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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 16-th Romanian Textiles and Leather International Conference, CORTEP 2016.

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 has attracted 114 participants from 14 countries. We will hear 40 oral presentations, and have the opportunity to see about 65 poster presentations.

For a number of important reasons, the CORTEP 2016 is organized in Iasi, the most important political, economic and cultural centre of the province of Moldavia as well as one of the oldest cities in Romania. Located in the northeastern part of the country, Iasi was for many centuries the crossing point of the most important commercial routes linking Poland, Hungary, Russia and Constantinople.

The city lies on the Bahlui River, a tributary of the Jijia (tributary of the Prut). The surrounding country is one of uplands and woods, featuring monasteries and parks. Iași itself stands amid vineyards and gardens, partly on hills, partly in the in-between valley.

It is a common belief that Iași is built on seven hills (Romanian: coline): Cetățuia, Galata, Copou-Aurora, Bucium-Păun, Șorogari, Repedea and Breazu, thus triggering comparisons with Rome.

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 Iasi. 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.

Assoc.prof.dr.eng. Mariana URSACHE
President of CORTEP’2016

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CONVERSION OF WATER VAPOUR PERMEABILITY OF TEXTILES OBTAINED BY VARIOUS TESTING METHODS AND PROBLEMS OF GRAVIMETRIC TESTING

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Faculty of Textiles

Abstract: *Recent functional textiles, namely protective and outdoor jackets usually exhibit labels indicating their water vapour permeability (WVP), mostly expressed in g/m^2 of evaporated water during 24 hours, or in the form of the evaporation resistance Ret [Pa.m^2/W] according to the ISO 11092. Along with this parameter, also resistance against hydrostatic pressure (leakage of liquid water) uses to be marked in the product label. The assessment of WVP by means of the Ret offers very explicit characterisation of WVP which is not the case of most of the gravimetric testing methods – when expressing the WVP in g/m^2/24 hours, you do not know the used driving force ΔP (the difference in partial pressures) as the number of the used standard is mostly missing. The missing level of the used ΔP may bring the commercial advantage to some resellers of the functional clothing, who, by using proper testing method, can mark higher WVP of their product, than the real one. In the paper, this problem is theoretically analysed and conversion of water vapour permeability data for textiles obtained by various testing methods is presented.*

Keywords: *water vapour permeability, textiles, conversion, uncertainty, standards.*

INTRODUCTION

Water vapour permeability (WVP) is the second most important parameter of clothing comfort, after thermal, insulation. That is why a big attention has been paid to the measurement of this parameter in this decade [1-4]. The quality protective and outdoor jackets usually exhibit labels indicating the water vapour permeability, mostly expressed in g/m^2 of evaporated water during 24 hours, or in the form of the evaporation resistance Ret [Pa.m^2/W] according to the ISO 11092. The assessment of WVP by means of the Ret offers very explicit characterisation of WVP which is not the case of most of the gravimetric testing methods – when expressing the WVP in g/m^2/24 hours, you do not know the used driving force (the difference in partial pressures) unless the number of the used standard is mentioned along with the WVP level.

That is why still exist many uncertainties when purchasing a semipermeable fabric from unknown manufacturer, who accompanies the delivered goods with an uncomplete certificate. The certificate gives the WVP value in g/m^2/24 hour, but does not define the testing conditions. Thus, the real WVP level of the purchased fabric can vary in large range. In the next chapter, thermomechanical analysis of some gravimetric methods is outlined, with the objective to determine selected factors, which may cause the measurement imperfection.

THERMAL MODEL OF GRAVIMETRIC METHOD CALLED "DIRECT CUP"

The largely used standard Direct cup method for testing of water vapor transmission of materials is the method according to the ASTM E96 – 2010 expressing the amount of moisture vapor in grams that passes through 1 m^2 of fabric in 24 hours at specified temperature and air relative humidity. At the version B the testing temperature is 23°C, whereas the version D employs the testing temperature 32.2ºC. The air relative humidity is always 50%. Here, the used light weight dish is up to ¾ filled with the distilled water and covered by the test specimen. Then the specimen is sealed and the cup + specimen are weighed before placing in the controlled atmosphere. Then the system is periodically weighed.

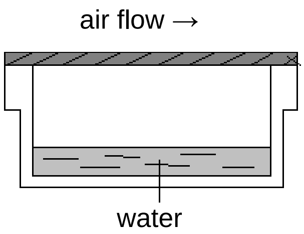

Figure 1: Direct cup WVP testing

During the testing of water vapour permeability of fabrics by this gravimetric method, vapour passes through the air gap above the water level in the cup, then it passes through the tested fabric, and finally it must overcome the convection boundary layer above the tested fabric (given by the parallel air flow with the velocity 2,8 m/s), as displayed on the Figure 1:

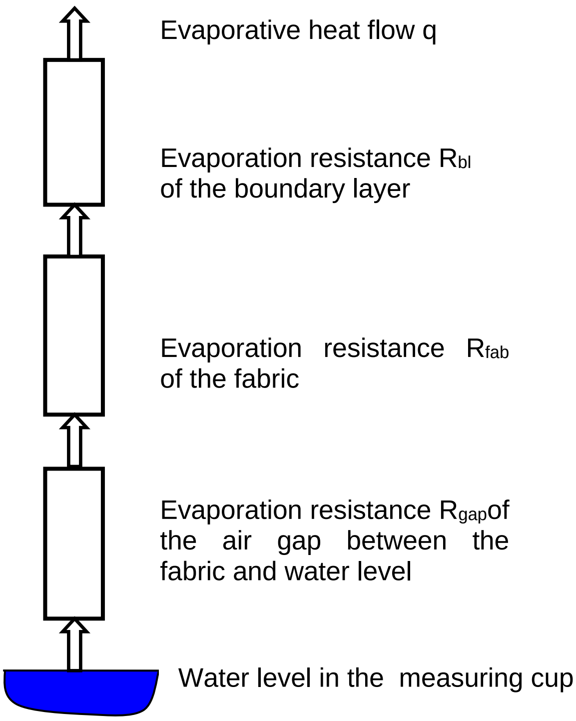

Figure 2: Structure of the total evaporation resistance between the tested fabric and the outside air

Here, the individual evaporation resistances are defined as follows:

The evaporation resistance R [Pa.s.m^2/kg] of the relatively narrow air layer (R_{gap}) without contribution of free convection (see in [10],) can be described by equation (3) as

$$R_{gap} = \frac{h}{D_p} \text{ [Pa.m}^2\text{/W]} \qquad (1)$$

The evaporation resistance of the boundary layer (R_{bl}) can be described by equation (2) as:

$$R_{bl} = \frac{1}{\beta} \ [Pa.s.m^2/kg] \qquad (2)$$

The mass transfer coefficient β is proportional to the square root of the air velocity v:

$$\beta = C\ v^{1/2} \qquad (3)$$

Total evaporation resistance is then given by the sum

$$R_{tot} = R_{gap} + R_{fab} + R_{bl} \qquad (4)$$

The evaporation resistance of the air gap reduces substantially the water vapour flow, moreover, the air gap thickness increases with the time of measurement.

The transferred mass per unit of the time through the area A yields the relationship

$$m^* = A\ (p_{sat,} - p_{air})\ /\ R_{tot} \quad [kg/m^2s] \qquad (5)$$

The transferred mass per the time τ than follows from the equation

$$m_\tau = A\ (p_{sat,} - p_{air})\ \tau\ /\ R_{tot} \qquad (6)$$

Now, let us introduce the water vapour permeability WVP [g/(m^2/24 h)] according to various standards

$$WVP = \Delta m\ /\ (A\ \tau) = 8{,}64\ .\ 10^7\ m_\tau \qquad (7)$$

$$WVP = 8{,}64\ .10^7\ (p_{sat,} - p_{air})\ /\ R_{tot} = 8{,}64\ .10^7\ (p_{sat,} - p_{air})\ /\ (R_{gap} + R_{fab} + R_{bl}) \qquad (8)$$

$$WVP = 8{,}64\ .\ 10^7\ [p_{sat}(t) - p_{air}(t)\ ]\ /\ \left(\frac{h}{D_p} + R_{fab} + \frac{1}{\beta}\right) \qquad (9)$$

In this equation, the mass transfer coefficient β is proportional to the square root of the air velocity v.

$$B = C\ v^{1/2} \qquad (10)$$

Fortunately, the diffusion coefficient D_p of water vapor passing through air is just a weak function of the air temperature t.

at 20^{0}C L = 2454 kJ/ kg 22^{0}C L = 2449 kJ/ kg 35^{0}C L = 2418 kJ/ kg
21^{0}C L = 2451 kJ/kg 28^{0}C L = 2453 kJ / kg 40^{0}C L = 2407 kJ/ kg

Thus, change of the testing temperature would not affect much the diffusion coefficient D_p.

On the other hand, the level of partial pressure of the water vapor p is a very steep function of the air temperature t.

at 20^{0}C p_{sat} = 2337 Pa 22^{0}C p_{sat} = 2642 Pa 35^{0}C p_{sat} = 5622 Pa
21^{0}C p_{sat} = 2486 Pa 28^{0}C p_{sat} = 3778 Pa 40^{0}C p_{sat} = 7375 Pa

If the outside air is always kept at humidity 50%, then increase of the testing temperature of the system from 23°C (version B) to 32°C (version D) would increase the difference of partial pressures of water vapor (driving force) roughly 2,4 times. Thus, the fabrics exhibiting the WVP 5000 g/m^2/24 h would reach the WVP 12000 g/m^2/24 h. Thus, the incorrect measurement procedure could cause problems for the garment manufacturers and clients as well [5].
For the case of the inverted cup method without the air gap according to the ASTM – 96 version BW, evaporation resistances $R_{fab} + R_{bl}$ in the equation (9) can be substituted by water vapour resistances R_{et} and R_{eto} introduced in the respected ISO 11092 on testing of thermophysilological parameters of textiles, as follows (the L presents the heat of water evaporation (2 500 000 J/kg at 21°C):

$$R_{bl} = L.\ R_{eto},\quad R_{fab} = L.\ R_{et} \qquad (11)$$

PRACTICAL OBSERVATIONS CONCERNING THE PRECISION OF THE WVP MEASUREMENT

From our measurements follows, that for the PES woven fabric of 180 g/m^2 with the thickness h = 0,4 mm the evaporation resistance of the boundary layer R_{bl} is approx. the same as the evaporation resistance R_{fab} of the proper fabric.

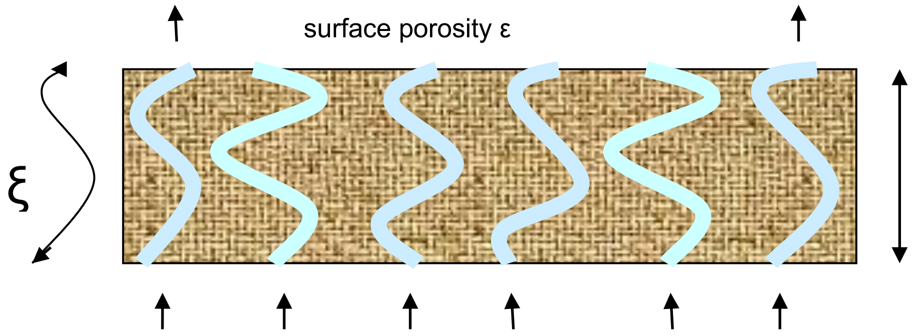

Figure 3: Thermal model of a porous fabric

If the air gap thickness h between the fabric and the water level is the same as the fabric thickness, then (roughly), the evaporation resistance of this gap is (ξ / μ) times lower then the eveporation resistance of the fabric. The symbol ξ means the average tortuosity of the transversal pores and μ here is the mean planar porosity of the fabric, as shown in the Figure 2.

For a certain structure, this ratio can reach the value e.g. 25. Therefore, for thin gaps, the effect of the mentioned air gap is negligible.

The very negative effect on the measurement precision exhibits the effect of the air gap thickness between the water level and the fabric. With the increasing time of measurement, the air gap thickness increases as well, which brings strong non-linearity in the measure-ment. The very permeable fabrics, which cause the bigger level of the air gap, became less permeable then they are in the reality.

However, during practical water vapour permeability tests, at the end of test, thickness of this air gap h may reach 10 mm, which is 25 times more then before. Thus, at the end of measurement, the evaporation resistance R_{gap} of the air gap can reach same value as the evaporation resistance R_{fab} of the fabric. Thus, at the beginning of this gravimetric measurement, the total evaporation resistance R_{tot} of the system presented double level of evaporation resistance of the tested fabric. At the end of the same measurement, the total evaporation resistance R_{tot} might be 3 times higher then evaporation resistance R_{fab} of the tested fabric.

This consideration serves as a proof that the direct cup gravimetric method may suffer from large imperfection. That is why in some countries this method was abandoned. This problem is avoided at the inverted cup method, with water inside the cup. However, other above mentioned negative efects of air temperature and velocity are still present here.

EQUATION OF CONVERSION OF THE FABRIC EVAPORATION RESISTANCE Ret AND THE MWTR FROM THE INVERTED CUP METHOD WITH ENHANCED PRECISION

When testing water vapour permeability of fabrics by inverted cup gravimetric method according to the ASTM 96 BW, the fabric is fixed on the bottom of the inverted cup filled with water, where the water penetration into the fabric is excluded by a semi-permeable but for water vapour 99%permeable PTFE membrane fixed between the water volume and the fabric.

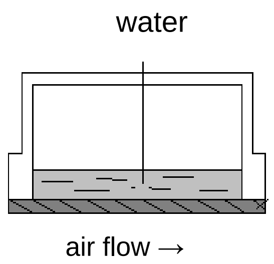

Figure 4: Inverted cup WVP testing

Outer surface of the tested fabric is exposed to the parallel air flow with the velocity 2,8 m/s. Then, the water vapour passes from 100% saturated water space by diffusion through the fabric and leaves the fabric by convection into the air with 60% relative humidity (saturation). Then the relative water vapour permeability P(measured e. g. by the PERMETEST instrument) is given by the relationship (at P=100% water vapour leaves the wet surface without any fabric resistance, only at boundary layer resistance R_{eto}):

$P = 100.R_{eto} (R_{eto} + R_{et})_l$ In this expression, the driving pressure ΔP is not involved. (12)

The R_{eto} and R_{eto} evaporation resistances [Pa.m^2/W] can determined on common SKIN MODELS and PERMETEST WVP testers according to the ISO 11092. However, when expressing the water vapour permeability in the MWTR units, [g/(m^2/24 h)], then the driving pressure will play essential role :

$MWTR = \Delta P.\ 8{,}64.\ 10^7/\ [\ L\ .(R_{eto} + R_{et})]$ – see the Eq. (11). (13)

As already stated, the driving water vapour pressure difference ΔP depends strongly on the testing temperature. This simple equation of conversion of the inverted cup MWTR method into the Ret values according to the ISO 11092 can be easily modified for other direct or inverted cup methods (see the Eq. 10). From the Eq. (12) follows, that simple conversion between the data obtained from gravimetric methods and the evaporation resistance Ret according the ISO 11092 is not easy, as it requires the knowledge of the basic R_{eto} evaporation resistance testing device. On the PERMETEST tester, the R_{eto} can be derived from the relative WVP.

Figure 5: The PERMETEST Skin model, a non-destructive tester of water vapour permeability of fabrics

The novel inverted cup method according to the ISO 15496 (inverted dessicant method) is based on the placement of the tested sample between two PTFE semipermeable membranes [5] . Outer surface of this sandwich is plunged into liquid water and the inner surface is exposed to the water vapour absorbtion force of the dry chemical called potassium acetate, sealed with the sample in the inverted cup. The advantage of this method is the zero dependence of the measurement results on the velocity of the outside air and short time of testing, given relatively high difference of the used high water vapour partial pressures. However, this method still exhibits one weak point, which will be analysed in the next research.

CONCLUSIONS

From the presented study follows, that the direct cup gravimetric method for testing the water vapour permeability of fabrics is basically imperfect, whereas the precision of the inverted cup method is higher. However, the unsteady velocity of the air flow along the sample and namely varying parameters of the temperature and humidity of the air on both sides of the sample can substantially affect the measurement precision.

The main finding of this study is that when the WVP value of the tested fabric is determined by some gravimetric method and expressed $g/m^2/24$ hour without information about the used testing method, then the real WVP level of the tested (and purchased) fabric can be substantially lower, which can harm the final client /user of the clothing.

The analysis also proved, that simple conversion between the data obtained from gravimetric methods and the evaporation resistance Ret according the ISO 11092 is not easy, as it requires the knowledge of certain parameters of the testing device.

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PERFECTION OF WHITENESS AND FLUORESCENCE IN THE CLEANLINESS AND HUMAN PROTECTION

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Faculty of Textile Technology

Abstract: *White is clearly preferred colour in many material fields and aesthetic application since it is the most often associated with innocence, perfection, cleanliness, the good and honesty. From physical point of view it is clear that white has the high level of luminosity, no saturation (achromatic one) and no hue. Considering textiles, chemical bleached materials never reach the complete elimination of natural colour and show sligth yellowness. However, when Paul Krais in 1929 discovered fluorescent compound Aesculine by water extraction from wild chestnu,. Nowadays, it is relatively easy to accomplish great whiteness and brightness of white textiles applying the fluorescent compounds, e.g. fluorescent whitening agents (FWA's). Based on electronically-excited molecular state by energy of UV-R (usually 340-370 nm) the FWA molecules show the phenomenon of fluorescence giving to white textiles the high whiteness of outstanding brightness by reemitting the energy at the blue region (typically 420-470 nm) of the spectrum. Recently, the new fluorescent compounds, UV absorbers, were developed for UV-B protection, and even can be applied in washing process to give a new dimension to white textiles.*

Keywords: *White, Whiteness, Quenching of fluorescence, Cotton fabric, UV protection*

INTRODUCTION

It is known that a wide range of white things are preferred colour in many materials and aesthetic application. White, besides being objectively quantifiable, is also a subjective connotation of quality which is greatly influenced by personal taste.

From physical point of view it is clear that white has high level of luminosity, no saturation (achromatic one) and no hue. As Brown said [1] - White surfaces posses a beautiful harmony of achromaticity. Although so important position in human being, the white is not much available in literature [2,3,4].

As other materials, textiles are never as white as necessary. For reaching the highest degree of whiteness, chemists tried to research the best compounds and bleaching procedure that finally succeed by using hydrogen peroxide at the very beginning of 20th century.

Chemical bleached natural textiles never reach the complete elimination of natural colour and little yellowness was known phenomena from the beginning of textile bleaching at the end of 18th century. At the beginning of 20th century consumers asked producers for better whiteness that resulted with historic discovering of first fluorescent compound Aesculine for application on textiles, plastics and other materials.
These compounds compensate the fabric yellowness based on property to absorb light in near UV region (UVA) and emit at in blue spectrum at about 440 nm. This phenomenon is photochemical reactions that occur as results of electronically-excited states with definite energy structure and lifetime. Modified diagram according Jablonski presented in Ranby & Rabek [5] is the most used diagram for processes involving electronically excited molecule (Figure 1).

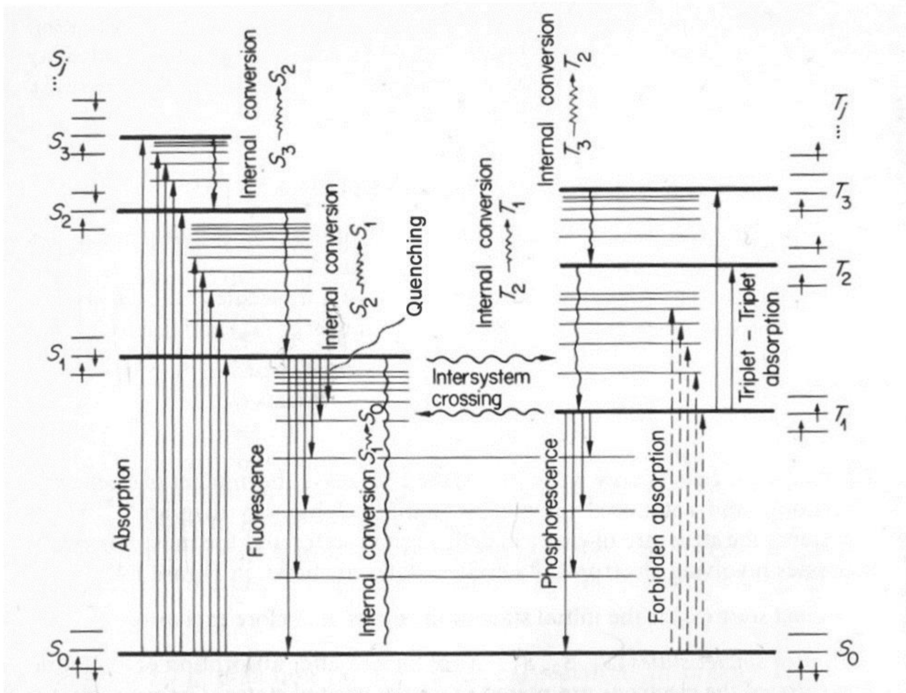

Figure 1: Modified Jablonski diagram

An electronically-excited molecule can lose its energy by emission of radiation which is known as "luminescence". One of these kinds of emission is fluorescence. According to Fig. 1 fluorescence is an emission process occurring from lowest excited state (S1) to the ground state (S0). The frequency of fluorescence radiation is lower than that of excitation light (which is known Stokes Law). For the same compound an ideal emission should be the mirror image of the absorption band system.
There are many organic compounds for application on textiles like stilbene, bis-benzoxazole, cumarine and pyrazoline derivates and many others. It is well know that fluorescent compounds show the high fluorescence intensity by application of very low concentration on textile and other materials, as well.

Based on electronically-excited state by energy of ultraviolet radiation the molecules of fluorescent whitening agents (FWAs) show the phenomenon of fluorescence giving to white textiles high whiteness of outstanding brightness by reemitting the energy at the blue end of the spectrum.
Recently, fluorescent whitening agents showed the good prevention of harmful UV rays transmission contributing to high ultraviolet protection factor (UPF). Based on these useful properties, and according to results presented by Grancarić et al. [6,7], it is to say that FWAs have multifunctional activity by giving the high whiteness, neutralizing the fabric yellowness, giving to the fabric the high luminosity and protecting fabrics against UV radiation.

Grancarić et al. published several papers [7-11] regarding the quenching of fluorescence. In some range of higher FWA concentration, deactivation of molecule excited state occurs.

Following are some simplified presentation of processes involving electronically excited states of excitation, fluorescence emission and quenching mechanism:

Excitation	$So + h\nu \rightarrow S_1$
Fluorescence emission	$S_1 \rightarrow So + h\nu'$
Quenching mechanism	$S_1 + Qo \rightarrow Q^* + So$
Deactivation	$Q \rightarrow Qo + heat$

Where So is molecular ground state, S_1 is molecular first exciting state, Qo is Quencher, Q* Quencher in exciting state, hν' is energy quantum.
Quenching of fluorescence can occur by other compounds under the name quenchers (Q) although the higher concentration of fluorescence compound itself can quench the fluorescence, as well.

In photochemistry by Ranby & Rabek [5] it is well known Stern-Volmer quenching equation:

$$\frac{\Phi_0}{\Phi_q} = 1 + \tau k_q [Q] \qquad (1)$$

where Φ_0 and Φ_q are quantum yields of fluorescence without and with influence of quencher, τ is unimolecular lifetime of exited state, kq the rate constant of deactivation in electronic energy transfer process, [Q] is concentration of quencher.

For investigation of quenching of fluorescence in this paper white cotton fabric for summer clothing were treated with FWA based on stilbene derivate, applied in a wide range of concentration.

The fabric whiteness, according to different theories – Whiteness Index according to Berger (WI-B), Hunter (WI-H), CIE (WI-CIE), Ganz-Griesser (WI-GG) and yellowness according to Yellow Index (YI) were calculated from spectral characteristics determined using remission spectrophotometer SF 600 PLUS CT(Datacolor). The relative intensity of fluorescence (Φrel) was calculated from measured fluorescence on adapted spectrophotometer Specol SV (Carl Zeiss).

Materials for human performance, such are medical, protective and sports, is one of nine themes according the European Technology Platform for the Future of Textiles. As the textile and clothing are person's second skin, it is the most suitable interface between environment and human body and ideal tool for personal protection and safety [12].
UV radiation (UV-R) can be divided into UV-A (from 400 to 320 nm), UV-B (from 320 to 280 nm) and UV-C (under 280 nm) radiation. UV-C radiation gets absorbed by atmosphere, but diminishing of the ozone layer results with the reaching of UV-B and UV-A rays on the Earth's surface. Even though the UV-A rays are necessary for vitamin D synthesis, longer exposure to UV-A and UV-B rays can cause acute and chronic reactions and damages such as erythema (sunburn), sun tanning, photocarcinogenesis and "photoaging", skin aging and recently the formation of skin malignant neoplasm [13-16]
Garment provides some UV protection. Fabric can reflect, absorb and scatter solar wavelengths, but in the most cases it does not provide full sun screening properties. This protection, among other large number of factors such are type of fiber, porosity, density, moisture content, type and concentration of dye and FWA in the case of white textiles, and on UV-B protective agents, if applied [6,15] highly depends on fabric surface and construction.

EXPERIMENTAL

Chemically bleached cotton fabric was used. It was plain weave fabric of 100 % cotton yarn of 20 tex and surface mass 125 g/m2.

Uvitex BAM (Ciba), derivate of stilbene disulphuric acid was used as FWA. It was applied in wide concentration range (c_1 = 0,2 g/l; c_2 = 0,5 g/l; c_3 = 2,5 g/l; c_4 = 5 g/l; c_5 = 7,5 g/l; c_6 = 10 g/l; c_7 = 25 g/l; c_8 = 50 g/l) by padding at wet pick up 100 %, in bath containing 5 g/l corn starch, 10 g/l glycerol, 20 g/l Na2SO4 and drying at T = 100 °C for t = 90 s.
On three samples (c_2 = 0,5 g/l; c_4 = 5 g/l; c_8 = 50 g/l) UPF was measured.

The fabric spectral characteristics were determined using remission spectrophotometer Spectraflash SF 600 PLUS CT (Datacolor). Whiteness index was calculated according to different theories:

a) using B = RZ (blue); G = RY (green); A = RX (amber)

1) Berger

$$WI\text{-}B = 3B + G + 3A \qquad (2)$$

2) Ganz

$$WI\text{-}G = 3B - 1.5G - 0.5A \qquad (3)$$

b) using Hunter coordinates (L, a, b)

$$L = 10\ RY1/2 \qquad (4)$$

$$a = 17{,}5 \cdot \frac{1{,}05\,RX - RY}{RY^{1/2}} \quad (5)$$

$$b = 7 \cdot \frac{RY - 0{,}919\,RZ}{RY^{1/2}} \quad (6)$$

3) Hunter

$$\text{WI-H} = L - 3b \quad (7)$$

c) CIE

$$\text{WI-CIE} = Y + 800\,(0.3138 - x) + 1700\,(0.3310 - y) \quad (8)$$

Yellow Index, YI was calculated according to DIN 6167:1980 Beschreibung der Vergilbung von nahezu weißen oder nahezu farblosen Materialien.

The relative intensity of fluorescence (Φrel) was calculated from measured fluorescence on adapted spectrophotometer Specol SV (Carl Zeiss). Illuminant is high voltage Hg bulb (λ_{max} = 366 nm). Fluorescent Reference Standard, Datacolor was used for Φrel. standard = 40, with amplifying of 200x.
Quenching of fluorescence was calculated according to Stern-Volmer eq. (1) for concentration quenching:

$$\frac{\Phi_{max}}{\Phi} = 1 + (c - c_{max}) \quad (9)$$

where cmax is FWA concentration for the highest fluorescence, Φmax is maximum fluorescence at cmax; c is concentration at quenching fluorescence begins and Φ is fluorescence at quenching area.

Varian Cary 50 Spectrophotometer was used for measurement of fabric transmission at different wavelengths. The fabric UV protection ability was determined according to AS/NZS 4399:1996 *Sun Protective Clothing: evaluation and classification.* It is expressed via *ultraviolet protection factor* (*UPF*) indicating the ability of body protection by textile materials to prevent erythem [6]. UPF value is determined according to eq. (10)

$$UPF = \frac{\sum_{\lambda=280}^{400} E(\lambda)\cdot\varepsilon(\lambda)\cdot\Delta\lambda}{\sum_{\lambda=280}^{400} E(\lambda)\cdot T(\lambda)\cdot\varepsilon(\lambda)\cdot\Delta\lambda} \quad (10)$$

where *E(λ)* is Sun's radiation, *ε(λ)* is erythematous effect of the spectrum, Δλ is measuring wavelength interval and *T(λ)* is spectrum permeability at a wavelength of λ.

RESULTS AND DISCUSSION

The spectral characteristics, whiteness degrees according to all presented formula (2)-(7) and relative intensity of fluorescence of cotton fabrics optically bleached in wide FWA concentration range are presented in Tab. 1.
In the present paper the parameter that characterize the fluorescent samples are relative intensity of fluorescence that contributes to samples the high whiteness and beauty in optimal range of concentration. Quenching of fluorescence is phenomena with negative appearance because of lower luminosity and yellowness.

Table 1: The whiteness degrees, spectral characteristics and relative intensity of fluorescence of optical bleached cotton fabrics in wide range of its concentration

Label	c_{FWA} [g/l]	WI-GG	WI-B	WI-H	WI-CIE	YI	Φ	R_{max} [%]	λ_{max} [nm]
c_0	0	84,0	73,1	85,3	73,9	4,27	0	86,03	700
c_1	0,2	85,9	110,8	109,6	111,3	-9,67	22,2	100,33	440
c_2	0,5	87,0	118,5	114	117,7	-12,17	25,5	105,01	440
c_3	2,5	89,1	129,7	119,1	125,1	-15,45	61,1	112,65	440
c_4	5,0	89,0	125,1	115,3	119,9	-13,58	58,3	110,61	440
c_5	7,5	88,9	123,3	113,8	117,7	-13,06	55,5	109,77	440
c_6	10,0	88,9	120,0	111,2	114,1	-11,62	52,4	108,45	440
c_7	25,0	88,4	96,3	94,2	88,7	-2,75	42,8	100,36	450
c_8	50,0	87,1	75,9	80,5	66,6	4,46	32,1	93,57	480

Using all presented whiteness degrees formula (Tab. 1) it is to be shown the highest whiteness degree reached by using 2,5g/L FWA. Ganz-Griesser whiteness degree is the measure for basic whiteness of sample without UV stimulation. In that case spectral characteristic were measured with UV filter applied. Therefore, there was no fluorescence and the obtained whiteness (WI-GG) was lower, but the basic whiteness was excellent. On the other hand, whiteness degrees that include UV stimulation, such are Berger, Hunter and CIE (WI-B, WI-H, WI-CIE) were very high following the fluorescence changes and all the beauty of whiteness giving the high its values (Fig. 2).

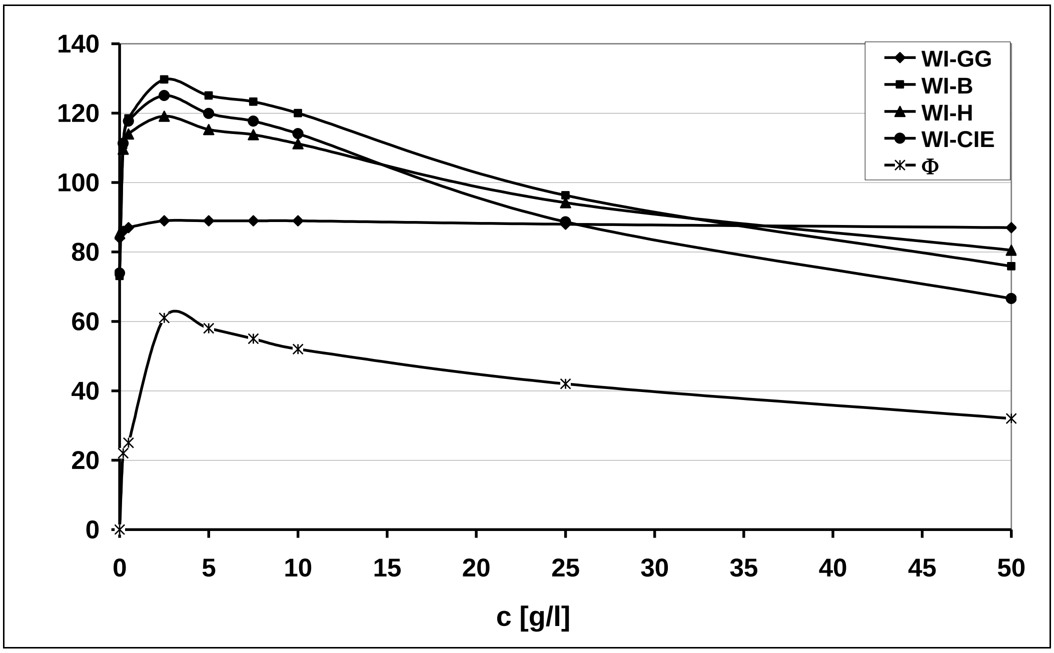

Figure 2: Whiteness Index according to Ganz-Grisser (WI-GG), Berger (WI-B), Hunter (WI-H) and CIE (WI-CIE) of FWA treated cotton fabrics under illuminate D_{65} and relative intensity of fluorescence (Φ_{rel})

Applied in the high FWA concentration range and presented in Fig. 3 it can be seen that changes in emission spectrum occurred by its batochromic shift and losing the fluorescence intensity by quenching phenomenon.

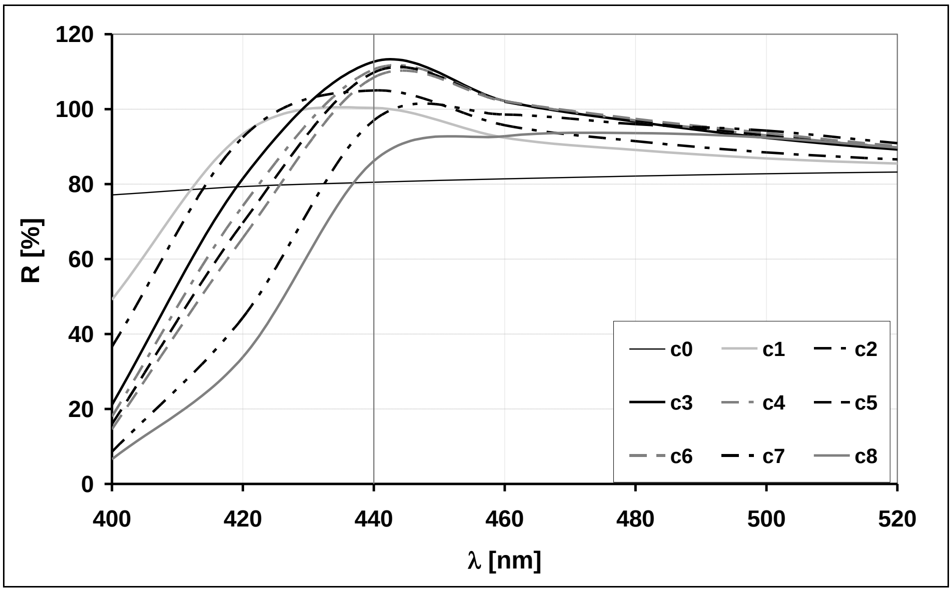

Figure 3: Remission spectra of FWA treated cotton fabrics under illuminant D_{65}

The samples chromaticity coordinates included in CIE chromaticity diagram (Fig. 4) show the whole psychological image of white fabrics in harmonic change from row cotton through its brilliant whiteness to its yellowness as the consequence of quenching of fluorescence.

