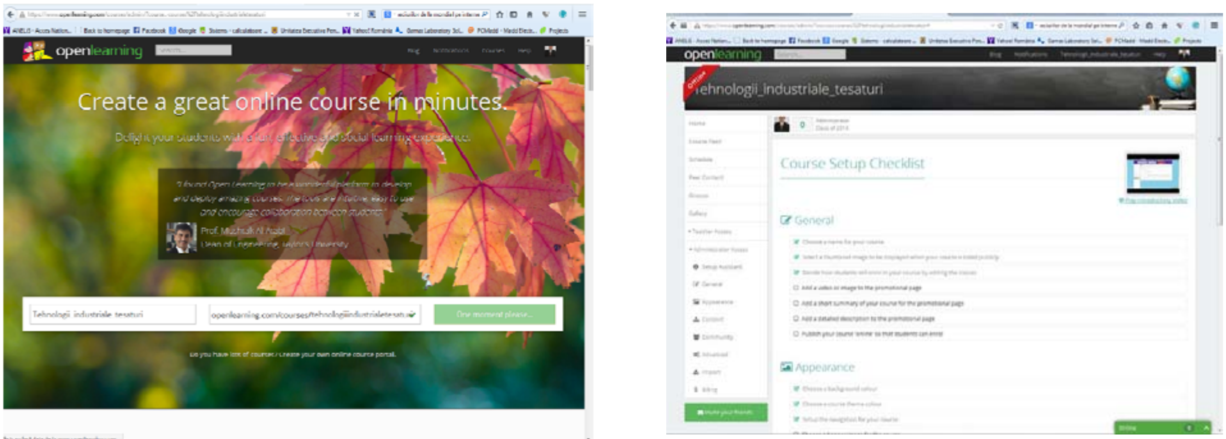
Udacity (https://www.udacity.com/) is another for-profit start-up founded by Sebastian Thrun, David Stavens and Mike Sokolsky with $21.1 million investment from venture capitalist firms, including Charles River Ventures and Andreessen Horowitz.

The most common revenue stream for the major new MOOC providers is to charge fees for certificates. Whilst edX is a not-for-profit MOOC platform with the goal of helping universities achieve shared educational missions, in the longer term it will also need to be self-sustaining. Coursera and UDACITY are examples of for-profit organisations, they are working on developing a variety of business models, and according to their published commercial strategies, these include: selling student information to potential employers or advertisers; fee-based assignment grading; access to the social networks and discussions; advertising for sponsored courses; and tuition fees for credited courses [6].

2.2 Open learning platform

In the last decade, distance education has changed significantly with the use of computer-mediated learning, two-way interactive video, and a variety of other technologies. Universities are forging ahead to provide learning at a distance, and many institutions are making substantial investments in new technologies for teaching. Free online classes are nothing new. Universities have offered free learning content in the form of open courseware which freely offered course syllabi, recorded lectures, notes, and other content taken from their traditional courses. Some open learning platforms are: Versal (https://versal.com/), Rcampus (https://www.rcampus.com/), OpenLearning (https://www.openlearning.com/), etc.

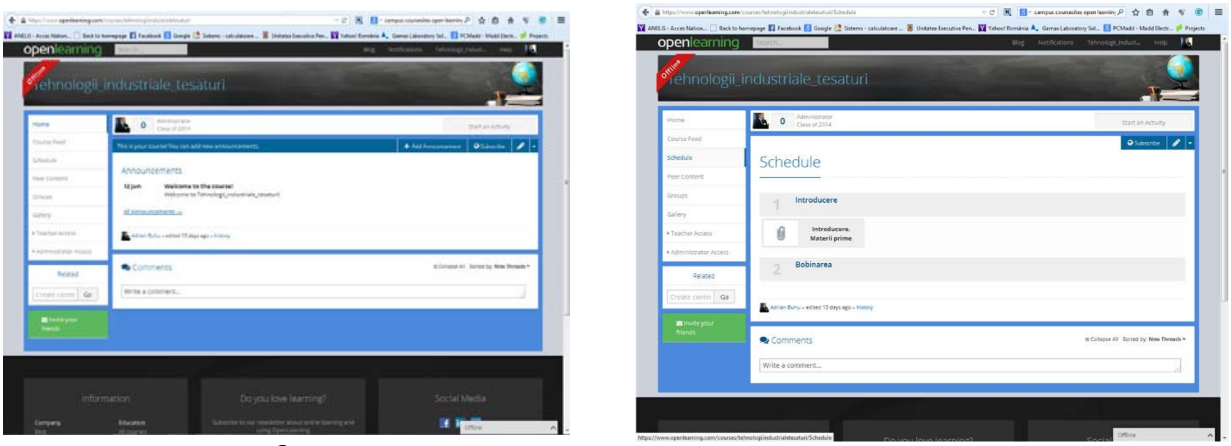
An example of a course being developed on an open platform is shown in figure 2.



a. b.

Figure 2: Course create on OpenLearning platform (a) and course setup (b)

A course is structured in several modules like the chapters of a classic course. The difference between the two is given by the fact that each module can be attached ii text documents (Word, Powerpoint, etc..), Links, pictures, videos, and can be attached to different files that can be downloaded by students, figure 3.



a. b.

Figure 3: Course structure (a) and modules (b)

However, there were some problems: learners usually didn't have access to enough information to really master the content, a syllabus or a few recorded lectures gave learners a good start, but it wasn't enough to guide them through the content like a traditional course would. Many open courseware resources didn't make so much sense without the content provided – students were missing the in-class discussions, the guest lectures, the assignments, the class demonstrations, and often even the textbook. It gave learners few options to study as a part of a community. People reviewed the content in isolation and tried to learn without access to professors. It is difficult to stay motivated or keep going when there was no easy way to get answers to their questions. Solving these problems related to the professor's ability to compensate for lack of F2F activities and communicating with students.

3. CONCLUSIONS

Open courses based on new structures, ways or working and use of technology can make higher education more cost effective and accessible and may also contribute to balancing work, family and social life. Learners have access to a variety of non-traditional learning models including access to courses and materials to self-direct their own learning beyond their classes and institutions. More flexible models and open approaches will encourage more mature students to participate in higher education and gain qualifications to further their careers.

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GRAPHICAL APPLICATION FOR INTERACTIVE LEARNING

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***Abstract**: The aim of the work is to create and use an animated graphical interface with interactive objects, in order to help the student or pupil to understand quickly and correctly aspects related to the construction, operation and adjustment of different mechanisms of automatic flat knitting machines. In order to reach this aim, we used the animated graphic program Corel R.A.V.E. (Real Animated Vector Effects), which allows the creation of interactive objects known as rollovers, in order to be used as navigation instruments in an html or flash document. The Corel R.A.V.E. program may export a movie created by its means in the several formats, which may be published in the World Wide Web network. The e-learning interactive tools presented in this paper represents the outcome of the process of innovating the working methods applied in the knitting laboratory of the Faculty of Textiles, Leather and Industrial Management of Iasi.*

***Keywords:** interactive learning, e-learning, module learning, animated effect*

1. INTRODUCTION

In order to reach this aim, we used the animated graphic program Corel R.A.V.E. (*Real Animated Vector Effects*), which allows the creation of interactive objects known as *rollovers,* in order to be used as navigation instruments in an html or flash document.
A *rollover* may be created with any object or group of graphical objects. *Rollover* objects may change their aspect when you click on them. A *rollover* object has 3 statuses: *Normal, Over* and *Down.* An object is *Normal* when it is not associated with any of its action by means of the mouse. The status *Over* initiates an action when the pointer of the mouse is placed above the object. The status *Down* initiates an action when you click with the pointer of the mouse above the object. For instance, when you click on it, a *rollover* object changes its colour or displays an explanatory text.
The Corel R.A.V.E. program may export a movie created by its means in the following formats, which may be published in the World Wide Web network: Macromedia Flash (.swf), GIF Animation (.gif), Video for Windows (.avi) and Quick Time.

2. THE USE OF MOVIE GROUPS CREATED WITH COREL R.A.V.E. FOR THE CREATION OF A WORK INTERFACE

We intended the design of a work interface with multiple windows that may be opened on command by means of some *rollover* graphical objects designed with Corel R.A.V.E.
Usually, the most used method in design is keeping several animations in a single place or in a single container. However, many times these animations may render the container too large or too difficult to access.
In order to produce an animated movie with multiple windows designed with Corel R.A.V.E., the most used method is to place all windows in a single file, using transfers in the file and producing the results of the action there. This method leads to a low performance and to a slow operation of the movie.
The alternative is to create small animation movies and to use a Flash Player program to regroup and to manage them according to the user's requirements.
Figure 1 presents a section through a needle bed where the knitting elements of a knitting machine may be seen. The image also includes 13 reference indications whereby each knitting element and their constituent parts are identified.
Each reference indication may be considered a button, respectively a *rollover* object. Clicking on any of the buttons, the explanatory text at the base of the drawing will change. Each text-type window represents a single independent movie, loaded by a click on that button.

Figure 1: Example of display from an animated movie for the interactive presentation and description of knitting elements of a knitting machine

3. METHOD USED

First of all are drawn the areas that we do not want to change ever and that we may consider a part of a fixed background (Figure 2). Around the drawing are placed 13 references considered *rollover* objects, which if pressed shall determine the display of an explanatory text at the base of the drawing. The drawing which is part of the background is saved as an original name using the command SAVE AS. In this case, the name used is "Movie ofo.clk".

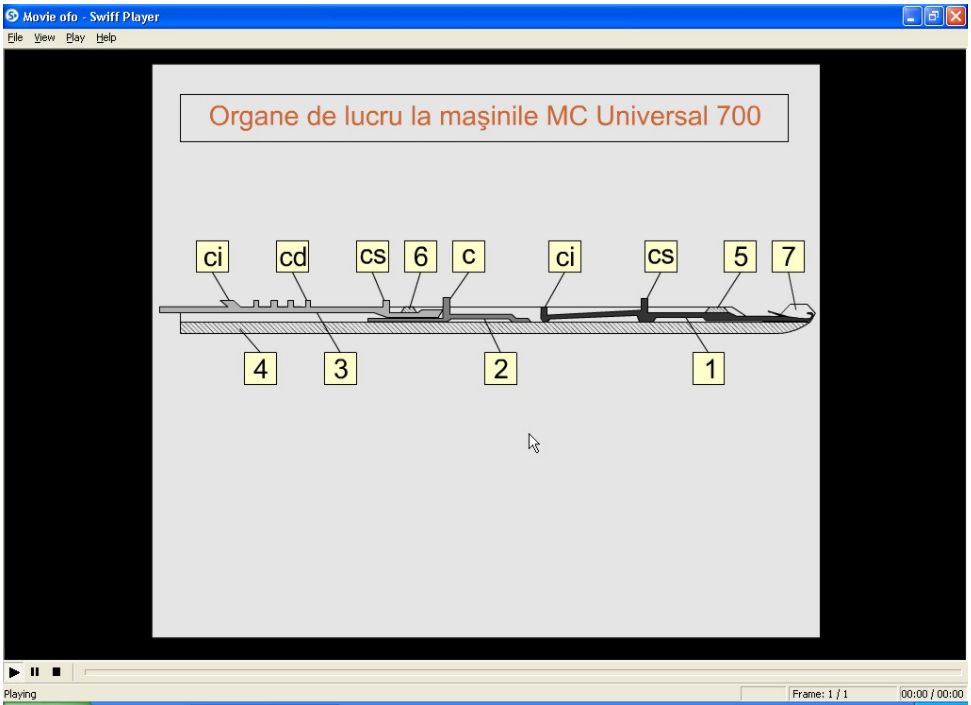

Figure 2: The background or scene considered fixed objects

We load the file "Movie ofo.clk" and add a frame where we place an explanatory text for a chosen reference. We delete from the drawing the part considered background and the resulting drawing shall be saved with the name of the reference (for instance, "Movie1.clk", Figure 3). Having the file "Movie1.clk" open, this drawing is exported as Macromedia Flash file, with the extension .swf ("Movie1.swf"). In the same manner, we repeat it with the other references, resulting other successive files: "Movie2.swf", "Movie3.swf" and so on, by "Movie13.swf".