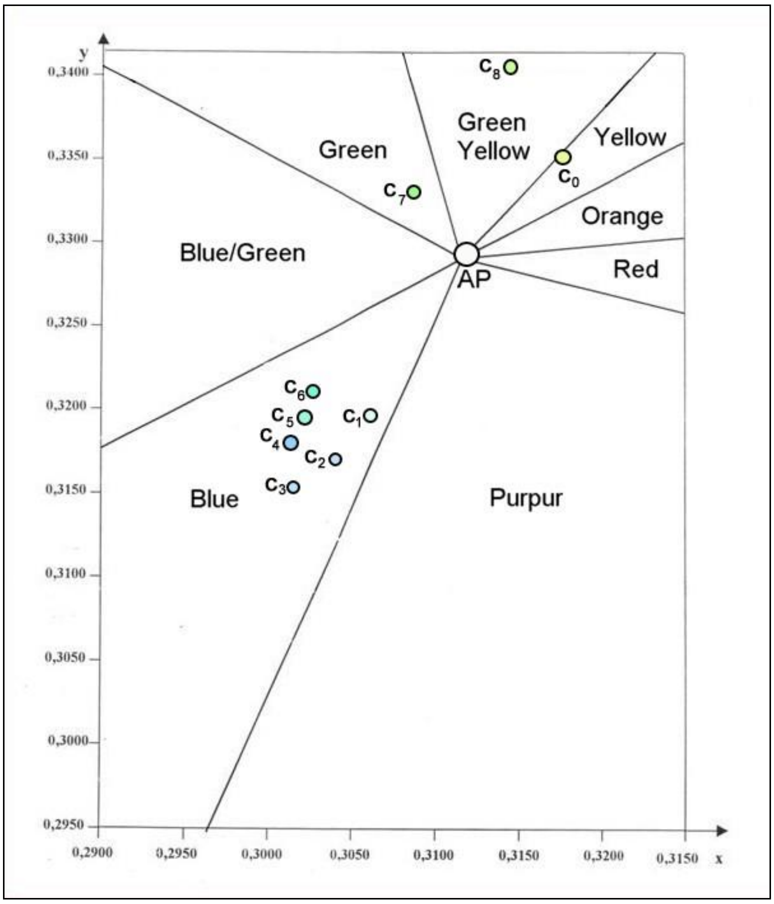

Figure 4: Part of CIE chromaticity diagram under D_{65} illumination (AP-achromatic point)

In this diagram the row cotton starts in yellow region, fluorescent bluish samples go to direction of bluish region but turn to blue-green and finally to green region with poor fluorescence intensity. At the low FWA concentration blue fluorescence neutralizes the yellowness of chemical bleached textiles giving the high luminosity and "most beautiful" white. In the range of higher FWA concentration yellow colour of FWA is overcomes and fluorescence quenched in the same time with a consequence of complete different feeling far away from white and all beauty that it brings. It is important this phenomenon for research it from psychological point of view.

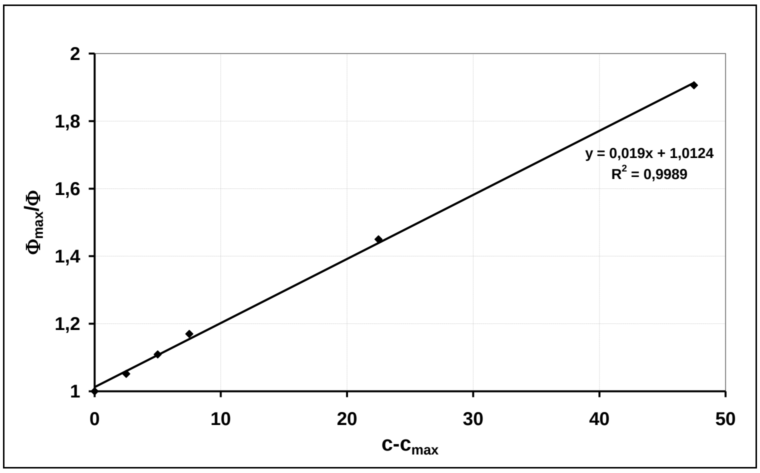

Figure 5:. Quenching of FWA fluorescence according to Stern-Volmer equation

It is clear that quenching of fluorescence presented in Fig. 5 is following Stern-Volmer linear equation with high variation coefficient (R ≈ 1.0).

Fabric protective ability from UV radiation (UV-R) was investigated in wet state as well. Results of UV protection expressed through mean UPF values are shown on Table 4.

Table 2: UV protection ability of cotton fabrics according to AS/NZS 4399:1996, expressed via ultraviolet protection factor (UPF), UVA and UVB transmission

Fabric	Mean UPF	τ_{UVA}	τ_{UVB}	UV protection	
c_0	21.254	9.989	3.650	15	Good
c_2	58.928	2.088	1.408	50+	Excellent
c_4	232.231	1.727	0.342	50+	Excellent
c_8	439.200	1.679	0.161	50+	Excellent

Pectine and waxes in raw cotton absorb small quantities of UV radiation; therefore raw fabric has good sun screening properties. Removing those impurities in scouring and bleaching, UV protection is lower, but still good. Therefore, for summer clothing additional fabric protection is necessary, as for fabric whiteness as well. By absorbing UV-A radiation optical bleached fabrics transform this radiation to blue fluorescence not transmitting this range of radiation what leads to excellent UV protection and high degree of whiteness. Cotton fabrics of the highest FWAs concentration have the highest UPF. On the other hand, transmission of UV radiation through fabrics in wet state, presented in Table 4, is getting higher. Therefore, all the fabrics give off lower UV protection than in dry state. For raw and bleached cotton fabric, transmission gets so high that fabrics become non-rateable. As for optically brightened fabrics, the transmission is higher, but they still give an excellent UV protection.

CONCLUSION

The fluorescence contributes to the high whiteness and beauty in optimal range of FWA concentration. The blue fluorescence of low FWA concentration neutralizes the yellowness of chemical bleached textiles giving the high luminosity and "most beautiful" white. In the range of higher FWA concentration yellow colour of FWA is overcomes and fluorescence quenched with the consequences of complete different feeling far away from white and all beauty that it brings. Quenching of fluorescence is phenomena with negative appearance because of lower luminosity and yellowness. It is important this phenomenon to research it from the psychological point of view. Fabric UV protection increase after FWA concentration.

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Section 1: New Fibers and Advanced Materials

FILTRATION PROPERTIES OF THERMALLY TREATED NANOFIBROUS WEBS

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After the industrialization world is changing rapidly, especially the quality of environmental has decreased day by day, inflictive pollutants are merged with air and water. Nowadays this main environmental issues resume and recur, and menace the all humanity. In developing countries more than 2 million people die annually due to water related diseases (Dirty Water: Estimated Deaths from Water-Related Disease 2000-2020, Peter H. Gleick). Water pollution and diminishing fresh water sources are mentioned that area of urgent solution must be found. The guess is more than %50 of nations in the world will encounter that global issues at 2025 and after, by 2075 having this trouble nations number increasing about %75 of all nations. At 2020 expected filtration market value would be up to US $700b. [3,4].
Currently many methods used for solving these concernes, seawater desalination is used by distillation, reverse osmosis(RO) or membrane distillation(MD) with progressing the new technologies[1].
Nanofiber filter media performed by electrospinning might be show potentially above mentioned properties, there are several methods for produce the nanofiber, some of them; island-in sea, gas jet techniques, drawing, template synthesis, phase separation, self-assembly, nanolithography and electrospinning. But all of these techniques have some usefullness for example; restricted material range, possible fiber assembly, cost and production rate. Electrospinning is challenging the other methods about low cost and relatively high production rate [2,3,5]. Electrospun nanofibrous membranes are promising material in the filtration industry. However, due to nature of electrospinning method, these electrospun nanofiber membranes are very thin and have poor mechanical strength thus necessitating the use of an additional support layer which can add to membrane thickness and resistance. In this study, polypropylene microfiber was used as a support layer. Polymer nanofiber mats based on polyacrylonitril (PAN), polyvinylidenefluoride (PVDF) and polyamid (PA) 6 were produced by using electrospinning method and applying thermal treatment and examined their morphology and water permeability.
All kinds of electrospun PA 6, PVDF and PAN nanofibers membranes were fabricated and tested the prepared specimen were then numerically examined and their area density values are determined. These results clarify that PAN-based specimen contains the largest amount of polymer material than PVDF and PA-6 based specimens. Regarding to this comparison; PAN-based membrane expected to have the worst water permeability without any thermal and mechanical deformation.
These results demonstrated that PAN has the coarsest fibers comparing to PA6 and PVDF, but this value also clarifies that PAN membrane owns the biggest pore sizes. On the other hand; mean fiber diameter of PVDF based membrane has the lowest value and also it has the lowest pore size compared to the others.

Keywords: *polypropylene microfiber, polyacrylonitril (PAN), polyvinylidenefluoride (PVDF) and polyamid (PA) 6, Electrospinning.*

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ANALYSIS OF PROPERTIES FOR CONDUCTIVE TEXTILE YARNS

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Abstract: *In this paper conductive yarns were made by coating the yarns with a solution having carbon black nanoparticles (CB) with an average diameter of 18 nm, polyvinyl alcohol (PVA) and water. For a continuous coating deposition it is necessary to obtain a solution of a certain consistency; for this reason, carbon black nanoparticles are mixed with the ingredients so that the resulting film deposited as a thin layer on the yarn to be conductive, and at the same time flexible. The carbon black nanoparticles tend to form aggregates; this is why the solution should be stirred continuously. The yarns used as support are different from the nature, fineness and structure point of view. Several variants of yarns were chosen in order to decide which ones are appropriate for obtaining conductive yarns that keep their specific initial properties. The variants of conductive yarns obtained were tested in terms of physical and mechanical properties (tensile strength, elongation), and from the viewpoint of electrical properties, electrical resistivity was measured. After coating the conductive layer, yarns shows greater rigidity, but can be used to obtain textile materials such as woven fabrics. After performing the measurements, it can be concluded that the yarns coated with a conductive solution based on CB shows electrical conductivity and can be used for obtaining conductive textile fabrics.*

Keywords: *conductive yarn, carbon black nanoparticles, mechanical properties, electrical properties.*

INTRODUCTION

Adding new properties, different from what we were used towards textiles became a major concern of researchers in the field of textile and beyond. These new properties allow the use of textiles in areas that have already been established, but also in other areas, depending on newer properties they own. Conductive textiles represent an attractive area of research, because they can be used for clothing, but also in areas such as medicine, military, heating elements, electronics, sports and leisure etc [1-7]. Materials and methods for obtaining conductive fabrics are diverse, depending on the domain to be used and the particularities of both the conductive substances and the conductive substrate used. Conductive yarns can be obtained from 100% conductive fibers or mixed in different proportions, conductive filaments, yarns coated with conductive polymers, metal-plated yarns, or yarns coated with conductive powders such as carbon or metal powders. Textile yarns used as a substrate can be from both natural and chemicals fibers [1, 2, 8-13]. Many of these types of threads are currently obtained on an industrial scale. The films used may be conductive polymer films, such as polypyrrole, polyaniline, polythiophene, polyacetylenes, as well as conductive metals such as silver, copper, gold, platinum, etc. The subsequent conductive yarns produced can be sewn, knitted, woven [14-16]. These may have applications such as antistatic, heating elements, signal transfer, electromagnetic shields materials. Nanoparticles of CB are widely used for applications in conductive fabrics, the reason being that they have conductive properties similar to electrically conductive metals and the coating of yarns with CB nanoparticles retains in a large measure the flexibility and elasticity of the textile material. The methods used often are: screen printing, coating, dyeing and manual deposition [7, 9-12]. In this paper conductive yarns having as base yarns that were coated with a conductive matrix were obtained. The conductive material component of this matrix is CB nanoparticles. In the literature, the conductive yarns have been carried out by various methods, from the polymerization of conductive polymers to electrolytic plating with the metal layer [1, 6, 8, 10, 13, 17]. The method used in this paper is to cover the yarns with conductive substance with CB nanoparticles because it is a method which allows uniform coverage, easiness and not least cheap method.

MATERIAL AND METHOD

This study deals with comparative analysis of mechanical and electrical properties of several yarns before and after coating them with a conductive layer of carbon based nanoparticles.

The yarns were conditioned under standard atmosphere of 65% ± 2% RH and 20ºC ± 2ºC temperature for 24 hours. The under test yarns (Y) were chosen to have approximately the same count, but from different raw materials and with different structures. In Table 1 the yarns analyzed are presented.

Table 1: The samples of yarns

	Fancy yarn **(Y1)**	Worsted spun yarn **(Y2)**	Textured yarn **(Y3)**	Worsted spun yarn **(Y4)**	Two-ply yarn **(Y5)**
Count of yarn, [tex]	74	26	16.7x2	40	2x7.8x2
Yarn composition, [%]	Polyester/ acrylic 40/60	Polyester/ viscose 60/40	Polyester 100%	Acrylic 100%	Polyamide 100%
Yarn structure	Spiral fancy yarn from PET textured yarn and spun yarns from acrylic fibers	Worsted spun yarn	Textured yarn, PET 167 f32x2	Worsted spun yarn	Two-ply yarn, PA6 2x78 f18x2

These yarns were coated with an electrically conductive layer deposited by immersing the yarn in a solution made according to the recipe: 10% nanoparticles of carbon black, 40% PVA, 50% water. 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 250 mm and the tensile testing speed was adjusted so that yarn break is reached in 20±3s. The variants of coated yarns (CY) were analyzed in terms of mechanical and electrical properties.

The mechanical properties analyzed were: breaking strength, coefficient of variation of strength, breaking elongation, coefficient of variation of elongation, breaking tenacity, coefficient of variation of tenacity. The breaking strength is one of the basic features of the yarns because it influences the behaviour of yarns in processing (for weaving preparation, weaving, knitting), thus establishing the technological parameters of the machines and their productivity. Coefficient of variation of breaking force influences the behaviour of yarns in the manufacturing process causing the machine's efficiency and product quality trough the number of nodes. Breaking elongation is a characteristic of the yarns which influence their behaviour in the technological processes and the characteristics of wearability of the product. The tenacity of the yarns was determined to compare them, because they have approximately equal count.

The electrical properties of the coated yarns were tested with a TTI 1705 True RMS Programmable multimeter.

The resistance of a yarn, *R* [Ω], with the length *l,* can be calculated with the following formula (considering annular cross-section):

$$R = \frac{l \cdot \rho}{A} = \frac{4 \cdot l \cdot \rho}{\pi \cdot d^2} \qquad (1)$$

where *R* is the resistance of the conductor [Ω], *l* is the length of the conductor [m], ρ is the electrical resistivity of a conductor [Ω.m], *A* is the cross-sectional area [m^2], *d* is the nominal diameter of the yarn [mm] [18].

Electrical resistivity, ρ [Ω.m] is a measure of how strongly the conductive yarn opposes electric current. A low resistivity indicates a yarn that allows the movement of electrical charge [18].

$$\rho = \frac{R \cdot A}{l} = \frac{\pi \cdot d^2 \cdot R}{4 \cdot l} \qquad (2)$$

Resistivity is expressed as the resistance per unit length, usually measured in Ω·cm. The textile fibers and yarns are irregular, their size varying. The thickness of the conductive solution is not uniform and the contact with the electrodes in the different points of measurement cannot be the same. In this case, the resistance of a fiber/yarn is proportional to the length of the material. However, the conductivity of the material is characterized as electrical resistance with the distance between the electrodes used for the resistance measurements. The two probe method was used to test the resistance of conductive yarns. Resistance of samples was measured with the distance between the ends of the specimen by 0.1 m.

The diameter was determined under the microscope by image analysis method using a magnification of 42x. 10 measurements were performed in 10 different positions along the length of the yarn. The yarn was tensioned with a force of 0.05 cN/tex.

RESULTS AND DISCUSSION

Regarding the electrical properties, the electrical resistance was measured and the resistivity of the coated yarns was calculated, according to the diameter of the yarn. In Table 2 are presented the mechanical properties for the tested yarns, before and after coating, and Table 3 indicates the electrical properties of the coated yarns.

Table 2: Mechanical properties of the yarns before and after coating with CB nanoparticles

Tensile properties	Variants of yarns									
	Y1	CY1	Y2	CY2	Y3	CY3	Y4	CY4	Y5	CY5
Breaking strength, [cN]	856	1002	318.8	389.8	1006	929	382.9	458.5	1507	1224
Coefficient of variation of strength, [%]	7.04	8.79	8.34	9.87	2.24	4.51	7.72	9.82	2.01	3.98
Breaking elongation, [%]	22.72	28.96	13	10.15	35.64	35.5	11.01	7.02	29.25	55.8
Coefficient of variation of elongation, [%]	4.994	8.27	7.36	18.42	5.77	6.58	10.44	36.63	4.65	9.49
Breaking tenacity, [cN/tex]	11.57	2.17	12.31	4.41	28.77	7.05	9.70	2.71	46.19	7.96
Coefficient of variation of tenacity, [%]	5.07	11.50	3.55	12.94	1.86	14.17	8.70	26.76	2.66	24.30

Analyzing the data of the table shows the following:
- *The breaking strength* of coated yarns increases by approx. 20% in the case of yarns from staple fibers, respectively CY1, CY2 and CY4. In the case of the yarns from continuous fibers (CY3 and CY5), their tensile strength decreases because the strength of the fibers from coated yarns is not completely utilized in yarn's strength. This decrease is smaller for the CY3 yarn, which is a simple textured yarn versus CY5 yarn which is a two-ply yarn.
- *Coefficient of variation of breaking force* increases for all coated yarns analyzed. The increase is by 24.86% for CY1, 18.34% for CY2 and 27.2% for CY4, while for the yarns from continuous fibers is by approximately 100%.
- *Breaking elongation* of the spun fibers (CY2 and CY4) decreases by about 20% after coating, while for the fancy yarn (CY1), breaking elongation increase by 27.46% due to its structure (spiral fancy yarn). The breaking elongation for the textured yarn CY5 almost doubled, and the elongation for the simple textured yarn (CY3) not changed very much.
- *Coefficient of variation for breaking elongation* increased for all variants of yarns due to a less uniform deposit of the conductive layer onto yarns.
- The effect of coating has reduced the values for *tenacity of yarns* at least twice, although the breaking strength of the coated yarns has increased. The decrease is justified by a higher increase of the weight of the coated yarns in relation to a smaller increase of their strength.
- *Coefficient of variation of tenacity* increased for all variants of coated yarns due to the fact that the conductive layer was deposited less evenly.

Table 3: Electrical properties of the coated yarns (CY)

	Variants of yarns				
Electrical properties	**CY1**	**CY2**	**CY3**	**CY4**	**CY5**
Electrical resistance, [kΩ]	36.384	563.4	75.5	0.2682	0.1422
Diameter of yarn, [mm]	0.8352	0.2645	0.3897	0.5845	0.4256
Electrical resistivity, [Ω·m]	0.1992	0.3094	0.0900	0.2365	0.2559

For all the coated yarns, the values for electrical resistivity are between 0.09 and 0.3094 Ω·m.
Analyzing the electrical resistivity is found that the yarns coated with the conductive layer can be classified as semiconductors, semiconductors have resistivity between $10^{-4} \div 10^{10}$ Ω·m [19]. In addition, as a result of resistivity values, these conductive yarns could be used to obtain products for electromagnetic shielding (EMI shielding).

CONCLUSIONS

All five yarns coated with the solution based on CB nanoparticles shows conductivity. The values obtained justify their use as components in a conductive fabric or a knitted fabric that can be used for electromagnetic shielding. Regarding the mechanical properties, the yarns used have higher, or about the same values for the the breaking strength comparative with the values obtained before coating with the conductive layer, and lower values of elongation, but not significant, so there is certainty that they will behave properly in further technological processes. The coating mixture allow obtaining of conductive materials using a method wich can be easily reproduced at industrial level, the next step is weaving / knitting these conductive yarns to see if the conductive layer stay onto the yarns and does not create discontinuities.

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BIOMATERIALS FOR TISSUE REGENERATION – SHORT REVIEW

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Abstract: *Wound healing is a complex and dynamic process. One therapeutic approach is tissue engineering, a concept described over 20 years ago, aiming to restore, maintain, or improve the tissue main function [Wong, 2012]. Currently available scaffolds tend to degrade quickly, before supporting tissue growth for enough time, or they have inadequate structure for vascularization. Lately, the process of creation of skin substitutes has relied on three-dimensional scaffolds, which provide a physical barrier against external infection as wound dressing, and also provide a template support for tissue regeneration [Bi, 2013]. A variety of scaffolds have been fabricated based on natural or synthetic materials [Asti, 2014]. The pore size and overall porosity are particularly important for cell infiltration and diffusion of nutrients and waste, and the design of optimal structures is critical [O'Brien, 2011]. Electrospinning is gaining much attention because it produces a fibrous, porous structure [Sundararaghavan, 2010].*
The article is a literature review of commercial or laboratory-tested biomaterials for wound healing.

Keywords: *skin, scaffold, porous structure, biomaterial, electrospinning.*

INTRODUCTION

Over the last 20 years, an increased number of research publications focused on biomaterials obtained from renewable resources such as proteins, polysaccharides that can be used for restoring tissue integrity. Several materials of biological or synthetic origin degrade into water and carbon dioxide and are considered to be suitable for use in tissue engineering. Biodegradable polymeric scaffolds for tissue engineering have received much attention because they provide a temporal and spatial environment for cellular growth and tissue in-growth.
This paper reviews biodegradable synthetic polymers focusing on their potential in tissue engineering applications. The major classes of polymers tested in laboratory in vitro and in vivo studies are briefly discussed.

1. STRUCTURE OF THE SKIN

Skin, the largest organ in our body, protects us against toxins and microorganisms from the surrounding environment and also prevents dehydration [4]. Its complexity comprises a wide number of interconnected constituents providing not only physical protection but also biochemical and adaptive immunity [1, 7]. The skin consists of three layers: the epidermis, the dermis and the hypodermis (Figure 1). The *epidermis* consists of a keratinized layer and keratinocytes which produce keratin. The epidermis provides protection against micro-organisms and loss of fluids. The dermis mainly consists of fibroblasts and interstitial connective tissue. The fibroblasts produce collagen and elastin, which provide the tensile strength of the skin. The *dermis* also supports hair follicles, sweat glands, blood vessels, and nerves. The dermis provides the tensile strength and elasticity that allows mobility of the skin. The *hypodermis* mainly consists of blood vessels and adipose tissue.

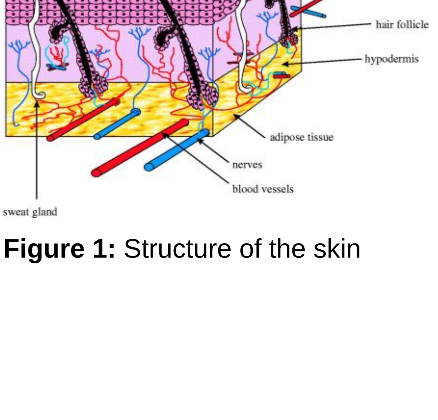

Figure 1: Structure of the skin

Source of image: Metcalfe A. D, Ferguson M. W.J, “Tissue engineering of replacement skin: the crossroads of biomaterials, wound healing, embryonic development, stem cells and regeneration”, available from: http://rsif.royalsocietypublishing.org/content/4/14/413

Vascularization is essential for skin repair. If there is extensive skin loss, and additionally, if the normal wound healing mechanisms are compromised because of poor vasculature, then skin repair can be slow or fail to occur. Achieving rapid vascularization in tissue-engineered materials is critical [2, 4].
The most common loss of skin integrity is caused by mechanical and thermal injury, trauma and chronic ulcerations or illness. Because of injury, substantial physiologic imbalance and ultimately significant disability or even death may result [1].

2. SKIN INJURY HEALING STAGES

Wound healing is a natural restorative response to tissue injury. The healing of wounds is a complex process that involves the activation and synchronization of intracellular, intercellular and extracellular elements, including coagulatory and inflammatory stages, fibrous tissue expansion, and deposition of collagen, epithelialization, wound contraction, tissue granulation and remodelling (Figure 2.) [5].

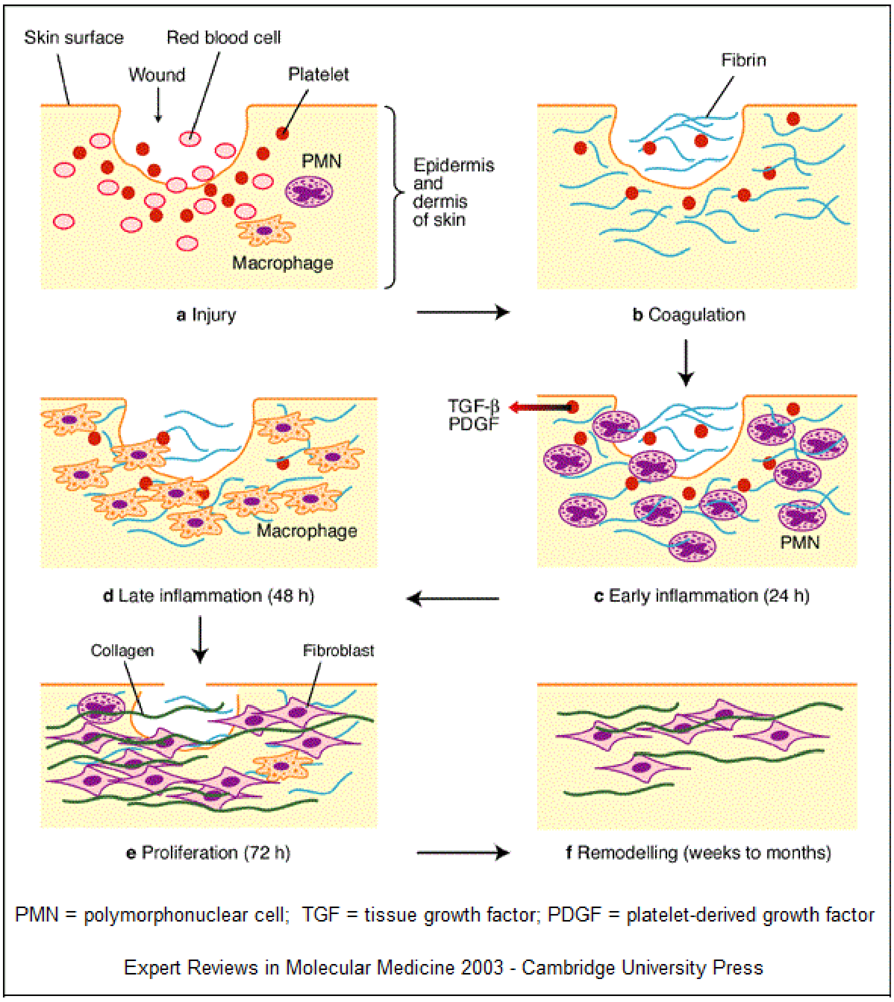

Figure 2: Skin trauma healing stages
Source of image:
http://www.intelligentdental.com/2012/01/20/wound-closure-techniques-other-than-sutures-part-1/

2.1 Inflammatory phase

This is the first stage and is essential for further stages of healing. Damaged blood vessels will suffer a reflex vasoconstriction, in order to reduce blood loss. As a result of haemorrhage, the wound fills up with clotted blood. Shortly after the vasoconstrictive phase, release of inflammatory mediators from damaged tissue causes an inflammatory vasodilation, which leads to increased local blood flow, and therefore increased flow of oxygen and nutrients to the injured area. These will be needed as raw materials in the process of repairing damaged cells and producing new ones. This is vital as wound healing is a very energy demanding process. A good blood supply and effective tissue oxygenation is vital in the process of wound healing. Inflammatory vasodilation has the effect of increasing the physical size of the gaps between adjacent capillary endothelial cells. This promotes increased capillary permeability which allows larger molecules, such as fibrinogen, to escape into these spaces. Fibrinogen is then converted into long sticky strands of the clotting protein fibrin. Networks of fibrin form a physical barrier to isolate the injured area and may play a vital role in preventing the spread of infection to healthy tissues. Fibrin and other proteins, provide the initial mechanical stabilisation of the wound [30, 31, 32].

2.2 Destructive phase

White blood cells and neutrophils are also able to migrate from the blood into the gaps between the capillary endothelial cells. Neutrophils phagocytose dead tissue cells and any foreign organisms, reducing the risk of infection.
Monocytes also migrate into the wound after about 24 hours. Once in the tissues, these cells also phagocytose bacteria and dead tissue, this causes them to grow and they become large cells called macrophages. Neutrophils and macrophages are chemically attracted to bacteria and dead tissue, so their phagocytic activity is well targeted. In addition to phagocytosis, macrophages also coordinate much of the healing process by release of growth factors. These locally acting chemicals stimulate the regrowth of epithelium, new capillaries and the migration of fibroblasts. At least 20 different growth factors are involved in normal wound healing. In the absence of monocytes, there are no growth factors to stimulate mitosis in adjacent healthy tissues. This means that regeneration of damaged tissues cannot occur [30, 31, 32].

2.3 Proliferation phase

This phase of wound healing starts about 2 to 3 days after the initial injury. By this time the phagocytic cells have cleaned out the wound and any dead tissue. It is now necessary for fibroblasts to migrate into the wound. Fibroblasts are essential for wound healing. They synthesise and secrete collagen and ground substance. Fibroblasts also secrete further growth factors which stimulate and regulate the regeneration of new blood vessels, a process called angiogenesis. Once in the wound cavity, the fibroblasts secrete collagen strands, these forms a three dimensional net through which repair can occur. 1-2 days after the injury, granulation tissue begins to form. Granulation tissue is a combination of fibroblasts, collagen, new capillary loops, new matrix and macrophages. Granulation tissue is fragile and bleeds readily because of the new thin walled blood vessels it contains. Viable epidermal cells divide by mitosis and start to migrate over the surface of the granulation tissue. Re-epithelialization (re-growth of epithelial tissue) may develop from the wound edges [30, 31, 32].

2.4 Remodelling phase

It begins about 3 weeks after the injury and may go on for a year or more, depending on the size of the wound. Collagen fibres progressively align themselves with the tensile forces passing through the wound, this gives progressively increasing strength. Eventually the strength of the wound is about 75% that of uninjured tissue. Wound contraction occurs because specialised fibroblasts, called myofibroblasts, join up and contract in a similar way to smooth muscle. Scar vascularity also reduces with time. Young scars have a pinkie red appearance, due to blood flowing through the tissue. As vascularity decreases the scar fades and will eventually become a similar colour to the surrounding skin. So we can reassure patients that scars will shrink and fade [30, 31, 32].
When the wound healing machinery does not work properly, it is necessary to use a therapeutic treatment to speed up the natural process in order to avoid more serious pathologies and to improve the patients' quality of life. The search of cost-effective therapies for wound healing is becoming an essential topic of ongoing research and discussion worldwide [7].

3. CURRENT POLYMERS USED FOR RESTORING TISSUE INTEGRITY

Wound dressings have developed over the years from the crude applications of plant herbs and honey, to tissue engineered scaffolds. Traditional dressings include cotton wool, natural or synthetic bandages and gauzes. These dressings are dry and do not provide a moist wound environment, therefore they tend to

become more adherent to wounds and are painful to remove, causing patient discomfort. Modern dressings have been developed as an improvement of the traditional ones, their main characteristic is to retain and create a moist environment around the wound, in order to facilitate wound healing. The modern dressings are mainly classified according to the materials from which they are produced including hydrocolloids, alginates and hydrogels, and generally occur in the form of gels, thin films and foam sheets [10, 11].
The knowledge of the physiology of the normal wound healing process provides a framework for understanding the basic principles of wound healing therapy [2]. One therapeutic approach of particular relevance to wound healing is tissue engineering, a concept described over 20 years ago as 'an interdisciplinary field that applies the principles of engineering and the life sciences toward the development of biologic tissues that restore, maintain, or improve tissue function [3, 6]. Tissue engineering evolved from the field of biomaterials development and refers to the practice of combining scaffolds, cells, and biologically active molecules into functional tissues. Tissue engineering integrates many fields of science and engineering in order to design, develop, and test tissue replacement for traumatically lost or disease-damaged tissue [8, 14].
There is no single dressing suitable for all types of wounds and often a number of different dressing types will be needed throughout the healing process. The wound-healing process may be disturbed if the bacterial concentration on a wound is higher than 105 per gram of tissue. A further increase of the bacterial load could spread from a local superficial infection to a systemic one, leading to septicaemia. Dressings containing silver have returned in advanced wound care and are found used in conjunction with many products [9, 13].

3.1 Natural polymers

Natural polymers used for scaffolds show excellent bioactivity, biodegradability, but poor mechanical properties which reveal their successful use in soft tissue engineering, but not for load bearing applications. Scaffolding natural polymeric materials with homogeneous and reproducible structures are other problems which limited their wide applications.

Collagen is considered as an ideal choice for tissue engineering scaffolds because it is the major fibrous protein in the extracellular matrix, and provides strength and structural integrity to connective tissues including skin, bone, tendons, cartilage, blood vessels, and ligaments. Twenty seven types of collagen have been identified and 80-90% of the collagen in the body consists of type 1, 2 and 3. In tissue engineering, collagen scaffolds are used in various forms such as porous sponges, thin sheets or gels. Collagen scaffolds possess the excellent biocompatibility, hydrophilicity, biodegradability, but poor mechanical strength. The degradation rate and tensile strength can be enhanced by physical and chemical cross-linking methods [20, 29].

Chitosan, derivative of chitin, is a linear polysaccharide polymer. Chitin exists in the exoskeleton of crustaceans and cuticles of insects. Chitosan has gained special attention due to its biocompatibility, low toxicity, biodegradability, controllable mechanical and structural properties, and capability of being processed in many forms, sizes and shapes. Pure chitosan as a polymeric tissue engineering scaffold is limited because of their weak mechanical properties and inconsistent behaviour with seeded cells. However, chitosan can be physically and chemically modified, and produce materials with wide range of properties [21, 23, 25, 26].

Alginate is a linear polysaccharide isolated from brown sea algae. Alginate can form stable and well characterized hydrogels by adding certain divalent cations (e.g. Ca2+, Sr2+, Ba2+, except Mg 2+) at low concentrations. To prevent immune responses after implantation alginate must undergo extensive purification. Alginate possesses biocompatibility, hydrophilicity, non-cytotoxicity, biodegradability, and it is thermally stable. But some drawbacks have limited their applications in tissue engineering such as weak mechanical properties, poor cell adhesion (due to its highly hydrophilic nature) and uncontrollable degradation. These limitations can be improved by mixing with other natural polymers, chitosan and agarose [27, 28].

Agarose is a polysaccharide extracted from red algae and seaweed. Agarose is purified from agar, by removing agaropectin. Agarose hydrogels are popular owing to their biocompatibility, native tissue like viscoelastic mechanical properties and ease of procesability into complex shapes and sizes [27].

Cellulose is a naturally occurring polysaccharide. Various properties of the polysaccharide which makes it suitable for wound dressing application are biocompatibility, high tensile strength, water absorption ability and also the ability to form fine fibrous network. In case of chronic wounds, it has been found that use of scaffold made from bioengineered cellulose as wound dressing reduces the healing time as well as pain. In case of partial or full thickness wounds these materials has been found to support the process of epithelialization and granulation. The cellulose based wound dressing materials can be also modified by incorporation of active molecules [19, 23, 27].

3.2 Synthetic polymers

Numerous synthetic polymers have been tried to produce scaffolds because of their advantages as a scaffold material and also due to their availability. Synthetic polymers can be biodegradable and non-biodegradable. Synthetic polymeric materials can be fabricated with a tailored architecture and properties (e.g. porosity, degradability, & mechanical properties), according to their applications. That means they can be produced under controlled conditions with similar properties and long usage time. During the degradation process, formation of acidic products that are lowering the local pH is a common problem associated with the use of synthetic polymers which can result in tissue necrosis.

A vast majority of biodegradable polymers studied belong to the polyester family. Among these poly (α-hydroxy acids) such as poly (glycolic acid) (PGA), poly (lactic acid) (PLA), and a range of their copolymers have historically comprised the bulk of published material on biodegradable polyesters and have a long history of use as synthetic biodegradable materials.

Poly (glycolic acid) (PGA) is a rigid thermoplastic material with high crystallinity. Because of high crystallinity, PGA is not soluble in most organic solvents; the exceptions are highly fluorinated organic solvents such as hexafluoro-isopropanol. Porous scaffolds and foams can also be fabricated from PGA, but the properties and degradation characteristics are affected by the type of processing technique. The attractiveness of PGA as a biodegradable polymer in medical application is that its degradation product glycolic acid is a natural metabolite. A major application of PGA is in resorbable sutures.

Poly (lactic acid) is present in three isomeric forms D (-), L(+) and racemic (D, L). Poly (L) LA and poly (D) LA are semi-crystalline solids, with similar rates of hydrolytic degradation as PGA. PLA is more hydrophobic than PGA, and is more resistant to hydrolytic attack than PGA. For most applications the (l) isomer of lactic acid (LA) is chosen because it is preferentially metabolized in the body. PLLA, poly (lactic-glycolic acid) (PLGA) copolymers and PGA are among the few biodegradable polymers with Food and Drug Administration (FDA) approval for human clinical use.

The degradation of PLA, PGA and PLA/ PGA copolymers generally involves random hydrolysis of their ester bonds. PLA degrades to form lactic acid which is normally present in the body. This acid then enters tricarboxylic acid cycle and is excreted as water and carbon dioxide.

Poly (ethylene glycol) (PEG): PEG, the most commercially important poly-ethers, also known as polyethylene oxide (PEO) or poly-ethylene-oxide (PEO) depending on its molecular weight, refer to an oligomer or polymer of ethylene oxide. PEG has some critical properties like good biocompatibility, resistance to protein adsorption and cell adhesion, for which it has been an important type of hydrophilic polymers in biomedical applications. The most common approach for making PEG hydrogel with biocompatibility and non-toxicity is photo-polymerization under mild conditions in the presence of cells and bioactive agents. To meet the diverse needs in tissue engineering, bioactive molecules have been incorporated into PEG hydrogels [16].
Polyvinyl alcohol (PVA) is a well-known pharmaceutical excipient used for various purposes. The simplest and the most commonly employed crosslinking reaction involving chemical crosslinking of PVA with glutaraldehyde in presence of acidic conditions has been covered extensively in many research reports. It has been reported that chemical crosslinking of PVA can be used as an effective way of producing pharmaceutically safe and useful products (hydrogels, sludge, foam, sponge etc.) for drug delivery [22, 24, 27].

CONCLUSIONS

Tissue engineering is one of the most exciting interdisciplinary and multidisciplinary research areas and is growing exponentially over time. To restore function or regenerate tissue, a scaffold is necessary to act as a temporary matrix for cell proliferation and extracellular matrix deposition, until the tissues are totally restored or regenerated. Scaffold materials and fabrication technologies play a crucial role in tissue engineering. Recent studies about biocompatible and biodegradable natural/synthetic polymers led to a substantial development of novel types of wound dressings and to outstanding applications in the biomedical area. Innovations in the material design and fabrication processes are the key element for the production of implants with good performance.
To achieve this objective, understanding of the physical and chemical properties is necessary, in order to obtain composite dressings which combine various polymers. This will be helpful for targeting many aspects of the complex wound healing process, and to ensure effective, complete wound healing and shorter healing times for chronic wounds and other difficult to heal wounds.

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Section 2: Textile science and technology

MODELLING THE IMPACT BEHAVIOUR OF COMPOSITES MATERIALS USING FEM

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Faculty of Textiles, Leather and Industrial Management

Abstract: *The impact resistance and the impact behaviour are two of the most important aspects that must be taken into consideration in the design stage of the composite materials. Knitted fabrics are known to have very good impact behaviour on certain directions that can be controlled through structure, especially the use of inlaid yarns.*
The paper presents the impact behaviour of 3D U shaped composite materials reinforced with 3D sandwich knitted fabrics made from technical yarns and Epoxy and polyester matrix. In order to simulate the impact behaviour using finite elements method (FEM) two models have been developed. One model was created in order to be meshed using the plate elements and the second one for simulation using brick elements. The finite element analysis (FEA) was carried out using ALGOR software application for the first model and Deform 3D software application for the second one. Due to the complex finite geometry specific to 3D weft knitted fabrics that are considered for the composites reinforcement, there are different approaches for the two considered models. In the first one, after each step the simulation is stopped and the model is reconstructed. This method offers a very good accuracy but also is time consuming. In order to resolve this aspect the second model was build based on a continuum-material equivalency. The 3D weft knitted fabric was replaced with a continuous material with similar mechanical properties (experimentally determined).
The low velocity impact behaviour predictions obtained through simulation are validated based on real impact tests carried out using Fractovis Plus testing equipment.

Keywords: *FEA, knitted fabrics, low velocity, continuum material equivalency.*

INTRODUCTION

Applied mathematics studies took into account boundary conditions in solving continuum mechanics. Studies of applied physics aimed at solving similar problems but were directed to obtain continuous functions based on approximated areas. Aerospace engineering research focused on finding optimal ways of expressing the influence of the rigidity coefficients, resulting in three distinct solutions, each expressing a different view on the same issue.

The term finite element method (FEM) defines a broad range of computing techniques that have certain common characteristics. Currently the main drawbacks related to application difficulties have been removed with the widespread use of computers and the development of a large range of analytic software such as ANSYS, Algor or Deform 3D.

In the textile domain modelling using finite element method has experienced accelerated growth in the last decade, being used in behaviour modelling of composite materials with woven reinforcement or the deformation of these structures [1 ÷ 4].

There are fewer FEM models for the mechanical behaviour of knitted fabrics mainly due to the complexity of the yarn geometry in the stitches and the high number of factors influencing their properties [5 ÷ 8].

In the case of polymeric composites with knitted reinforcement, the main efforts for modelling were concentrated on composites reinforced with multiaxial warp knitted materials and weft knitted fabrics with basic evolutions (plain jersey).
Sandwich weft knitted fabrics with knitted connections are well suited for composite reinforcement because of their 3D to shape architecture. One possible application for such composites can be for mechanical protection to dynamic strains such as impact.

The paper presents a study regarding FEM models of polymeric composites reinforced with 3D knitted sandwich materials made of Kevlar yarns. Another novelty of the study is the use of sustainable raw material (linen yarns) to partially replace the HPF Kevlar without diminishing the mechanical characteristics. Para-aramid fibres are the choice for any products used to improve impact behaviour, but they are rather expensive. Currently, the trend is to use Kevlar fibres in combination with other raw materials that are less costly. Linen is a technical fibre that is cheap and presents acceptable tensile characteristics.

MATERIALS AND METHODS

The knitted reinforcement is a sandwich fabric where the independent outer layers (plain jersey) are connected through knitted layers placed perpendicularly to them. The distance between the connecting layers is 1 mm. The 3D knitted fabrics were produced on STOLL CMS 320 TC flat knitting machine, gauge 10E. The fabrics were made of para-aramid (Steel Kevlar and Twaron) and technical natural yarns (Linen). The raw material for the outer and connecting layers was different, as presented in Table 1. The fabric compactness required to increase the volume fraction of the composites was improved by introducing transversal Twaron yarns.

Table 1 Raw materials used for producing sandwich fabrics

Fabric	Outer layers		Connecting layer	
	Yarn type	Linear density (tex)	Yarn type	Linear density (tex)
1	Kevlar 49®	28	Kevlar 49®	28
2	Kevlar 49®	28	Linen	20
3	Kevlar 49®	28	Kevlar 49®	28
	Twaron®	6		
4	Kevlar 49®	2	Linen®	20
	Twaron®	6		

The 3D composite materials studied in this paper were produced using 3D knitted fabrics as performs and epoxy EPICURE 04908 and polyester DISTITRON 3501S as matrices. The composite materials were made using the Vacuum Assisted Resin Transfer Moulding (VARTM) technology. Both resins were cured at room temperature (23°C), the composite with epoxy for 46 hours and the one with polyester for 23 hours. The epoxy matrix had a mixing ratio of 30% EPIKURE Curing Agent 04908 and 5% Dearing agent BYK A535, while for the polyester resin the mixing contained 1.5% of initiator for unsaturated polyester resin NOROX MCP 75 and 0.08% polyester inhibitor NLC 10.
Figure 1 presents the final aspect of the knitted sandwich reinforced composite.

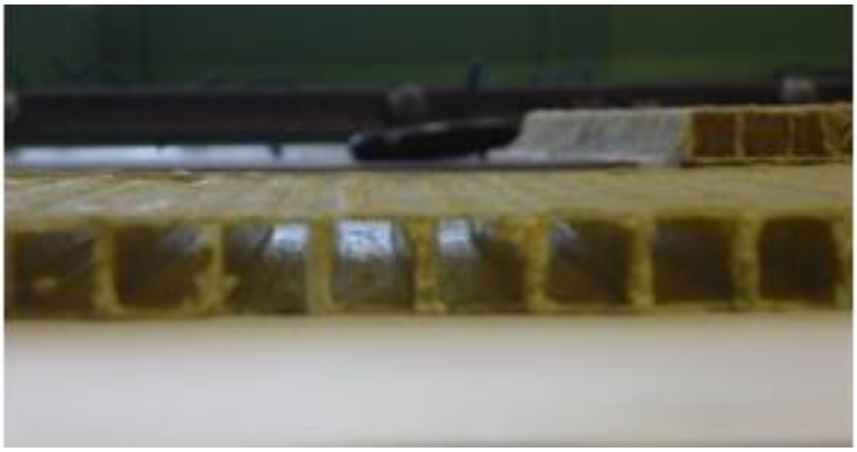

Figure 1: Composite reinforced with sandwich knitted fabrics

The physical-mechanical properties of the reinforcement and composite materials necessary for finite element analysis to model the behaviour to low intensity impact experiment are shown in Table 2.

Table 2. Considered physical mechanical parameters

	Structure variant				Polymeric matrix	
	Kevlar – Twaron		Kevlar – linen		Epoxy resin	Polyester resin
	Row	Wale	Row	Wale		
Young module [N/mm^2]	6376	30411	6161	5513	2900	4000
Force [N]	2430.59		745.18		-	-
Thread weight [g]	6.4		3.7		-	-
Composite sample weight [g]	19.3		14		-	-
Volume fraction [%]	33%		26%		-	-
Dimension of the impactor head [mm]	20					

RESULTS

Two models were developed in order to simulate the behaviour of the textile reinforced composite structure on impact. The first model was created to be meshed with 'plate' type finite elements and the second one was designed to be meshed with "brick" or "tetrahedral" elements [9].
The modelling and analysis for the first model was done with ALGOR FEA software. The meshed model with "plate" elements is illustrated in Figure 2. The number of finite elements of mesh nodes used in the structure and boundary conditions are shown in Figure 3. The structure is considered embedded on the lateral walls. Only the translations along the Y axis and the moments in the circled area (see Figure 3) are blocked.

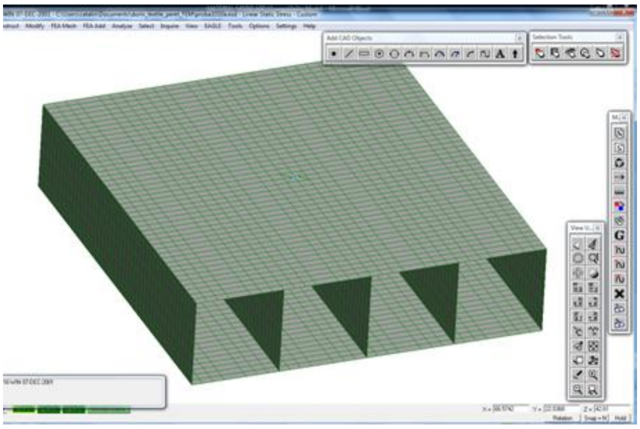

Figure 2: Meshed model presentation with "plate" type elements

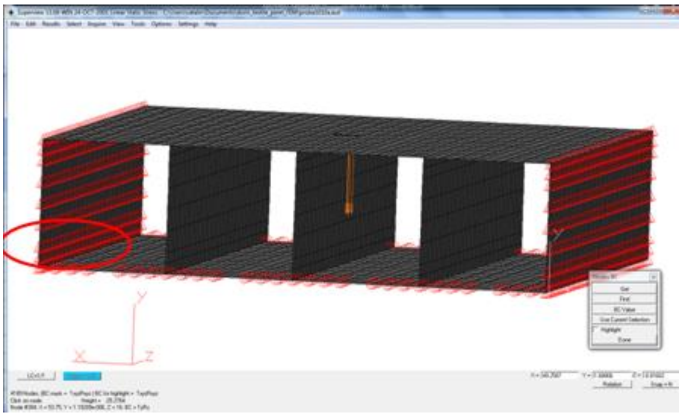

Figure 3: Number of nodes and meshed finite elements and boundary conditions on contour

Figure 4 presents the characteristics of the plate type elements, while the physical-mechanical properties of the structure are illustrated in Figure 5.

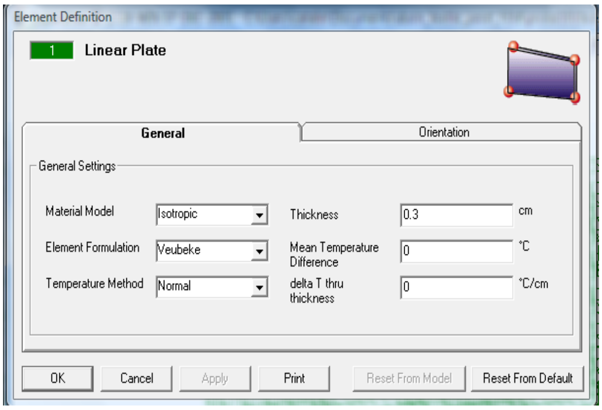

Figure 4: Plate type element features / characteristics

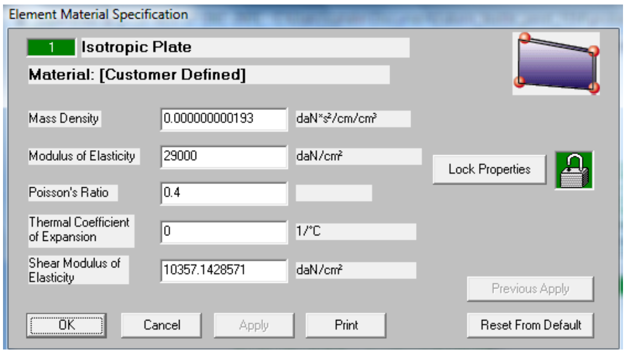

Figure 5: Physical-mechanical features / characteristics of the structure

Considering the duality of the composite structure made from two materials with different behaviour and the fact that the software cannot take into consideration separate data, an equivalent composite structure was used.

The second model was built using another FEM software DEFORM 3D. The model was based on “brick” finite elements.

Unlike the previous case, when the impactor was materialized through a field of pressure and the clamping elements through boundary conditions, in this case all physical pieces involved in the impact testing were modelled, as exemplified in Figures 6 and 7.

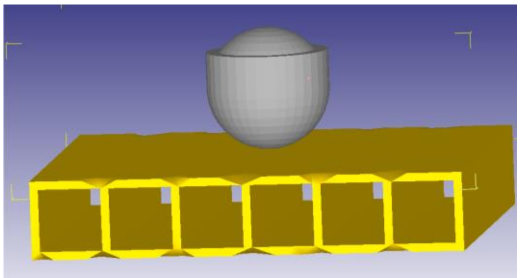

Figure 6: Impactor head and composite structure

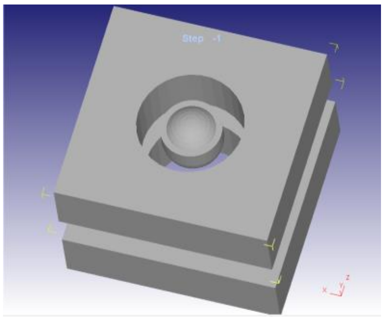

Figure 7: Impactor head and structure clamping plates

In this case, the loading and processing speed were determined based on the captured data, as illustrated in Figure 8.

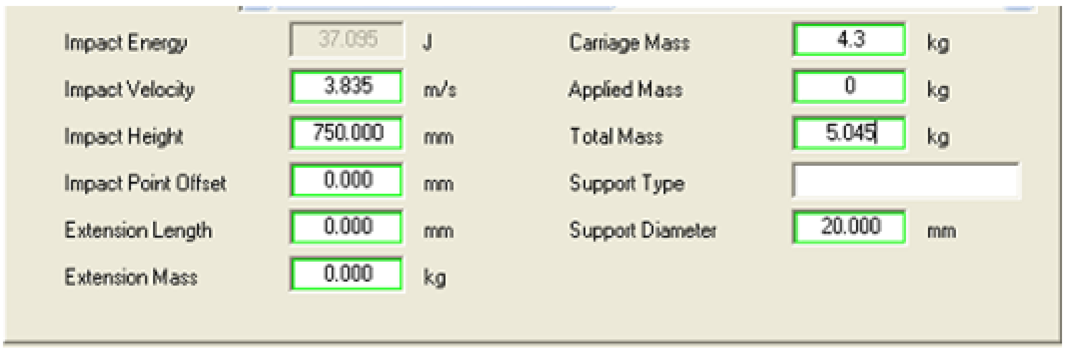

Figure 8: Working parameters

DISCUSSIONS

First essential information obtained from the finite element analysis refers to the deflection of the structure. Its importance is more significant due to the dynamic character of the process and its short duration.

In the case of the first model, the program shows all deformation stages during impact up to breaking of the composite structure. For this reason, it is considered that the process is conducted as a quasi-static accumulation of steps. It is considered that at the time t1 pressure “p” is distributed over an area S1 of the composite structure, at time t2 pressure “p” is distributed on surface S2 and so on. Each step is obtained by transferring the modified structure and considering it as a new model.

The structural analysis will be considered to be nonlinear static of a solid equivalent e structure will be considered as being of a solid, so we stand in solid mechanics. Figure 9 shows the deforming of the structure with meshed “plate” finite elements.

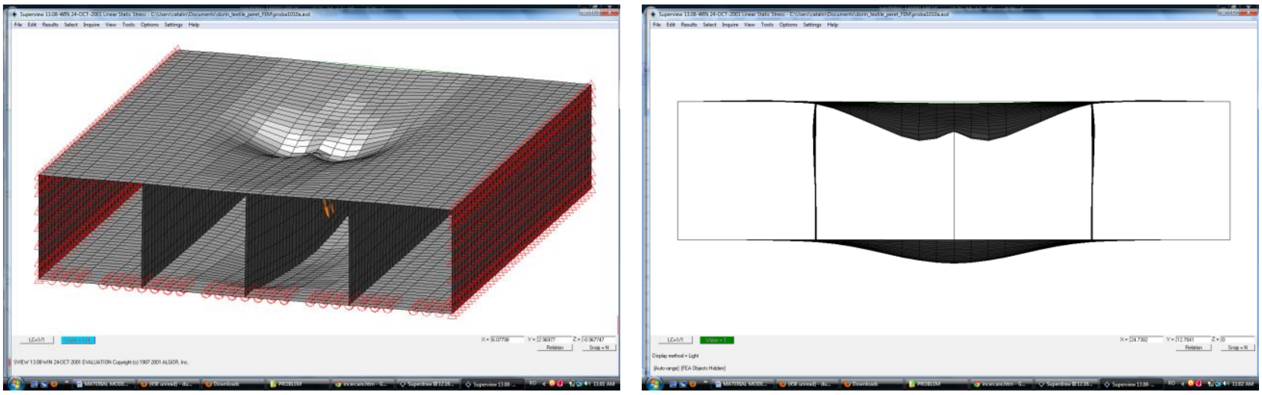

Figure 9: Deformation of the composite structure

The complete processing of the deformation using ALGOR is difficult and time consuming. For this reason, another software was considered (DEFORM 3D). The simulation of the action of the impactor on the 3D composite is easier, the results being shown in Figure 10.

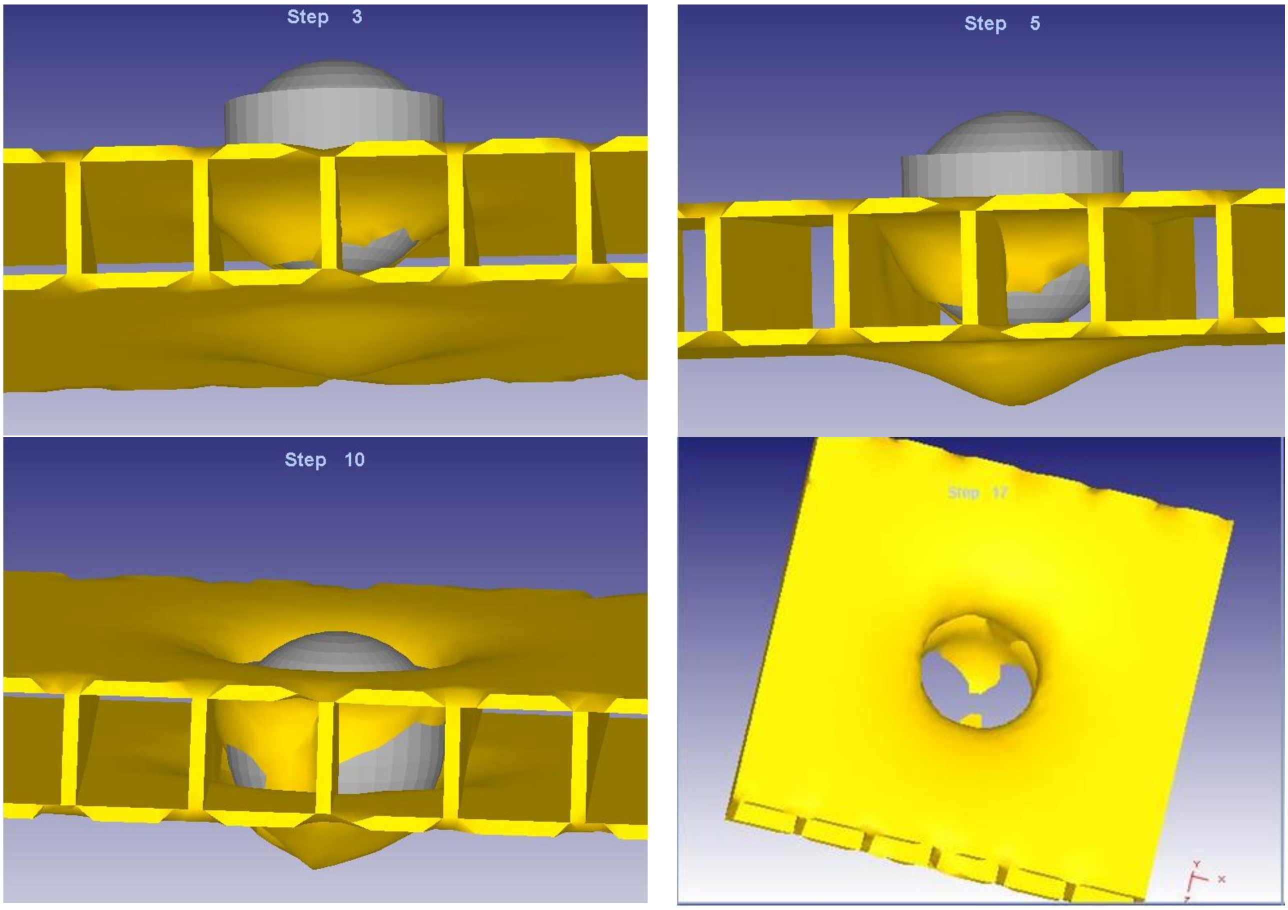

Figure 10: Modelling the impact behaviour using Deform 3D

The program provides information on the time frames for each deformation snapshot and about the characteristics of the process in that moment (work speed, force deformation, the value of the impactor stroke, etc.), as illustrated in Figure 11.

Figure 12 presents the variation on the three axes of the strain forces on the composite structure following the impact.

Step No.	Mesh No.	Stroke	Time	Load X	Load Y	Load Z	Speed X	Speed Y	Speed Z	Volume
-1	1	0	0	--	--	--	0	0	0	61478.8
5	1	0.892857	0.00357142857143	4.7649	1272.9	2.4996	0	250	0	62600.4
10	1	1.78571	0.00714285714286	0.851317	1296.5	5.0737	0	250	0	62600.5
15	1	2.67857	0.0107142857143	2.3586	1362.9	5.6681	0	250	0	62600.5
20	1	3.57143	0.0142857142857	1.4461	1449.8	1.5543	0	250	0	62600.5
25	1	4.46429	0.0178571428571	2.2943	1522.6	10.955	0	250	0	62600.5
30	1	5.35714	0.0214285714286	101.61	1604.9	103.43	0	250	0	62600.5
35	1	6.25	0.025	2.7895	1638	25.168	0	250	0	62600.5
40	1	7.14286	0.0285714285714	124.62	1706.6	49.233	0	250	0	62600.5
45	1	8.03571	0.0321428571429	132.49	1830.6	47.951	0	250	0	62600.5
50	1	8.92857	0.0357142857143	160.64	1865.8	20.883	0	250	0	62600.5
55	1	9.82143	0.0392857142857	9.905	1932.3	4.7249	0	250	0	62600.5
60	1	10.7143	0.0428571428571	181.59	2004.4	16.246	0	250	0	62600.5
65	1	11.6071	0.0464285714286	149.33	2023.4	2.2658	0	250	0	62600.5
70	1	12.5	0.05	140.42	2091.5	14.438	0	250	0	62600.4

Figure 11: Extracted information obtained from finite element analysis

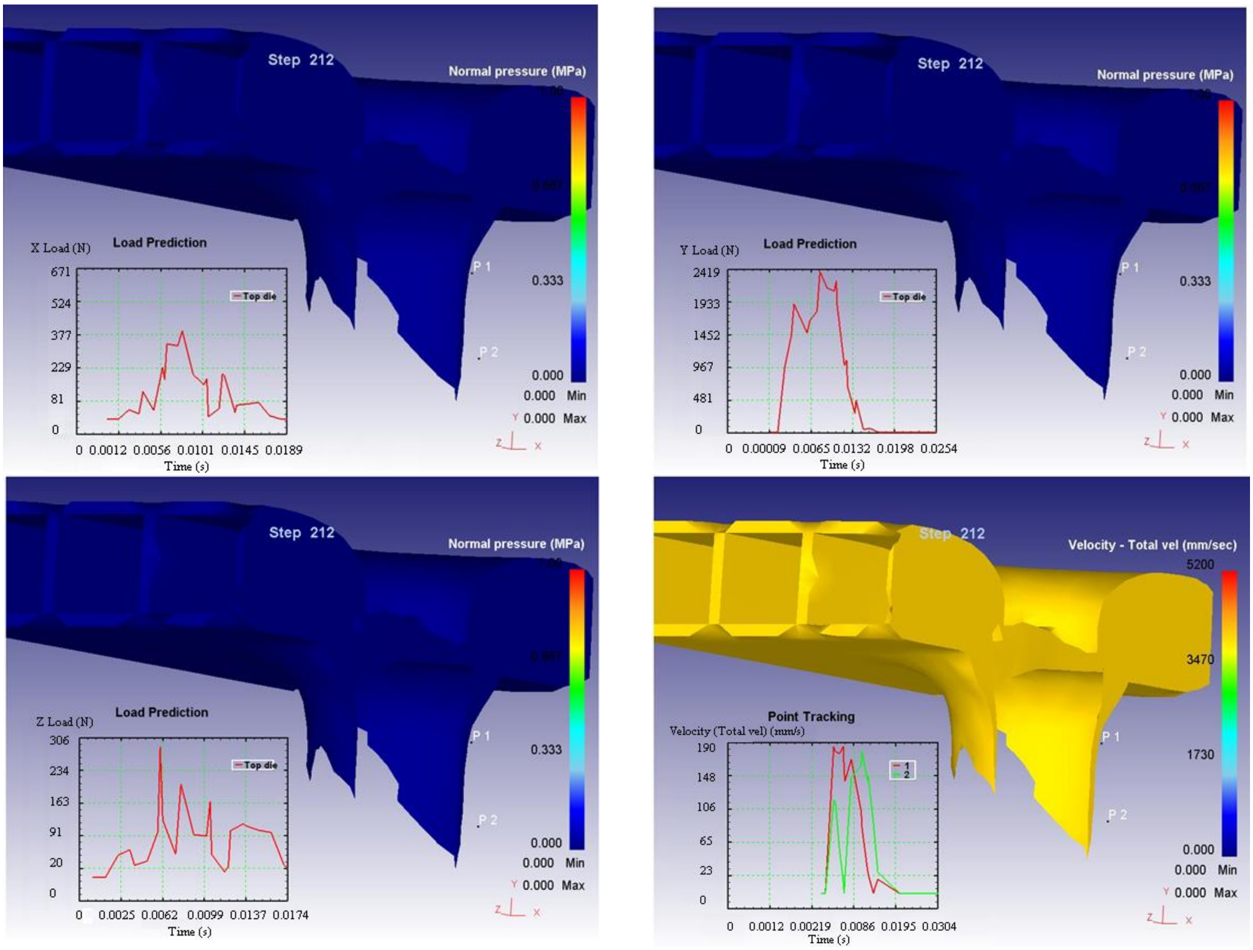

Figure 12: Variation on the 3 axis of the strain force and velocity

The models created must be validated with practical results, as illustrated in figure 13.

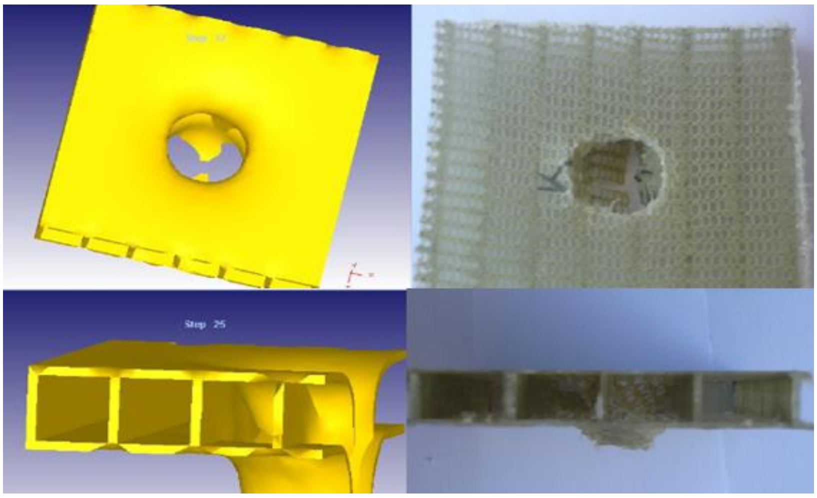

Figure 13: Comparison between the simulated model with the real test (model validation)

CONCLUSIONS

Modelling and finite element analysis are particularly important in the present research context, providing an impressive amount of information regarding the impact behaviour of polymeric composites reinforced with knitted 3D sandwich fabrics. However, this information has no value if not validated by one or more experimental tests carried out in similar conditions to those under which the analysis was performed.

Based on these considerations, the finite element simulation has been confirmed: the forces in the system are similar to the ones measured practically. Thus the values have a magnitude of thousands N (egg. from 1200 to 2480 N) for the forces measured during the experiments, while the forces in the simulation vary from 1276 to 2781 N.

The FEM model offers information concerning the behaviour structure during impact. The behaviour can be visualised for the structure as a whole and for different sections considered significant. Furthermore, the structure's strain can be visualized at any moment. In real impact tests, this is not possible due to the very short time interval and the impossibility to film inside the structure, as well as to record all significant stages using conventional means.

Apart from the information regarding the material deformation (that can be presented as a 'movie' about this event) important data are gained concerning the displacement/strain/stress/forces fields, as well as the deformation forces for single moments during the impact and a diagram of their evolution throughout the entire phenomenon.

Future work will include a diversification of reinforcement knitted structures, of raw materials and 3D shapes.

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PEEL STRENGTH IMPACT OF FUNCTIONALIZED POLYETHYLENE TO THERMOPLASTIC POLYURETHANE CALENDERED ON A POLYESTER FABRIC

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Abstract: *Many producers use the extrusion calendering process for thermoplastic polyurethane coated fabrics. However, a technological lock is the ability to get a good adhesion of the coating with the fabric. Producers could increase the coating extrusion temperatures but TPU have a narrow extrusion temperatures range making it difficult to extrude. One solution is to make a blend with another polymer which has a higher extrusion temperature range. In the present work, the studies of the addition of LDPE and LLDPE-g-Ma in polyurethane coating on the tensile strength of the sheet and on the peel strength with a polyester fabric have been studied as well as the influence of the extrusion temperature. SEM observations and viscosity measurements have been performed to understand the behaviour of the different blends. Results show that extrusion temperature and penetration depth of the coating in the fabric have an influence on the peel strength.*

Keywords: *Polyurethane, Fabric, Peel strength, Calendering, Polymer.*

INTRODUCTION

Coated technical textiles are widely used for several applications like paragliders or inflatable boats and the demand is still on the rise. These light technical textiles are usually manufactured with a polyester fabric and a PolyVinyl Chloride (PVC) matrix. However, environmental constraints force the manufacturers to find a substitute material for the PVC which is harmful and difficult to recycle. For this purpose Thermoplastic PolyUrethane (TPU) is a good substitute material for the PVC. Depending on its formulation and the components, TPU can have good properties such as UV resistance (1) and abrasion resistance (2). Due to these properties, TPU is widely used for coated textiles and to achieve the quality of natural leather. Despite all these good properties, there is still a technological lock. Some industrials report that they are recalcitrant to use polyurethane sheets for coated textile because of very low peel strength of the sheet on the polyester fabric after calendering.

Six theories have been proposed to explain the different mechanism of adhesion: mechanical interlocking (3), wetting (4), diffusion (5), electrostatic (6), chemical (7) and weak boundary layer (8). All these theories show that the adhesion between two materials is linked with the interface as outlined by Mittal (9). Further studies explain that the quality of adhesion between the fabric and the matrix is a key parameter to obtain good mechanical performances of the composite (10). As a consequence, several treatments have been developed to enhance the quality of the interface. Previous research used different treatments for the fabric such as atmospheric air treatments to modify the surface energy of the fabric and increase the adhesion of the coating. For example, Leroux et al. showed that the adhesion of a silicon resin on a polyester fabric after atmospheric air plasma treatment has been multiplied by two (11). However Novak et al. showed that the shelf-life of this treatment for a polypropylene material with polyvinyl acetate was only about 50 days due to the loose of the surface oxidation (12). Other research used corona treatments (13) or chemical treatments (14) to increase the wettability of the fabrics.

There is less research about the plastic sheet that is calendered on the fabric. A solution to enhance the adhesion of the sheet on the fabric could be to modify the sheet that is extruded before being calendered. One possibility is to increase the extrusion temperature in order to modify the viscosity and the surface energy. The problem is that TPU has a narrow range of extrusion temperatures and an increase of only 5°C can generate a drop in the viscosity of the polymer making it impossible to calender on a fabric. The objective of the present study is to propose a blend with Low Density PolyEthylene (LDPE) with the aim to extrude the sheet at higher temperatures. Because of their high difference of polarities and their high interfacial tension, Polyurethane and Polyethylene are two immiscible materials. However, previous researches explain that it is possible to have a compatibility if the PE is grafted with maleic anhydride (LLDPE-g-Ma) (15). These compatibilizers are capable to stay at the interface and entangling with both sides. The final material is then prepared by calendering the sheet of TPU/LDPE blend on a polyester fabric. According to the literature, there is no previous research about the influence of this blend on the adhesion on a polyester fabric.

The value of the adhesion of the sheet on the fabric is the main proof of the influence of the blend. For this study, the sheet viscosity, the miscibility of the LDPE and PE-g-Ma in the TPU, the penetration depth of the coating in the yarns of the fabrics and the FTIR analysis are used to analyse and explain the results of the adhesion.

MATERIALS AND METHODS

2.1 Materials Characterization

The coating has been calendered on the polyester fabric described in the Table 1.

Table 1: Main properties of the fabric

Composition	Polyester
Weaving	Plain
Additives on the surface	No
Number of yarns per cm : weft	18
Number of yarns per cm: warp	18
Thickness (µm)	170
Number of filaments per yarn	48
Filament diameter (µm)	23
Yarn count (g/km)	280
Mechanical properties: weft (daN/5cm)	155
Mechanical properties: warp (daN/5cm)	155

This fabric has been woven without the use of any additives like sizings on the surface of the yarns to avoid a decrease of the wetting ability.

Several blends have been realized with Low Density Polyethylene (LDPE), Thermoplastic PolyUrethane (TPU) and Linear Low Density Polyethylene Grafted Maleic Anhydride (LLDPE-g-Ma). References and properties of LDPE, LLDPE-g-Ma and TPU are gathered in Table 2.

Table 2: Main properties of LDPE (Low Density Polyethylene) and LLDPE-g-Ma (Linear Low Density Polyethylene grafted maleic anhydride) and TPU (Thermoplastic Polyurethane)

	LDPE LD 171 BA	LLDPE-g-Ma OREVAC OE825	TPU IROGRAN A 90 P 5055 DP (Aromatic Polyether)
Manufacturer	EXXON MOBILE®	OREVAC® by ARKEMA	HUNTSMAN®
Density	0.929g/cm^3	0.913g/cm^3	1.2g/cm^3
Additives	no	Maleic anhydride	no

All the blends prepared are presented in the Table 3.