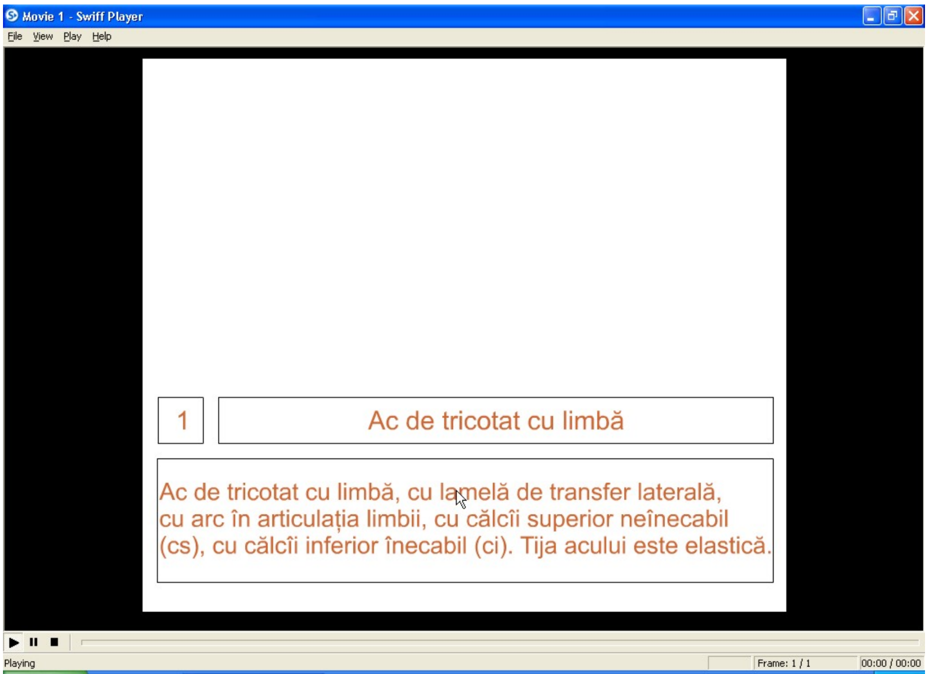

Figure 3: Text window loaded at the same time with the movie "Movie 1.swf"

After all windows were designed and transformed in Flash-type individual movies, we proceed to their assembling. First of all, we open the file "Movie ofo.clk" which is defined as work interface and which contains all objects that are to be ordered (references of operating parts on the drawing). These shall be transformed one by one in *rollover* objects by the commands EFECTS-ROLLOVER-CREATE ROLLOVER.
In the command bar INTERNET, the status of the *rollover* objective shall be set DOWN. Then we press the action button to open the dialog window in order to choose the actions in the film (Figure 4).

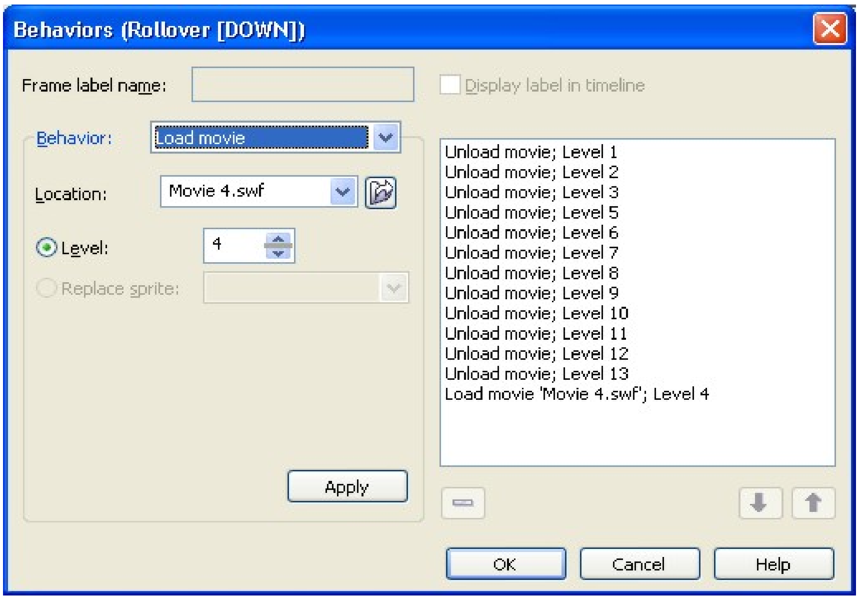

Figure 4: "Behaviors" Window

For instance, if we want the pressing of the button "4" on the drawing to display the text window associated with this button, we download the movies "Movie1.swf", "Movie2.swf", "Movie3.swf", "Movie5.swf", "Movie6.swf", "Movie7.swf", "Movie8.swf", "Movie9.swf", "Movie10.swf", "Movie11.swf", "Movie12.swf" and Movie13.swf", no matter whether they appear active or not, and we load the film "Movie4.swf".
After proceeding the same with all 13 buttons (references), the file "Movie ofo.clk" shall be exported as a Macromedia Flash animated movie ("Movie ofo.swf). The file "Movie ofo.swf" and all the 13 individual files ("Movie 1.swf", "Movie2.swf", ... , "Movie13.swf") shall be placed in the same director (Figure 5).

Figure 5: "Open" Window

Running the file "Movie ofo.swf" shall be made with a Flash Player or with Internet Explorer. The application may run without referring to the original program used for its creation (Corel R.A.V.E.).

4. ACHIEVED RESULTS

The presented work method was applied to 4 animated movies with the following themes: interactive study for knitting elements, interactive study for the plate with actuating cams of knitting needles, presentation of the selection method of knitting elements and generation of trajectories for the buts of the knitting needles. The package of applications may be used in laboratory activities at knitting subjects in the university and pre-university education.
Figure 6 presents an example of screen from the application which describes the system of actuating cams of knitting elements from the knitting machine MC Universal 700.

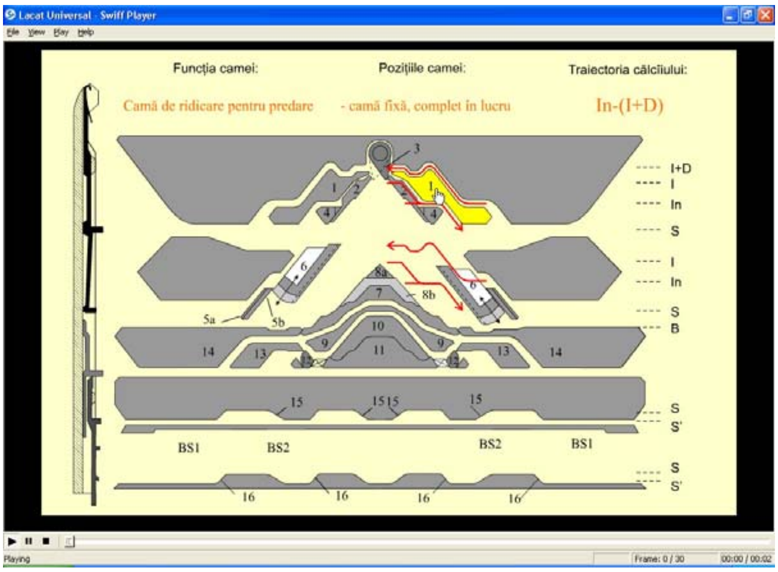

Figure 6: Example of screen from the description of the construction of the cam system

Each cam is an interactive object which presents the function of the cam in the text box, and the trajectory of butt is marked in red.
The animated movie from Figure 7 presents the movement sequences of knitting elements during the selection process. The objectives are: acquaintance with the lifting method of the inferior but of the knitting needle above the surface of the needle bed, acquaintance with the movements of needles for knitting of stitches, the formation of loops and the retention of structural elements formed in the previous knitting cycle, acquaintance with the source of movement of each operating part.

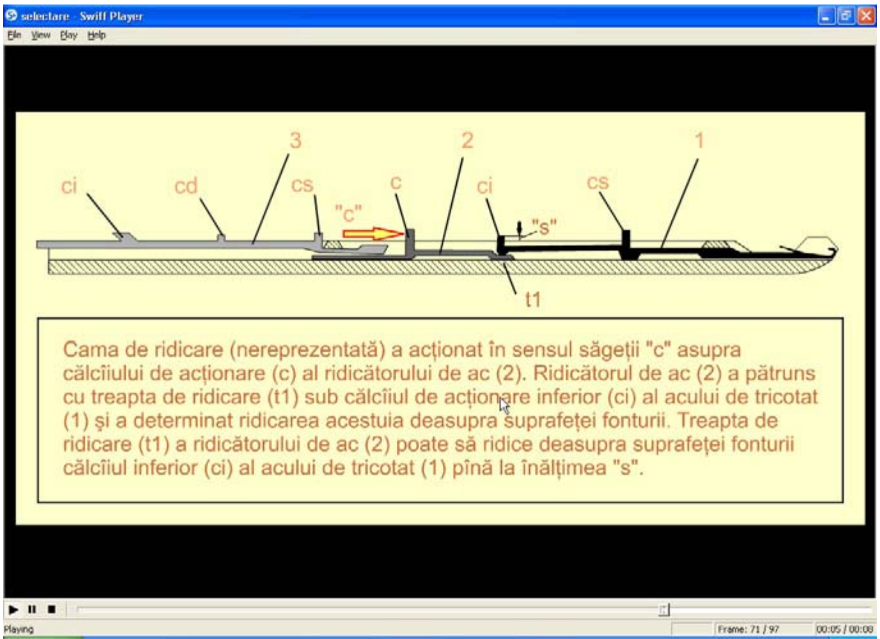

Figure 7: Description of selection sequences of knitting elements

The animated movie may be associated with recorded sounds in order to explain the mode of achievement of selection of knitting elements from the knitting machine. Sound files *.vav shall be launched and stopped from running depending on the moment chosen by the programmer.
Figure 8 presents an example of screen displayed by pressing the button no. 8. It is shown and explained how the trajectory of buts of the knitting elements was obtained up to this point, which cams achieve the actuation of buts and indicates what height presents the inferior but of the knitting needle above the surface of the needle bed.

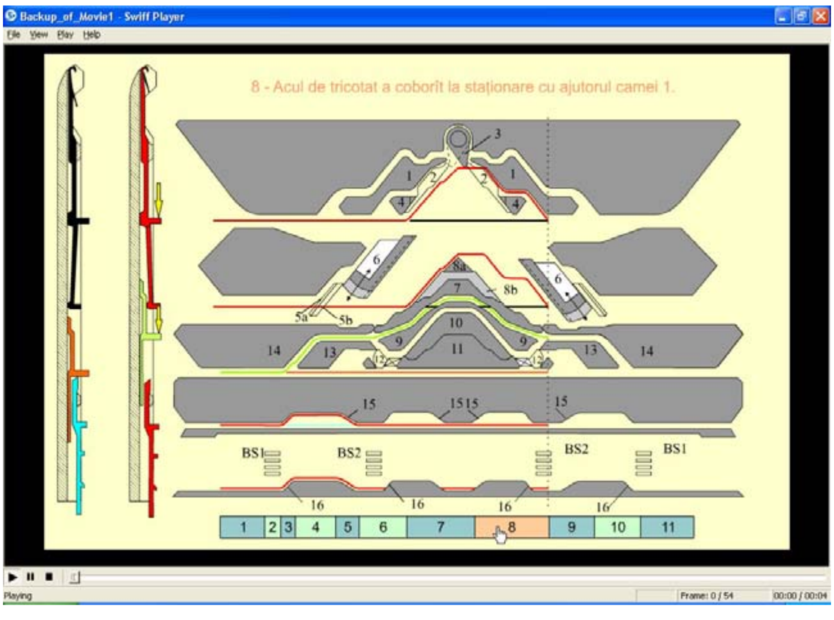

Figure 8: Generation of complete trajectories of buts of the operating parts

The user has the possibility to recommence the animated movie from any point of the cam system and may stay in a certain point as long as he wants.

5. CONCLUSIONS

Simulation by means of animated movies is an important instrument in the learning activity, which continuously maintains the student's or pupil's attention. Computer-assisted learning may apply individually or in a group in the classroom and individually in the library or at home.
Computer-assisted interactive learning is more appreciated by people in comparison with the group learning in the class, consisting of listening specialty courses. People wish to get the information at the top of their fingers and at the time they want.
There are various methods of delivering computer-assisted lessons: by Internet and Intranet, CDs, programs ran on the computer etc.
We hope this article will inspire you to think to other practices using the same operating method.