Table 3: Composition of the prepared blends

Sample number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
% TPU	83.4	81	81	77.5	85	71	77.5	83.4	85	100	0	0	71	71	0
% LDPE	16.6	19	19	22.5	15	29	22.5	16.6	15	0	100	100	0	26	0
% PE-g-Ma	0	0	0	0	0	0	0	0	0	0	0	0	29	3	100

EXPERIMENTAL METHODS

3.1 Blend Preparation

The PE/TPU blend has been prepared in two steps. The pellets of TPU and LDPE (and/or LLDPE-g-Ma) have been well mixed in a container.

3.2 Extrusion – Calendering Process

Extrusion has been performed with a laboratory-scale extruder Polylab system composed of a HAAKE RheoDrive4 motor coupled with a HAAKE Rheomex 19/25 OS single screw extruder with a Maddock mixer.
The system was piloted by PolySoft OS software to set and control temperature zones and screw speed. The extruder unit was equipped with a fish-tail designed die of 100mm wide and 450µm thick to process the molten polymer into a film. The extruder was connected to the air network which provides ambient temperature air to cool the hopper zone. The calendering was performed on only one face of the fabric using a 3-roll laboratory calender from THERMO SCIENTIFIC. The rolls were 200mm wide and were cooled with a HAAKE Phoenix II P1 thermostat (THERMO SCIENTIFIC) with oil and regulation pump speed. All the process parameters and extrusion temperatures for extrusion-calendering are respectively given in Table 4 and Table 5.
In the purpose to test separately the mechanical performance of the film that was calendered on the fabric, the same film was prepared with the same parameters.

Table 4: Process parameters

Parameters	Value
Die gap	450µm
Die temperature	[174°C; 209°C] (+/-1°C) (see Table 5)
Extrusion speed	60 rpm
Calendering speed	6 rpm
Temperature of the thermoregulated rolls	40°C
Distance between the die and the rolls	20mm

Table 5: Extrusion temperatures of the prepared films (in °C)

Sample number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hopper zone	211	180	202	196	202	196	216	187	180	170	180	196	196	196	170
Zone 1	211	180	202	196	202	196	216	187	180	172	180	196	196	196	172
Zone 2	206	175	197	191	197	191	211	182	175	174	175	191	191	191	174
Die	199	174	196	190	196	190	210	181	174	175	174	190	190	190	175

The different heating zones of the extruder are presented in Figure 1.

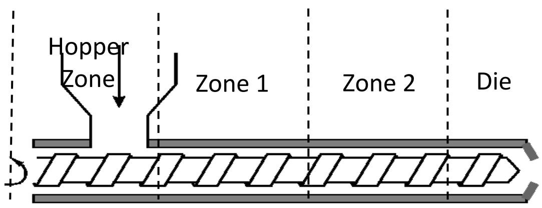

Figure 1: Scheme of the extruder and temperature zones

3.3 Analysis of the Peel strength

The peel strength of the coating sheet on the fabric has been determined by a peel test carried on a Zwick Z010 tensile machine according to the standard NF EN ISO 2411. The 50 mm width coating sheet and the fabric were clamped separately on the machine with a distance of 50 mm between grips. A crosshead speed of 100 mm/min and a 0.5 kN cell were chosen. During the test the force was recorded as a function of displacement thanks to TestXpert® II software (Zwick). Reported data are the average of five samples.

3.4 Analysis of the mechanical properties of the sheet

Tensile strength of blends sheets was measured during a tensile test on a Zwick Z010 with a crosshead speed of 500 mm/min and a 0.5 kN cell. Strip-shaped samples were prepared with a cutting press. The length between grips and width of samples is 40 mm and 10 mm respectively and the thickness is measured for each sample and varies between 180-220µmmm.

During the test, the force was recorded as a function of the displacement thanks to TestXpert® II software (Zwick). Reported data are the average of 10 samples. The tensile strength was obtained by dividing the force applied at the breaking by the initial section of the sample.

3.5 Analysis of the shear viscosity of the blend

The dynamical rheological measurements were performed on disks using a strain controlled rheometer ARES (TA Instrument) equipped with a 25 mm parallel plates geometry in continuous shear mode at the same temperatures than those used for the different calendering tests. According to prior experiments consisting in determining the linear viscoelastic domain for which the behavior of the polymer does not depend on the strain, the frequency sweep at strain was kept at ε=3% and the pulsation ω was in the range of 0.1 to 100 rad/s. Nitrogen was used to decrease the ageing of blends. Disk samples of 1.8 mm thick and 25mm wide were prepared by injection. The gap was set at 1.5mm. The result is the average value of three samples.

3.6 Analysis of the coated textile sections

The section of the coated textile has been analyzed with a Scanning Electron Microscope using the detection of backscattered electrons and a magnification of x500.
The penetration of the coating on the fabric was measured as following. Red arrows in Figure 2 indicate the depth of coating penetration (+/-2µm):

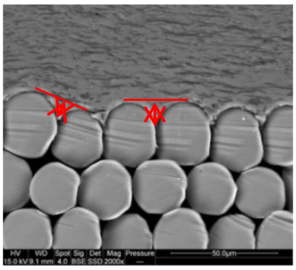

Figure 2: Measurement method of the coating penetration on the fabric

3.7 Analysis of the Chemical Composition

Infrared measurements at room temperature were performed on a Perkin–Elmer Spectrum One FT-IR (Fourier Transformed Infrared) Spectrometer with 32 scans and a resolution of 2 cm^{-1} in the absorption mode to determine the chemical composition of the different blends.

RESULTS

4.1 Peel Strength of TPU/LDPE Blends

According to Table 6, peel strengths of neat TPU do not exceed 7N/50mm. For the blends given in Table 6, an increase between 200% can be highlighted for experiment number 9 (15% of LDPE and extrusion temperature 174°C) and 430% for experiments 4 and 6 (respectively 23% and 29% of LDPE and extrusion temperature 190°C). However neat LDPE (at both 174°C and 175°C) also exhibit a very low peel strength which means that the increase of the peel strength of the blends is not only due to the LDPE.

For a same amount of LDPE, an increase of the extrusion temperature seems to increase the peel strength. For example, for a same amount of 19%wt of LDPE (samples 2 and 3) but different extrusion temperatures (respectively 174°C and 196°C), the peel strength is doubled (13.0N/50mm and 27.4N/50mm respectively). The same trend is observed with samples 1 and 8, while the opposite trend is observed with samples 4 and 7. This can be explained by the very high die temperature employed for sample 7 that may cause a degradation of the blend. This is further correlated to an important decrease of the tensile strength.

Conversely and for a same extrusion temperature the amount of LDPE seems to have slight influence on the peel strength. For example, experiments 2 and 9 were both performed at 174°C with respectively 19%wt and 15%wt of LDPE but the peel strengths are identical. This observation is also true for experiments 4 and 6 and experiments 3 and 5. The complete substitution of LDPE by LLDPE-g-Ma leads to a decrease of the peel strength (experiment 13). The substitution of only 3% of LDPE by LLDPE-g-Ma does not have a significant influence on the peel strength (experiment 14).

Table 6: Peel strength of neat TPU, neat LDPE and TPU/LDPE blends

Sample number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Peel strength (N/50mm)	22.3	13	27.4	30	29.1	30	21.2	17	13	7	1.8	4.5	16.5	30.8	4.9

4.2 Tensile Strength of TPU/LDPE Blends

Tensile strengths of the different blends are displayed in Table 7. Tensile strengths of neat TPU extruded at 175°C is about 23 MPa while the tensile strength of neat LDPE depends of the process temperature (24.6MPa and 42.6 MPa for extrusion temperatures of, respectively, 174°C and 190°C. The difference can be due to the partial fusion of LDPE pellets at a temperature of 174°C while the fusion is complete at 190°C). Excepted for experiment 9, the tensile strength of all blends is lower than the tensile strength of neat TPU and neat LDPE which means that there is an incompatibility between TPU and LDPE. This is consistent with the literature (15). For an extrusion temperature of 210°C, the film seems to be degraded. The corresponding tensile strength is only 11.6 MPa while it is more than 14 MPa for all other blends. It is important to note that the tensile strength of TPU/LDPE blends seems to depend on temperature. Indeed, except for experiment 3, an increase of the extrusion temperature leads to a decrease of the tensile strength. The addition of only 3% of LLDPE-g-Ma in the blend leads to an increase of the tensile strength (experiment 14). With the complete substitution of LDPE by LLDPE-g-Ma (experiment 14), the tensile strength reaches 37.9MPa which is a strong increase in comparison (at the same extrusion temperature) with the uncompatibilized blend (experiment 6).

Table 7: Peel strength of neat TPU, neat LDPE and TPU/LDPE blends

Sample no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Tensile Strength (Mpa)	14.3	22.5	17.9	13.9	17.8	18.6	11.6	18.7	25.5	23.1	24.6	42.6	37.9	23.5	28.1

4.3 Analysis of The Chemical Composition

The Ma group can be seen between around 1700 cm^{-1} and 1800 cm^{-1} as explained on previous research on PP-g-Ma (16). Figure 3 shows the FTIR spectrum of samples 2 and 6. Although the peel strength is very different (sample 6 displayed a peel strength almost 3 times higher than sample 2), the two spectrums are similar. No difference was observed on the FTIR spectrums of the samples 1 to 9. The FTIR spectrum of experiments 6, 13 and 14 is presented in Figure 4 and the same conclusion can be made. The percentage of Ma in the blends 13 and 14 is so weak that it is almost not visible on the FTIR experiment except for the peak around 1730cm^{-1}. The large peak around 1700 cm^{-1} is a peak from TPU corresponding to the urethane group (C=O) (17) and cannot been attributed to Ma.
In conclusion to these analyses, no significant difference on the FTIR spectrum has been observed between all the blends. It may be that there is no new bonds creation by mixing TPU and LLDPE or LLDPE-g-Ma so the noted better adhesion is not due to a chemical link between the fabric and the coating.

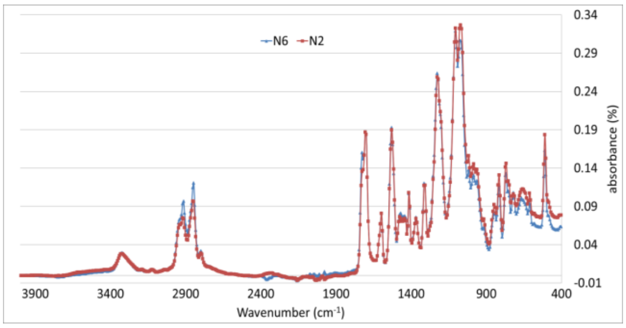

Figure 3: FTIR of experiment 2 and 6

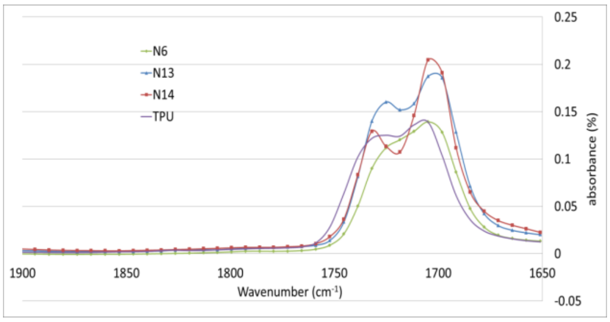

Figure 4: FTIR spectrum (1650-1900cm-1) of neat TPU and experiment 6, 13 and 14

4.4 Analysis of The Shear Viscosity of The Blend

The viscosity of the sheet is important because the ability of the polymer to penetrate inside the yarn depends of this viscosity. The shear viscosity given in Table 8 is the viscosity of the different blends at the corresponding extrusion temperatures for a shear rate between $10s^{-1}$ and $100s^{-1}$. These shear rates are those corresponding to the calendering process according to the literature (18).

At the same die temperature, the viscosity of neat LDPE and neat LLDPE-g-Ma is 7 times higher than the viscosity of neat TPU. Although the viscosity of LLDPE-g-Ma is lower than LDPE ones, the blend of LLDPE-g-Ma/LDPE/TPU (experiment 14) has a viscosity twice higher than that of experiment 6 for a same temperature of process. This must be linked with the miscibility of the different materials and it should be compared with the mechanical performance and the morphology of the blends. For the same LDPE/TPU blends, the higher the process temperature is, the lower is the viscosity. For example for an amount of 22.5%wt of LDPE and a shear rate of $10s^{-1}$, the viscosity is about 421 Pa.s for a temperature of 190°C and 47 Pa.s for a temperature of 210°C.

Table 8: Shear rate viscosities of neat TPU, neat LDPE, neat LLDPE-g-Ma and of the different blends at the corresponding processing temperatures and for a shear rate between $10s^{-1}$ and $100s^{-1}$

Sample number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Shear rate viscosity (Pa.s)	110 - 93	481 - 284	119 - 96	222 - 166	112 - 99	421 - 267	47 - 43	447 - 276	487 - 335	237 - 188	3800 - 960	2900-700	445 - 248	884 - 485	2980 - 1300

4.5 Analysis of the coated textile sections

The analysis of the coated textile section gives important information about the depth of penetration of the polymer between the filaments of the yarns that compose the fabric. Table 9 gives the depth of penetration for each experiment. The coating has a better penetration when extruded at high temperature especially if the temperature is above 190°C (experiments 1. 3, 5 and 7). It could be due to a difference of surface energy or viscosity. However it is important to notice that the diameter of a filament is 23 µm so the coating never penetrates inside the fabric but always keeps on the surface.

Table 9: Penetration depth of the coating for each blend in the fabric

Sample number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Penetration depth (µm)	13	6	11	10	9	7	14	8	7	2	5	6	8	6	2

ANALYSIS

5.1 Analysis of the Peel Strength Increase

FTIR shows that no new chemical bonds have been created in any of the different blends. Indeed, despite the large difference of peel strength, all FTIR spectrums are identical. It means that the peel strength difference is not due to the creation of new chemical bonds between the fabric and the coating.

Regarding the theories of wetting and mechanical interlocking, the observations of the coating penetration depth in the fabric give good information. As expected, the lower is the viscosity, the better is the penetration. According to the results, peel strength seemed to increase when coating penetration was higher than 7µm For example, on sample 7, the penetration is about 14µm and the peel strength is 21.2 N/50mm while penetration is only 2µm for sample 10 and the corresponding peel strength 1.8 N/50mm. But this trend could not be generalized; in fact sample 6 displayed 30 N/50 mm peel strength with a penetration depth of only 7µm. The conclusion is that the coating penetration depth in the fabric, and the related viscosity, has a strong influence on the peel strength but is not the only parameter involved. Actually, the temperature seems to have a strong impact on the peel strength. The temperature dependence of surface energy has been shown by previous papers (19).This modification of surface energy could lead to a better affinity between the fabric and the coating. As said previously, for a same amount of LDPE, an increase of the extrusion temperature leads to an increase of the peel strength until a maximum value for a temperature of 190°C. For higher temperatures (experiments 1, 3, 5 and 7), the peel strength decreases as a consequence of the polymer degradation, which could be observed by the decrease of the tensile strength.

5.2 Maleic Anhydride Influence

As observed previously, the complete substitution of LDPE by LLDPE-g-Ma has a negative impact on the peel strength, but a substitution of only 3%wt of LDPE by LLDPE-g-Ma did not degrade this property while it increases its tensile strength. The LLDPE-g-Ma is needed to get good peel strength and also good tensile properties. One interesting point is the difference of viscosity between experiment 6, 13 and 14 which have the same amount of LDPE or LLDPE-g-Ma. At the same temperature, LLDPE-g-Ma has a lower viscosity than LDPE. But also for a same temperature, the viscosity of the blend 14 made of 26%wt of LDPE and 3%wt of LLDPE-g-Ma is 2 times higher than the viscosity of the blend 6 made with 29%wt of LDPE and blend 13 with 29%wt of LLDPE-g-Ma. This increase of viscosity means that there is a good compatibility between LDPE and LLDPE-g-Ma. The complete substitution of LDPE by LLDPE-g-Ma have no impact on the viscosity of the blend at 190°C as it was found by comparing experiment 6 and 13.

CONCLUSION

In the present paper, the impact on peel strength of the addition of low density polyethylene and linear low density polyethylene to a thermoplastic polyurethane sheet calendared on a polyester fabric has been studied. In the first part, the study has shown that the addition of LDPE in the TPU coating has no direct impact on the peel strength while the die temperature has a strong influence. Because of the short sheet extrusion range of TPU, the LDPE is essential to extrude the coating at temperature above 175°C. However it is important to note that the best peel strength is obtained for an extrusion temperature of 190°C which is not the highest temperature. This must be due to a degradation of the film at higher temperature as shown by analyzing the tensile strength. The increase of the peel strength can be attributed to several phenomena among which the penetration of the coating in the fabric which creates a mechanical interlocking, and the extrusion temperature which create a different surface energy of the coating resulting in a better affinity with the fabric. In fact, it has been proved in previous research that for liquids (19) or for polymer films (20) the temperature of the material has a high impact on the surface energy. This theory will have to be proved for our study in a future work by using a pendant drop experiment as previously realized by Kwok et al (20).

In a second part, the influence of maleic anhydride as a compatibiliser between TPU and LDPE has been studied with the addition of LLDPE-g-Ma. It has been shown that the substitution of LDPE by LLDPE-g-Ma has a negative impact on the peel strength but hugely increases the tensile strength. However the substitution of only 3%wt of LDPE (among 29%wt) by LLDPE-g-Ma has no impact on the peel strength but still increases the tensile strength.

In future work, this experimental investigation will be continued with a study of the surface energy of the extruded coating sheet depending on the die temperature. The effect of the temperature on the surface energy will be helpful to confirm the theory proposed in our conclusion to explain the better adhesion.

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INVESTIGATION REGARDING THE INFLUENCE OF THE FABRIC CHARACTERSITICS ON VARTM EFFICIENCY FOR TEXTILE COMPOSITES

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Abstract: *Vacuum assisted resin transfer moulding technology (VARTM) is used with excellent results for the production of textile reinforced composite materials, especially using 2D and 3D textile reinforcements. Such materials have certain advantages: low weight, controlled anisotropy and excellent formability. The complexity and specific physical and mechanical properties of the textile structures affect the efficiency of the resin flow during the VARTM process. It is very important to know the yarn geometry, reinforcement structure density and the rate of infusion in order to set up the optimum technological conditions that will lead to product with highest possible quality. The paper presents an experimental study regarding the optimisation of the VARTM process for different types of materials considering different types and positions of the infusion and vacuum lines. The efficiency of the VARTM process is measured based on the infusion time (in correlation with the gel time) and the uniformity of resin flow front.*

Keywords: *closed processes, resin flow, infusion time*

INTRODUCTION

Polymeric composite materials with textile reinforcement are a well-established group of materials that are characterised by an excellent weight to strength ratio, controlled anisotropy and complex shapes. They are used mainly for mechanical applications, as components for different type of machinery, for cars, boats and airplanes.

Woven fabrics are the most common reinforcing material, as they exhibit very good mechanical properties, especially when using high performance fibres like glass, carbon or aramid. Knitted fabrics are less used for reinforcing composites, but the last 15 years have seen a strong development of such materials for composite reinforcement. Initially, multiaxial warp knitted fabrics were developed with good results, but then the weft knitted fabric started to be considered. Their main advantages refer to their high formability and the possibility of obtaining extremely complex shapes through flat knitting [1].

There are two types of processes for the production of textile reinforced composites, namely open and closed processes. VARTM (Vacuum assisted resin transfer moulding technology) is a closed process that ensures high quality composites [3 to 5]. It is a relatively easy process that involves a pump to create vacuum in a bag where the reinforcement is placed [2, 6]. Resin is then transferred into the fabric.

The paper targets the way the reinforcing fabric affects the resin transfer process during the production of the composites. Knitted fabrics have a specific geometry that is different from the one of the woven fabrics and is characterised by a high amount of openings in the material. It is interesting to see how the nature of these materials influences the VARTM process.

The paper presents an experimental study regarding the optimisation of the VARTM process for different types of knitted reinforcing materials (plain jersey and sandwich fabrics) made of 1 or 2 Kevlar yarns and considering different types and positions of the infusion and vacuum lines. The efficiency of the VARTM process is measured based on the infusion time (in correlation with the gel time), composite weight fraction and the uniformity of resin flow front.

EXPERIMENTAL

The experimental matrix contains three independent variables, presented in Table 1:

- Fabric structure – the structure was selected based on the number of layers it could include - jersey (1 layer, the stitches are in a single plan) and sandwich (2 separate layers connected through yarns)

- Number of yarns – the fabrics were produced using one and two yarns
- The method to deliver the resin when producing the composites – the resin was introduced in the fabric through line and through nuzzle, the two elements being positioned differently in the vacuum bag.

Table 1: Experimental matrix

Sample code	Input variables		
	Resin feeding system	**Fabric structure**	**Yarns**
G1F-b L	Line	jersey	1yarn
G2F-b L	Line	jersey	2 yarns
G1F-b D	Nozzle	jersey	1yarn
G2F-b D	Nozzle	jersey	2 yarns
S1R L	Line	sandwich	1yarn
S2R L	Line	sandwich	2 yarns
S1R D	Nozzle	sandwich	1yarn
S2R D	Nozzle	sandwich	2 yarns

The fabrics were knitted using Kevlar 29 yarns, 72 tex on a CMS Stoll knitting machine, gauge 8, with similar technological parameters. The structures considered in the experiment – jersey and sandwich are represented in Figs. 1 and 2.

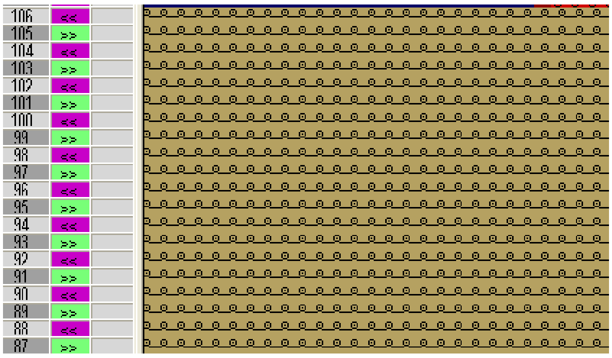

Figure 1: Jersey fabric – structure programming

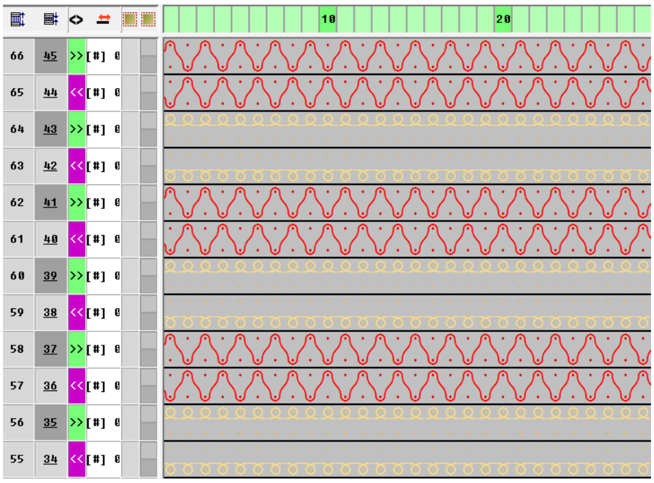

Figure 2: Sandwich fabric – structure programming

The composite materials were produced using the VARTM method. A PES resin was used as matrix with a gel time of 40 min. The samples were cut at 15x20 cm, recording their weight and thickness. After the production of composites, the weight and thickness of the material was again determined and the values were used for comparison.

The composite materials were produced in vacuum bags, using different elements to introduce the resin:

a) a line placed at the edge of the fabric (see Figure 3)
b) a nozzle placed in the centre of the fabric (see Figure 4)

Apart from the devices for resin transfer, the vacuum bags included a resin exit line, peel ply layers covering the fabric and a net structure over the last layer of peel ply. This net structure expedited the resin transfer process. Initial experiments showed that without this net, the duration of the resin transfer increases 4-5 times.

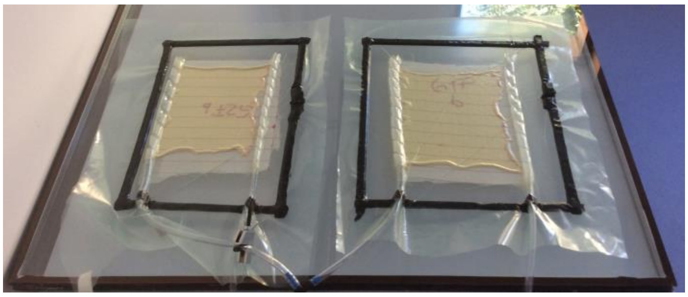

Figure 3: VARTM for jersey fabric – aspect of the vacuum bags with lines for resin transfer

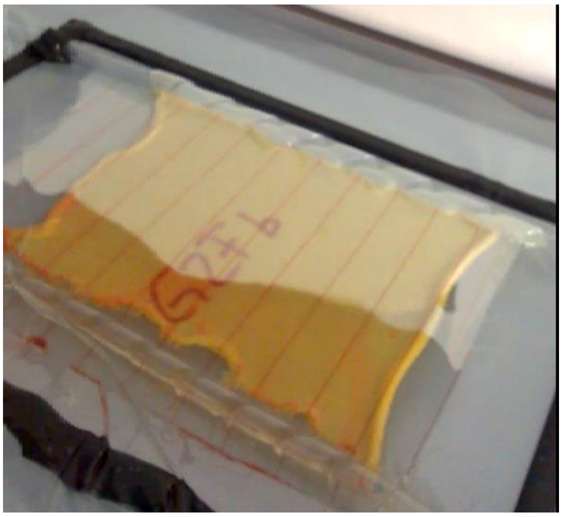

Figure 4: Aspect of the resin front for situation a

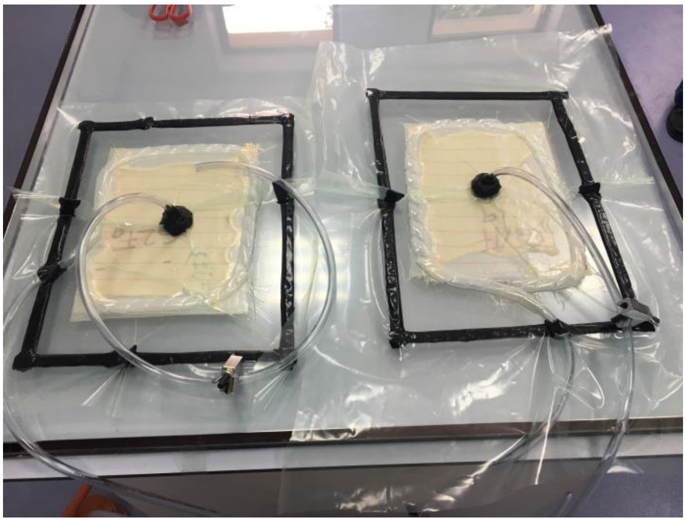

Figure 5: VARTM for jersey fabric – aspect of the vacuum bags with nozzle for resin transfer

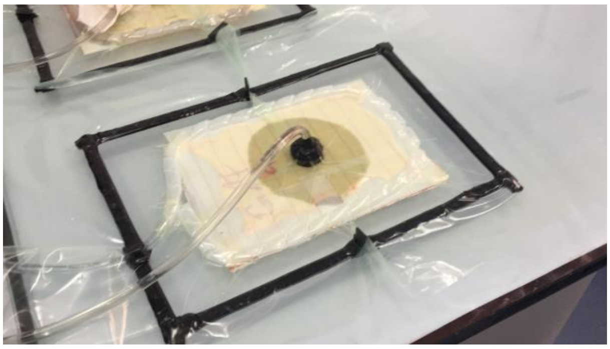

Figure 6: Aspect of the resin front for situation b

The term weight fraction may be applied to any of the constituents of a composite material, in this case the reinforcement (the knitted fabrics) and the matrix (PES resin). The weight fraction W is expressed as the ratio between the weight of the constituent and the weight of the composite material. The sum of the weight fractions for all constituents is 1:

$$\Sigma W_i = 1 \quad (1)$$

RESULTS

The infusion front was uniform for all samples produced, therefore the process was conducted without any problem from this point of view.

The experimental data obtained from producing polymeric composite materials with knitted reinforcement are presented in Table 2. The Table contains the weight and thickness of the materials, as well as the ones for the composites produced using VARTM. The fabrics and the composites were weighed with a 0.01g precision and the thickness was measured with 0.01 mm precision. The VARTM process for each sample was filmed and the duration of the process was determined.

Table 2: Experimental values

Sample code	Weight (g)		Thickness (mm)		VARTM process duration (sec)
	Fabric	Composite	Fabric	Composite	
G1F-b L	5.90	20.92	0.58	0.74	149
G2F-b L	10.42	29.27	1.05	1.06	126
G1F-a D	5.15	15.61	0.58	0.76	63
G2F-a D	12.09	31.69	1.10	1.07	79
S1R L	14.34	46.91	1.55	1.37	189
S2R L	16.69	45.97	1.65	1.57	162
S1R D	13.25	36.92	1.48	1.28	92
S2R D	18.61	11.79	1.68	1.60	75

DISCUSSION

Analysing the data from Table 2, it is obvious that the amount of resin transferred into the fabric is higher when it is done through line. This amount also depends on the fabric structure, as the sandwich fabric presents two layers instead of one. Figures 7 and 8 illustrate the variation of weight for the composites reinforced with plain jersey and sandwich fabrics.

Figure 7: Weight variation for the composites reinforced with jersey fabrics

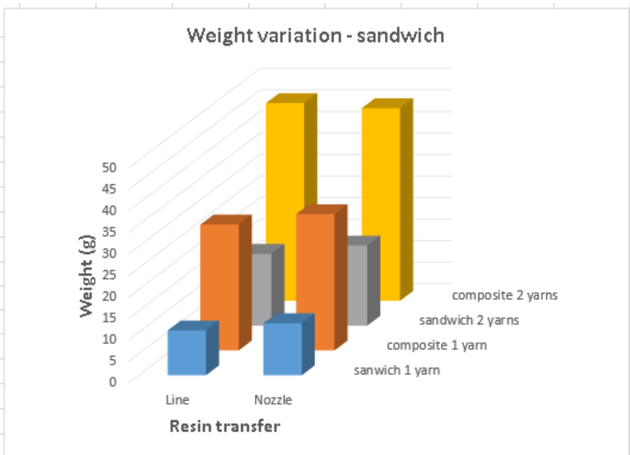

Figure 8: Weight variation for the composites reinforced with sandwich fabrics

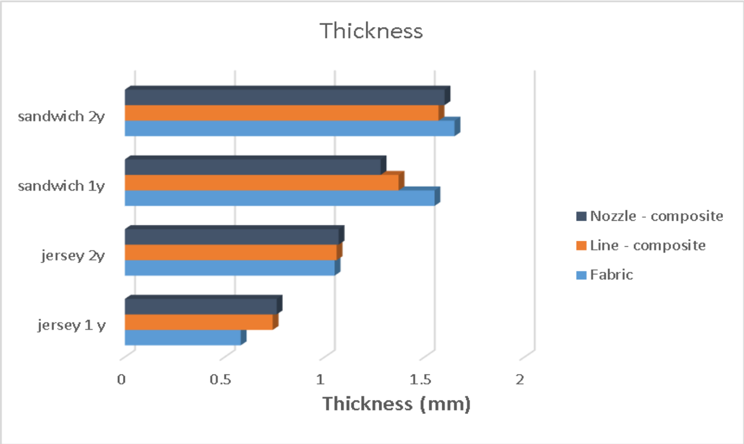

Figure 9: Thickness variation for the composites in comparison to the reinforcement

Figure 9 shows how the thickness of the composites varies in comparison to the thickness determined for the knitted samples. For the composites produced with plain jersey reinforcement, the thickness increases due to the resin transferred in the material. The increase is more significant for the jersey produced with 1 yarn, as the hollow spaces are bigger. For the composites made with sandwich reinforcement, their thickness is lower than the one for the knitted fabric. This is due to the VARTM process, as the vacuum compresses the fabrics before the resin is transferred. It is an interesting aspect and this 'crushing' should be taken into consideration when processing such fabrics. The position of the connecting yarns is modified and could affect compression mechanical behaviour.

The influence of the device used for resin transfer during VARTM is presented in Figure 10. The influence is expressed through the value of the weight factor. The Figure also emphasises the influence of the number of yarns used to produce the reinforcement.

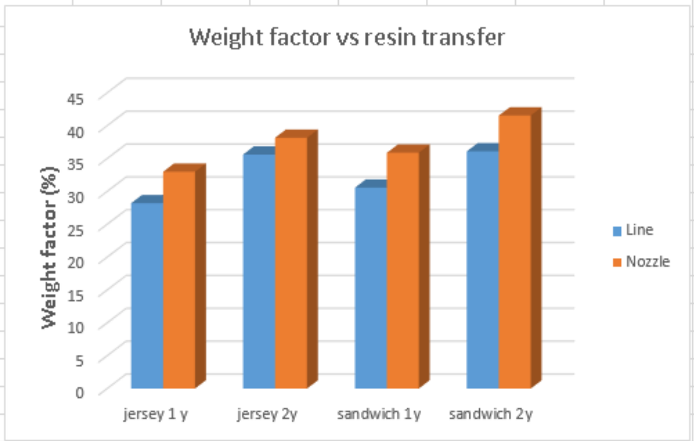

Figure 10: Influence of the resin transfer process on the weight factor of the composites

The graphic shows that the resin transfer through nozzle leads to a higher weight fraction for the resulting composites. For the composites produced with the nozzle, the interval of variation for the weight factor is 33-42%, while for the composites produced with resin transfer line the weight fraction varies between 28% and 35%. The influence of the structure of the reinforcement material on weight fraction is less important than the number of yarns used for the fabrics.

The influence of the device for resin transfer on the duration of the process is presented in Figure 11. The graphic shows clearly that by using the nozzle, the duration of process is significantly reduced, up to 50%. Considering that the resin transfer through nozzle also ensures a higher weight fraction, it can be stated that it is more efficient to conduct the resin transfer in the VARTM using nozzles.

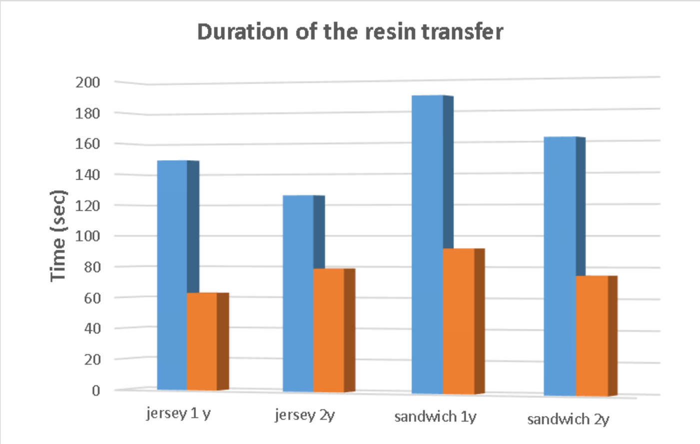

Figure 11: Influence of the type of resin transfer on the duration of the process

CONCLUSIONS

The paper studied the efficiency of the VARTM process for the production of composites reinforced with knitted materials. An experimental matrix was considered with the following input variables: fabric structure (layers), number of yarns used to produce the reinforcement and the device for resin transfer (line or nozzle).

The efficiency of the process was estimated based on the duration of the resin infusion (transfer) and the weight fraction of the knitted reinforcement. Based on the experimental data, it was concluded that the nozzles are the most efficient way of transferring resin during VARTM, leading to higher weight fractions and lower process times.

Future work will include an extension of the experimental matrix and a related study concerning the mechanical behaviour of the composite materials.

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EFFECT OF CuBr LASER PARAMETERS ON THE CONTRAST WHEN MARKING A TEXTILE FABRIC

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Abstract: *The laser-based marking process represents a serious competitor of the conventional technologies of marking and labelling of textile materials. However if the parameters of the laser are not set properly, the fibers become burnt or cut. In this study, the influence of pulse power on the contrast of the specimens of different colour and different material for varied velocity of marking are investigated. Samples of cotton, polyester and cotton/polyester fabrics have been marked with CuBr laser. The quality of the image has been evaluated according to the contrast. The obtained results allow expanding the practical application of this innovative technology in the textile industry.*

Keywords: *laser-based marking, textile materials, matrix code, contrast.*

INTRODUCTION

The marking of products is an integral part of modern life. Every day several thousands of laser systems are in use around the world for marking. The “TRUMPF” company are the first to introduce industrial marking lasers to the market and their lasers are marking a countless variety of goods that need to be uniquely marked for traceability [1]. Marking is regulated by series of European standards [2]. It is necessary for both manufacturers and users. During the process of production it has to trace all the stages in order to control the quality of the products and to remove the defects immediately. Marking gives the user information about certain characteristics and parameters of the product. The main function of marking is informational, but frequently it is used for decoration too.

The technological process of laser marking is complex and in order to get a good result, with economically justified costs, it is necessary to find the right laser for the respective production. Marking of textile polymers requires lasers with a wavelength that is best absorbed from the textile materials with low impulse energy and with a power density lower than that marking metals. A huge variety of laser sources and laser technological systems with different characteristics and applications are offered on the world market [3,4]. But only a small part of them is applicable to the marking of textile products. Textiles, plastic materials, wood, cardboard, paper and leather are marked with relatively low-power lasers. This makes it necessary to choose a laser with good quality of the beam and with a wavelength that will be best absorbed by the specific material for each specific case.

To conduct the experiments a copper bromide vapour (CuBr) laser has been selected. This laser emits rays in the viewing area and is an original Bulgarian invention. The first copper bromide vapour laser is a development of Prof. Nikola Sabotinov from the Bulgarian Academy of Sciences (BAN). It is protected by Bulgarian and international patents (Patent no. 28674.1975 Bulg) [5]. The laser with a vapour of copper and its compounds emit in the visible region of the green light with a wavelength of λ=510.6 nm (~70% of power) and the yellow light λ=578.2 nm (~30% of power). It is the most powerful source in the viewing area and is widely used in various fields: in the microprocessing industry of materials - punching, cutting, marking and engraving. People often do not distinguish between marking and engraving in the practice. The two processes are similar, their main difference is in the depth of penetration of the laser beam. Fabrics have a small thickness and for them it is more suitable to apply marking. The process of laser marking influences the surface layer of the product as the part of material (with a thickness of several microns) is melted or evaporated. The laser beam causes structural changes in the area of impact of the material. In this way different information can be drawn over the textile product in the form of letters, numbers or images. It can be encoded information, identification symbols, logos, inscriptions, bar codes and two-dimensional codes, serial or batch numbers, date and so on. Laser processing for the purpose of marking is widely applied in practice, but there is no information in the scientific literature concerning the control and management of these processes.

In this study some factors influencing the process of laser marking of materials are discussed. In order to study the possibility of marking of textile materials with CuBr laser some experiments have been carried out. The image quality has been evaluated by the resulting contrast. The contrast is the most important characteristic when the information obtained by laser marking (bar-code, data matrix code) must be read automatically by an electronic device. If the parameters of the laser are not set properly, the fibers become burnt or cut [6]. The physical and mechanical properties of the fabric get worse, depending on the percentage of the damaged fibers. In order to receive a good contrast, the technological process of laser marking of cotton and polyester fabrics has been analyzed depending on some key parameters of the laser system.

EXPERIMENTAL

The samples are from cotton, polyester and cotton/polyester fabrics. They are marked by the laser system in industrial conditions. The selected materials have the greatest application in the textile industry [7]. The main physical and mechanical characteristics of the materials are presented in Table 1. Four groups of samples with different composition and characteristics have been marked and analyzed. Each group of samples was represented by various colors: black, blue and white. Marking was carried out in accordance with the test field, consisting of small squares that were marked with different parameters of laser system [8]. This is a quick and effective way to see if a given combination of a laser and material will get a good contrast marking.

Table 1: Basic physical and mechanical characteristics of the materials [24]

Material	Mass per sq.m $g.m^{-2}$	Density		Thickness mm	Compactness $kg.m^{-3}$	Tensile strength $N.mm^{-2}$
		warp	weft			
R1	430	140	95	1,20	1,52	350-370
R2	180	369	260	0,75	1,52	350-370
R3	190	376	290	0,80	1,38	1000-1300
R4	185	369	260	0,75	1,45	675-835

*R_1– cotton, R_2– cotton, R_3 – polyester, R_4– cotton/polyester

2.1 Reference to heating

Fabrics are produced from natural or chemical fibers. Some of the very often used materials are cotton, polyester or mixtures of cotton/polyester for manufacturing of textiles. They possess a good complex of exploitation characteristics. Cellulose is the main component of cotton (95-98%). Upon heating, cellulose becomes carbonized without melting. When the polymers are heated above a certain temperature, a thermal decomposition occurs melting or breaking down. The laser beam turns out a thermal impact on fabrics. Most commonly, the laser marking is a surface process.

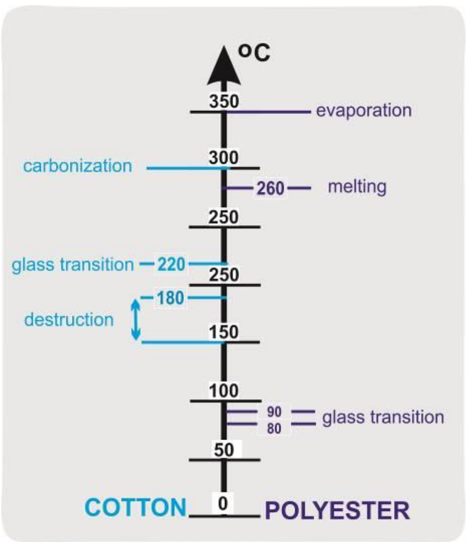


Figure 1: Behavior of cotton and polyester to heating

The marking processes for textiles include one or a combination of the following processes [9]:

- Black carbonisation;
- Structural changes (glass transition, bleaching or changing the dye layer of fabrics);
- Phase modification of the fabric surface by vaporisation or by melting.

When the cotton and polyester fabrics are treated by a laser with copper bromide vapours, the textiles surface changes greatly and a mark is formed with sufficient contrast to be read by an electronic reading device. When cellulose, and consequently cotton, are heated, they become charring (carbonized) without melting. Thermal destruction occurs between 150÷180^{0}C and the strength of fibres is substantially reduced, the color also changes – Fig.1. The cellulose polymer chain breaks as a result of decomposition, as its length decreases and its average molecular mass decreases too. The glass-liquid transition occurs at about 220^{0}C when the cellulose goes from viscoelastic to pseudoplastic stage. When the temperature is 300^{0}C, there is a carbonation. When the polyester fibres are heated to a temperature of 80÷90^{0}C, glass-liquid transition and structural changes occur. At 250^{0}C the polyester fibres become soft, and when the temperature reaches 260^0 C they melt. At 350^{0}C the fibres become completely destroyed (vaporized) [10,11].

The laser system with CuBr laser used in the experiments is shown in Figure 2. The marking of CuBr laser samples was carried out in a series of experiments:

- The frequency of impulses was amended in the range 1÷11 kHz with step 2,5 and the impulse power - P_{Pi} was calculated by the formula 1 (20÷233 kW);
- The velocity of laser radiation – Vi was amended with step 25 in the range 40÷140 mm.s^{-1}.
- The defocusing Δf was 1mm, the step of marking - Δx=0,01mm.

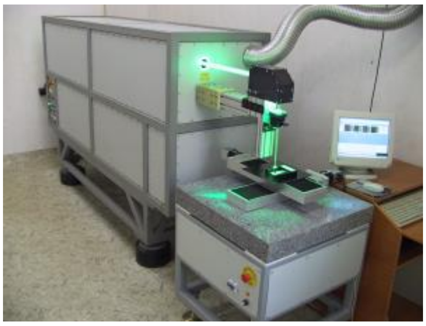
The average power for the marking of textile materials does not have to be big, a power in the range 10÷50W is enough. The duration of pulses is 30ns. The laser marking of textiles was carried out with laser sources operating in pulse mode, and much more important are: P, Pp, Ep, τ, υ. They were calculated according to the following formulae:

$$P_p = \frac{P}{\tau . \upsilon}, kW \qquad (1)$$

$$E_p = P_p . \tau, mJ \qquad (2)$$

Where:

P - average power; P_p - pulse power; E_p - pulse energy;
τ – duration of pulses, ns; υ – frequency of pulses, kHz.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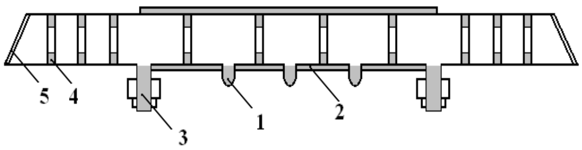


б)

Figure 2: a) A laser system with CuBr used in the 'Pulslight' company [154] b) Schematic diagram of a laser tube: 1-tanks with copper bromide, 2-thermal insulation on active volume, 3-copper electrodes, 4-inner diaphragms, 5 - output windows [12,13].

2.2 A methodology of determining the contrast of the marking

The best results of marking are obtained only when there is a proper combination of pulse power, pulse energy, duration of pulse, frequency and processing speed. In order to find the proper combination, i.e. to optimize the process, it is very important to know and analyze the criterions of quality for the marking.

Quality criterions for assessment of the marking [14]**:**

- Contrast – it is the visual difference between the apparent brightness of the marked surface and the unmarked surface of a workpiece;
- Homogeneity — it is when the density for the entire marked area is uniform (except in the case of marking for decoration when the goal is to get a certain image);
- Clarity of contour – it is when you can see the smallest details of the image;
- Durability – it is when the marking remains unchanged during the period of operation of the goods (to be resistant to external influences such as washing, for example).

The quality of laser marking is defined to the greatest degree by the contrast (k*), which characterizes the brightness range of the image and is expressed through the relationship between its maximum and minimum brightness. The contrast is determined by the difference between the background brightness (Lf) and the brightness of the image (Lx), divided into the background brightness in percentages (3) [15]:

$$k^* = \frac{L_f - L_x}{L_f} . 100\% \qquad (3)$$

The mark has a certain threshold (border) contrast k^*_{thr}, over which it can be deciphered. The threshold contrast is different when the marking is perceived visually through the eyes and automatically via electronic devices. According to various studies [16,17], a good mark for perception of the human eye is when there's a contrast threshold k^*_{thr}=50%. Scientific instruments, such as spectrophotometers, are designed for measuring the color based on the fact that each colour has a specific wavelength. A minimum of 20% threshold contrast against the background is sufficient for reading by electronic readers of the marking of 2D codes and bar codes [18].
There are various modern methods for the determination of the color difference of textile fabrics, which for brevity is called contrast (k*). The standard "BDS EN ISO 105-J03-2009 Calculation of colour differences" refers to tests for coloured fabrics [19]. This standard specifies a method for the calculation of the difference in color between two samples of the same material, measured under the same conditions as E is the numerical value of the total difference in quantitative degree of color. The measurements are made with a spectrophotometer "Datacolor SF 300" – an apparatus for measuring the color parameters of textiles - Fig.3. The data is processed by a specialized computer software "DataMASTER V 2.3". The methodology of the work is as follows: the sample is placed and fixed against the measuring aperture of the spectrophotometer, it is irradiated from the light source, located in the appliance, and the length of the waves of reflected and absorbed part of the incident light are measured.

Figure 3: Spectrophotometer „Datacolor SF 300” [20]

The measured data are stored in the computer database and are used to calculate the color values of parameters - CIE Lab Difference: ∆ E - is a color difference which is expressed through the contrast - formula 4, also ∆L - lightness, ∆C - saturation, ∆H - hue are accounted [21]. The software package allows for measuring the color parameters of the textile materials immediately and eliminates the subjective visual assessments.

$$\Delta E^*_{ab} = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \qquad (4)$$

All the samples are conditioned under standard atmospheric conditions: t = temperature (20 ± 2)°c and a relative humidity of φ=(65±2)% for 24 hours before treatment (BDS EN ISO 139:2006). The described methodology makes it possible to examine the impact of a number of technological factors on contrast k*.

RESULTS

The dependence between impulse power and frequency of the impulses for CuBr laser is given in Figure 4.

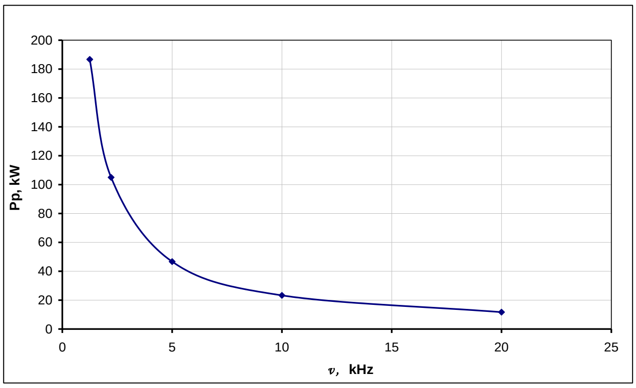
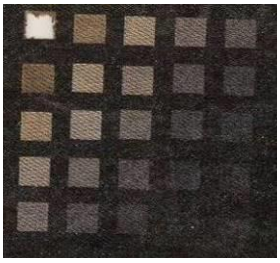


Figure 4: The pulse power depends on the frequency for CuBr laser

The influence of the impulse power over the contrast (k*) for different color and composition specimens when marking with CuBr laser have been studied. The dependence between the contrast and the impulse power for different velocity of markup is shown in the following graphs: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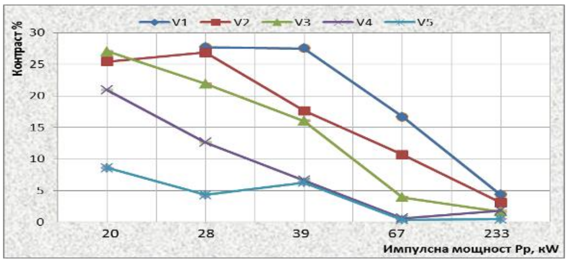
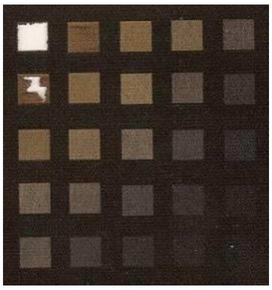


b

Figure 5: The contrast (k*) depending on impulse power (Pp) for the sample R1 - 100% cotton, black color, marking by CuBr laser with velocity: V_1=40, V_2=65, V_3=90, V_4=115, V_5 =140 mm/s: a) sample, b) graph.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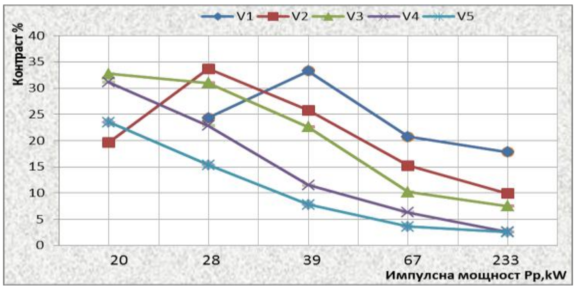
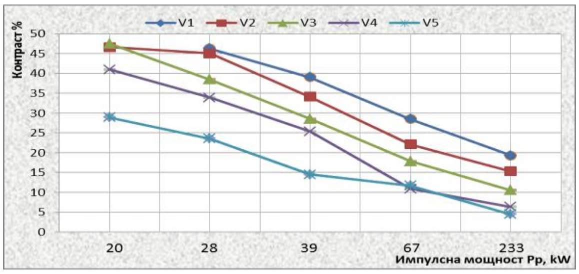


b

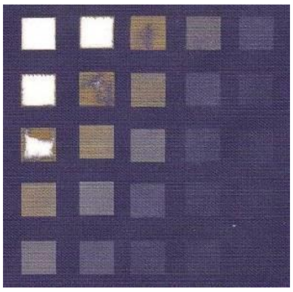
Figure 6: The contrast (k*) depending on impulse power (Pp) for the sample R2 - 100% cotton, black color, marking by CuBr laser with velocity: V_1=40, V_2=65, V_3=90, V_4=115, V_5 =140 mm/s: a) sample, b) graph.


a



b

Figure 7: The contrast (k*) depending on impulse power (Pp) for the sample R1 - 100% cotton, blue color, marking by CuBr laser with velocity: V_1=40, V_2=65, V_3=90, V_4=115, V_5 =140 mm/s: a) sample, b) graph.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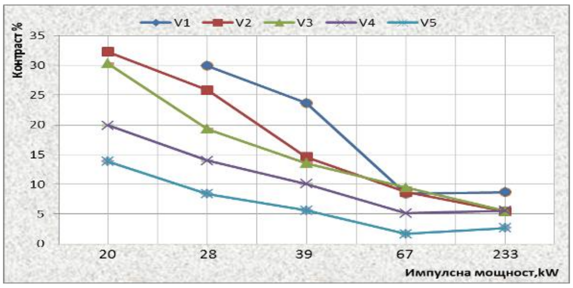
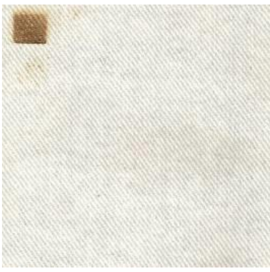


b

Figure 8: The contrast (k*) depending on impulse power (Pp) for the sample R2 - 100% cotton, blue color, marking by CuBr laser with velocity: V_1=40, V_2=65, V_3=90, V_4=115, V_5 =140 mm/s: a) sample, b) graph.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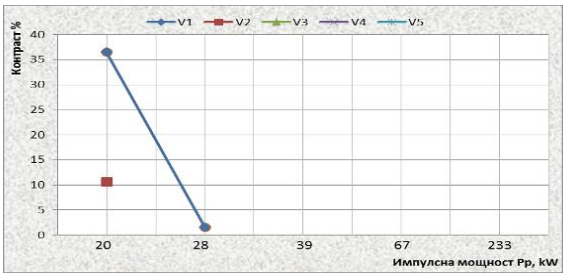
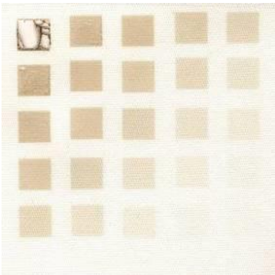


b

Figure 9: The contrast (k*) depending on impulse power (Pp) for the sample R1 - 100% cotton, white color, marking by CuBr laser with velocity: V_1=40, V_2=65, V_3=90, V_4=115, V_5 =140 mm/s: a) sample, b) graph.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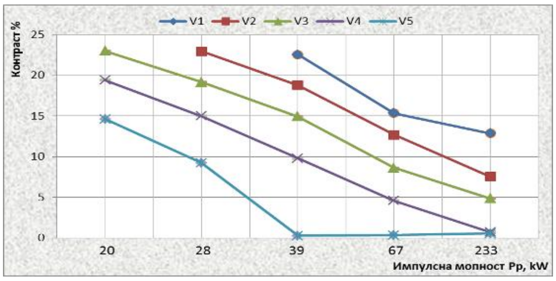

b

Figure 10*:* The contrast (k*) depending on impulse power (Pp) for the sample R3 - 100% polyester, white color, marking by CuBr laser with velocity: V_1=40, V_2=65, V_3=90, V_4=115, V_5 =140 mm/s: a) sample, b) graph

The percentages of contrast are shown in Figure 11. From the test fields 2D matrix codes are created that have been tested by an electronic reading device – Figure 12.

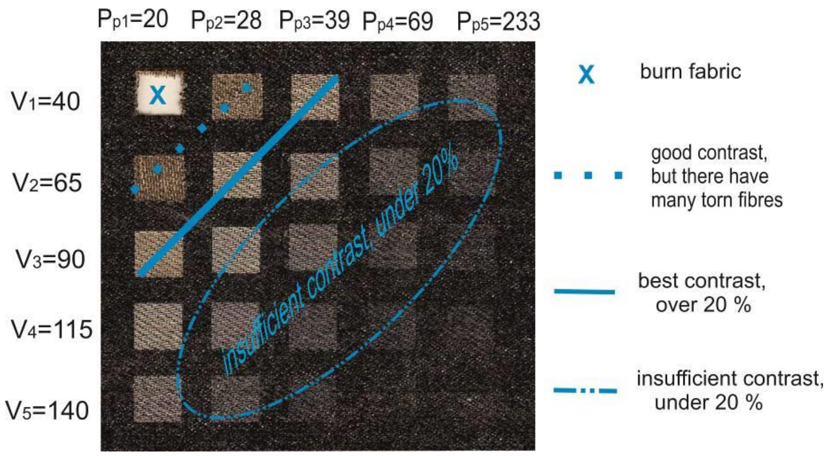

Figure 11: The test field for sample 100% cotton, black color, marking by CuBr laser

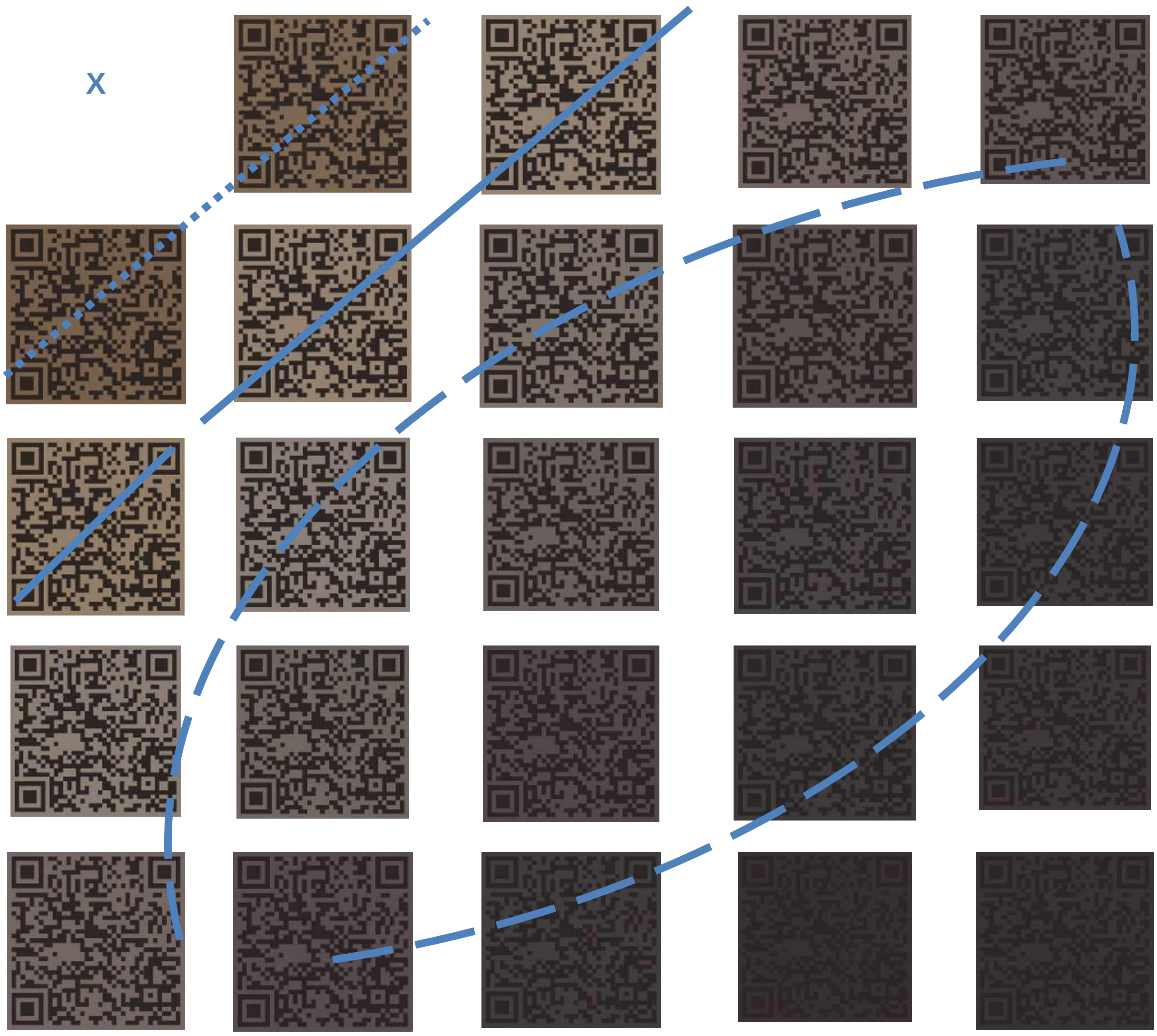

Figure 12: The samples of 2D matrix codes

DISCUSSION

The experimental study is focused on the analysis of the interrelationships between the technological parameters of the process of laser marking of textiles. The advantages of the laser marking give us a reason to believe that it is a very suitable method for fabrics. The main problem is to define the optimal combination of the laser parameters to obtain the best results of marking for the specific material.
Looking at the resulting graphic results, we can say that the contrast of marking reduces with increasing the pulse power of the laser radiation (Pp). This can be explained by the reduction in the frequency of repetition of impulses at a constant length of pulses and a constant average power. Also the speed of marking has a significant impact on the contrast of the marking. How much the speed is higher (v_5) so much the contrast is less. The reason for this is that at high speeds the time of effect of laser on the processed material is shorter. For small values of the speed (v_1) and the pulse power, respectively high values of the frequency of repetition of impulses, there is not a contrast recorded, because the sample is destroyed.
Comparing Fig. 9 and Fig. 10 it can be concluded that the material of the samples for the white colour proves to be a very significant impact on the outcome of the marking. This can be seen from the photos of the test squares of the corresponding samples of 100% cotton and 100% polyester. For the samples of cotton with white color another solution should be looked for, such as adding a colouring agent(e.g. titanium dioxide mineral supplement-TiO_2). For the textile fabrics which are not receiving a good contrast of the markings, supplements can be used to enhance the optical absorption coefficient of the material, in order to improve the process of marking only by increasing the speed of temperature rise. Through the inclusion of increased absorption and appropriate laser wavelength we can improve the ability to markup.

CONCLUSIONS

The research, carried out in this work, is aimed at the application of the method of laser marking of textiles. The obtained results:

- ⇨ Allow to extend the practical application of this innovative technology in the textile industry;
- ⇨ Confirm that during the treatment of fabrics from cotton and polyester with a laser with copper bromide, the surface changes greatly and a mark is formed with sufficient contrast to be read by an electronic reading device;
- ⇨ Established that the speed of the laser beam and pulse power (the time of the impact and frequency of repetition of impulses respectively) are parameters of the laser marking process, which have the greatest impact on the contrast of the mark;
- ⇨ Prove that the quality of marking is determined both by the parameters of the laser system and by the composition, structural and color characteristics of the fabric.

With the aid of the laser technology 2D matrix codes with good contrast are created on textile fabrics.

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OPTIMIZATION OF EMULSIONS OBTAINED FROM ESSENTIAL OIL OF SAGE AND BEESWAX/CHITOSAN, INTENDED FOR FUNCTIONALIZATION OF TEXTILE MATERIALS

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Abstract: *The paper presents the results of a study on optimizing the properties of cellulosic fabrics treated with essential oil of sage. For this purpose, 100% cotton plain weave fabrics treated with emulsions from essential oil of sage embedded in different matrices containing beeswax and chitosan were used. The regression equations obtained from processing the experimental data have allowed determining the optimum conditions for the emulsion composition. The emulsion that presents the better time stability is the one containing 26.6 % essential oil of sage, 3 % beeswax and 3.33% chitosan. This emulsion was used to treat the textile material by impregnation, squeezing and drying at room temperature. The antibacterial activity of the materials obtained by this treatment has been investigated against the Staphylococcus aureus ATCC 29213 and Escherichia coli ATCC 25922 bacteria.*
The values of comfort indices for the treated samples are influenced by the amount of essential oil of sage and by the amount of beeswax contained in the emulsions. By increasing the amount of beeswax and essential oil, increases the permeability to water vapour and decreases the hygroscopicity. Regarding the air permeability, it diminishes with the increase of beeswax content, but is not significantly influenced by the concentration of essential oil. The obtained results showed that the treated materials do not show antibacterial activity against Escherichia coli ATCC 2592, but exert a moderate sensitivity (16 mm) against Staphylococcus aureus ATCC 29213.

Keywords: *antibacterial activity, emulsion, essential oil of sage, beeswax, chitosan*

1. INTRODUCTION

Thanks to some valuable properties such as pleasant touch, air permeability, vapour permeability, capacity of moisture absorption, biodegradability, textile materials made from natural fibres are widely used in hospitals and healthcare facilities in form of bed sheets, blankets, towels, personal clothing, uniforms, gowns etc. [1].

Meanwhile, under certain conditions these materials can provide an excellent environment for the growth of various types of microorganisms, which represent one major disadvantage. Bacterial contamination and the spread of infections is a common issue in hospitals and it is very important to prevent the textiles to act as an incubator and a vehicle for the transfer of pathogens. For this reason nowadays there is an increasing interest regarding the medical textiles with antimicrobial effect that can control the development of potentially harmful microorganisms [2].

Antimicrobial properties may be conferred to the textile material by chemical or physical incorporation of antimicrobial agents into fibres or onto fabrics. Textile materials made from cellulosic fibres (woven fabrics, nonwoven, knitted fabrics, composites) can be used as support to incorporate the biologically active principles in order to obtain medical textiles used as bandages, skin care products, plasters etc. For these products, the comfort indices are important criteria in assessing the quality of treated textile substrate. The effectiveness of the medical textiles is given by their high capacity of moisture absorption, elasticity, draping ability, air permeability and ease of application [3-4].

In this regard, the paper presents the optimization of the emulsions obtained from essential oil of sage and beeswax/chitosan applied to cellulosic fabrics in order to improve their antimicrobial properties.

2. EXPERIMENTAL WORK

In the first stage of the research, emulsions containing beeswax and chitosan as matrix and essential oil of sage as core were obtained. The emulsions were prepared as following: beeswax was melted at 80ºC in a thermostatic water bath; glycerine, Tween solution (30%), chitosan and water were added in the melted beeswax. After cooling the mixture to 60 °C, the essential oil of sage was added dropwise under continuous stirring. In the composition of emulsions was varied the amount of essential oil of sage and the ratio between beeswax and chitosan (the amount of chitosan was kept constant at 3.3%, varying only the content of the beeswax).

In order to optimize the emulsion composition we used a factorial experiment, by adopting a central composite rotatable design, with two independent factors [5-8]. This method aims at the description of functional dependency between one or more response parameters (dependent variables) and two independent variables. The codification of parameters was done such as to include the full range possible to be technically achieved (Table 1). In this case, as independent parameters were selected:

X_1 – beeswax percentage in the composition of emulsion, %;
X_2 – percentage of essential oil of sage, %.

As dependent variables, three main comfort indices have been considered: hygroscopicity, water vapour permeability and air permeability.

Table 1: **Correspondence between the real and codified values of independent parameters**

Real value \ Codified value	-1,414	-1	0	+1	+1,414
X_1 - (%) beeswax	0	0.88	3	5.12	6
X_2 - (%) essential oil of sage	10	14,4	25	35,6	40

In the second stage of the research, the emulsions obtained according to the experimental design were applied on the 100% cotton fabrics by impregnation of the textile material, squeezing (squeezing degree 80%) and then drying for 24 hours at room temperature.

The comfort parameters of treated materials are highly important when studying the bandages and dressings, if the materials are intended for these applications, because the comfort characteristics of treated textile materials modifies through emulsion application on their surface. Therefore, following comfort indices were considered as dependent variables and were measured accordingly: the hygroscopicity (Y_1) [9], the water vapour permeability (Y_2) [10] and the air permeability (Y_3) [11]. The obtained results are presented in Table 2.

Table 2: Experimental design and the values of dependent variables

Exp. no.	X_1(%) beeswax		X_2 (%) oil of sage		Hygroscopicity	Water vapour permeability	Air permeability
	code	real	code	real	Y_1 (%)	Y_2 (g/m^2·h·10^4)	Y_3 (m^3/m^2·min)
1	-1	0.88	-1	14.4	65.58	7.44	8.36
2	+1	5.12	-1	14.4	70.23	6.47	8.31
3	-1	0.88	+1	35.6	84.84	6.02	8.26
4	+1	5.12	+1	35.6	84.55	5.42	3.67
5	-1.414	0	0	25	81.57	8.30	7.96
6	+1.414	6	0	25	88.06	8.57	4.49
7	0	3	-1.414	10	88.11	7.73	8.36
8	0	3	+1.414	40	91.48	7.47	3.31
9	0	3	0	25	78.02	6.71	8.67
10	0	3	0	25	81.05	5.05	5.10
11	0	3	0	25	79.09	5.18	4.84
12	0	3	0	25	78.78	5.28	5.00
13	0	3	0	25	78,77	5.15	5.05

The functional relationship between the independent parameters and the dependent variables is a regression equation of the form:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_{12}X_1X_2 + b_{11}X_1^2 + b_{22}X_2^2 \qquad (1)$$

Based on the experimental data presented in Table 2, the coefficients of the regression equations were determined using the method of least squares. Mathematical models were statistically analyzed by testing the significance of the coefficients using the Student test, and for the adequacy of model, using the Fisher test. Mathematical models contain only those coefficients that resulted significant. Thus have been obtained the regression equations for the analysed properties, of which coefficients are presented in Table 3.

Table 3: The coefficients of regression equations

No.	Y_1	Y_2	Y_3
1	b_0 = 79.162	b_0 = 5.4740	b_0 = 5.7320
2	b_1 = 1.692	b_1 = -0.1485	b_1 = -1.1933
3	b_2 = 4.793	b_2 = -0.3547	b_2 = -1.4851
4	b_{12} = -1.235	b_{12} = 0	b_{12} = -1.1350
5	b_{11} = 0.0752	b_{11} = 1.0605	b_{11} = 0.5265
6	b_{22} = 2.565	b_{22} = 0.6430	b_{22} = 0.3315

3. RESULTS AND DISCUSSION

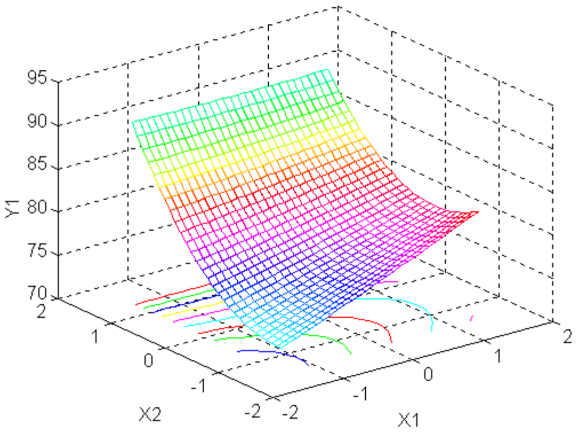
3.1 Interpretation of mathematical models

The mathematical models obtained were plotted using the Matlab software. Highlighting of the interactions effects of the relevant factors on the target functions (Y_i) was performed by plotting the response surfaces and the constant level contours representing the values of the dependent variables.

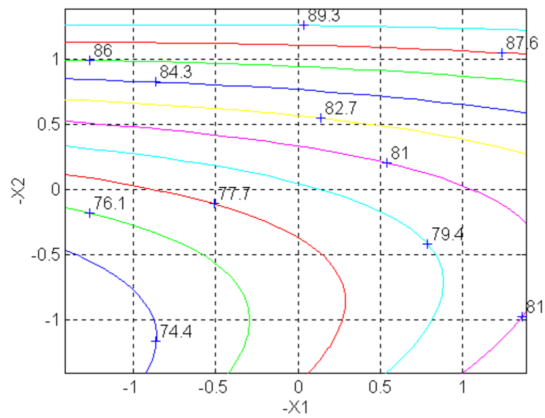
By analysing the plotted surfaces and the constant level curves, we can draw several conclusions regarding the influences of independent parameters on the target functions (dependent variables). Finally, optimal values of the independent variables that maximise or minimise the target function can be determined. By transforming the coded values of independent parameters, are obtained their actual values which allows getting the optimal values desired for the dependent variables.