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Project presentation

STEP TO SUSTAINABILITY
How to Implement Sustainable Manufacturing in Footwear
New occupational profile and training opportunities

Rita SOUTO,
Centro Tecnológico do Calçado de Portugal

Abstract: *Step to Sustainability project aims at creating, designing, developing and piloting a new occupation and qualification profile and correspondent training course on the subject of "How to implement sustainable manufacturing in Footwear" coping with the visible shortage of VET skills in this field targeted to Footwear and Leather Goods sector, as well as anticipating the major need of these skills and competences in the near future, mainstreaming it within Education & Training Systems and contributing for a systemic view on sustainable manufacturing strategies implementation in Footwear, from all stakeholders, for the benefit of the European Footwear Industry competitiveness and enhancement of job opportunities. Sustainability in the footwear industry, is familiar to the big producers of sportswear brands, with many brands divulging their concern about protecting people and environment and adopting an environmental friendly communication approach.*
The market for "green shoes" is in an expanding development, reflecting the big change in the consumer behaviour, worldwide, representing a huge opportunity of growth for the Footwear sector in Europe, especially the casual/fashion segment. This segment of footwear is constituted by SMEs without qualified resources in the matter of sustainability, for whom the development of skills and competences in this field is very important..

Keywords: *footwear, sustainability, manufacturing, occupation and qualification profile, skills, competences*

INTRODUCTION

This project will bring a significant and determinant evolution in many perspectives:

Sustainability in Footwear: an already in place research outlined examples of some brands divulging their worries about protecting people and the environment, publicising the adhesion to occupational safety regulations and to products using "green" materials, adopting a social and environmental friendly approach communication: NIKE with "Better cotton initiative" and "Nike-reuse-a-shoe", using leather from "The Leather Working Group"; ADIDAS being the leader on sustainability since 2000 according to Dow Jones Sustainability Index with the initiative "Ecologic imprint" and "Better Place"; ADIDAS and PUMA with "zero discharge shoe" till 2020; TIMBERLAND, with the initiative "Earth keepers" making products with recycling materials and "Earth Day". Actually, these players have an important action of modelling the consumption, creating the "green attitude", opening space for other players who have the willing to take the challenge. In Germany, companies are pioneering biodegradable / compostable footwear. The 2013 GDS fair has seen the first compostable shoe developed by a German footwear company. However, examples of SME in fashion leather footwear, professional footwear, high quality casual/comfort footwear segment, acting in this field are hard to find. SMEs represent the most important entrepreneurial tissue in European Footwear Industry.

Training offer/opportunities: many courses are being delivered all over the world focus on the managerial aspects of sustainability in economic, social and environmental level, but none focuses on the production itself as for Footwear or for any other sector. This training will adopt and approach to aspects of economic, social, environmental, but always articulated with the qualifications, skills and competences and activities addressed to the new profile of expert focused on the technical part of the implementation of a sustainable manufacturing in Footwear, since the design and product engineering till expedition, adding aspects of Marketing and the use of "sustainable" image, assuring a sustainable process and product and correspondent dissemination. The validation will be based in a strong piloting phase within the countries involved.

Occupational profile: there isn't an occupation/qualification profile in the field of sustainability in NACE re2, 15 Manufacture of leather and related products, nor in other occupational databases. They don't predict occupations related to sustainable production in Footwear nor in the most traditional sectors. There is no formal occupation/job in this field in Footwear and Leather Goods, as well as certified training opportunities work based oriented. This is very important for the development of the state-of-art in this field, as well as for the competitiveness of the sector, since this is a development driven which will bring a renewed breath and consolidate the positioning comparing to other players.

Target-group: the new profile will reflect the opportunities of qualification and certification of existing competences spread in education system and the life of work, seeking also the possible recognition of informal acquired competences. The project will widen the issue of sustainability, since VET till higher education. The learning opportunities that will be delivered, will adopt methodologies of b-learning supported by a e-learning platform with a training/coaching follow-up and work-based training workshops in the VET sites and/or in the SMEs shop floor. The innovation is due to the combination of the two methodologies of training, possible to be spread worldwide and to the work-based training offers.

Consortium quality: this project is the result of the work of the expertise around Europe, based on real tested and validated previous project results, gathering the attentive vision of so many different perspectives described above.

RATIONALE OF AND BACKGROUND TO THE PROJECT

The footwear world-wide production is estimated to has reached the 21 billion pairs in 2011 (most recent data available in www.worldfootwear.com) with Asia continuing to be the powerhouse of footwear industry, with an overall share of 87%. Europe with its 3% share of production is responsible for 11% share of exportations, with the highest worldwide average price close to 25 USD, against Asia's 5 USD. European Footwear Industry definitely found its positioning in terms of price but the potential of Asia shouldn't be overlooked, as well as other players in Oceania and South America. European footwear industry is constantly looking for aspects that differentiate products and services, (new product concepts, business models, functionalities articulated with fashion, quality, high performance) and, more recently, sustainable manufacturing which comprehends a multifaceted framework from design till distribution. Consumer behaviour toward sustainable conscientiousness opens notably opportunities for growth for European Footwear Industry. For the consumers, sustainability is also an attitude, increasingly a way of being updated, a trend that came to stay. The market for "green shoes" is in an expanding development, not only in sports, but also in fashion, high quality and all sorts of high performance footwear. European Footwear Industry understood that it is a powerful way of differentiation and wants to embrace it successfully. Sustainability meets multiple frameworks, namely economic, social and environmental, not only at a management level, but as referred, above all, at technical level. A footwear company, wanting to start up a sustainable strategy for its business, needs to develop a multidisciplinary knowledge at technical level, target-oriented, which doesn't exist. The most of the casual and fashion Footwear subsector in Europe is constituted by SMEs for whom is difficult to address a sustainable manufacturing strategy, due to the lack of qualified resources.

The success of this kind of strategies largely depends on the knowledge and domain of the frameworks and application to practice. In fact, besides isolated cases encountered among the big players (Nike, Timberland, etc.) there isn't capacity nor training opportunities at technical level to implement a sustainable manufacturing strategy. Footwear has, this way, an opportunity of growth and to contribute to job enhancement, namely new comers (22% of young people 18-24 in Europe is unemployed). A European ECO LABEL project was already established for Footwear in 1999 but SME lack knowhow on how to meet the requirements. The lack of target-oriented technical vocational training/education at this level is evidenced in all countries involved in the consortium, representative of the Footwear sector in Europe.
Portuguese Footwear industry is constituted by 1500 companies mainly SMEs and 35.000 workers, being one of the world leaders in the manufacturing and marketing of leather footwear. The focus is in the innovation and differentiation and, through the action of the most important agents such as APICCAPS (Footwear Association) and CTCP, the sector has been reinforcing its competitiveness – it's now the 11th most important exporter in value with the 2nd highest average export price (32USD) worldwide. Sustainability is the today step forward to competitiveness which assures a solid position in the global market but the lack of education/training in the field is evident and provokes the big constrain for the implementation of a successfully strategy.

As a leader of shoe manufacturer in Europe, Italy represents the third largest exporter of footwear in the world. The sector has more than 80.000 employees and accounts more than 5.500 companies divided in many districts. The Italian Footwear Industry is constantly innovating and provides advanced quality products for a demanding market. Sustainability means a repositioning in the market requesting an application of new professional profiles, with expertise in technical areas, and training, anticipating future skill needed. The project ECOINNOVATION - IMAGIN_E "For a Made Green in Europe" 2009 - 2012 was the first step forward.

Romania is the fourth EU27 footwear producer which brings an important contribution at national total GDP - around 4% (source: national statistics and Eurostat). The Romanian footwear sector has been affected by recent economical crisis, requiring important changes by adding value to its products. And the added value comes from new business concepts, as sustainable manufacturing. In Romania there is not an occupational profile and correspondent training that could cover the issue of sustainable manufacturing, nor graduated people, managers or engineers from footwear SMEs have necessary skills and competences for sustainable manufacturing. The project SMDTex - Sustainable Management and Design for Textiles, was also an introductory step.

The German footwear industry faces a strongly increasing customer demand for sustainable as the rest of the European footwear industry. Consumers are more and more aware of the production conditions, the situation of the workers, the materials used, the carbon imprint of the products, and their recyclability. However SME need guidance, skills and qualified people to drive such projects of implementing sustainable manufacturing in Footwear. Target-oriented training opportunities in the field of sustainable footwear production would definitely be beneficial for all.

Spanish footwear industry experienced lately a significant growth based on foreign trade which reached the combined figure of almost €4 billion, with a cover rate of 90%. However, the situation is very complex because of the extent of internationalisation, the nature of global trade and the great diversity of Business strategies. In Spain Footwear is undergoing continuous technological expansion, related to the environmentally-consciousness, anticipating the need of skills and competences on Sustainability in order to support successful strategies in the field. Also LIFE10 projects in the environment field is being the start of the awareness on the need of a new profile and learning opportunities for the sustainable manufacturing in Footwear.

Up to 2011 there are 442 companies in Slovenia with 10.794 employed persons and almost 1.000 millions EUR of year revenue. The lack of qualifications is high at all level, especially in the frame of innovative skills and competences that can bring a renewed breath to Footwear sector.
Sustainability is understood as a driven for success, also in Czech Republic producing 4.4 million pairs per year specially high add value professional and security footwear and returning to child and health, with 4300 employees. COKA is a strong and motivated player with many projects going on in the field.

All the partners (figure 1) are strongly engaged with the project, had previous experiences together in many project including in CEC Made SHOE which was a first project working out the "Sustainability" issue, centred in the customer, coordinated by CEC and created in the frame of European Technologic Platform for Footwear. The project idea emerged from the registered evidence needs in each partner country and the work of CTCP, INESCOP and TUIasi in EC ESCO Project, that noticed the lack of an occupational profile in the field of Sustainability (NACE re2_15 Manufacture of leather and related products nor in others occupational/professional databases).

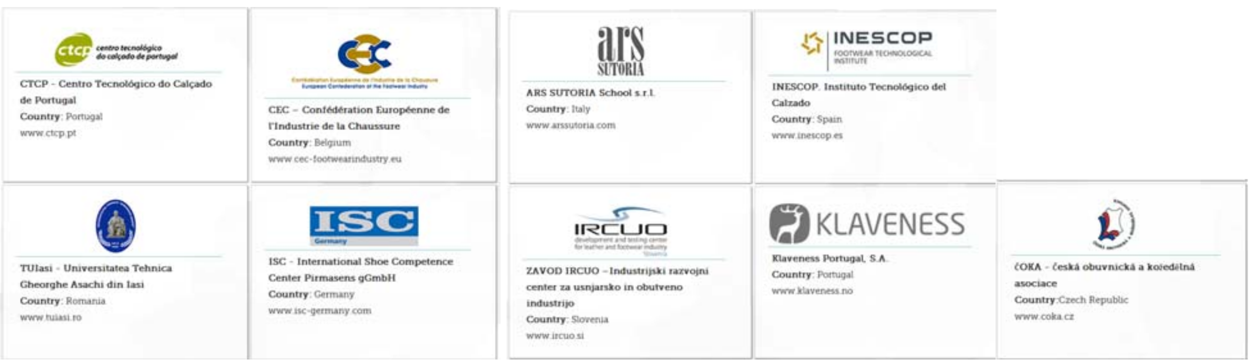

Figure 1: Project's partners

As exposed above, the partners are determined to develop a specific occupational and qualification profile for an expert on sustainable manufacturing in footwear who is capable to deal with the implementation of manufacturing sustainable strategies in Footwear, turning sustainability a variable of differentiation, contributing for the competitiveness of European Footwear Industry and creating jobs opportunities. Moreover, they have willing to develop target-oriented training adapted to the needs of SMEs, possible to be disseminated in a great scale format, involving ICT based training and a strong work-based training, contributing for a systemic response in the field of Sustainability.

AIMS AND OBJECTIVES

The Project aims at creating, designing, developing and piloting a new occupation and qualification profile and correspondent training course on the subject of "How to implement sustainable manufacturing in Footwear" coping with the visible shortage of VET skills in this field targeted to Footwear and Leather Goods sector, as well as anticipating the major need of this skills and competences in the near future, mainstreaming it in Education & Training Systems and contributing for a systemic view on sustainable manufacturing strategies implementation in Footwear, from all stakeholders, for the benefit of the European Footwear Industry competitiveness and enhancement of job opportunities.