Hygroscopicity variation

The dependence between the textile materials hygroscopicity (Y_1) and independent parameters (the beeswax concentration - X_1 and the percentage of essential oil - X_2, is graphically presented in figures 1.a and 1.b.



a. Response surface



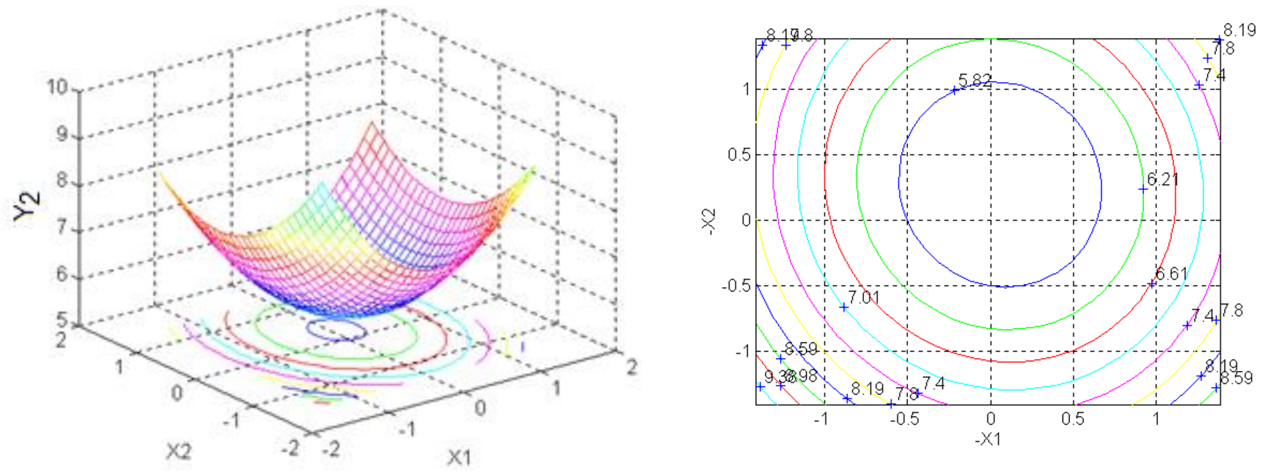
b. Curves of constant level

Figure 1: **The influence of independent variables X_1 and X_2 on the hygroscopicity (Y_1)**

From figure 1.a, one can see that both independent parameters influences the target variable, but the beeswax concentration (X_1) affects in a higher degree the fabrics hygroscopicity compared to the percentage of essential oil of sage (X_2). Analyzing the contours of constant level (fig.1b), one can observe that starting from a certain value of the concentration of essential oil (X_2 > 1), the hygroscopicity remains constant, regardless the beeswax content used in the emulsion composition.

Water vapour permeability

Figures 2.a and 2.b graphically present the dependence between water vapour permeability (Y_2) and the two independent parameters. The response surface is an elliptic paraboloid with a minimum point, which in this case could not be considered as an optimum. Analyzing the curves in figure 2.a is observed that the maximum values of permeability are obtained at the edge of the chosen experimental field, namely at low levels of beeswax and essential oil, or at high concentrations of beeswax and essential oil.

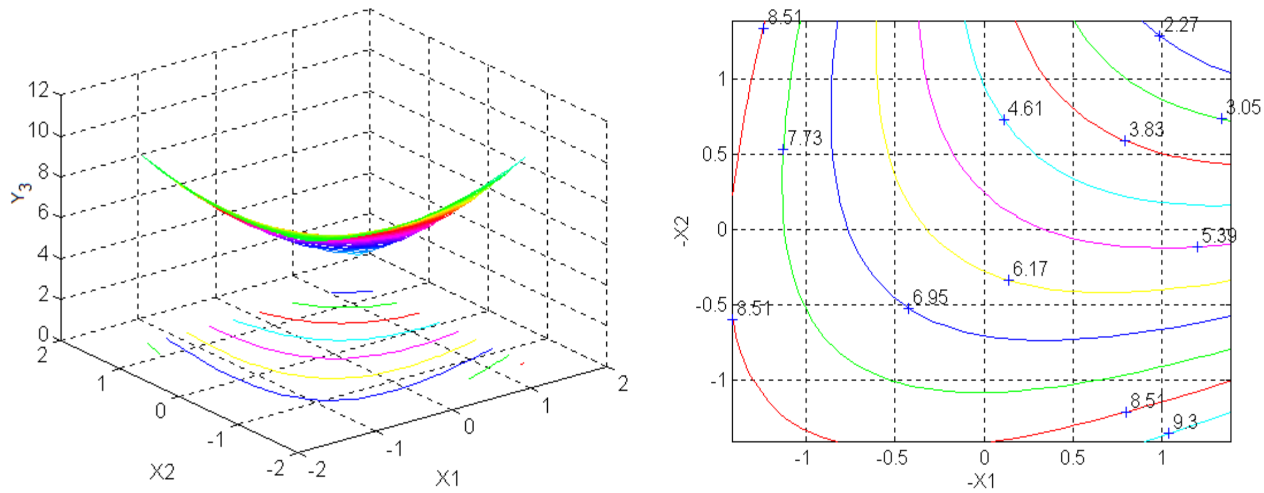


a. Response surface b. Curves of constant level

Figure 2: The influence of the independent variables X_1 and X_2 on the water vapour permeability (Y_2)

Air permeability

The influence of independent variables on the air permeability is graphically presented in figures 3.a and 3.b. From figure 3.a it is noted that the air permeability decreases both with increasing of beeswax concentration as well as with the amount of essential oil. For a constant concentration of the essential oil, by increasing the wax content, the air permeability decreases. High air permeability values may be obtained either by using small amounts of beeswax and large amounts of essential oil or by using higher amounts of beeswax and small quantities of essential oil.



a. Response surface b. Curves of constant level

Figure 3: The influence of the independent variables X_1 and X_2 on the air permeability (Y_3)

3.2 Evaluation of antimicrobial activity

Based on the previously presented analyses, the optimum values for the independent parameters were determined:

X_1 - beeswax percentage in the composition of emulsion: 3%

X_2 - percentage of essential oil of sage: 26.6%.

The emulsion containing 26.6 % essential oil of sage, 3 % beeswax and 3.33% chitosan presents the higher stability in time and was used to treat the textile material by impregnation, squeezing and drying at room temperature. The antibacterial activity of the materials obtained by this treatment has been investigated against the gram positive bacteria (*Staphylococcus aureus* ATCC 29213) and gram negative bacteria (*Escherichia coli* ATCC 25922), both of them being recommended for agar diffusion assay.

The evaluation of antimicrobial effect consisted in measuring the inhibition zone created around the textile material sample which is directly proportional with the sensitivity of the reference bacterial stem. The more effective is the active substance from the essential oil, the more extended is the inhibition zone (where bacterial colonies cannot grow). The results obtained after evaluation the antimicrobial effect are presented in Table 4.

Table 4. The antimicrobial effect of emulsions containing essential oil of *Salvia Officinalys*.

Microorganisms	Zone of inhibition (mm)	
	Blank sample	Treated sample
Staphylococcus aureus ATCC-29213	10	16
Escherichia coli ATCC 25922	10	-

The obtained results showed that the materials treated with the studied emulsions exert only a moderate bacteriostatic activity (16 mm) against the gram positive bacteria *Staphylococcus aureus* ATCC 29213. The specialized literature confirms the sensitivity of these gram positive bacteria to the active principles from some essential oils, as compared to the gram negative ones [12-13].

CONCLUSIONS

The paper presents an attempt to optimization of the emulsions obtained from essential oil of sage and beeswax/chitosan intended for the treatment of cellulosic fabrics in order to improve their antimicrobial properties.

The comfort parameters of treated materials are highly important when studying the bandages and dressings, therefore following comfort indices were evaluated: the hygroscopicity, the water vapour permeability and the air permeability.
The values of comfort indices for the treated samples are influenced by the amount of essential oil of sage and by the amount of beeswax contained in the emulsions. By increasing the amount of beeswax and essential oil, increases the permeability to water vapour. Regarding the air permeability, it diminishes with the increase of beeswax content, but is not significantly influenced by the concentration of essential oil.

Regarding the antimicrobial activity, from the obtained results one can notice that the treated materials do not show antibacterial activity against *Escherichia coli* ATCC 25922, but exert a moderate sensitivity against *Staphylococcus aureus* ATCC 29213.

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KERATIN HYDROLYZATE AS A FOAMING AUXILIARY FOR TEXTILE DYEING PROCESS

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Keratins are fibrous proteins which are the main constituent of wool fibres. Keratins are abundantly available in nature and also available as by-product from wool industries, horn and hooves from slaughterhouse, feathers from poultry, animal hair from tanneries. Keratin, due to its natural abundance, has found various applications–such as insulation pads, animal feed, chelating agents etc. Proteins are similar to the amphiphilic synthetic surfactants, because they are composed of both hydrophobic and hydrophilic amino acids that afford them a certain degree of surface activity. The purpose of this work is to understand the impact of alkaline hydrolysis on the foaming behavior of keratin hydrolysates, in relation with their applications in textile dyeing. The effect of hydrolysis temperature and the concentration of alkali were investigated. Superheated water alkaline hydrolysis was carried out in small lab scale rector at temperatures of 130-180 °C, with a material liquor ratio of 1:15, for 1 h, to achieve complete solublization of wool in water. The hydrolysis parameters were optimized using response surface methodology. The keratin hydrolysate obtained after the hydrolytic treatment consist of polypeptide chains of variable length, which are natural oligomeric surfactants, and can be applied as potential textile auxiliary and can be used as effective foaming agent in textile foam dyeing process. In the investigated variant, hydrolysis is an ecofriendly process in terms of conservation of water, chemicals, and less load on waste water treatments. Keratin hydrolysates are easily biodegradable, and the foam dyeing technology is less adds on technology, resulting in saving of large amounts of water and energy.

Keywords: *wool fibres, keratin hydrolysates, foam dyeing, saving water.*

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SELECTIVE STUDY ON DEGREE OF ACCEPTANCE AND POTENTIAL OF AROMATHERAPEUTIC TEXTILES

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Abstract: *Internationally the concept of functional materials is well developed, it is a target for Research and Development in universities, research centers as well as in textile companies. In literature there are many examples of materials with advanced functionality, all references are to approximately 12 areas of technical articles (agriculture, construction, protection, textile, medicine, industry etc.). A thorough study of the existing literature suggests that functional materials is an open area and the possibilities to development are endless. Given that the textile industry suffers from replacement lohn system with a system based solely on market requirements and competition, functional materials is a possible alternative to traditional production, which could open up new market niches both at the national and international level.*
Among multifunctional textiles, aromatherapeutic textiles occupy a significant role. This marketing research aims to test the acceptability and potential of aromatherapeutic products.

Keywords: *Aromatherapeutic textiles, market survey, purchase frequency, the criteria of choice.*

INTRODUCTION

The new development in textile materials is focused on the promotion of environmental and health aspects. Besides protection effects, multifunctional textiles shows healthcare effect [1]. The enhancement of textile materials performances according to the consumers' demands includes a higher added value [2]. Essential oils have been used widely in many fields such as the tobacco, food, medicine, textile, leather, papermaking, cosmetics etc., due to their antibacterial, sedative or relaxing effect. In the last years textile finishing with essential oils is an important commercial target [3-7].

This marketing research aims to test the acceptability and potential of aromatherapeutic products such as bandages with anti-acne toning, anti-cellulite and anti-stress effect.
Objectives of the study is to determine purchase intent of aromatherapeutic products, determining the purchase frequency of natural products, identification of criteria for the selection of aromatherapy products, identifying preferences toward a certain type of products, assessing the amount that potential consumers are willing to spend to purchase a natural products. This research aims to analyze the frequency for each studied variable. Research variables used in this study are attitude towards natural products, frequency of purchase, advantages of using, usefulness of natural products, the selection criteria, profile selection, the promotion degree, natural product items, preferences profile, price, gender, age, occupation, income, rural or urban area.

RESEARCH METHODOLOGY

Rational approach used to reach the objective proposed is to use as a method of quantitative research - survey. As a methodological tool in achieving survey a questionnaire was used. The questionnaire comprises 15 questions. This will help determine purchase intent of aromatherapeutic products. Advantage supporting the effectiveness of the method chosen is the possibility of a rigorous control of the data collection process.
Sampling was determined using simple random sampling method, each individual (over 18 years), being able to be sampled. There was no restriction imposed prior, outside of the people surveyed have over 18 years, whereas there is a greater ability to understand the questionnaire. The method allows to obtain a sample that tends to have a distribution of studied characteristics similar to that existing in the community. Survey results were processed using SPSS 18 program [8].

INVESTIGATED GROUP

Investigated group includs 27% men and 73% women. Most of them have higher education and come from urban environment.

RESULTS AND DISCUSSION

To carry out this study was used the calculation method of frequencies in percents.
Variable 1: *Attitude towards natural products*
The aim of this question was to find out the attitude of potential customers towards aromatherapeutic products and analyzing their responses. According to their responses, the most interviewed customers express their interest for such kind of products. As shown in figure 1, 99.3% of the group have a positive attitude towards the use of natural products and only 0.7% of them have a negative attitude.

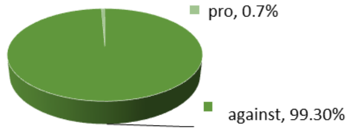

Figure 1: Attitude towards natural products

Variable 2: *Frequency of purchase*
The aim of this question was to know which is the purchase frequency of natural products and analyzing the results. As can see in figure 2, quite a few persons have no bought till now natural products, for various reasons (either unknown this market, either fear of being disappointed by such kind of products). Thus, 29.1% of the group, frequently buys natural products, 20.9% of the group buys rare this kind of products, 3.7% of them have never bought an aroma therapeutic product and 46.3% of interviewed persons have not bought till now, but are interested in such kind of products.

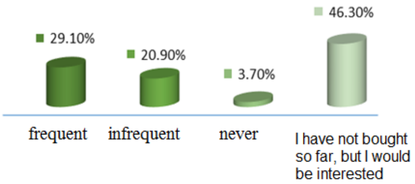

Figure 2: Frequency of purchase

Variable 3: *Advantages of using natural products*
By analyzing this variable the opinion of potential buyers on the benefits of using natural products was established, and based on the responses received was observed that most of the respondents (65.7%) believe that the use of natural products is less toxic to the body than synthesized products.

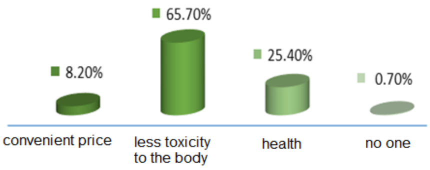

Figure 3: Advantages of using natural products

Variable 4: *Usefulness of natural products*
This question gives a view regarding the demand of the new product (aromatherapeutic products). As we can see, most of those interviewed expressed their interest in aromatherapeutic products.

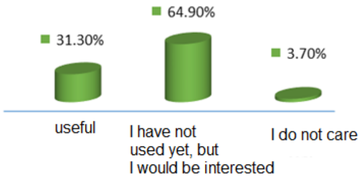

Figure 4: Usefulness of natural products

Variable 5: *The selection criteria*
This variable was used to determined what are the consumers criteria in terms of choosing a natural product and based on the responses received was observed that 63.9% of respondents choose quality as the selection criteria.

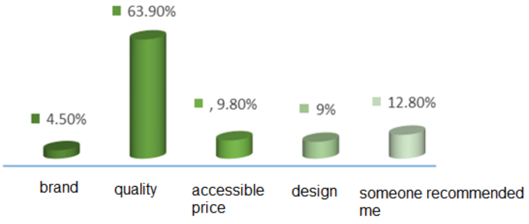

Figure 5: The selection criteria

Variable 6: *Selection profile*
The role of this question was to find out which is the order consumer preferences regarding four types of aromatherapeutic products: anti-acne, anti-stress, anti-cellulite and toning effect. According to the responses of the interviewees were found nine profiles:
Profile 1: price, quality, packaging, advertising
Profile 2: quality, advertising, price, packaging
Profile 3: quality, price, packaging, advertising
Profile 4: price, quality, advertising, packaging
Profile 5: quality, price, advertising, packaging
Profile 6: quality, advertising, packaging, price
Profile 7: price, packaging, quality, advertising
Profile 8: advertising, packaging, price, quality
Profile 9: quality, packaging, price, publicity
As can be seen, the data from Figure 6 shows that 48.9% of the interviewed persons chose profile 3.

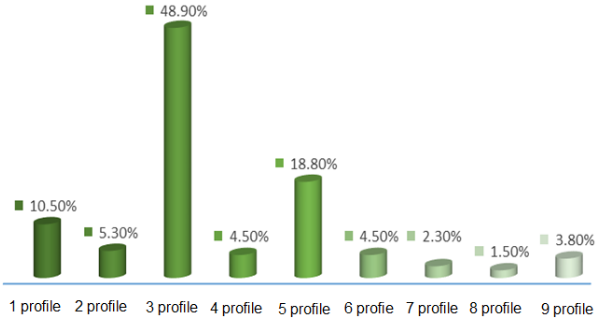

Figure 6: Selection profile

Variable 7: *The promotion of natural products*
The question gives information on the awareness of the population about the promotion of natural products on the Romanian market. 37% of them believe that natural products do not sufficiently promoted.

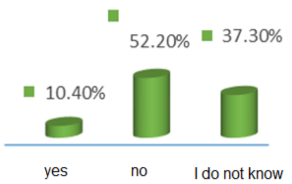

Figure 7: The promotion of natural products

Variable 8: *Referred type of aromatherapeutic product*
This variable was chosen to found out the wishes of individuals with regard to the type of aroma therapeutic products. Thus, in a proportion of 53.4% of those surveyed was expressed their interest for antistress bandages.

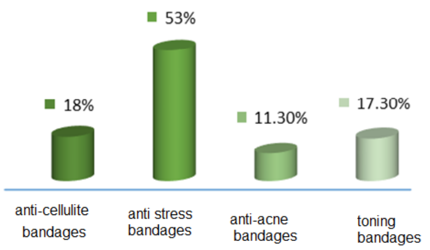

Figure 8: Preferred type of aromatherapeutic product

Variable 9: *Preference profiles*
The aim of this question was to find out which is the order of consumer preferences regarding the type of aromatherapeutic product. According to the responses of those surveyed were found 15 profiles of preference:
Profile 1: anti-stress, toning, anti-cellulite, anti-acne bandages
Profile 2: anti-acne, anti-stress, anti-cellulite, toning bandages
Profile 3: anti-stress, anti-acne, toning, anti-cellulite bandages
Profile 4: toning, anti-stress, anti-cellulite, anti-acne bandages
Profile 5: anti-acne, anti-celuitice, toning, anti-stress bandages
Profile 6: anti-cellulite, anti-stress, toning, anti-acne bandages
Profile 7: anti-stress, anti-cellulite, toning, anti-acne bandages
Profile 8: anti-cellulite, toning, anti-acne, anti-stress bandages
Profile 9: toning, anti-acne, anti-stress, anti-cellulite bandages
Profile 10: toning, anti-stress, anti-acne, anti-cellulite bandages
Profile 11: anti-acne, anti-stress, toning, anti-cellulite bandages
Profile 12: anti-acne, toning, anti-cellulite, anti-stress bandages
Profile 13: anti-acne, toning, anti-stress, anti-cellulite bandages
Profile 14 anti-cellulite, anti-acne, anti-stress, toning bandages
Profile 15: anti-stress, toning, anti-acne, anti-cellulite bandages
As can be seen, the data in Figure 9 show that most people have opted for profile 1 (27.8%), profile 6 (15%) and profile 3 (12%).

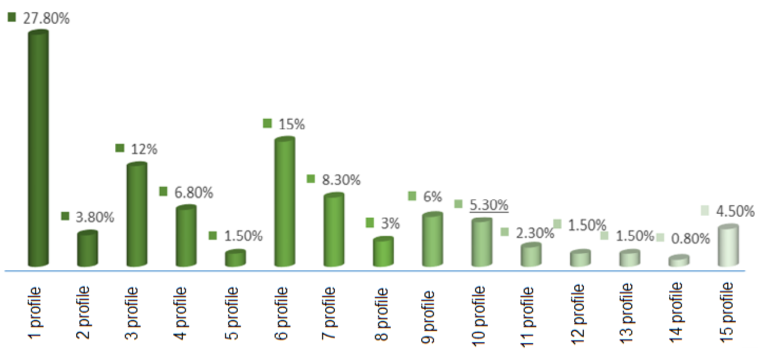

Figure 9: Preference profiles

Variable 10: *Price*
By analyzing this variable was determined amount that potential customers would be willing to spend to procure an aromatherapeutic product. Thus, 58% of those surveyed would be willing to pay between 10 and 50 RON for an aromatherapy bandage.

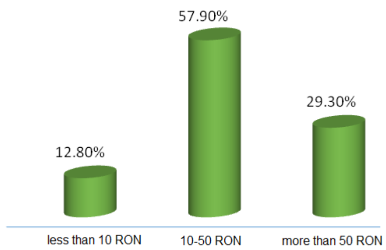

Figure 10: Price

Variable 11: *Gender*

From the results it is observed that the rate of 73.1% of the respondents are female, and the remaining 26.9% are male.

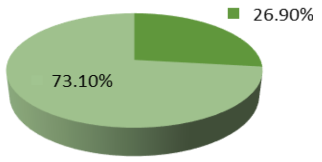

Figure 11: Gender

Variable 12: *Age*
By analyzing this variable was determined the age category of interviewees. Thus it can be seen that 36% of interviewees fall into the age category 26-35 years, 28% of them fall into the age category 18-25 years, 27% of interviewees fall into the age category 36-45 years and 9% of subjects fall into the age category of over 46 years.

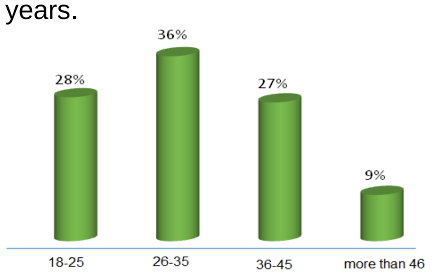

Figure 12: Age

Variable 13: *Occupation*
The aim of this question was to find interviewees occupation. Thus, 60.4% of the interviewees are with hight education.

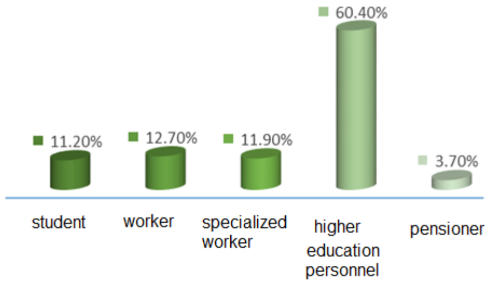

Figure 13: Occupation

Variable 14: *Income*
The results presented in Figure 14 shows that most interviewed people have an average income.

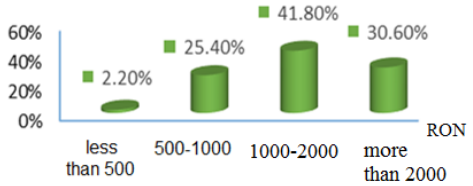

Figure 14: Income

Variable 15: *Income*
The results presented in Figure 15 shows that 97.8% of interviewed people are from urban area and 2.2% of them are from rural area.

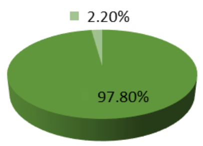

Figure 15: Urban or rural area

CONCLUSIONS

This study took into account a quantitative analysis based on questionnaire. The analysis was carried out by means of a number of 134 questionnaires, on a random sample, that provides a margin of error of 5% and a confidence interval of 95%.

The study shows that people are increasingly interested in natural cosmetic products, 99% of them stating that they are for this kind of products. Although natural products are not promoted enough, in the last years has seen a change in consumer preferences regarding this kind of products.

Even some of the subjects have never used natural products till now, they expressed their interest in recommended products (46%). From our study results that people are interested in what they are using for their body. The majority of respondents focus on the highest quality products (63.9%) and more less of them focus on the presentation of the product (9%). Of the 9 profiles identified by the analysis of the questionnaire, the biggest share has a profile selection no. 3: quality, price, packaging, and advertising.

In terms of the type of aromatherapy bandage, Romanians' preferences are turning to anti-stress effect bandages.

Results from this study have highlighted the following significant aspects:
- Affordability of natural products;
- high confidence in natural products;
- Romanians perceive a higher quality of natural products against chemically synthesized products.

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LINEAR COVER COEFFICIENT – THE MAIN INDICATOR IN THE EVALUATION OF THE FUNCTIONAL CHARACTERISTICS OF THE KNITTED FABRICS

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Abstract: *The evaluation of the quality of products in general and particularly knitted fabrics starts with determining their most important quality characteristics as an initial step in the multi criteria analysis used to establish the optimum ratio between the requirements of the users and the product's quality.*
The behaviour of the knitted products during use is essential for the users, the characteristics related to functionality being important for the quality evaluation and the decision for their acquisition. The producers are the ones that must ensure products with the required characteristics by controlling the production process.
The cover coefficients connect the structure of the knitted fabric (stitch length, the stitch surface or volume) to the characteristics of the yarn (yarn diameter, the volume of the yarn in the stitch). These parameters can be used to evaluate the behaviour during use related to comfort – fabric compactness, air permeability and thermal insulation.
The paper presents a methodology to determine the variation intervals of the linear cover coefficient for a group of double jersey fabrics produced of cotton yarns of different counts. The method allows a quick estimation of this coefficient that indicates the fabric compactness and the fabric functionality. This way it is possible to control the quality of the technological process and the quality of the final product.

Keywords: *knitted fabrics, quality, functionality, structural coefficients.*

INTRODUCTION

Knitwear has the largest industrial use being intended primarily for clothing products for all wearers and seasons (warm, cold and transitional seasons). In order to obtain the specific properties, according with the product's use, it is possible to control the fabrication process by choosing the raw material characteristics, the structure and structure 'parameters and finalizing process.

The design, redesign and assessment of the knitwear quality is usually done through simple parameters (A – the step of the loop, B – the height of the loop, C – the density factor, l_o – loop thread length), which, although important, do not allow the assessment of some functionality factors [4].

Unlike these, the covering and filling factors, make the connection between the structural elements of the knitwear (loop thread length, loop thread surface or volume) and the thread characteristics (thread diameter, lateral loop area projection in knitwear plane or loop thread volume) thereby determining the characteristics manifested during knitwear use (air permeability, thermal isolation, UV protection capacity).

On these considerations this paper proposes a method for estimating quickly and correctly the values of the most important indicator that highlights the degree of compactness of the fabric. On this basis we can control the quality of the technological process and quality of the fabric obtained.

The main complex coefficients of the structural parameters that influence the properties and the behaviour of knitted products during use, their calculus relations and some of their characteristics are shown in Table 1 [2, 3].

Table 1: Complex coefficients of structural parameters

Coefficient	Calculus relation	Characteristics
Density coefficient C	$C = \frac{Do}{Dv} = \frac{B}{A}$	Density coefficient gives an indication of the degree of compactness of the fabric. The coefficient varies in certain intervals with values for each type of bonding.
Linear cover coefficient δ_l	$\delta_l = \frac{l_o}{F}$	Linear coverage coefficient δl varies within certain limits, depending on the type of bonding. Values towards the lower limit mean high surface density (low values of the stitch width and height, so a **higher compactness**) and those placed by the upper limit refer to low surface density. Its values significantly influence dimensional stability and resistance to various strains of the knitwear.
Kover factor K	$K = \frac{\sqrt{T_{tex}}}{l_o}$	The Kover factor [$tex^{1/2}$/mm] is in opposition to the linear coverage factor δ_l. When the compactness degree increases (l – lowers and/or F increases), linear coverage factor lowers and Kover factor increases.
Area covering factor δ_s	$\delta_s = \frac{A \cdot B}{l_o \cdot F}$	Area covering factor δ_s expresses the surface coverage ratio and by default the air permeability.
Filling factor δ_v	$\delta_v = \frac{\pi \cdot F^2 \cdot l_o}{4 \cdot A \cdot B \cdot g_t}$	Filling factor δ_v is the expression of filling capacity. Through it the thermal insulation capacity can be appreciated. The closer to unity the coefficient vales are, the compactness and thermal insulation capacity of the fabric are higher.

Note: The calculus formula for the area covering factor requires corrections for each type of bonding, which is why it is not subject of this paper.

DETERMINATION OF TECHINCALLY ADMISSIBLE VARIATION INTERVALS FOR LOOP THREAD LENGHT AND LINEAR COVERAGE COEFFICIENT

The technically admitted variation intervals represent the fields (intervals) corresponding to statistical populations (characterized by type random variability), which include the majority of values of some process parameters.

To determine these intervals, it is necessary to know the technical characteristics of knitting machines and their mechanisms construction. [1].

Based on previous research carried out on threads, double jersey structures and Metin machines, the determination of technically admitted variation intervals was possible, experimentally finding:

- the variation intervals of the thread feeding belt speed;
- the efficiency ratio of the feeding belt speed in the thread feeding speed;
- variation intervals of consumption length (Lc) by measuring this control parameter using the WESCO apparatus;
- variation intervals of loop thread l_o for double jersey structures 1:1 and 2:2, realized on Metin machines.

Consumption length is a special parameter because it serves to:

- ➢ Calculate the loop thread length with the relation:

$$lo = \frac{Lc \cdot 10}{Na} \quad \text{[mm]} \tag{1}$$

where Na – represents the number of working needles in between the two frames;

- ➢ Determining and installing other technological parameters of the knitting process;
- ➢ Identical control and tuning of the knitting systems;
- ➢ Reproduction of mass knitwear without doing the redesign calculus, etc. [2].

The technically admitted variation intervals determined experimentally for consumption length Lc and loop thread length lo, on Metin machines knitting double jersey structures 1: 1 and 2: 2 from cotton yarns of different counts, are shown in tables 2, 3. Also calculated at the same time were the variation intervals for the linear cover coefficient δl.
It is noted that the thread diameter of each count was measured by experiment.

Table 2: Technically admissible variation intervals for double jersey structures 1:1

<table>
<tr><th rowspan="2">Thread count/ measured thread diameter</th><th colspan="2">Variation interval for consumption length Lc</th><th colspan="2">Variation interval for loop thread length l_o</th><th colspan="2">Variation interval for linear cover coefficient δ_l</th></tr>
<tr><th>Lc min</th><th>Lc max</th><th>l_o min</th><th>l_o max</th><th>δ_l min</th><th>δ_l max</th></tr>
<tr><td>Nm 34/1
F = 0,247</td><td rowspan="4">669,36</td><td rowspan="4">1259,98</td><td rowspan="4">1,74</td><td rowspan="4">3,28</td><td>7,045</td><td>13,279</td></tr>
<tr><td>Nm 40/1
F = 0,234</td><td>7,436</td><td>14,017</td></tr>
<tr><td>Nm 50/1
F = 0,214</td><td>8,131</td><td>15,327</td></tr>
<tr><td>Nm 60/1
F = 0,164</td><td>10,610</td><td>20,000</td></tr>
</table>

Table 3: Technically admissible variation intervals for double jersey structures 2:2

<table>
<tr><th rowspan="2">Thread count/ thread diameter</th><th colspan="2">Variation interval for consumption length Lc</th><th colspan="2">Variation interval for loop thread length l_o</th><th colspan="2">Variation interval for linear cover coefficient δ_l</th></tr>
<tr><th>Lc min</th><th>Lc max</th><th>l_o min</th><th>l_o max</th><th>δ_l min</th><th>δ_l max</th></tr>
<tr><td>Nm 34/1
F = 0,247</td><td rowspan="4">669,36</td><td rowspan="4">1259,98</td><td rowspan="4">2,61</td><td rowspan="4">4,92</td><td>10,566</td><td>19,920</td></tr>
<tr><td>Nm 40/1
F = 0,234</td><td>11,154</td><td>21,026</td></tr>
<tr><td>Nm 50/1
F = 0,214</td><td>12,126</td><td>22,991</td></tr>
<tr><td>Nm 60/1
F = 0,164</td><td>15,914</td><td>30,000</td></tr>
</table>

DETERMINATION OF THE REAL VARIATION INTERVALS OF LOOP THREAD LENGHT AND LINEAR COVERAGE COEFFICIENT

Taking into account the destination of the analyzed knitted (apparel products for the hot season) measurements were conducted on a large number of knitwear double jersey structures 1:1 or 2:2, made from cotton yarns of different counts on universal Metin machines, so that it was possible to determine the real variation intervals of loop thread length as well as linear cover coefficient. These are shown in Table 4 and 5 respectively.

Table 4: Real variation intervals of loop thread length and linear cover coefficient on double jersey structures 1:1

<table>
<tr><th rowspan="2">Thread count/ thread diameter</th><th colspan="2">Variation interval for loop thread length l_o</th><th colspan="2">Variation interval for linear cover coefficient δ_l</th></tr>
<tr><th>l_o min</th><th>l_o max</th><th>δ_l min</th><th>δ_l max</th></tr>
<tr><td>Nm 40/1
F = 0,234</td><td>2,801</td><td>3,040</td><td>11,97</td><td>12,99</td></tr>
<tr><td>Nm 50/1
F = 0,214</td><td>3,007</td><td>3,268</td><td>14,05</td><td>15,27</td></tr>
</table>

Nm 60/1 F = 0,164	2,836	2,967	17,29	18,09

Table 5: Real variation intervals of loop thread length and linear cover coefficient on double jersey structures 2:2

Thread count / thread diameter Nm/F	Variation interval for loop thread length l_o		Variation interval for linear cover coefficient δ_l	
	l_o min	l_o max	δ_l min	δ_l max
Nm 34/1 F = 0,247	3,661	3,903	14,82	15,80
Nm 40/1 0,234	**3,201**	**3,721**	**13,68**	**15,90**
Nm 50/1 F = 0,214	3,409	3,507	15,93	16,39

By comparing the real variation intervals of loop thread length and of the linear cover coefficient, determined from the analyzed double jersey structures, with the technically admitted variation intervals, the following **conclusions** can be drawn:

In the case of double jersey structures 1:1

- ✓ For all thread counts, the variation intervals of loop thread length and cover coefficient are situated in the technically admitted ranges;
- ✓ Both of the variation intervals for loop thread length and cover coefficient, on knitted realized from yarns of 40/1 and 60/1 counts respectively, are situated near the central right of the technically admitted field;
- ✓ In the case of knitted with 50/1 count threads, the variation intervals of loop thread length and cover coefficient come very close to the superior limit of the admitted field almost touching this limit.

In the case of double jersey structures 2:2

- ♦ For knitwear realized with Nm 34/1 count yarns, both the variations for loop thread length and cover coefficient are placed near the centre of the technically admitted field;
- ♦ For the Nm 40/1 and 50/1 counts knitted, the variation intervals of loop thread length and cover coefficient are placed near the left centre of technically admitted field.

DETERMINATION OF STRUCTURAL PARAMETERS AND COMPLEX COEFFICIENTS

In order to verify the established findings and to determine all structural parameters, there were realized and analyzed three variants of double jersey structures made of 100 % cotton yarns of Nm 40/1 count.
The knitwear was made on universal Metin machines with the following technical characteristics: D = 30"", K = 20 E, S = 60, Na = 2x1920 for double jersey 1:1 and Na = 2x1280 for double jersey structure 2:2 respectively. The results obtained are shown in Tables 6 and 7.

Table 6: Structural parameters for three knitted variants double jersey 1:1

Measured parameter	Measuring unit	Knitted variants		
		V1	V2	V3
Measured structural parameters				
Lc (on machine)	cm	1040	1070	1100
l_o (on knitted)	mm	2,85	2,92	3,00
Columns density Dc	c50cm	52	52	52
Rows density Dr	r/50cm	75	74	72
Mass M	g/m^2	227	223	215

Measured parameter	Measuring unit	Knitted variants		
		V1	V2	V3
Thickness g_t	mm	1.081	1.075	1.068
Complex calculated parameters and coefficients				
Loop step A	mm	0.962	0.962	0.962
Loop height B	mm	0.667	0.676	0.694
Density coefficient C	-	0.693	0.703	0.722
Linear cover coefficient δ_l	-	12.179	12.479	12.821
Kover factor K	$tex^{1/2}/mm$	1.752	1.710	1.665
Filling factor δ_v	-	0.177	0.180	0.181

Table 7: Structural parameters for three knitted variant double jersey 2:2

Measured parameter	Measuring unit	Knitted variants		
		V1	V2	V3
Measured structural parameters				
Lc (on machine)	cm	909	820	800
l_o (on knitted)	mm	3.70	3.31	3.23
Columns density Dc	c/50cm	58	58	58
Rows density Dr	r/50cm	57	70	75
Mass M	g/m^2	193	213	224
Thickness g_t	mm	1.493	1.511	1.534
Complex calculated parameters and coefficients				
Loop step A	mm	0.862	0.862	0.862
Loop height B	mm	0.877	0.714	0.666
Density coefficient C	-	1.02	0.828	0.773
Linear cover coefficient δ_l	-	15.120	14.145	13.803
Kover factor K	$tex^{1/2}/mm$	1.349	1.508	1.545
Filling factor δ_v	-	0.141	0.153	0.158

By comparing linear cover coefficient values, determined from the double jersey structure variants analyzed, with the real variation intervals of the same parameter, the following **conclusions** can be drawn:

In the case of double jersey structures 1:1

- ✓ on all knitted variants the linear cover coefficient is situated in the real variation intervals of the analyzed parameter, around the centre Tc = 12,48;
- ✓ even if the linear cover coefficient values are close, the lowest of these is on the V1 variant, which indicates a higher compactness of the knitted and a better thermal isolation capacity. These conclusions are also sustained by the values of the other coefficients (C, K, δ_v).

In the case of double jersey structures 2:2

- ✓ on all knitted variants the linear cover coefficient is situated in the real variation intervals of the analyzed parameter;
- ✓ the lowest value of the linear cover coefficient was obtained on variant V3 (higher compactness), and the highest value on variant V1 (lower compactness, higher air permeability).

According to the destination in the knitted products realised and the requests of the beneficiary, a variant of preffered knitted can be chosen, or certain values can be established for these variable parameters.

CONCLUSIONS

Linear cover coefficient is considered the main indicator of quality that allows appreciating the behaviour of the knitted during their use (by the degree of compactness and permeability).

Although the presented method to establish the variation intervals of this coefficient is rather laborious, it allows the acquiring of accurate and precise data that can be accessed anytime in order to compare it to the results obtained at a precise time. Through this data, conclusions can be drawn on the behaviour of knitted products in use, or decisions can be made by conducting the knitting processes to ensure the quality characteristics predetermined by the beneficiary.

The method can be extended to other groups of structures, realized on different types of knitting machines, provided accurate knowledge of the technical characteristics and built of the mechanical components, as well as correct measurements of all variable elements.

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WORKPLACES ERGONOMY FOR PEOPLE WITH DISABILITIES

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Abstract: *The phisical, sensory and mental faculties vary from one person to another. Some diferences can be deepened with age or/and social condition, can be from birth or as a result of accidents or deseeas. At young population level, there are special schools for people with disabilities, based on an adequate educational and therapeutic rehabilitation process. In the ready made cloth field, in order to increase the efficiency of the practical activity of those pupils, the quality of the workplace design consists mainly of the maximisation of the interface operator – machine.*
The papers objectives is ergonomic configuration of the workplace, corelated with the anathomic particularities of the users.
The case study was made in a ready made cloth school workshop for people with disabilities.
The case study in the paper emphasize the fact that small investments can significantly facilitate pupils' activity and increase the level of work security.

Keywords: *disability, sewing, workplace configuration*

INTRODUCTION

The phisical, sensory and mental faculties vary from one person to another. Some diferences can be deepened with age or/and social condition, can be from birth or as a result of accidents or deseeas.
The persons can be with different types of disabilities, according to the duration:
a. persons with permanent disability (Figure 1);
b. persons during the recovery period, after an accident;

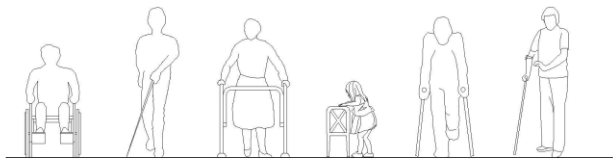


Figure 1. Persons with temporary or permanent disability

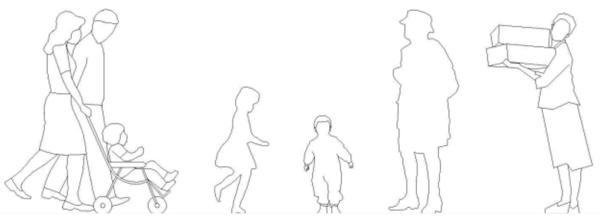


Figure 2. Disability correlated with the physical or social environment or with the situation

c. persons with special conditions– pregnant women, people caring children in baby strollers, or people caring objects (Figure 2).

On theoretic level a great number of companies are acknowledge the fact that the expenses for health and security at the workplace are money well spent. They realize that the social cost of the work incapacity is translated in a cost of the national economy and an immobilized worker is a burden for the community. To invest in the work place design, especially to adapt the workplaces and/or supply special equipment, etc., in many cases, does not signify to transform these people in assisted persons.

At young population level, there are special schools for people with disabilities, based on an adequate educational and therapeutic rehabilitation process.

In the clothing field, in order to answer to the particularities of this industry (mostly manual-mecanical work, the strong dependence between the operations of the technological process, the high importance of the human factor in the products' final quality), it is necessary for the pupils to know the activity from the point of view of the work method, place in the process and the necessary technical endowment.

EXPERIMENTAL

In the ready made cloth field, in order to increase the efficiency of the practical activity of those pupils, the quality of the workplace design consists mainly of the maximisation of the interface operator – machine. This is very important for maintaining the health, already affected, of those young pupils.

In this way there can be used two ways of designing the work places for persons with disabilities [1]:

- ✓ Work place configuration similar with the one for the persons anthropometricaly normal,
- ✓ Dedicated or coustomised configuration, for persons with severe handicap, destinated only for one person or for a small group of persons.

Using one of these methods is influenced esspecialy by the age when the handicap occured. A person, an accident victim at adult age, will not be significantly different, on antropological level, from a healthy person.

This fact will allowed that the person with disability will be considered in the group of workers anthropometricaly normal. On the other hand, a small child, an accident victim, will very likely have an antropological development very different from a normal person.

The work places design, from the ergonomical point of view, follows the one or more steps:

- ✓ Changing the workload by spliting the work load in smaller work loads, easier to handle;
- ✓ Changing the working tools;
- ✓ Compensating the pupil incapacity with suplimentary ergonomic endowment or with help from other people;
- ✓ Designing coustomised working tools.

The efficiency of these measures depends on technical aspects and functional changes that will be integrated in the new configuration [2].

The papers objectives are:

- The selection of the workplaces in which the pupils can have long time efficacy, using their capabilities, so that they will be able to earn their living with this job,

Ergonomic configuration of the workplace, corelated with the anathomic particularities of the users.
The case study was made in a ready-made cloth school workshop for people with disabilities. The pupils of one classroom with combined deficiencies were studied.

The methodology used in the paper consists in:

1. establishing the load of the human body at every work place from the workshop. Knowing these specific profesional factors is of high importance for finding the best corelation between the pupils' personal simptomatology and the profesional factors (generated by the workload type, the working environment and the workplace configuration).
2. To corelate the work tasks of every pupil with his health, the posibility to work at alternative or dedicated workplaces (for pupils with severe disbilities).
3. Re-configuration of the workplaces, according with the antropometric dimensions of the pupils. The reconfiguration is based on the standard SR EN ISO 14738: Machine Security. Antropometric requirements for designing the work position at the machines

The pupils from the studied classroom were splited in the following groups:

- Pupils with mobility deficiency (subject 1 doesn't have one arm, caused by an accident when he was a teenager, subject 2 has diabet, with a supurated plague at one leg), without mental problems,
- Pupils with vision problems, associated with mild mental problems (subject 3 and subject 4),
- One pupil (subject 5) with uneven legs, without mental problems,
- One pupil (subject 6), psihically normal, with mental problems regarding movements coordination,
- One pupil (subject 7) in wheel chair.

Design constraints, based on the colected data, were treated for the same reason and according with the same data as for the healthy subjects.

The methodology used in the paper consists in acquiring the following data:

- ✓ Pupils' anthropometric profile,
- ✓ Biomechanical data (moving range, phisical load etc.),
- ✓ Ergonomical measures that can be applied at the existent workplaces,
- ✓ Identification of the safety measures for every workplace.

RESULTS

For this purpose:
a) All the pupils were measured and their anthropometric profile was made, using the sizes necessary for the sewing workplace configuration (table 1):

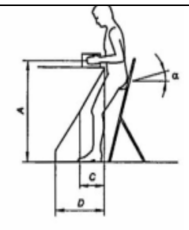
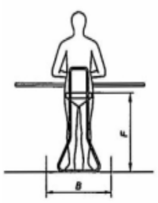
Table 1: Anthropometrical dimensions of studied pupils (sequence)

Anthropometrical dimensions	Sizes subject 1 (cm)	Sizes subject 2 (cm)
1. Leg length	53	48
2. Body height, standing	168	150

b) Work tasks were alocated, corelated with the subjects' wealth, as follow:
   1. For the pupils with movement problems, without mental problems, the ergonomical configuration was made according with pupils' typodimensions, also using the rotation principle for compensating the movement problems. The lockstitch and the overlock machine were alocated to these pupils.
   2. For the pupils with vision problems, associated with mild mental problems, the ergonomical configuration took into account the sight limitation and there qwere used sewing machines with low speed, according with their phisical capabilities,
   3. For one pupil with uneven legs (subject 5), without mental problems, the workplace is orthostatic, with support on the gluteal region,
   4. For one pupil phisicaly normal, with mental problems regarding movements coordination (subject 6), a coustomed workplace was designed, for chalk signing, in orthostatic position,
   5. For one pupil in wheel chair (subject 7) a coustomed workplace was designed, according with the anathomical particularities of this pupil and the limitations imposed by the wheel chair.

c) At re-configuration of the workplaces, the most complex case was for the pupils with alternating positions at two different sewing machines (lockstitcher and overlock), where, for a proper configuration:
   - initially the two pupils' dimensions were compared,
   - „enough" dimensions (centile 5) and „fitting" dimensions (centile 95) were selected for the specific work place,
   - the necessary data were introduced in the calculus tables from SR EN ISO 14738, for sitting position (table 2) [3].

Table 2. Orthostatic position, with middle support for subject 5 (sequence)

Position	Code	Value (cm)	Value Significance
 	A B	1,3x88=114,4 27+35=62	Working height: A= k.h_4(P95) k = 1,1 ÷ 1.3, according with visual acuity. h_4=elbow heigh Space widh for legs: B=$a_{1\gamma}$(P95)+y $a_{1\gamma}$=widhbetween hips y=350mm, for legs movement

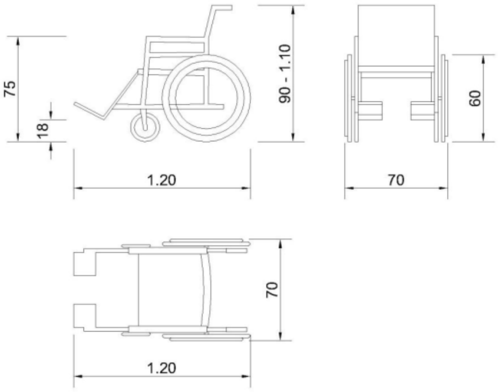


Figure 3. Wheel chair size

The same procedure was applied for all the other groups of pupils. For the coustomed workplace (subject 7) the wheel chair dimensions were considered. The usual wheel chair dimensions are presented in Figure 3.

Subject 7 has also major physical problems and has limited access to the most sewing machines from the workshop. As the aim is mostly occupational therapy, the customized workplace has a working table situated at elbow level. The scissors is light (150 g) for reducing the hands stress and it is not very well sharpened.

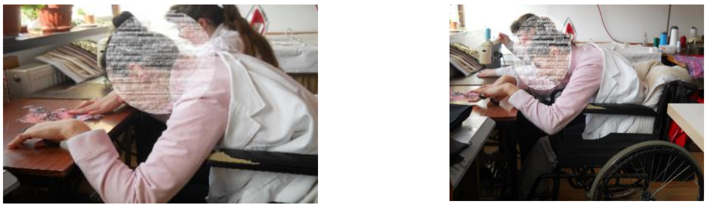


Figure 4. Dedicated work place, for pupil in wheel chair

CONCLUSIONS

The case study in the paper emphasize the fact that small investments (foot stands, chairs for alternate positions, form other workroom, wood pieces etc.) can significantly facilitate pupils' activity and increase the level of work security. For example, for the first group, as the pupils are working altenatively on both machines:

- comparring with the ssewing machine's table of 71cm and the overlock machine's table of 73.5cm, the lockstitcher must be raised with 3 cm.
- the machines should have feet support, with adjustable height, between 0 cm, for subject 1 and 4 cm, for subject 2.

The procedure presented in the paper can be enlarged to other fields, according with the anthropometric particularities and the specific symptomatology.

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WORK METHODS FOR THE SEWING MACHINE FOR PRODUCTS WITH SPECIAL DESTINATION

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Abstract: *Being part of the European Union implies for the garment manufacturers a new set of restrictions, more and more complex, aiming also the security of the customer's life. Based on the hypothesis that in specific conditions of the protective equipments, the work methods design must be rationalized, considering the impact of the product's manufacturing over life security and execution time in strict limits. Paper's aim is to analyze different solutions for the sewing operations for equipments designed to carry grenades or radio stations. The case study was made in a clothing company, with the particularity that, for increasing work responsibility, one operator is responsible for all the operations for a product.*
Implementing the optimum work method at the production system level will result in decreasing the time for the order, in 100% quality conditions.
The improvement solutions, once implemented, lead to automatism at sewing sequences.

Keywords: *protective equipments, work method, sewing.*

INTRODUCTION

Being part of the European Union implies for the garment manufacturers a new set of restrictions, more and more complex, aiming not only the physical elements of the garments but also the security of the customer's life. Approaching these European problems constitutes for the manufacturers a system of objectives, priorities and instruments, their applicability being a problem of know how transfer, industrial culture and financial resources.
One of the fields that imply the use of these proceedings is constitute by the products for equipments designed to carry grenades or radio stations (figure 1).

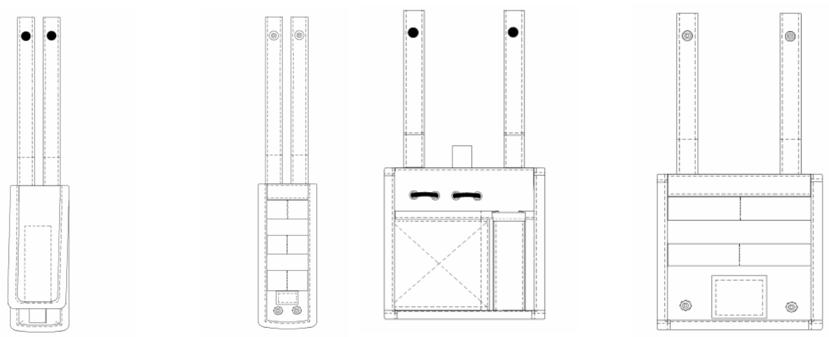


Figure 1. Equipment for caring grenades or radio stations

From the conceptual point of view this type of products must answer the standard functions set, the differences being in their percentage in the products utility. So, there are important: safety using, functionality and not at last the esthetic function [1].
Satisfying the specific functions implies solutions for some technical complex problems, from the designing stage, as following:

- Establishing the proceedings for standard using, for all the customers;
- Selecting the raw materials according to the requests, such as: proper behavior at the physical mechanical, stress in using process, superior hygiene characteristics, easy maintenance, attractive color;
- Selecting the auxiliary materials: tapes, buckles, snaps, Velcro etc. on different criteria as for the clothing products. So, if at the classical products the option is based mainly on the price and aspect, at the products for babies transport the main function is the life security;

- The peculiar technical solutions for some of the products functions, materialized by the patterns and technological design.

From technical point of view, the following aspects are important:

- technologies with a high degree of interdependence, with well established following preceding: for example manufacturing group z is preceded by group y, and its development is conditioned by manufacturing group x;
- intensive technologies, involving a large number of equipment and methods (established by a decisional process) for every type of product, the combination between these being correlated with the type of the intelligent function (like visibility, communication, sealing) .

From the optional criteria point of view, the technologies can be:

- basic technologies, including the equipment and knowledge compulsory for a product or process, containing documentations, operation specifications, execution schemes, prototypes;
- unspecific technologies for a product or process, that are the same for every process or product, necessary for manufacturing activity or for knowledge generating (sub components execution plans).

For protective garments it is very important to know and respect these criteria, because of the complexity of this equipment functions and their "hybrid" structure. So, both the basic and unspecific technologies, can be traditionally or up to date. Based on the hypothesis that in technological design are always more than one variant for product manufacturing, the accent should be put from just drawing the technological processes to a rational approach, in strong connection with the destination. So, depending on the body area that must be protected, if its exposure to the risk factor varies on the body, the protective function has different dimensional levels and the functional structure of the constitutive elements of the product is different. The garment's functional elements are, at their level, composed of cut pieces, well defined by the characteristics of the raw materials and by their shape.

This paper analyzes the case of the classic technological solutions for grenade caring equipment. This paper's objective is to identify solutions for decreasing the time for these type of equipment production.

2. RESEARCH PATH

In order to solve the papers' objective, the following steps are followed:

1. General structure identification of the production system for the studied products (figure 2).

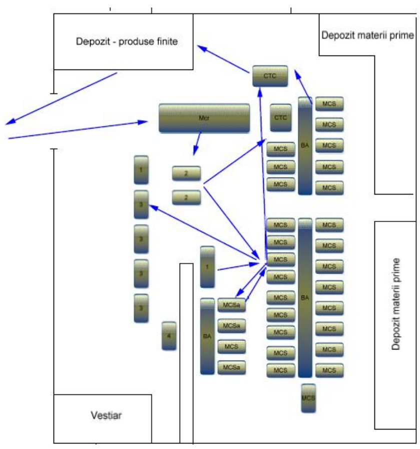
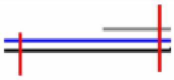


Figure 2. General structure of the production system for the studied products

2. sewing operations for the studied products (table1):

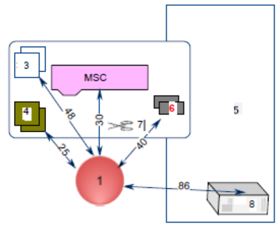
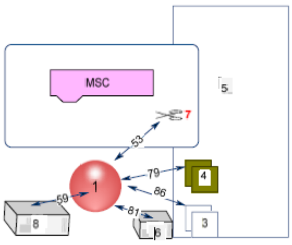
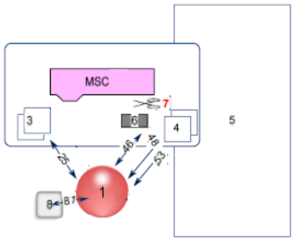
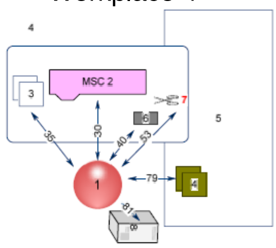
Table 1. Sewing operations considered (sequence)

No.	Operation	Picture	Sketch	Equipment	Time (min)
3	Run-stitch basic fabric with PVC cut pieces			Lockstitch sewing machine	9
4	Sew the Velcro on the basic fabric, at sign			Lockstitch sewing machine	3.5

3. The analyze of the selected sewing operations reveals the following:

- The operators execute all the operations for one product, in this way increasing the work responsibility, for 100% quality products,
- The time for the same operations varies from one operator to another (the timing is based on an average of the operation time, from 4 workers, the operators do not depend on the previous or next operation),
- The handling of the sewing parts is difficult, due to the stiffness of the materials, of different structures (PVC impregnated materials, supporting tapes, metallic rings, Velcro) and the different number of layers, leading to variation of the operational times for the same task.
- The frequent needle break affects the time rate, depending on the operator's handling ability (numerous back tacking at the beginning and end of the sewing line),
- Significant differences are at the picking up phase of the sewing operations. The analyzed work places are presented in table 2.

Table 2 Studied workplaced: configuration and picture for feeding sequence of the sewing operation

Workplace 1	Workplace 2	Workplace 3	Workplace 4
			
Workplaces configuration 1-operator, 2-lockstitch sewing machine, 3-basic fabric cut piece 4- PVC cut piece, 5- auxiliary table, 6 - VELCRO tape, 7–scissors, 8- finished pieces			
			
Pictures of the feeding sequence of the sewing operation			

4. Analyze and evaluation of the picking up and placing under the pressing foot of the cut piece of basic fabric and the cut piece of PVC material.
The analyze was made at four workplace.
The results (work method and MTM estimations) are presented in table [2].

Table 3 Analizing the feeding sequence of the sewing operation for 4 operators (work method and MTM estimations)

Operator 1:
Preparing the workplace:
Placing the cut pieces of basic fabric bundle on the right side of the machine table,
Placing the cut pieces of PVC material bundle on the right side of the machine table,
Placing the box with the Velcro tape on the right side
Placing some of the Velcro tapes on the right side, under the back tacking lever,
Placing the scissors on the machine table,
Placing the box for the finished pieces on the left side, near the chair.

Working method:
1.Pick the PVC cut piece with left hand. Place on the machine table, in the sewing area,
2. Pick the basic fabric cut piece with left hand. Place upon the PVC cut piece,
3. Check the cut pieces edges,
4. Place under the presser foot.

Estimation of the operational time using MTM method (for 5 pieces)

Basic Motions	MTM	TMU	t(min)
1.Reach the left hand, grab PVC cut piece, bring the left hand on the machine table, positioning PVC cut piece	(R25A G1A M25B P1SE)x5	111.5	0.067
2.Reach left hand, grab basic piece, move left hand on the machine table	(R48AG1A M48B)X 5	201.5	0.121
3.Positioning basic piece on the PVC piece, arrange the edges	(P2NSD M4C) X5	155.5	0.093
4.Positining the assambly under the presser foot	P2NSDX 5	133	0.0798
Total		601.5	0.3609

Operator 2:
Preparing the workplace:
Placing the cut pieces of basic fabric bundle on the right side, on the auxiliary table,
Placing the cut pieces of PVC material bundle on the right side, on the auxiliary table,
Placing the box with the Velcro tape on the right side, on the chair,
Placing the scissors on the machine table,
Placing the box for the finished pieces on the left side, near the chair.

Working method:
1. Pick the basic fabric cut piece with right hand from the auxiliary table,
2. Pick the PVC cut piece with left hand auxiliary table
3.Place the PVC cut piece on the basic fabric. Place on the machine table in the sewing area,
4.Check the overlapped cut pieces edges,
5. Place under the presser foot.

Estimation of the operational time using MTM method (for 5 pieces)

Basic Motions	MTM	TMU	t(min)
1.Reach right hand with body rotation and pieces visualisation, grab basic fabric piece, bring the right hand on the machine table, positioning the piece	R(80+6)A G1A M(80+ 6)B P1SE)X5	302.5	0.1815
2.Reach left hand, grab PVC cut piece, move left hand on the machine table	(R79A G1A M79C)X5	261	0.1566
3.Positioning basic piece on the PVC piece,	P2NSDX 5	133	0.0798
4.Arrange the edges	P2NSDX 5	133	0.0798
5.Positining the assambly under the presser foot	P2NSDX 5	133	0.0798
Total		962.5	0.5775

Operator 3:
Preparing the workplace:
Placing the cut pieces of basic fabric bundle on the left side of the machine table,
Placing the cut pieces of PVC material bundle on the right side of the machine table,
Placing the box with the Velcro tape on the right side, on a chair,
Placing some of the Velcro tapes on the right side,

Operator 4:
Preparing the workplace:
Placing the cut pieces of PVC material bundle on the right side, on the auxiliary table,
Placing the cut pieces of basic fabric bundle on the left side, on the machine table,
Placing the box with the Velcro tape on the right side, on the chair,
Placing some of the Velcro tapes on the right side,

under the back tacking lever,
Placing the scissors on right, on the machine table,
Placing the box for the finished pieces on the left side, near the chair.

Working method:
1.Grab the PVC cut piece with right hand from the machine table,
2.Placing the basic piece on the PVC piece,
3.Arrange the pieces edges. Placing the overlapped pieces on the left side of the machine table,
4.Grab the overlapped pieces,
5.Place under the presser foot.

Estimation of the operational time using MTM method (for 5 pieces)

Basic Motions	MTM	TMU	t(min)
1.Reach the right hand, grab PVC cut piece bundle, bring the right hand on the machine table with the PVC cut pieces bundle.	R48A G1A M48B P1SE	45,9	0,0275
2.Reach left hand with the PVC pieces bundle, grab PVC pieces bundle, arrange the PVC bundle in cascade, grab PVC piece with left hand.	R2A G1A P2SE	20,2	0.0121
3.Bring the PVC piece on the machine table, releace the PVC piece	(M2B RL1)X5	20	0.0012
4.Reach left hand to the machine table, grab basic fabric piece, bring and overlap with PVC piece.	(R25A G1A M25BP1SE)X5	139,5	0.0837
5.Grab the bundle with PVC and basic fabric pieces overlapped with both hands and arrange the bundle, rich the left hand with the bundle and place it on machine table, left side.	G1B P2NSD M25B P1SE	47,5	0.0285
6.Reach left hand, grab basic fabric and PVC pieces, bring to sewing area.	(R25A G1 M25B)X 5	111,5	0,0669
7. Positining the assambly under the presser foot.	P2NSDX 5	133	0.0798
Total		601,5	0,23609

under the back tacking lever,
Placing the scissors on the machine table,
Placing the box for the finished pieces on the right side, near the chair.

Working method:
1.Grab the PVC cut piece with right hand auxiliary table,
2.Grab the basic fabric cut piece with left hand,
3.Place the PVC cut piece on the basic fabric,
4.Check the overlapped cut pieces edges,
5.Place under the presser foot.

Estimation of the operational time using MTM method (for 5 pieces)

Basic Motions	MTM	TMU	t(min)
1.Reach right hand with body rotation and pieces visualisation, grab PVC piece, bring the right hand on the machine table.	(R79A G1A M79B P1SE)X5	255	0,153
2.Reach left hand to the basic fabric bundle, grab basic fabric cut piece, move left hand and posision it over the PVC piece.	(R35B G1A M35A P1SE)X5	180,5	0.1566
3.Arrange the edges of basic and PVC fabric cut pieces.	P2NSD	26.6	0.0159
4.Positining the assambly under the presser foot.	P2NSDX 5	133	0.0798
Total		595	0.3571

3. RESULTS

The study reveals the following:

a. After the MTM evaluation of the picking up the cut pieces and placing under the foot, at the four workplaces, it can be noticed that the operator from the workplace no.3 has the best method (minimum time). This method should be extrapolate to the entire operation and to all the 27 sewing machines from the sewing room.

b. Analyzing the feeding phase of the sewing operation of the basic fabric with the PVC material cut pieces, some other improving solutions can be suggested:

1. repositioning the bundles with the basic fabric and PVC material cut pieces,
2. changing the positioning way for the basic fabric and PVC cut pieces on the machine table at the feeding sequence of the sewing operation.
3. changing the sewing method:

-chain sewing (50 pieces), first the right side, with picking up simultaneous the cut pieces from the right side, 10 cm from the presser foot,
- separation of the sewed pieces (50 pieces),
- chain sewing the left side, placing the bundle at 10 cm in front of the operator,
- separation of the sewed pieces (50 pieces),
- chain sewing the bottom side, placing the bundle at 10 cm in front of the operator,
- separation of the sewed pieces (50 pieces). Next, for sewing the Velcro tapes, the bundle with cut tapes must be positioned under the back tacking lever and the bundle with the semi fabricates on the right side, close to the lever. This position allows the pick up, in one move of the right hand, of one Velcro and one semifabricat,
-the eviction of the central element with the Velcro sewed on will be made once at 20-25 overlapped elements, on the left part, at 15 cm,

4. Replacing the sewing machine with one with thread cutter.

CONCLUSIONS

Extending the results of the study at the entire company level will decrease the time necessary for getting the order in time, 100% quality level. The improving solutions, resulted from the work method analyze, implementation lead to:

- Developing of automatism at picking and placing the cut piece under the presser foot,
- Cutting once for 50 pieces, will eliminate the moves of hand reaching for the scissors, bringing the scissors and cutting,
- No more repositioning of every piece at changing the sewing direction (7 repositioning are eliminated for every semi products),
- Training automat motions at methodical placing the elements after sewing and thread cutting.

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FLEXIBILITY AND PREDICTABILITY ON THE VALUE CHAIN OF GARMENTS WITH UNCONVENTIONAL FINISHINGS

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Abstract: *The main objectives of the unconventional finishing technologies of garments are the esthetical diversification and the psycho- sensorial comfort improvement of the textile garments, through physical and chemical procedures carried out by companies, which provide services for the modern garment industry.*
In the case of manufacturing textile garments with unconventional finishing, by the externalization of the latter, the stages of the value chain materialize through the interference of the specific activities, which are carried out by 2 different economical entities that make use of different technologies and fluxes:
1.The garment manufacturer;
2.The company that provides the unconventional finishing (pre-washing, painting, laser treatments, etc.)
In this context, it is necessary to re-define the manufacturing process by re-drawing the fabrication flux, dividing and coordinating all the activities from the internal value chain.
The objective of this paper is the analysis and the interpretation of the impact made by some unconventional finishing, by taking into account :

- *the degree of adaptability of the quantitative and qualitative variability of the products;*
- *the safety predictability of the dimensional, esthetical and functional parameters of the products;*
- *the optimization of the production planning and scheduling for the 2 economical entities involved in the process of materializing the stages of the internal value chain.*

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Keywords: *unconventional finishing, prewashing, painting, garment products, value chain.*

1. INTRODUCTION

The customer needs and the apparel market map register important and fast-rate changes, determined by:

a) the change of the customer physiology, the increase of the non- conformism degree, the new definition, and perception of the aesthetical values, the re-configuration of the product maintenance for a comfortable and not ironed cloth;
b) the market demands for cheap products, with a very big variety, in small quantities for each model, but with different colours. The customer wants to find a generous offer of customized products at affordable prices (repetitive models are not required).

The main purpose of the special finishing treatments is to diversify the clothes from an aesthetical point of view and to improve the psycho- sensorial comfort. This is possible through physical and chemical processes, carried out by specialized service companies for the clothing industry. The big predictability degree of the results is a sustainable factor in foreseeing the predicted safety effects. [1,2]
In a competitive environment, which is characterized by dynamism it is necessary to develop new ideas, in a very short time in order to satisfy the most exclusive quality requirements. The unconventional technology/ finishing treatments offer the clothes companies a great deal of solutions for diversifying and adapting the products to the customer needs.
This paper is focused on a systemic approach on the ability to develop, produce and deliver garments with unconventional or special finishing treatments with added value according to different stages of the value chain.

1.1. The opportunity of developing unconventional finishing treatments

A manufactured garment is diversified in a unique manner, by applying innovative finishing technologies, such as special effects, pre- washing or post- painting processes. In this way, the supply chain is simplified as much as possible.
For the implementation of the finishing processes it is necessary to consider:

- The improvement of the product psycho-sensorial and ergonomic comfort;
- The diversification of the product from an aesthetical point of view;
- The colour flexibility. It is possible to launch the model in one colour and the other colours will be obtained through finishing processes;

- Special advantages in logistics, management and supply with materials, in reducing the inventory (for fabrics, knit and accessories);
- A quick answer to fashion colors trends;
- Special finishing treatments on the surface of the manufactured product.

Nowadays, about 60% of the garments models are casual and 40% are classical ones.

1.2. Consequences on the clothing industries

a) The reduction of the volume series for a garment model, because the merchants avoid stocks and the consumers want to have individualized products. This type of product is manufacturable if the producer is able to adapt to the market demands in a short time.
   The producer flexibility means "quick response", "just-in-time" or "reactivity", but in the same time means adaptation to the market demands by: “fashion product”, “very good technological achievement”, short delivery time, which means, "what the consumer wants".
b) The traditional method of organizing a company is outdated. The way by which the product goes from the design stage to the selling one ***is divided into distinct entities***, through specialized companies. The technological processes must be distributed between these two economical entities.

These two economical entities are not competitors one to another. Usually, they must divide the stages from the value chain, in order to produce the same garment with unconventional finishing treatments.
The technological effects from different stages of the generating value chain are considered consequences of the quality and production flexibility. [3,4]
The flexibility feature of these two entities in the value chain structure is sustained by the diversity of the materials, products, models, and effects obtained by unconventional finishing treatments.

2. THE CHARACTERIZATION OF THE INTERNAL VALUE CHAIN FOR GARMENTS WITH UNCONVENTIONAL FINISHING TREATMENTS

The manufacturing process of garments with unconventional finishing treatments using externalized finishing services also includes activities in which these two entities interfere. The stages of the value chain are:

- The apparel company
- The nonconventional finishing company of garments (pre- washing, painting, laser treatments, etc.)

The special service company (special finishing treatments) may be located at a big distance from the customer and from the fabric supplier (see figure 1). On these terms, the garment company is a provider of orders and a final client of the special unconventional finishing company. [2,3,5]
These two companies are involved alternatively for producing the same garment. These companies define the unitary structure of the value chain (LVI). The nonconventional finishing treatment is integrated as an intermediary stage of the LVI and it is connected to the input and output of the apparel company. On these terms, the management of the informational and material flow is relevant, because it interferes with both of these two entities and flips between them.
The integration of the supplementary stage in the value chain determines a new configuration, a redrawing, rehabilitation and its flexibility. In this case, it is necessary to redefine the production process, to redraw the production line and to divide and coordinate the activities of the chain value.
The “value analysis” concept, defined by Porter in 1984, considers the manufacturing company as a cumulus of different activities, which generate added value on different development levels. The stages of the internal value chain are determined by all the designing, manufacturing, delivering and supporting activities in the production process of the garment. [4]
The analysis of the internal value chain is based on the efficiency estimation of different specific activities needed to fulfill the consumer needs.
The precise definition of these requirements and the formulation of specific solutions adequate for the internal value chain stages ensure the optimization of the products performance and maximize the company efficiency.
The precision degree of the predictability results of the LVI components has also got a major influence on the LVI stage parameters and on the production planning and safety.

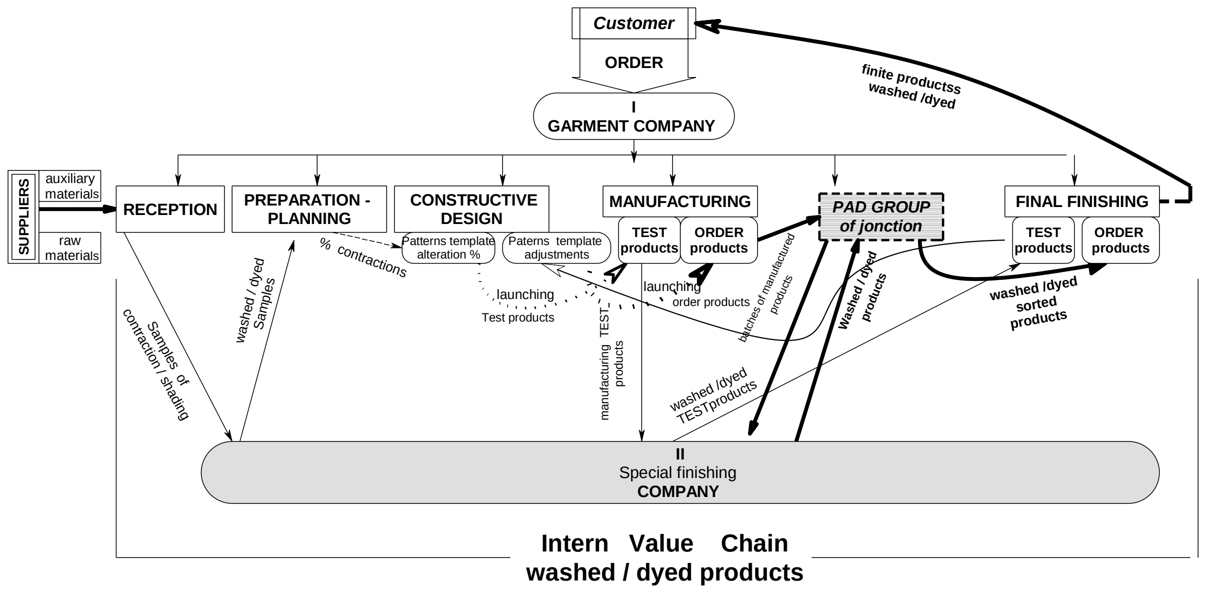

Figure 1 The structure of the internal value chain for a garment manufacturing process with special finishing treatments

3. WORK METHODOLOGY

The main objective of the paper is to analyze and interpret the characteristics (flexibility degree) of the unconventional finishing processes influences on the product, by taking into account:

- the variability of the materials, models, and finishing effects;
- the prediction of the product parameters: dimensional, aesthetical and functional one;
- the optimization of the production planning and programming activities according to the level of these two economic entities, which are involved in the internal value chain.