The specific objectives and their contribution for the identified needs are the following:

- To develop a deep knowledge on occupation and training needs based on an evidence-based research, concerning competences and skills to implement sustainable manufacturing in Footwear and possible existing learning opportunities. The research will involve SMEs, Associations, Trade Unions private research centres, adult education institutes, Universities, technical schools, VET institutions, other entities from Education & Training System and the outputs will help to support and refine all the development to be produced from then in the project;
- To develop a new occupation/qualification profile of the expert in sustainability, capable to deal with all frameworks of sustainability issue, and above all, to apply that knowledge to the companies' shopfloor, conceiving taylor-made strategies, attending the context – this allows also to create job opportunities contributing for the decreasing unemployment of youngsters in Europe at the moment situated in 22% of the 18-24 years old (Eurostat 2012).
- To develop a learning programme capable of coping with the identified skills and competences which compose the new profile articulated with the identified training needs, with the presuppositions and principles of European Credit System for Vocational Education and Training (ECVET), allowing the possibility to transfer and/or accumulate the predicted learning outcomes from other forms of education, and to other educational itineraries and seeking the certification;
- To develop (design, development and test) training units targeted to the new profile an other people in companies, with association to assessment procedures, transferability, validation and accumulation of learning outcomes - integrating European Credit System for Vocational Education and Training (ECVET) and quality assurance principles in VET, European Quality Assurance in Vocational Education and Training (EQAVET), providing basis for certification;
- To development the b-learning course, structuring e-learning component and work based learning workshops that together contribute for the acquisition of the predicted learning outcomes, and potentiate the mass dissemination of the training, transforming that in real and accessible learning opportunities. Complete it with a demo in all languages and EN and an user manual for trainers and coaches;
- To pilot the results, the training course including e-learning component and the work based training workshops, involving a significant number of SMEs, for the successfully accomplishment of this objective, training partners will provide special workshops for trainers/coaches to lead with the e-learning component follow-up and with the work-based training workshops.
- To create awareness for the need of a sustainable manufacturing strategy and correspondent challenge that has been undertaken by some players as a driver of competitiveness, and disseminate the results in order to optimize their mainstreaming in the Education & Training System at National and European level transforming the deliverables in real occupation, qualification and training opportunities.

- To exploit results through European, national and local networks and platforms, enterprises, business organisations, guidance organisations, as well as other relevant media, inside and outside Europe.
- To enlarge the networking between the partners (core and associated partners) under an effective and qualitative management, both results oriented and respecting the differences between cultures, ways of performing, values.

RESULTS

The envisaged project results/products are the following (figure 2):

Research on training needs based on evidences

Competences and skills to implement sustainable manufacturing in Footwear among Europe companies/Universities/technical schools/ET entities;

New qualification profile based in a new research combined with already existing studies on sustainable manufacturing;

Training Programme to fit the new qualification profile, according to the presuppositions of ECVET for credits transfers (European Credit System for Vocational Education and Training)

Learning units based on qualifications targeted to the new profile an other people in companies, with association to assessment procedures, transferability, validation and accumulation of learning outcomes achieved in formal, informal and non-formal contexts - integrating ECVET (European Credit System for Vocational Education and Training) and quality assurance principles EQAVET;

E-learning course;

Results piloting reports;

Quality Evaluating Report

Dissemination material and events for exploitation of results.

The products will be delivered in the following languages: English, Portuguese, Spanish, Italian, Romanian, Slovenian, Czech, French and German.

Figure 2: Project's website, http://www.step2sustainability.eu/

CONCLUSION

Sustainability in the footwear industry is till now a subject worked out by the major producers of sportswear, with many brands divulging their concern about protecting people and environment and adopting an environmental friendly communication approach.
The market for "green shoes" is in an expanding development, reflecting the big change in the consumer behaviour, worldwide, representing a huge opportunity of growth for the Footwear sector in Europe, especially the casual/fashion segment. This segment of footwear is constituted by SMEs without qualified resources in the matter of sustainability, for whom it's important to develop competences and skills in this field.
The project STEP to SUSTAINABILITY intends to add value to the footwear industry in terms of qualification skills and competences in the field of "Footwear Sustainable Manufacturing" enabling to cope with the visible shortage of vocational skills, potentiating the best use of the outcomes in the field of materials, machinery, processes, developed in the frame of previous European Research & Development Projects with sustainable purposes, improving competitiveness in Footwear.

ACKNOWLEDGEMENTS
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WOMEN RESEARCHERS IN THE TEXTILE FIELD

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Abstract: *The increase of women participation in the research field is an objective shared by many scientific institutions in Europe, as evidenced by the public consultation initiated by the European Commission, with the purpose of defining Horizon 2020 framework programme for research and innovation. ERA (European Research Area) strategic vision sets the objective that by 2030 half of all scientists across all disciplines and at all levels of the science system shall be women. As the textile-clothing sector hires predominantly female personnel, further research is needed on the "woman researcher" theme in view of an integrative approach of gender equality, and also a systematization of data referring to women distribution. The paper presents aspects referring to women promotion obtained in an ongoing project (FEMTEXCONF) conducted by INCDTP.*

Keywords: woman researcher, textile, gender dimension, gender equality

1. INTRODUCTION

Studies conducted in the European Union evidence that despite being an absolute requirement, gender equality legislation does not guarantee conformity with legal provisions, thus leading to a need to modify both the work conditions and the mentalities. These changes should be supported and encouraged by various institutions, in an effort to allow women to benefit of the advantages stipulated by laws.
Promotion of gender equality is one of the key priorities set by the European Commission to establish the European Research Area (ERA).
The objective of this paper is to promote a better integration of the gender dimension in the science and business career opportunities for women in the textile – clothing field.
Aspects referring to women promotion strategy and integrative gender equality approach strategy complementarity are presented and data referring to the actual situation of women researchers in Romania, and especially in the textile – clothing field are provided.

2. GENDER EQUALITY AND GENDER MAINSTREAMING

The European Community mobilized all measures and general policies in order to achieve gender equality, which became vital for the preparation, application and monitoring of all EC policies, measures and activities. It has also become the guiding principle for the Community Action Programme on medium term for gender equality, which was adopted in December 1995.
In February 1996 the European Commission has published an important document which explains a new method for the application of the integrative approach, entitled <Incorporating equal opportunities for women and men into all Community policies and activities>, a document which states that the principle of equal opportunities for women and men is a basic principle of democracy.

Gender mainstreaming is not equivalent to equal treatment and opportunities, but it means to set equal chances for approaching situations, processes and possibilities based on gender. In 1998 the Council of Europe has formulated the following definition: *Gender mainstreaming* is the (re)organisation, improvement, development and evaluation of policy processes, so that a gender equality perspective is incorporated in all policies, at all levels and at all stages, by the actors normally involved in policymaking.
Therefore all activities and actions should take into consideration both the needs of women and those of men in, for example: project planning, drafting employment offers, resources use decisions, personnel policies, communication, financial planning etc.
It is equally important to note that the integrative approach of gender equality complements the gender equality policies, the two being interdependent.

The documents referring to an integrative approach of gender equality underline the necessity to use a twin strategy in EU policies: *Twin Track Strategy* – women promotion strategy and gender equality integrative approach strategy. Table 1 briefly presents the differences between the two complementary strategies:

Table 1 Women promotion strategy and gender equality integrative approach strategy

WOMEN PROMOTION	GENDER EQUALITY INTEGRATIVE APPROACH
Seeks to achieve:	
• Equal opportunities for women through promotion and affirmative action; • Creation of special spaces for women.	• Correct society in terms of social gender approach; • Expansion of room for manoeuvre for women and men.
Highlights:	
• Women (sometimes seen as a special interest group).	• Gender relation; • Structures.
Measures consist in:	
• Projects and programmes for women	• Integration of the gender perspective in all problems and at all levels; • Raising awareness of men and women involved; • Gender analysis at various levels; • Budget analysis from a gender relation perspective.
The strategy has as objectives:	
• Complementary approach; • Lack of men's involvement.	• Inter-sector strategy development; • Analysis of gender neutrality; • Raising accountability of both women and men.

3. WOMEN RESEARCHERS

The Commission communication *Europe 2020 – A strategy for smart, sustainable and inclusive growth* stipulates that only 63% of women in Europe are employed, in comparison with 76% of men, and one of the strategy's objectives is to increase the number of women employed. The document also concludes the need for actions that eliminate the obstacles that impede successful women's scientific careers. The Commission committed to fulfil the 40% target in terms of women participation in its consultative structures and guarantees that the calls for proposals requirements and the evaluation processes shall reflect the differences between women and men, if applicable.

As part of the important initiative *"An Agenda for New Competences and New Employment Opportunities***"**, member states shall promote at national level new ways to balance professional and personal life, active ageing policies and increase equal opportunities for women and men.

EU reports referring to gender dimension stipulate that EU guarantees that women scientists have the right to enjoy the advantages offered by a science career and to decide upon research priorities.

Romania deals at present with the same problems that confront the other EU member states. Despite the fact that gender equality was formally stated in Romania, in reply to EU requirements, many things still need to be done to put it into practice. During the transition period Romanian research underwent restructuring and this led to a steep decline of funds allocated to science, a decrease of the number of researchers and disappearance of several industrial branches. Although changes have equally impacted on men and women active in research, the transition consequences place women in a vulnerable position.

The message of the latest edition of "She Figures" report published by the European Commission indicates that, although the proportion of female researchers in Europe is increasing, the under-representation of women in scientific disciplines and careers still persists. Women represent only 33% of European researchers, 20% of full professors and 15.5% of the heads of institutions in Higher Education sector. The European Commissioner for Research, Innovation and Science stated: "Despite some advances in recent years, women in research remain a minority, and a glass ceiling is in particular blocking women from top positions. This is a serious injustice and a scandalous waste of talent. The Commission is focused on fostering gender equality in our research programmes, and working to change a deeply-rooted institutional change."

According to the report, women represent approximately 40% of the researchers in the higher education sector, 40% in the government sector and 19% in the business enterprise sector.

Despite the fact that in all sectors women numbers are more rapidly growing than men numbers (+ 5.1% for women, compared to +3,3% for men during 2002-2009), women researchers continue to face big difficulties when accessing decision positions, with on average only one woman to every two men on scientific and management boards across Europe.

The proportion of female students (55%) and graduates (59%) in 2010 exceeded that of men, but men outnumbered women among PhD students and graduates (women representing respectively 49% and 46%). It is noteworthy that climbing up the ladder of the academic career, women represented 44% of the researchers with a PhD and only 20% of those in top positions.
A big majority of European officials believe that a higher involvement of women in the science field shall contribute to social and economic growth.
The slow advances in achieving gender equality are mainly explained by: wide persistence of gender stereotypes on the labour market, lack of support at higher level in the research institutions, slow progress in modernizing research institutions.

In the European scientific institutions the idea that under-representation of women in science and technology is a waste of resources that neither science, nor economy can afford is more and more widely accepted.
Statistics indicate that 60% of the graduates of European universities are women who graduate with very high marks, often higher than those of their male colleagues. And such highly qualified personnel have difficulties in finding a job in the system and many technological fields are dominated by men. On average women represent below 30% of the total number of students.

The National Research and Development Institute for Textiles and Leather in Romania conducts a project whose objective is to promote women and a better integration of the gender dimension in the textile – clothing field, both in the research and education sector and in the economic sector.
The focus is on a better integration of gender neutrality in research – development – innovation by dissemination of practices and research studies currently existing on an international level and on statistical data referring to women in the textile / clothing sector.

4. WOMEN IN RESEARCH IN ROMANIA

Table 2 presents numbers and percentages for women working in research in Romania in 2010, 2011, 2012 in the 4 sectors considered in this activity.

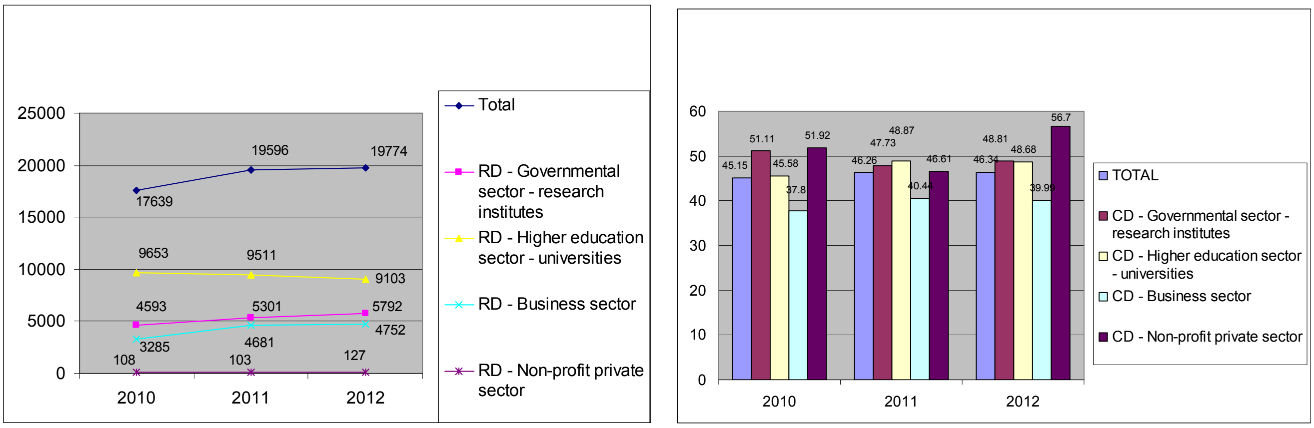
Table 2 Employees in research – development in various sectors of activity in 2010, 2011, 2012.

	2010[1]			2011[2]			2012[3]		
	Employees, total	Out of which: women		Employees, total	Out of which: women		Employees, total	Out of which: women	
		Number	%		Number	%		Number	%
TOTAL, Out of which:	39065	17639	45,15	42363	19596	46,26	42674	19774	46,34
RD – Governmental Sector – research institutes	8987	4593	51,11	11106	5301	47,73	11867	5792	48,81
RD – Higher education sector-universities	21179	9653	45,58	19461	9511	48,87	18700	9103	48,68
RD – Business sector	8691	3285	37,80	11575	4681	40,44	11883	4752	39,99
RD – Private non-profit sector	208	108	51,92	221	103	46,61	224	127	56,70

Figure 1: R&D Activity from – number of women from 2010, 2011, 2012

[1] *National Institute of Statistics, Press release no. 203 din 27.09.2011;*
http://www.insse.ro/cms/files/statistici/comunicate/comtanuale/Activcerctdezv/activtcdr10.pdf
[2] *National Institute of Statistics, Press release no. 237 din 5.10.2012;*
http://www.insse.ro/cms/files/statistici/comunicate/comtanuale/Activcerctdezv/activtcd11r.pdf
[3] *National Institute of Statistics, Press release no. 277 din 12.11.2013;*
http://www.insse.ro/cms/files/statistici/comunicate/comtanuale/Activcerctdezv/activtcd12r.pdf

A comparison of the statistical data for the 4 RD sectors in 2012 shows that universities register the highest number of women in RD (9.103), followed by research institutes (5792), business sector (4752) and only 127 women in the private non-profit sector. In terms of percentage, the highest figure for 2012 is registered by the private non-profit sector with 56.70%, followed by institutes and universities (48.81% and 48.68%), and 39.99% in the business sector (Fig. 1). The three year evolution shows that, except for the women in higher education, the other categories are on a slightly ascending trend.



a) Women number b) Women percentage

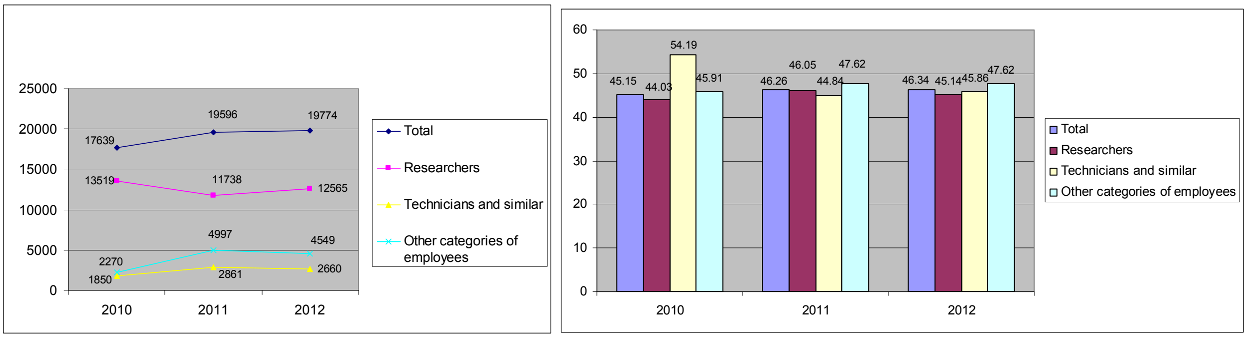
Figure 1: Women in RD in Romania, on sectors of activity

Table 3 presents numbers and percentages for women working in research, by occupations: researchers, technicians and similar personnel, other categories of employees for 2010, 2011, 2012.

Table 3 – Numbers and percentages for women working in research, by occupations

	2010			2011			2012		
	Employees, total	Out of which: women		Employees, total	Out of which: women		Employees, total	Out of which: women	
		number	%		number	%		number	%
TOTAL, Out of which:	39065	17639	45.15	42363	19596	46.26	42674	19774	46.34
Researchers	30707	13519	44.03	25489	11738	46.05	27838	12565	45.14
Technicians and similar	3414	1850	54.19	6380	2861	44.84	5800	2660	45.86
Other categories of employees	4944	2270	45.91	10494	4997	47.62	9036	4549	50.34

A comparison of the statistical data for 2012 referring to women employed in the 3 occupational categories of research (researchers, technicians and similar, other employee categories) in Romania (Fig. 2) shows that women researchers register the highest number (12565), followed by other employee categories (4549) and then technicians and similar (2660 women). The section "Other categories of employees" registers the highest percentage of women (50.34%), followed by technicians and similar with 45.86% and women researchers 45.14%. The number of women researchers decreased by 14% in 2011 compared to 2010, and increased by 7% in 2012 compared to 2011.



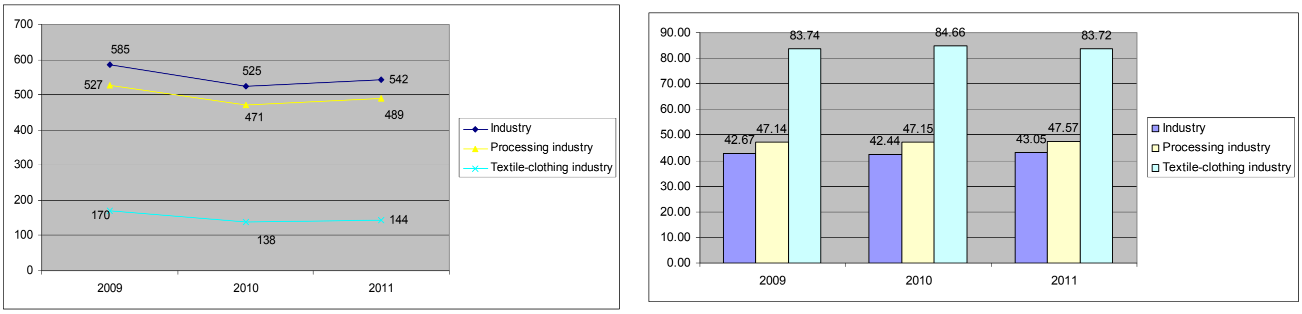
a) Women number b) Women percentage

Figure 2: Women in RD in Romania, by occupations, in 2010, 2011, 2012

5. WOMEN IN TEXTILES - CLOTHING

In contrast with other sectors, women employees are predominant in the textile-clothing sector. The textile – clothing sector in Romania is a dynamic sector at present, with high performance levels and which hires an important female labour force. In 2011 approximately 26% of the women employed in industry were working in the textile – clothing sector, which is 144 000 in the textile field out of 542 000 (Fig. 3).

The percentage of women out of the total number of employees in the textile-clothing field is almost twice the percentage of women in industry, that is 83.72% compared to 43% of the total number of employees in 2011. Similarly, the percentage of women in the processing industry is significantly lower than the percentage of women employed by the textile – clothing sector, that is 47.57% compared to 83.72% in 2011 (Fig. 3).



a) Women number b) Women percentage

Figure 3: Romania – Women employed in industry, processing industry and textile-clothing industry

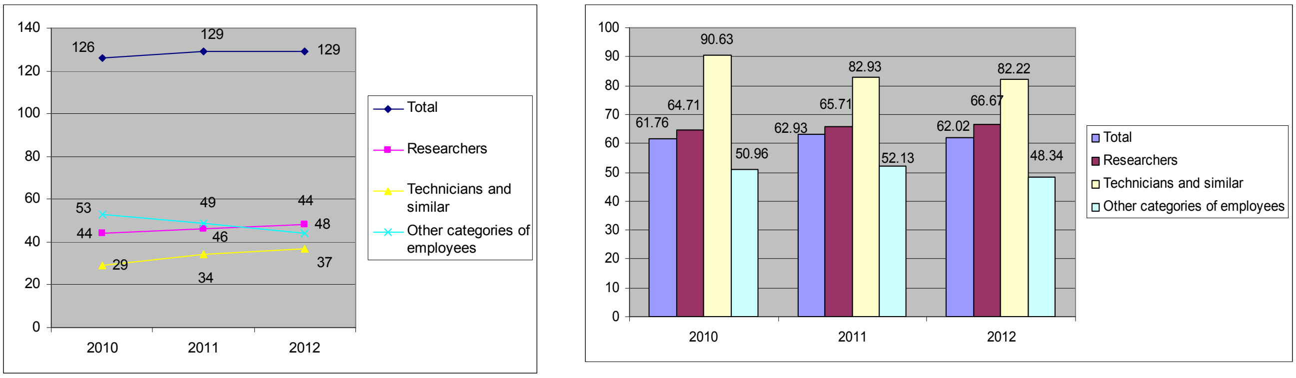
It is noteworthy that the Clothing Articles subsector (CAEN 14) occupies a leading position among the 24 branches of the processing industry in Romania in terms of average number of employees. In terms of average gross salary, this same subsector occupies the 23 position, which is last but one.

The textile – clothing sector contributes to social stability, being represented in all the counties (a total number of 5428 textile companies existed in 2011, out of which 4111 clothing companies and 1317 textile companies). This sector has an important weight in the export operations (7.88%) and has a 2.49% contribution to Romania's PIB.

6. WOMEN IN RESEARCH – DEVELOPMENT – GOVERNMENTAL SECTOR – RESEARCH INSTITUTES

The National Research and Development Institute for Textiles and Leather (www.certex.ro) is the only research and development institute in this field. Statistical data similar to the ones for research in Romania were analysed for women employed by INCDTP.

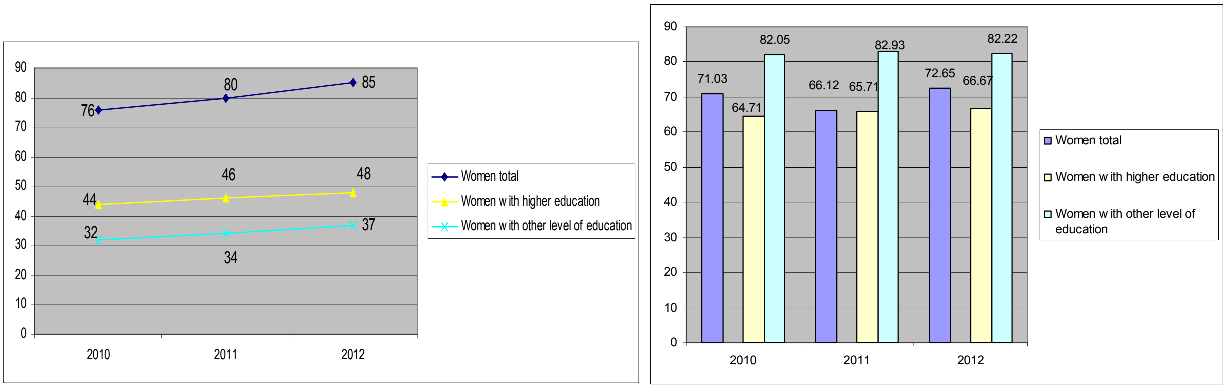
Fig. 4 presents the number of women employed by INCDTP in 2010, 2011 and 2012. The numbers are divided on occupations: researchers, technicians and similar, other categories of employees. The diagram shows small variations of the number of women personnel in INCDTP, divided on occupations.



a) Women number b) Women percentage

Figure 4: INCDTP – Number of women on occupations in 2010, 2011 and 2012

A comparison of the 2012 statistical data referring to women employed by INCDTP in the 3 research occupation categories shows that the numbers are approximately similar and that women technicians and similar register the highest percentage (82.22%), followed by women researchers with 66.67% and other categories of employees with 48.34%



a) Women number b) Women percentage

Figure 5: INCDTP – Women involved in RD activities in 2010, 2011 and 2012 divided by educational background

Fig. 5 shows a diagram that presents variations of the number of women employed by INCDTP in RD activity, depending on their educational background. It is noteworthy that the number of women with higher education is higher by 25%.

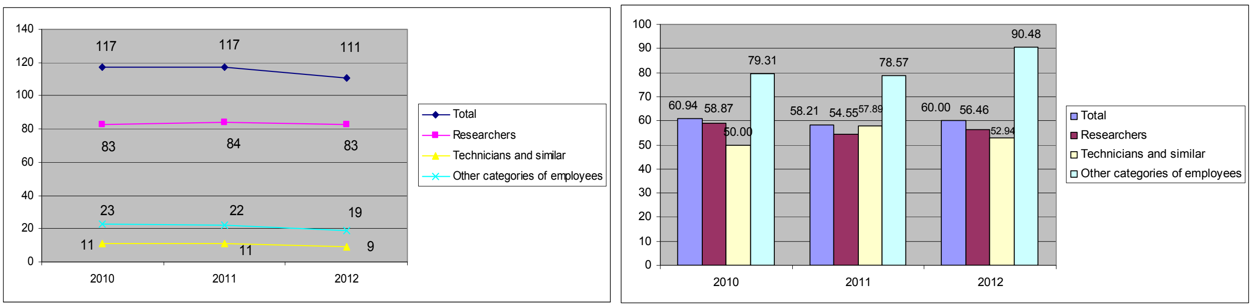
In 2012 a percentage of 72.65% out of the total number of RDI employees were women, while the women with higher education represented 66.67%.

7. WOMEN IN RESEARCH - DEVELOPMENT– HIGHER EDUCATION SECTOR - UNIVERSITIES

For the purposes of this study a representative higher education unit was chosen, a traditional and most important one in the field, the Faculty of Textiles, Leather and Industrial Management in “Gheorghe Asachi” Technical University of Iasi (FTPMI – UTI).

Fig. 6 presents the evolution of the number of women employed by FTPMI – UTI, on occupations: researchers, technicians and similar, other categories of employees for 2010, 2011 and 2012. The diagram

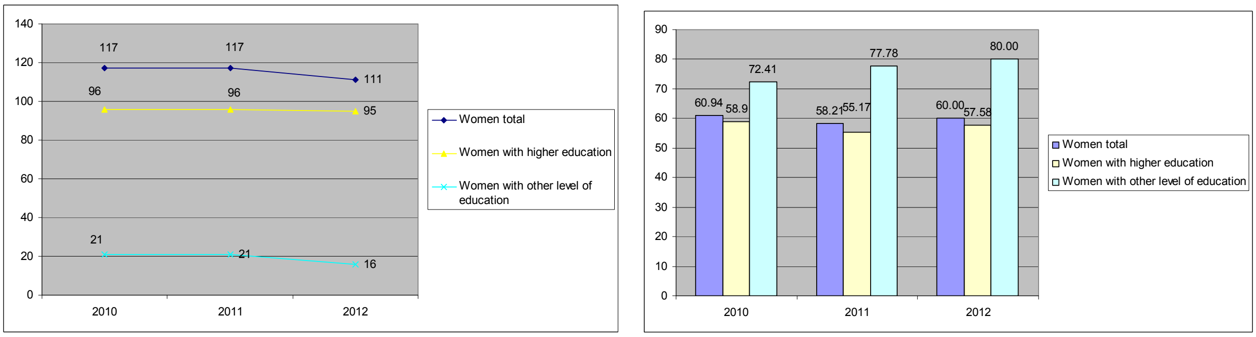
shows small variations of the women personnel numbers in FTPMI – UTI on occupations and the high numbers of women researchers compared to the other categories.



a) Women numbers b) Women percentage

Figure 6: FTPMI – UTI – Women on occupations in 2010, 2011 and 2012

The highest percentage is registered by the “Other categories of employees” (Fig. 6b).
Fig. 7 presents the diagram of the variation of the number of women in FTPMI – UTI who are involved in RD, out of which the focus is on women with higher education and women with a different type of education.



a) Women number b) Women percentage

Figure 7: FTPMI – UTI – Women involved in RD, depending on educational background in 2010, 2011 and 2012

It is noteworthy that the number of women with higher education is approximately 4.5 times higher. But the percentage of women with higher education out of the total number of employees involved in RD is lower than that of women with a different type of education. In 2012 a percentage of 60% of the total RDI employees were women, while the women with higher education registered a percentage 57.58% (Fig. 7 b).

8. CONCLUSIONS

To support an integrative approach of gender equality, research should continue on “women scientists” subject and data referring to women and men distribution should be organized and particularities of the textile-clothing sector, which is a predominantly feminine sector, should be taken into consideration.
Policies for equal opportunities for women and men are needed in order to increase the participation of the labour force, which will contribute to growth and social cohesion. Women’s increased participation shall improve the research and innovation quality and compensate for the existing deficit of highly qualified and experienced scientists who are needed to increase competitiveness and European economic growth.
Researches in the field shall be a basis for establishing new European and international partnerships, all the more so as since 2013 INCDTP is a member of COST Action TA 1201, Gender, Science, Technology and Environment – GenderSTE, which comprises representatives of the research, academic, business environment and women organizations all over the world..
The participation of our institute in this consortium, which promotes mobility and good practices exchanges in a very actual field, which has good prospects for the scientific community, shall contribute to the alignment of Romanian research with the HORIZON 2020 strategic directions, to increasing involvement of women in scientific research and economic environment in a moment when there is a serious lack of qualified personnel. It will also strengthen the image and visibility of Romanian research in general, and of textile – clothing research in particular. Through convergent actions that aim at increasing competitiveness in the

research-development and innovation sector, stimulating women participation, training and professional evaluation, attracting young people to a successful career, INCDTP shall contribute to achieving its strategic objectives as important support for the textile – clothing industry and research.

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Scholarly communication paper

THE RELATIONSHIP BETWEEN THE TEACHER AND THE STUDENT IN THE TECHNICAL HIGHER EDUCATION

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Abstract: *Teacher-student relationship is one of the major problems of contemporary education, about which is often concerned the global pedagogical thinking, like that of our country. From the historical point of view, both in literature and in educational practice were outlined two opposing views on teacher-student relationship: one characteristic to the traditional pedagogy based on a unilateral communication from teacher to student, the other modern, which considers the student exclusively as the subject of education, without any guidance from the teacher. The contemporary pedagogy sees the teacher-student relationship as a profound relationship in which both partners work together continuously and in which is well established the status of each one of them: the teacher as an educational factor and the student as an object and a subject of the education.*

Keywords: *Humanization, Engineer, Teacher-student relationship, Feedback, Training.*

THE CONCEPT „RELATED EDUCATION"

According to the „Pedagogical Dictionary" the pedagogical relationship refers to the specific education relationship between the adult and a child or a teenager in a systematic order „The construct contains descriptive and normative parts". Descriptive are the statements about the relationship between teacher and pupils/students in terms of understanding, anticipation, perspectives, knowledge, skills, judgments, actions and indications about the interim of the pedagogical relationship. The pedagogical relationships should, however, be understood as some normative categories, the teacher has to be distinguished by certain characteristics. Then from a primary perspective, a normative one, the pedagogical relationship must meet the following criteria: recognition of the child's personality/student and individuality, his comprehensive and formative education, to claim the responsibility of each party (H. Schanb, K.G. Zenke, 2001 p. 240). This definition of pedagogical relationship emphasizes the role of the personality of the one who teaches and the responsibility of each actor in maintaining the educational relationships in which the student is formed. In the pedagogical relationship, the responsibility belongs to both subjects of the educational process. Teacher-student interaction requires active involvement of both parties in different proportions.

The relationship teacher – student impregnates and affects everything when it comes to teaching situations, especially as any relationship supposes the reciprocal control of behavior. At one extreme this relationship can be a battlefield, the teacher changing the „recipes" for forcing pupils/students to do what he wants, pupils/students changing "recipes" between them in order to escape. When this battle is won by the teacher, is said that he gets along well with pupils/students, and the losers are labeled as „good pupils / students". When, on the contrary, the teacher loses, it's talked about a „weak class" and the „winners" are on the verge of repeating the year. When no one wins it is „a difficult class". At stake is personal dignity of both sides.
At the other extreme of the teacher-student relationship is a totally identified with the class teacher, fighting for it with the officials of the school and the inspector (S. Marcus, 1999, p. 11).

These are the two theoretic extremes of a continuum. In reality, teachers and students should neither be in a face to face conflict, nor identified, which would cancel the purpose of the educational act. Desirable, but also the most difficult to reach and to maintain is the middle position, because it is not sufficient theoretical knowledge of teaching science or just understanding but also the love for the students.

As an interpersonal relationship in the pedagogical relationship there is a interdependence between the teacher's and student's behavior in the sense that the action from a side causes a change in the behavior of the other. But through his privileged position the teacher can take the initiative of the interaction which causes reactions from students. He can make so that the behavior of the students would be, more or less, dependent on him and from his behavior to result the atmosphere of a group within the class. It is therefore not an exaggeration to state that the construction of student autonomy depends heavily on pedagogical relationship, of the teacher's behavior.

From a historical point of view, both in literature and in educational practice were outlined two opposing views on the relationship between the teacher and the student. Both points of view (the first puts emphasis on the teacher's authority, and the second on the total freedom of the student) are, however, unilateral rejecting the possibility of achieving real communication between the two poles of the educational act.
For the purposes of contemporary pedagogy, the teacher-student relationship is seen as a profound relationship in which both partners work together continuously and in which it is well established the status of each side: the teacher as an educative factor and the student as object and a subject of education.

Thus, the teacher, in order to realize his duty as an organizer and as a decision maker in establishing the educative strategies, as a mediator of the access to information and as a school performance evaluator has to know the psychology of the student to translate himself in the way of being, of feeling and acting of the student. He has to have the purpose of changing the place and role of the student in the educational act, to stimulate the activity and the engagement of the student in the process of his own formation.

As for the student, in his position as an object of the educative influence and as the subject of his own formation, there should be a dialectical relationship, the efficiency of the educative action being dependent on its degree of engagement and participation in the instructive-educative steps.
The approach of the teacher-student relationship within the requirements of the formative education is necessary especially since in the educational practice, still linger some attitudes characteristic to the traditional education, according to which the student is treated as a passive object of education involved only unilateral in the assimilation of the information provided by the teacher.

It can be said that the teacher-student interaction is influenced by existing relational systems in the group class. The socio-emotional climate existing here affects the students' behavior, their self-image. In this sense, the learning process, in addition to cognitive aspect involves cooperation and sociability. They are formed due to specific group class relations and may encourage and stimulate or on the contrary, to stop or inhibit the open and free communication between the teacher and the students.

In this paper we aim to highlight the following data:
- ✓ a few moments in the development of the teacher-student relationship in traditional and modern school;
- ✓ the types of teacher-student relationships in the contemporary society was another important point in our analysis;
- ✓ the realization of a study on the mutual perceptions of the relationship between the two partners in order to humanize the relationship between them.

Table 1 below shows the keywords that characterize traditional and humanized school.

Table 1: The key words that characterize the traditional and the humanized school.

Traditional school	**Umanized school**
Key-words	
Competition	Cooperation
Classifications, awards and penalties	Encouragements, self learning, tolerance, responsability
Listening	Participation, envolvement
Transmition, reception	Analisis, manifestation, conversation
Restraint	Liberty

There are no good or bad students – it is the teacher's problem to educate them, to refine them and bring to light the virtues of each one of them, helping them to discover their potential abilities, to give weight and value to their words, taking care always that this exercise is complete.
To provide a teacher-student relationship, based on cooperative relationships, on direct communication and guidance to encourage the individualization of the work, is a premise for productive after schoolwork.

The modern didactics changes the vision of the student, putting him in the spotlight, aiming to make it interactive subject, co-participant and co-author of his own formation.
The teacher has to guide, mentor, and facilitate the instruction and the education.
G. Leroy says that **„the process of education starts when you teacher learn from the student, when you, translate yourself in his place, and you understand what he understood in the way he understood".**

The work of the teacher is primarily to ensure pupil/student with the resources, the key that will help him in his learning process (A. Sangra, 2001, p. 3).

TYPES OF TEACHER - STUDENT RELATIONSHIPS

The teacher – student relationship can be seen from many points of view (M. Zlate, 1972):

a) strict didactic(in the process of teaching and listening);
b) methodological-pedagogical (selection, organization and the prioritization of the teaching methods);
c) psychological (the two partners are regarded as some state ensembles, processes and their characteristic mental attributes).

A closer analysis of the interactions within the class/group revealed several types of relationships between teachers and students. Among them, we can mention:

- ✓ communication relationships;
- ✓ management relationships;
- ✓ socio-affective relationships.

a) **Communication relationships** can also be of several types. So based on the teaching functions performed there are:

of transmission, itself, the information (to explain new terminology, the statement of facts, interpretation of statements, expression of views, etc..)
of structuring the information and concentration of the attention on the subject or on the work procedures;
of requesting of some verbal or physical relationships from the students, stimulating their focus on issues etc.;
of student's response to the teacher's requests;
of reaction, acceptance, rejection, modification, extension, etc., of what has been said before;
of assessment by the teacher of the student's answers etc.;
of expression of some affective states (satisfaction, pleasure, annoyance, contentment, amazement, etc.).

b) **The relationships of management** of the class activity. They may establish limits of directing rigorously and the boundaries of the students' independence. Therefore, they can be:

- ✓ **relations of domination by the teacher**, managed to create a „climate" of authority.

The emphasis in this case fall, on directing and order, on severe constraint and scolding of the students, on the stimulation of unconditional obedience, on the obedient acquiring knowledge, on their passive reception, on remembering and not thinking, on the suppression of the will of initiative, of independence, of creativity. Such relationships are unidirectional (the teacher decides, orders, gives commands - the student obeys, listens and executes) and conflicting, arousing feelings of aversion to the students by the teacher. The authoritarian professor is conservative, lack flexibility, is rigid, and does not take account of experience, interest and pupils judgment in realizing the pursued goals; the authoritative teacher appreciates the reproduction of the acquired knowledge without putting value on the originality or the authenticity of the students' thinking. Kenneth Moore, believes that authoritarian teacher's behavior can be described by the following verbs: to punish, to impose, to criticize, to use a sharp voice, to dominate, to inspire fear, to humiliate, to be harsh to require mandatory , to pressure.

- ✓ **the democratic relationships** - assume a new position towards the student, towards the ways of training and education and personality formation. Democratic teacher is essentially the empathetic type of teacher. The teacher's behavior is based on the tendency to integrate himself in the classroom's climate, to identify himself with the students' life and activity, his leading role is achieved through teaching methodology, such as to encourage the active participation of students, continuously enhance independence and their initiative, their spirit of responsibility, he suggests more than impose, stimulates more the interest and the curiosity, encourages the manifestation of spontaneity and creativity.

These are multi-directional relationships: of cooperation, of support to self-activity, of indirect influence, of cooperation, proving to be more effective and consistent with the principles of democratizing the school and our society. According to Kenneth Moore, democratic teacher's behavior can be described by the following verbs: to be friendly, to encourage, to help, to persuade, to be open to influence, to be firm, to stimulate, to direct, to be careful.

- ✓ **indulgent relationships** (laissez-faire - to let it to be done) focus on the free development of the student, to leave the conduct of his work to the chance, considering that any intervention of a closed thinking is felt by the individual as a threat.

In this sense is denied any form of authoritarian intervention of the teacher, guidance or orientation to learning, training (pedagogical liberalism). But here the pedagogical liberalism misunderstood, pushed to anarchy and disorder because the teacher does not intervene lenient than only when the educational situation threatening to escalate into conflict, etc.).

c) **Socio-affective relationships** we point out that between teacher and pupils/students may experience spontaneous feelings of attraction or rejection, sympathy or antipathy, acceptance or non-acceptance, etc. In general, when the teacher comes to the class just as simple transmitter of information, concerned only with their reception, without any vibration emotional, affective - class relations become traumatic for the students and the more so, as the students are younger. Those mentioned here are intended to highlight the variety of types of relationships that can be establishes between teacher and pupils/students in the educational process and their implications many and what they may have on learning outcomes and school education.

HUMANIZING THE TEACHER-STUDENT RELATIONSHIP

The humanization and personalization of educational interaction involves substantial restructuring of the role of the teacher, the teacher „is the person who creates the conditions for the pupil/student to behave in a certain way, to put issues and tasks of knowledge, stimulate and maintain student activism investigator / student" (I. Neacsu, 2000):

the teacher is not just the person who proposes content, gives lessons, make tasks but stimulate and maintain student activism investigator creates conditions for him to behave in a certain way, to discover and to put matters;

to orient to specific student interests and capabilities is its attention to the achievements and creations. Teachers must possess the qualities necessary centering mainly on the expectations, demands, the needs and interests of students;

the teacher must be able to be a double and work from his perspective and the group, be able to guess the order interpersonal characteristics of students collecting adequate capacity preferential relations between students, the anticipated social attitudes of students in relation to future learning situations.

In our era, deeply computerized, the man has found a new „partner" computer inter-human relationships has its specificity. A quality interpersonal relationship involves an attitude of mutually beneficial partnership in which partners give and receive what they are given alternative or what they lack and obvious that each man has „pluses" and „minuses".
A prerequisite for effective teacher-student relationship is the manifestation of the sense of responsibility that must prove each role and its status (A. Pasca, 2012, p. 8).

Investigations carried worldwide on the impact of education on social development come to show us that it is essential that the idea of forming man to inspire a philosophy of preparing him for a life in relation to complex modern cohabitation requirements or declare that thus fall outside reality. Both prospective education and its performance is emerging as ideas coming from their position and project requirement shall be based pedagogy to develop his own theory demanded an education intended to form man throughout his life size, and in accordance with the requirements of the third millennium, found a much greater extent in science and technology imperatives designed in indissoluble unit.

The questionnaire conducted in the educational institution were obtained following relevant data: the question which determinants that influence student success in school, 55.73% of respondents said that personal effort is the most important, 41.15% - teaching style, 32.81% - 30.73% and the quality of teaching - the relationship between teacher / student and only 2.08% thought otherwise (figure 1).

So, the students realize that only through personal effort they can achieve perfection. But do not forget that for an incentive and motivate students to work is very important and attractive personality of the teacher by his attire, readability and style of teaching applied, the quality of teaching and not least the relationship between teacher and student, often regretfully longer Meet and currently being authoritative Teacher, which causes him to lose student interest and desire to do the book and taught himself matter.

A style preference of students on the relationship between teacher and students was distributed as follows: for freestyle was delivered 46% of respondents to the Democrat - 43% for the authoritative - 9% and only - 2% of respondents wanted other styles than the above (figure 2).

While the teachers believe that the relationships style encouraging/motivating the student to learn is: 55% Democrat, 20% liberal, authoritarian 21% and only 4% cited other styles (figure 3). From the data presented it can be concluded that the preferential relations style both for students and for teachers is democratic style. Although now it tends to avoid the exercise of authority over the students, but from the data below shows that the authoritarian style is currently in the process of education, which gives department managers thought and institutions of higher education to train teachers and familiarize them with the new trends in science education in the country and worldwide.

In summarizing the above analysis, we can say that the democrat style is that style that encourages/motivates the student to learn and be successful in school, but it is also the style that should prevail in the teacher-student relationship, which characterizes the relationship According teacher with student teachers.

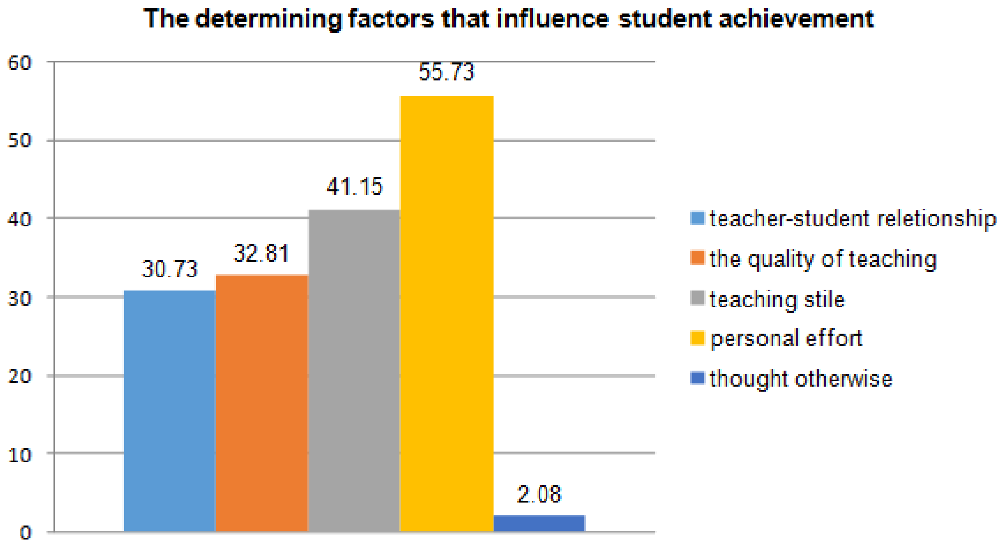

Figure 1: Diagram showing the share of determinants that influence student success in their view

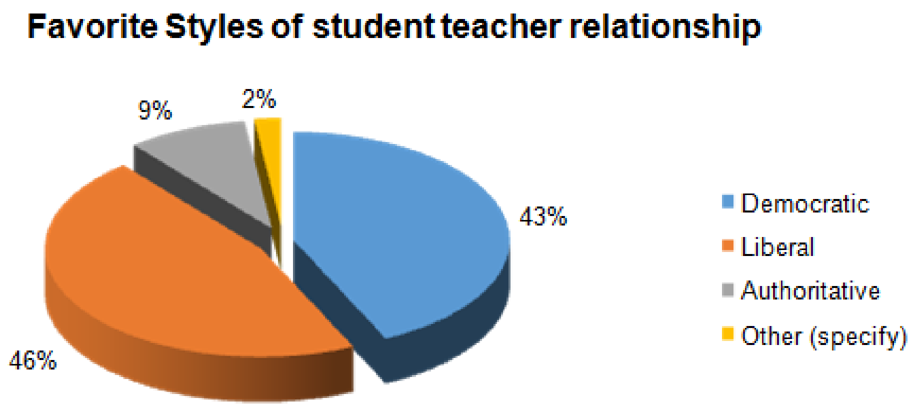

Figure 2: Diagram showing the style preferences of students on the relationship between teacher and students

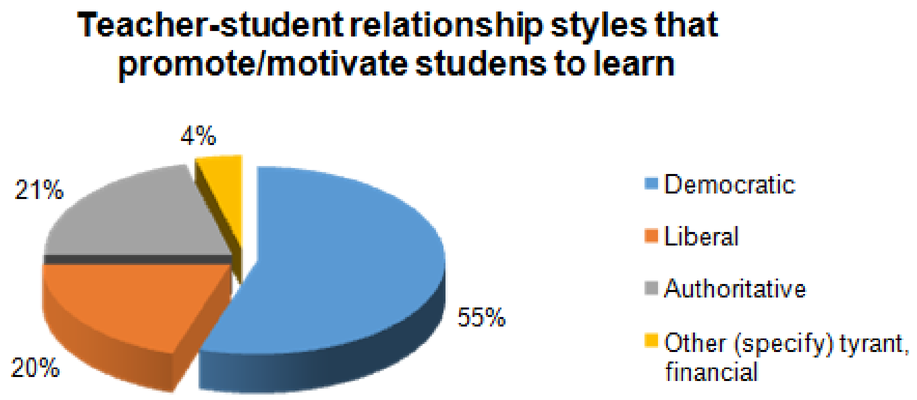

Figure 3: Diagram showing the teachers view the relationship between teacher and student style that motivates the student to learn

CONCLUSIONS

The process of education is essentially a process of communication, it is important to acquire skills to communicate. Both teacher and student must be open to others and willingly to „give" and „receive", abandoning the prejudice that „yes" is more valuable than „receive".

The professor may be considered, metaphorically speaking, a well charged battery with expert information and some experience of life, and the student is a battery that is being „loaded" in school.

In such a possible applicative vision, the analysis that we realized can only be a starting point, a stimulus for future, research in the broad issues of human inter knowledge. From this point of view, we note that we do not claim to have exhausted the topic under discussion; this study can only be a reference point for certain theorizing concepts.

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Scholarly communication paper

MODULAR TRAINING IN VOCATIONAL TECHNICAL HIGHER EDUCATION

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Abstract: *The present study concerns the necessity of modular instruction in the vocational training. The evident elements of the module are technical contents, training situation, the exact objective of module, and the module instruction manual. The use of modules gives the following advantages and conditionings: it is a strategy of academic progress, it offers big opportunities of the inter-disciplinary links and is integrated in all structures of the modular training in higher vocational technical education, eliminates or reduces redundancy, covers lacunas or omissions, provides the link between training, correction, specialization and other advantages.*

Keywords: *curriculum, knowledge, education system, skills, abilities, competence*

In conditions of limited resources and often insufficient for financing certain areas such as education, culture, health, standard of living rising, which increasingly depends on more production and trade competitiveness, which in turn are influenced by motivation, knowledge, understanding and skills of those engaged in the creation of goods and services, the quality of preparation of specialists is becoming a major task for higher technical education.
One of the main conditions for its solution is certainly, enhancing the pedagogical mastery of all teachers based on search forms, new methods and principles of teaching and learning process in vocational training. Major deficiencies, at present, appear in connection with the development of effective teaching methods of specialized disciplines.

Traditional methods used in the current time (lecture, laboratory work, independent work of students, course and diploma design and production practices) have a number of shortcomings. These relate, first of all, the incoordination while the discordance between different forms of training.

Another drawback presented by existing training process is low efficiency and insufficient development of independent activities of students, training future specialist competence. Competence is the synthesis of such qualities of the specialist knowledge mobility, flexibility method and critical thinking. Skills training in such acceptance require the integration of three leading factors: "brevity", modulation and problematization, and then drawing on this basis of a special teaching technology and modular training in any discipline of study. Mobility of knowledge in the structure of professional competencies of a specialist shall ensure by the brevity and modulation factors, by the flexibility of professional activity, which together constitutes the mobility and problematization factors, and the critical character of thinking is supposed that will form by means of problematization factors. Thus, determining the need for modular training scheme can present technological guidance of modular design, which can be applied in training (Fig. 1).

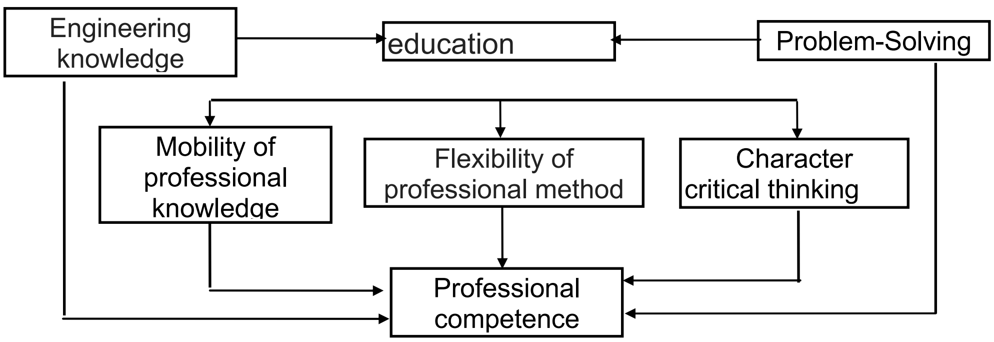

Figure 1: Model of modular training

In order to establish the essence of modular training in vocational training should be first and foremost determined: what is its foundation, on which is it based? The philosophical basis of modular training is the holism, i.e. the ability to conceive a totally integrated unit of information items, that they lose sequenced features. The concept of teaching mode is not still rigorously defined.

The most descriptive definitions posed as a set of specific educational elements that can be run independently from the rest of the system, which provides knowledge or skills prescribed, uncentred on content, but on learner's priorities who integrates the itineraries and various teaching logic. Expressing ourselves figuratively, the modular education is based on the general theory of functional systems, neurophysiology of thinking and pedagogical psychology. In capacity as principles serve principles of systemic quantification, modulation and problematization, the underlying operating systems of the human psychological activity, received through the different signalling systems (languages, graphics etc.). The following principles serve quantifying systemic principles, and problem-modulation, the underlying operating system of the human psychological activity, received through different signaling systems (language, graphics, etc.).

Along with these principles are involved principles: motivation, cognitive visualization, support on mistakes and economy learning time, etc.
In his conception of L.D Hainaut, the pedagogical module must satisfy the following criteria [2]:

- to present or define a set of learning situations;
- to possess a private function specified with care and to aim carefully defined objectives;
- to offer evidence to guide the studying and / or one who teaches and provide them a feedback;
- to be able to integrate in itineraries and logic learning contexts.

According to the study done by UNESCO concerning the methodology of the elaboration of a modular program for vocational and technical education, a module is considered as a process or a product that includes the following elements [3]:

1. The technical content, i.e. the discipline that is studied and ultimately will lead to the acquisition of knowledge gained in the process.
2. Learning situation: the context in which the content is studied;
3. The object of the module, formulated in operational terms;
4. Guide operation of the module;
5. Evaluation of the content understanding of the module;
6. The summary document for the learner.

If you compare Figure 2 and the UNESCO study, we observe that the modular training system developed by us include modular UNESCO program elements: defining portions autonomous teaching material (the quarter included a maximum of eight modules) are scheduled laboratory work, independent activities. Upon completion of each module is a microexamen. Group consultations are liquidated, period of session, educational year is a year with integrity, in the group is performed only laboratory work, other activities are individual.

So the training module shows the integrity of the types and forms of instruction, subjected to the general theme of the course. The dimensions and requirements of modules shall be determined by analyzing the content and structure of the discipline that would ensure the volume of knowledge, skills and exhortation of students shown in qualifying-functional feature of future specialists. As the parts of the modular organization of the training contents were chosen:

- general picture of modules developed to cover the subject and marking module position on the picture, as part of the whole course;
- summary of the module content;
- average length of scroll module;
- conditions for access to module (previous knowledge and skills);
- indication of modules that can be completed simultaneously;
- training methods and procedures of the theme module (content);
- bibliographical or documentary material and its sources of procurement.

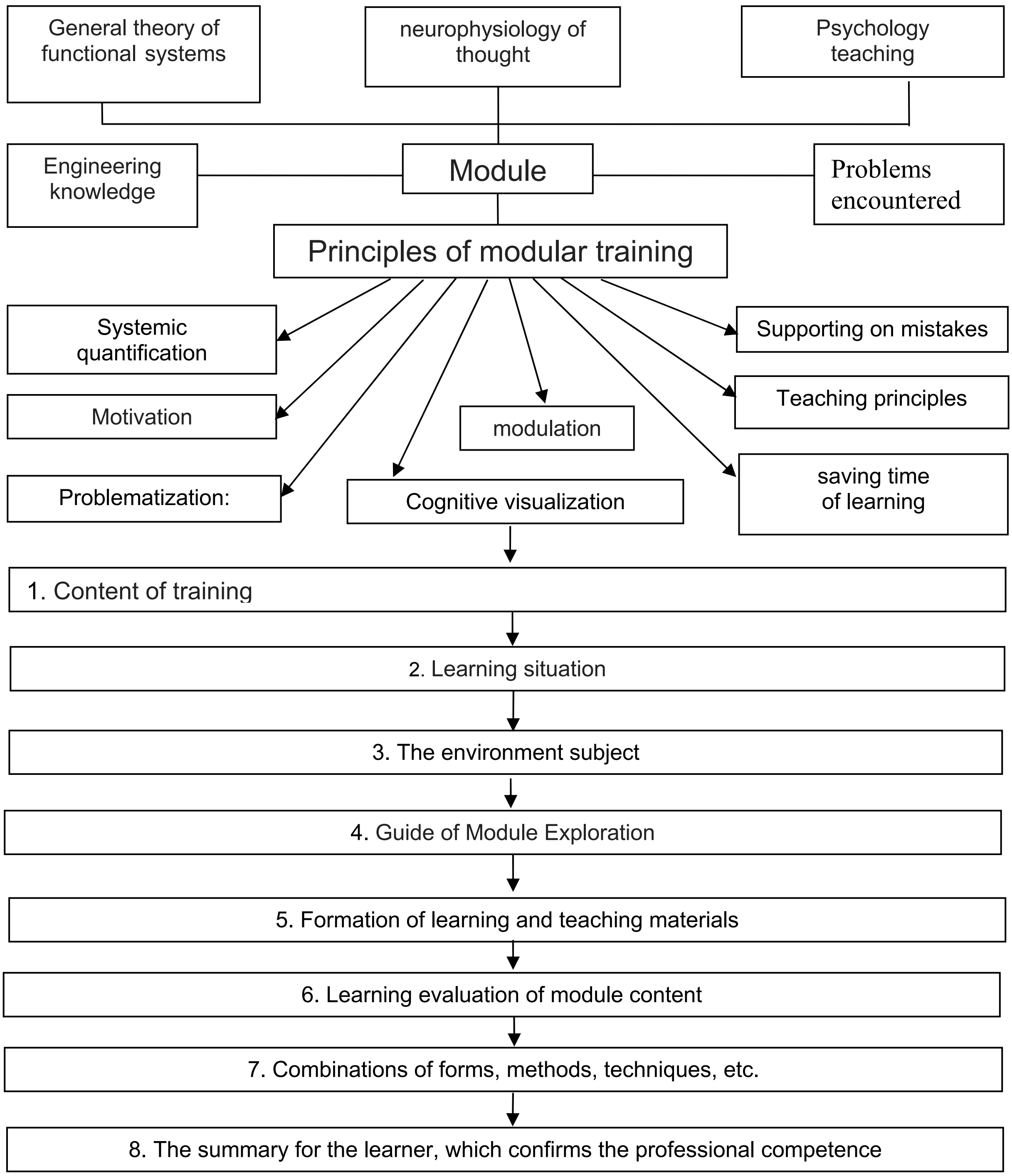

Figure 2: Methodology of modular design

Each module must be equipped with illustrative material, checklist of knowledge. The final stage of work should contain recommendations for the use of knowledge gained by students in the course and diploma projects, as well as postgraduate work.

Modules can be combined to form modular assemblies which covers knowledge and skills more complete. The modular system of initial formation in vocational and higher technical education can be adapted to lifelong learning because it allows any person, regardless of age and its initial formation, learn a job and refine.

Establishment of discipline from modules makes it possible to refund the time reserved for the separate studies of training process, increasing the share of laboratory work, as well as the independent work of students. The changes indicated may concern, firstly, the volume and content of the teaching material in the form of traditional, descriptive- illustrative; the lecturer is required to seek new forms of lesson in which the student receives basic training along with knowledge and skills needed in the chosen specialty; laboratory lessons of the module are processed in complex with lectures.

The positive effect of modular training can only be achieved at the concentration of all types of training, provided by the module. Here different versions may be possible, planned several activities; two hours lecture, laboratory work four academic hours, activities and independent work of students (obligatory presence of the lecturer) in which they are studying some aspects of the topic taught in class.

The time allocated for independent work of students in the auditorium must be at least two hours. Practice of partial concentration of lessons can enhance the effectiveness of this form of training. However it appears the possibility of reducing the number of hours allocated for lectures. Finally, the lessons focus on this topic has another positiv aspect - improving the current control of students learning, what perspective can bring to the organization without training session. It is certain that the implementation of modular training will require organizational restructuring of the training process. It pertains to the planning activities of lecturers, laboratory training base, forming the contingent of students, taking into account the workshop production capacities; endowment the course with didactic-methodical materials, starting with intuitive and ending with recomendations for the study of modular program chapters.

The use of modular training leads to return to his true vocation teacher educator, allow him the fulfillment of tasks that will will help students to acquire knowledge, raises the possibility of individualization of learning for the selection and training of young talents. A drawback of modular training is the fact that the composition of the programmes is particularly voluminous and heavy.

Application of modules during "constructive-technological design of clothes" has allowed us to detect the following benefits and conditionality:
- connects formal learning objectives;
- allow the articulation of formal and non-formal education;
- facilitates continuous updating of contents;
- opposed to the rigidity of traditional structures and programs that offer unique curricular paths;
- each module can easily articulate to other modules in an optimal structure for a given situation;
- provides the glue between learning, correction, specialization;
- lends itself easily to implement in computer programming languages;
- open wide possibilities of interdisciplinary contributions;
- allows individualisation, offering a range of alternative courses for the same subject;
- integrates into all structures of higher technical vocational education (and not only this);
- represents a relay of the democratization of education;
- cost and time of didactic module elaboration are considerable, requiring extensive work on cooperation between experts from different curricular hours;
- to increase awareness in the training of teachers and educators;
- modularisation has the status of innovation in the current academic educational practice and, as such, is facing with administrative resistance;
- modularity as a way of rigorous training, may reduce the risk of conventional examinations for admission to the higher cycles.

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