The research methodology used in this paper considers these two companies as a whole functional entity, but in which each part plays an important role in the internal value chain, creating products with added value by special finishing treatments.[8÷12].
This research is based on the production reality and on the author's expertise (synthesized in the dissertation papers from master degree studies in the field of Innovative Systems of Clothing Production at the Faculty of Textiles, Leather and Industrial Management).
The way in which the informational and material flux is adapted to the value chain, considering these two economic entities, the variation of the loads generated by the order are the considered studied cases.
This paper presents the systematization of the special finishing solutions, which contribute to the production of garments with added value.

4. RESULTS AND INTERPRETATION

4.1. The side effects of the special finishing processes

One of the consequences of every type of washing / dying process is the alteration of the texture, of the fabric structure, or the reach of a specific color tone. However, these can be accompanied by unwanted technological side effects. Most side effects become visible only after a few washing cycles have been performed by the consumer – with serious consequences for the manufacturer.
The unconventional finishing procedures may have a wide range of side effects at the level of garment manufacturing processes, such as: *fabric contraction, fabric bulging, the modification of the resistance structure, color tone shift of accessories and fabric.*
Fabric contraction: (x,y dimensional alternations) can be generated by:

- The fabric's behavior under the influence of finishing special agents
- Incompatibility of the base, secondary and auxiliary fabrics.
- Interferences between the behaviors of the base, secondary and auxiliary materials in the finishing process

The negative effects of contraction become visible through two phenomena:

a. The creasing of the garments/seams on the assembly line
b. The dimensional garment modifications with implications on the fitting degree, ergonomic comfort, shape, and aesthetics

Fabric bulging: (z-dimensional increase due to humidity, temperature, and machine-drying) can make the sewing thread length become insufficient, causing:

- A reduced seam extensibility
- The creasing of the materials on the seam line
- The alteration of the seam structure (orientation, step uniformity)

Edge and assembly resistance alteration : These areas are more exposed to chemical and surface abrasive mechanical stress, stretching, and centrifugation, as they are on raised level from the fabric. These may cause:

- Edge deterioration on the seam line, accentuated through wear/use.
- Diminished thread friction resistance
- Reduced seam elasticity, with the risk of breakage through cyclic longitudinal stress.

Accessory appearance alteration caused by:

- An incorrect accessory choice
- An incorrect determination of the **LVI** stage for insertion in the garment structure
- Technological deficiencies of the unconventional finishing process program

Colour tone differences of post-dyed products, generated by:

- Deficiencies in the color tone testing of the batches
- Non-compliance with the structuring of the products from a single fabric layer
- Deficiencies in constituing the batch for the post dyeing processes

These negative secondary effects require a series of technical, technological and organizational measures , carried out throughout the LVI stages, for their reduction, elimination or prevention.

4.2. Resources for improving the predictability of special finishing effects.

Within the paper's scope are the resources for improving the predictability degree and quality parameters, as well as the planned order delivery timelines specific to the LVI stages, which unfold within entity I and at the interference with entity II, respectively. (fig. 1)

4.2.1 Materials testing

On a first step of the qualitative reception materials, tests are being conducted, for both washed and post-dyed products. The tests are conducted for each batch separately, as contraction and tone can vary between them. The number of lots/ small batches will be defined by taking into account the homogeneity of the results.

Establishing the fabric contraction using the principle of "quadrant method"

The samples are undergo pre-washing or post-dyeing processes, and the contraction percentages are represented on the two axes. The results will be used in the adaptation of the constructive project for the product, and for sorting the batches for the order into lots.

The color tone test – conducted using the "carpet method" for fabrics and the "comparative row of sewed samples" for fabrics and threads.

The samples undergo a post dyeing process, different color tones are compared, and batch groups are being defined for launching cutting, while expedition batches for dyeing.

For the post-dyed products, the color tone test must be carried out within the special finished specialized company, prior to the contraction test.

4.2.2. Specific solutions for the constructive design phase

In order to compensate the impact of fabric contraction on the dimensional parameters of the products with special finishing, it is necessary to make some modifications at the level of constructive design.

The modification scope depends on the dimensions and homogeneity of the contraction values, and of the fitting degree of the product models (on-body adjustment). This process includes two stages:

A. The stencil modification, which is done proportionally with the fabric contraction values, for the test products manufacturing:

A.1. with average contraction values, given test results homogeneity

- in framing, for contraction values ≤ 4%, for products with low adjustment degrees
- on component, for contraction values > 4%, for products with low adjustment degrees
- on the component, for products with high body fitting degrees

A.2. When the test results lack homogeneity within batches (variance greater than 1.5%), a suborder sorting according to the dispersion of contraction values will be implemented. As a result, stencil adjustments will be made for each suborder.

B. The correction of the component stencils, when the “test products” would have completed the production flow (fabrication, pre-washing, dyeing, and final finish). The values of the corrections are determined by comparing the test product measurements to the values of the model dimensions table, by also taking tolerances into account. Usually, the allowed tolerances are +/- 1cm for length, +/- 1cm for width for loose fit garments and +/1 0.5cm for fitted models.

4.2.3 The inclusion of additional activities into the production planning

For the improvement of the aesthetical and dimensional parameters of specially finished garments, a series of additional activities are necessary during the planning stage:

- The preparation of fabric samples for the color tone and contraction tests, of test products, shipment, reception and interpretation of results.
- Orders for the modification of the constructive project A,B (stencils and framing)
- Preparation of “test product” production launch
- The planning and programming of the shipment and reception of the products from an order by lots and batches to and from the finishing company.

4.2.4 Technological solutions for the quality assurance of products with special finishing

The intensity of the mechanical stress in humid environments and under high temperatures, can generate destructive effects. In this context, the specific technological solutions adopted in the process of manufacturing garments with special finishing aim to protect the fabrics and ensembles throughout the processes of washing and dyeing by:

- The adoption of higher sewing and bending reserves
- The protection of reserves through bordering with protection strips
- The selection of highly resistant threads
- The correlation between the fineness and shape of the needle with the characteristics of the fabric (thinner needles, SUK type point)
- The optimization of the thermo-bonding and sewing parameters
- The protection of the metallic accessories (zippers, studs, etc.)
- The transfer of particular technological phases to after the washing/dyeing process, within a final finishing group.
- An additional assurance of the relative layout of the product components
- The use of limiting devices, in order to enforce for sewing direction.

4.2.5. Production flows adaptation

As the production process takes place within two legal entities at different locations, and due to the fact that a smooth flow between them has to be ensured, a series of structural adaptations must be made:
For the junction of the value chain elements between the two entities (see figure1), a group control buffer block is inserted into the technological flow, in order to manage the ins and outs between the firms :

- The formation of batches of products on orders for their shipment to the finishing company.
- The reception and sorting process of the products by order, type, size, as well as the preparation for their shipment to the final finishing group.

5. CONCLUSIONS

The analysis of the internal value chain is based on combined pieces of information, which reflect the contribution of each LVI stage, pertaining to the two economic agents involved in the added value creation for the product with special finishing.
The inclusion of additional activities at different LVI stages (color tone, contraction, two correction steps of the constructive project, the shipment and reception of samples, test products, and production lots from an order, as well as additional technological phases) determine an increase in the production cycle.
The production practice has confirmed the following important aspects in the manufacturing of garments with special finishing:

- The type, volume, and interpretation of the tests conducted on the fabrics – the resource for the growth of the predictability degree of the technological effects and of the dimensional product parameters
- The implementation of actions based on test results at different LVI stages – a resource of increased manufacturing flow efficiency, with impact at the level of planned production.

- The correlated choice of secondary and auxiliary products (thread, inner layers, zippers, buttons, etc.) – resource for ensuring the product quality, which has also got an impact on the duration of the production process
- The handling of the material and informational flux between the two entities during the preparation and production stages for the manufacturing of specially finished garments.

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PRACTICAL STUDY REGARDING THE STRUCTURAL PARAMETERS OF WEFT KNITTED FABRICS

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Abstract: *Estimating yarn consumption is a significant part of the design stage. In the case of basic evolutions, there are geometrical and mechanical models for the stitches that can be used to estimate the yarn consumption with certain restrictions. However, in the case of patterned fabrics, the complexity of the geometry makes it hard to make an accurate prediction for the yarn consumption.*
The paper presents a practical study regarding the variation of the stitch length for jersey structures, based on an experimental matrix with input variables related to the raw material and technological parameters. Three different structures were produced - jersey, jersey with miss stitches and jersey with tuck stitches. The samples were relaxed and the stitch length was determined. The results were compared and conclusions were drawn.

Keywords: *stitch length, normal stitch, elongated stitch, modified geometry*

INTRODUCTION

One of the most important problems in designing knitted fabrics is the evaluation of the stitch length, especially when the fabric is patterned and the normal evolutions are modified.

The literature includes numerous models for stitch geometry that are used to predict the mechanical behaviour of knitted fabrics [1]. Such geometrical models were created based on the specificity of the fabric evolution (plane jersey, rib, purl, interlock) and the specificity of yarns and have different simplifying assumptions. All of them consider in their final equations the stitch dimensions (width and height) and the yarn diameter. The accuracy of these models is limited mainly due to the difficult estimation of the yarn shape and dimension of its cross section.

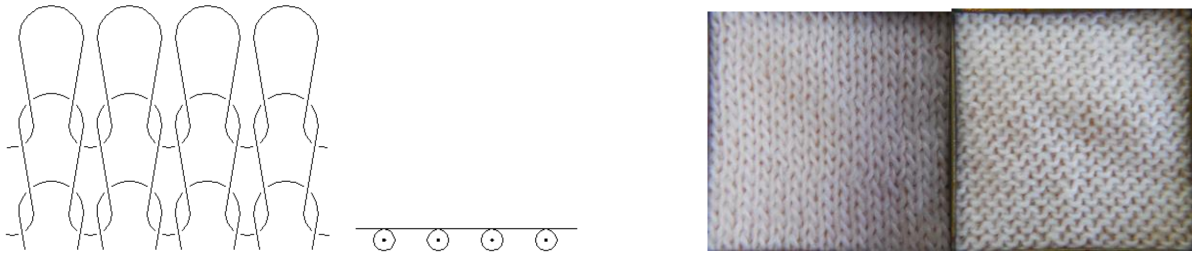
Another problem is the presence of patterns that alter the normal structural parameters (stitch density, stitch length and fabric mass per square meter). The question is how and how much the stitches with modified geometry change the values of the structural parameters. Furthermore, these changes depend on the type of pattern to be used – miss, tuck or transferred stitches. For example, the presence of tuck stitches increases the stitch width and subsequently the fabric width, while decreasing the stitch density and fabric mass.

In these conditions, predicting the yarn consumption for patterned fabrics becomes difficult. It is important to understand the modification of the yarn geometry in relation to the normal stitches. The paper considers the patterns with miss stitches and tuck stitches, that both include an elongated stitch. The elongation is produced after forming the stitch, by not discharging it immediately after its formation. In this case, the stitch height increases due to the migration of yarn from the neighbouring stitches and after jamming occurs the elongation of the yarns.

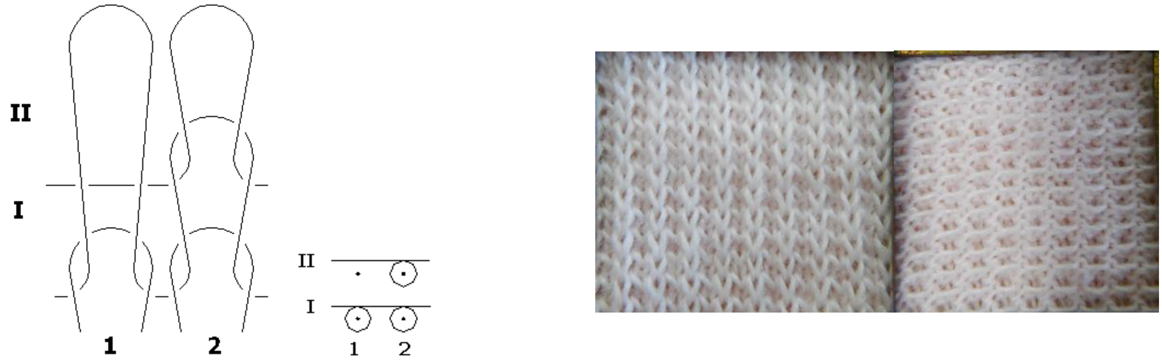
The paper studies the influence of miss and tuck stitches on the yarn consumption for plane jersey fabrics by comparing the length of normal stitches with the length of miss or tuck stitches. The fabrics are produced based on an experimental matrix that includes the raw material and technological parameters (position of the stitch quality cam and yarn tension).

EXPERIMENTAL

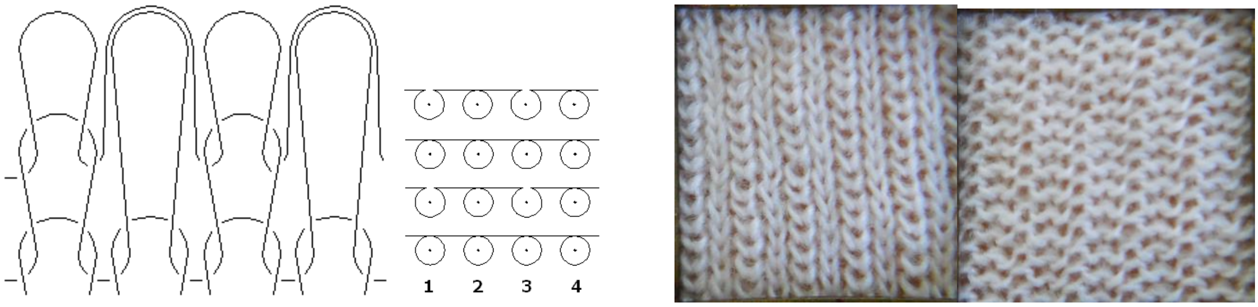
The study took into consideration three fabrics: a jersey fabric, without pattern, a jersey fabric with miss stitches and a jersey fabric with stitches (half cardigan). Fig. 1 presents these fabrics (representation and fabric aspect).



a) jersey fabric, without pattern



b) jersey fabric with miss stitches



c) jersey fabric with tuck stitches

Figure 1: Fabrics used in the study – representation and aspect (front and rear)

The experimental matrix used for the present study is presented in Table 1 and includes three independent variables: the yarn composition, the position of the stitch quality cam and the tension in the yarn during knitting. The yarns are made of acrylic fibres, mixed with wool, respectively cotton. The presence of cotton fibres will give a more rigid yarn, thus influencing differently the elongation of the stitches in the patterned structures. The position of the stitch quality cam was selected according to the fabric evolution (jersey), while the yarn tension was varied within an interval and was measured before the yarn the machine case (on the lateral tensioning device), due to the difficulties measuring it closer the knitting area.

Table 1. Experimental matrix

Fabric structure	Raw material	Technological parameters			
		Stitch quality cam (NP)		Yarn tension (cN)	
No pattern	Yarn 1 – Nm 16 80%PNA+20% wool	NP1=11.0	NP2=12.0	T1=250±2	T2=150±2
Miss stitches		NP1=11.0	NP2=12.0	T1=250±2	T2=150±2
Tuck stitches		NP1=11.0	NP2=12.0	T1=250±2	T2=150±2
No pattern	Yarn 2 – Nm 36/2 80%PNA+20%cotton	NP1=11.0	NP2=12.0	T1=250±2	T2=150±2
Miss stitches		NP1=11.0	NP2=12.0	T1=250±2	T2=150±2
Tuck stitches		NP1=11.0	NP2=12.0	T1=250±2	T2=150±2

The resulting 24 variants were knitted on a CMS 530 multigauge 6.2 machine (Stoll). The fabrics were subjected to dry relaxation for 72 hours and the yarn consumption was determined by using a 5g weight to straighten the yarns. The length was measured for 50 stitches, according to BS EN 14970 [2]. In the case of patterned structures, the stitch length was determined for each row in the pattern.

RESULTS

The experimental results for the stitch length (average values) are presented in Tables 2 to 4, for each type of evolution. For the patterned fabrics, the values for the stitch length are presented for both pattern rows.

Table 2. Experimental values for the stitch length of jersey fabrics

Sample code	Yarn 1		Yarn 2	
	Length/50 stitches	Stitch length (mm)	Length/50 stitches	Stitch length (mm)
G_11.0-T1	210.7	5.27	271.4	5.43
G_12.0_T1	303.9	6.08	326.4	6.53
G_11.0_T2	279.7	5.59	288.1	5.76
G_12.0_T2	330.7	6.61	342.7	6.85

Table 3. Experimental values for the stitch length of the jersey fabrics with miss stitches

Sample code	Pattern row	Yarn 1		Yarn 2	
		Length/50 stitches (mm)	Stitch length (mm)	Length/50 stitches (mm)	Stitch length (mm)
GR_11.0_T1	**R1**	262.6	5.25	274.8	5.50
	R2	175	3.50	183.2	3.66
GR_12.0_T1	**R1**	308.4	6.17	328.6	6.57
	R2	198.6	3.97	209.4	4.19
GR_11.0_T2	**R1**	278.8	5.58	286.4	5.73
	R2	187.6	3.75	190.8	3.82
GR_12.0_T2	**R1**	336.5	6.73	341.6	6.83
	R2	219.2	4.38	220.8	4.42

Table 4. Experimental values for the stitch length of the jersey fabrics with tuck stitches

Sample code	Pattern row	Yarn 1		Yarn 2	
		Length/50 stitches (mm)	Stitch length (mm)	Length/50 stitches (mm)	Stitch length (mm)
GD_11.0_T1	**R1**	209.4	5.23	224.8	5.62
	R2	202.2	5.05	214.8	5.37
GD_12.0_T1	**R1**	251.4	6.28	264.8	6.62
	R2	244	6.10	254.2	6.35
GD_11.0_T2	**R1**	225	5.62	230.4	5.76
	R2	219	5.47	220.9	5.52
GD_12.0_T2	**R1**	268.4	6.71	272	6.80
	R2	259.8	6.49	265.4	6.63

DISCUSSION

The most important part of this discussion refers to the values of the jersey stitch length and the existing differences between different structures. Table 5 presents the comparison between the values for jersey, jersey with miss stitches and jersey with tuck stitches. Figures 2 and 3 show the influence of the fabric structure on the value of the stitch length for both types of yarn.

Table 5: Comparison for the stitch length determined for the experimental variants

Sample code	JERSEY		Differen ce	MISS STITCHES		Difference	TUCK STITCHES		Difference
	Yarn 1	Yarn 2		Yarn 1	Yarn 2		Yarn 1	Yarn 2	
G_11.0-T1	5.27	5.43	**3.04**	5.25	5.5	**4.76**	5.23	5.62	**7.46**
G_12.0-T1	6.08	6.53	**7.40**	6.17	6.57	**6.48**	6.28	6.62	**5.41**
G_11.0-T2	5.59	5.76	**3.04**	5.58	5.73	**2.69**	5.62	5.76	**2.49**
G_12.0-T2	6.61	6.85	**3.63**	6.73	6.83	**1.49**	6.71	6.8	**1.34**

It is clear that the position of the stitch quality cam is the most important factor from the chosen experimental matrix. The stitch length of each type of evolution (normal stitches, elongated stitches, floats or tuck loops) strongly depend on the value of this technological parameter.

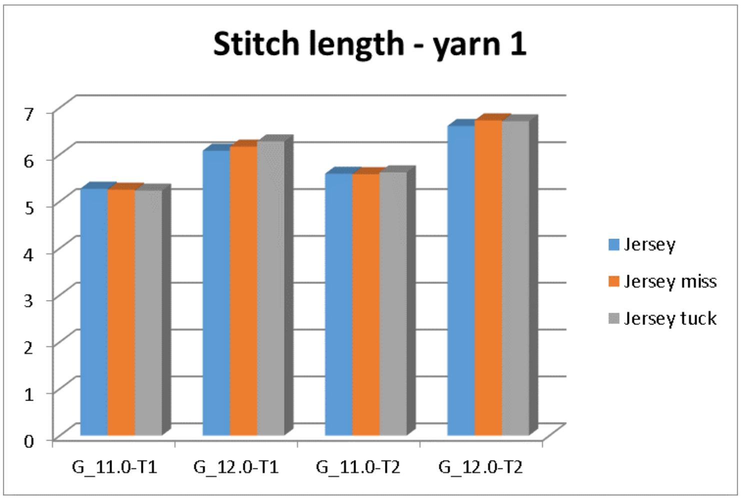


Figure 2: Comparison of the jersey stitch length for yarn 1 – influence of the fabric structure

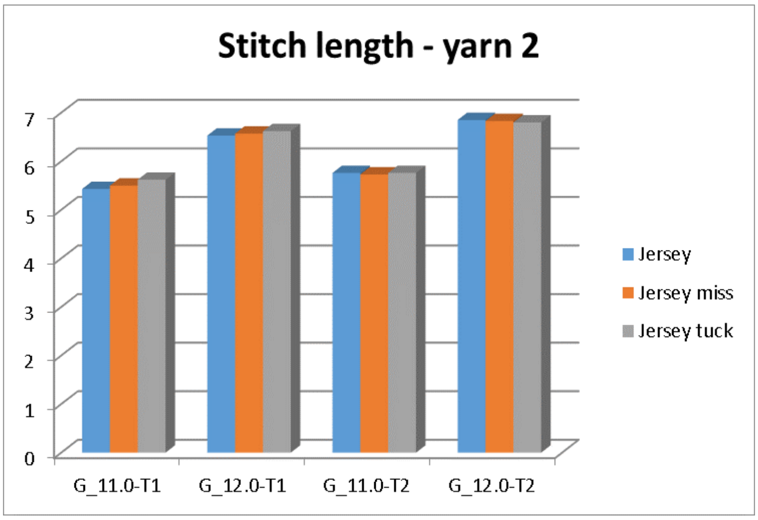


Figure 3: Comparison of the jersey stitch length for yarn 2 – influence of the fabric structure

With regard to the influence of the yarns, the experimental results show that the stitches produced with the second yarn (acryl mixed with cotton) are sligthly longer than the stiches produced with yarn 1 (acryl+wool), even if the latter is a bit thicker. For most samples, the differences are lower than 5%.

The yarn tension has a certain influence on the yarn consumption, more visible for the maximum value for the position of the stitch quality cam.

Figure 4 shows the cumulated influence of the yarns and yarn tension on the length of the jersey stitches by presenting the differences between the stitch lengths for the samples with the same position of the quality cam. It is clear that regardless of the structure, the differences are more significant for the first yarn, suggesting that this yarn is already reaching its limit for elastic behaviour. The evolutions with elongated stitches present lower differences than the normal values, especially for tuck stitches. It indicates that stitch is further stressed during the formation of the tuck loop in the second row.

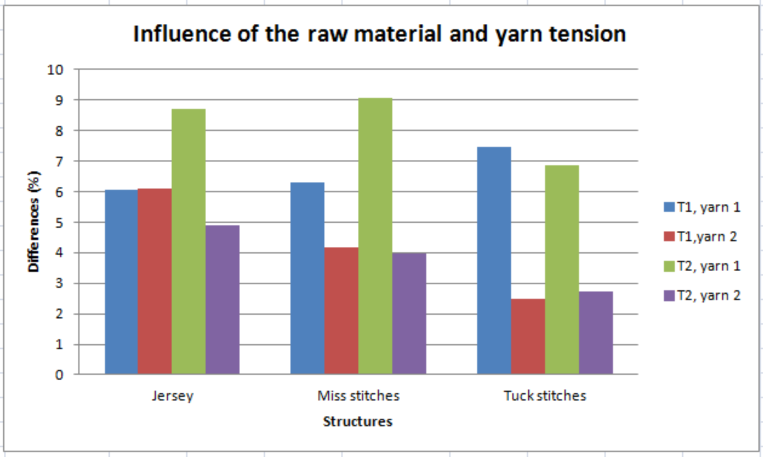


Figure 4: Influence of the raw material and yarn tension on the yarn consumption

For the samples with miss stitches, the length of the float is longer for yarn 2, as illustrated in Figure 5. An interesting aspect is the fact that when compared to the machine pitch, the differences are between 66% and 110%. When comparing to the stitch width, the variations are even higher (140% to 175%) but this situation must be considered in light of the changes produced by relaxation. It is obvious that during relaxation there was a migration from the stitch toward the float, increasing the length of the latter. The influence of the yarn tension is evident, as the intervals for the differences between the float length and stitch width are not the same (higher yarn tension leads to higher differences).

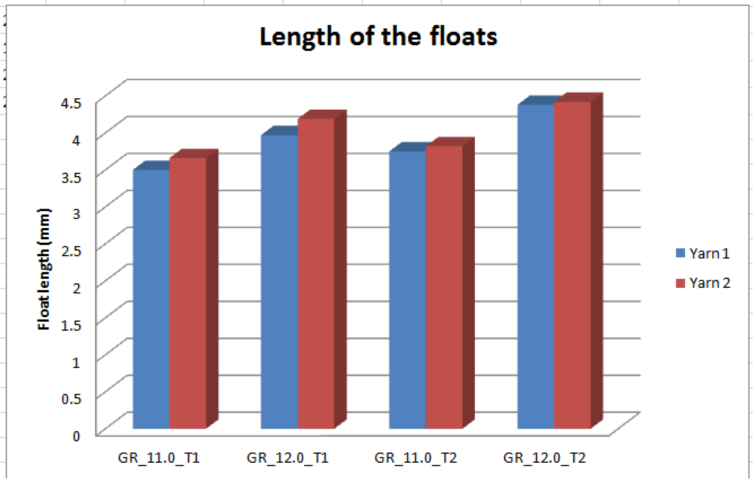


Figure 5: Variation of the float length for the samples with miss stitches

For the tuck loops, the influence of the raw material is rather lower, indicating that the yarns in the tuck loops were not over stressed during their formation (see Figure 6). The length of the tuck loops is slightly lower than the length of the jersey stitches (the first row, normal and elongated stitches).

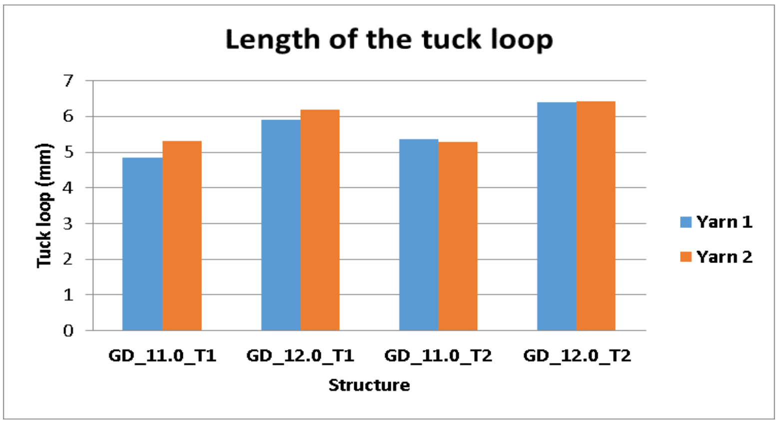


Figure 6: Variation of the tuck loop length for the samples with tuck stitches

CONCLUSIONS

The following conclusions can be drawn from the study of the variation of the stitch length with the raw materials and technological parameters:

1. The input variables selected for the experimental matrix are significant.
2. The raw material influences directly the stitch length – yarn 1 (PNA + wool) produces stitches with lower length than yarn 2 (PNA + cotton).
3. The main factor of influence is the position of the quality cam and the level of influence is high.
4. The yarn tension has a stronger influence in the case of the first yarn, made of PNA and wool fibres. The values of the stitch length for all samples indicate that the maximum yarn tension selected for the experiment maintained the yarn within the elastic limit.
5. Comparing the length for the normal stitches with the values obtained for the structures with miss and tuck stitches, it is clear that these values are placed in a very small interval. It can be concluded that no significant modifications are brought to this type of yarns when the stitches are discharged in the second knitting cycle after formation.
6. However, the elongation of the stitches causes a certain increase in the stitch length, suggesting jamming was reached and a small elongation of the yarns. The highest differences are determined for the tuck stitches, as these stitches are looped once more during the formation of the tuck.
7. The length of the floats is higher than the machine pitch with 60 to 110%. It can be suggested that during relaxation, yarn migrates from the stitches toward the floats.
8. The length of the tuck loops is slightly lower than the average values determined for normal and elongated stitches.

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Section 3: Textile structures and properties

MODELLING OF WARP KNITTED STRUCTURES AT FILAMENT LEVEL

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Abstract: *This work starts with a short overview about the 3D modelling of warp knitted structures. The most of the current research works and commercial software are based on presentation of the yarns as a single tube with constant cross section. The modelling of the cross section behaviour of the yarns with FEM requires the knowledge of the material behaviour of these, which measurement until now is complicated procedure. Application of new methods, where the single filaments in the yarn are presented shows good results for the case of braided structures and in several other applications. This method is applied for warp knitted structures as extension of the existing models. Some defects of the generated coordinates of the single filaments, based on the curve torsion are demonstrated and should be taken into account during the modelling of such structures.*

Keywords: *warp knitting, filament level, modelling.*

INTRODUCTION

The form of the loop of the knitted structures and its mechanical behaviour was investigated in several works during the last century. Doyle [1], Munden [2] and Leaf and Glaskin [3] concentrate their works on the geometry, fundamental aspects and general plain loops. Hart, De Jong and Postle [4] demonstrate the power of the energy minimisation technique for the analysis of the mechanical behaviour of warp knitted structures.
Despite of the significantly higher citation of the paper of Göktepe and Harlock [6], published in 2002 about the computer modelling of warp knitted structures, the work of Robitaille et al [5] presented already 2000 strong approach, which is applicable for industrial performance for one class of fabrics.
The first models, really implemented into industrial software and able to model several classes of warp knitted structures were created by Renkes and Kyosev, and were reported in [7] and described in more details in [8].
The principle of the generation of warp knitted structures with 3D form (tubular, spacer) is presented in [9]. In the following works, several aspects of the models are extended, but the most of these are based on tubular yarns with constant circular cross section. In [10] several aspects about the modelling of knitted loops with elliptical cross section are presented, but one of the most complete explanations of Finite Element Method modelling of textile structures with compressible yarns is the work of Philippe Boisse et al. [11] where the complexibility of the measurement and the modelling becomes visible.
Some authors try to avoid the use of FEM for the modelling of the compressibility of the yarn cross section using yarns, where the larger set of filaments are modelled [12, 13]. Applying suitable contact detection and time integration algorithms, such methods become already very useful with the current computer technique.
This paper concentrates on some steps of the filling of the yarns with filaments for creation of multifilament models, where these algorithms can be applied.

3D GEOMETRICAL MODELS AND THEIR REFINEMENT

The geometry of the loops is based on the parametric description of few contact points between the yarns, as described in [8]. Using the loop and yarn data, for instances within the TexMind Warp Knit Editor [14], the idealized geometry of the warp knitted structure can be generated. In the current case the implementation of the algorithms from [8] in the software Loop3D [15] was used.

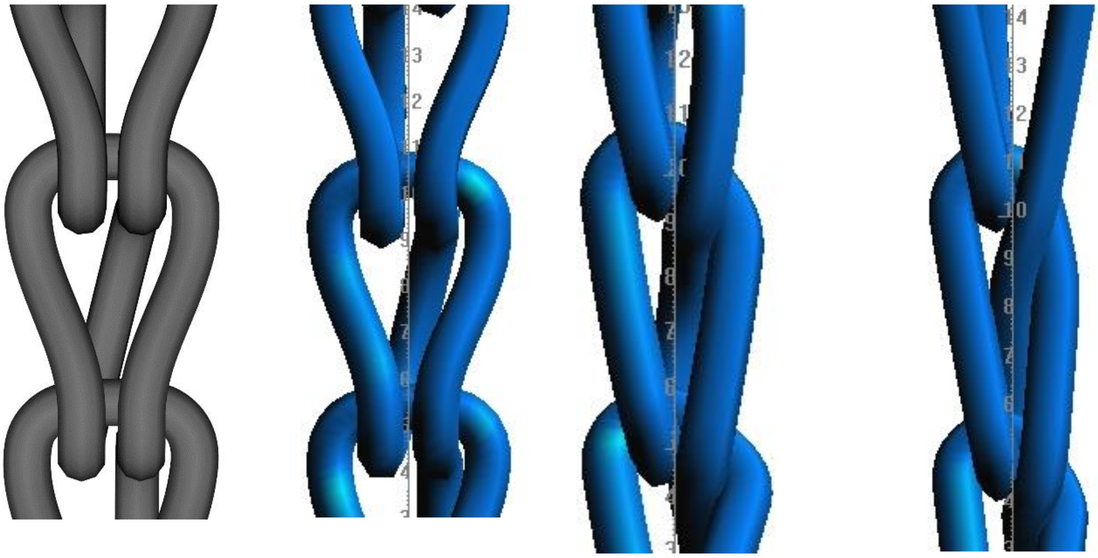


Figure 1: Geometrical model of warp knitted loop a), and three stages of its relaxation process with digital chain method [13, 14] b) – d)

The idealized loop (Figure 1a) is created using pure geometrical algorithm and do not consider the deformations and redistribution of the yarn length at that point. Such processes can be modelled using the digital chain technique [13, 14]. Initial step (Fig 1b) and two configurations after different time of axial loading and relaxation (Fig. 1c and 1d) demonstrates, that this method can be applied for creation of realistic geometries of warp knitted structures.

MULTIFILAMENT YARNS MODELLING

The 3D geometry, created for single yarn with circular cross section can be used as a basis for the generation of single filaments within each of these yarns. The point of the curve of one loop is described as a curve, based on several points P (Fig. 2)

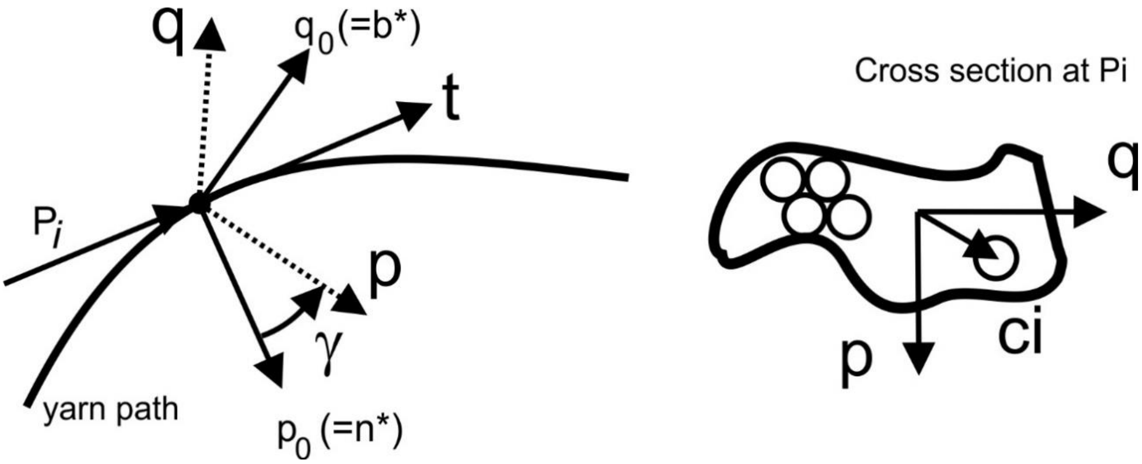


Figure 2: Point of the 3D yarn axis and its characteristic vectors, vectors p and q determine the local coordinates of the cross section of the yarn at each point [16]

From the rules in computational geometry is well known, that tangent vector can be calculated as following

$$t(s) = \frac{p(s)'}{|p(s)'|} \tag{1}$$

And the binomial and normal vector to the curve at this point:

$$b(s) = \frac{p(s)' \times p(s)''}{|p(s)' \times p(s)''|} \quad (2)$$

$$n(s) = b(s) \times t(s) \quad (3)$$

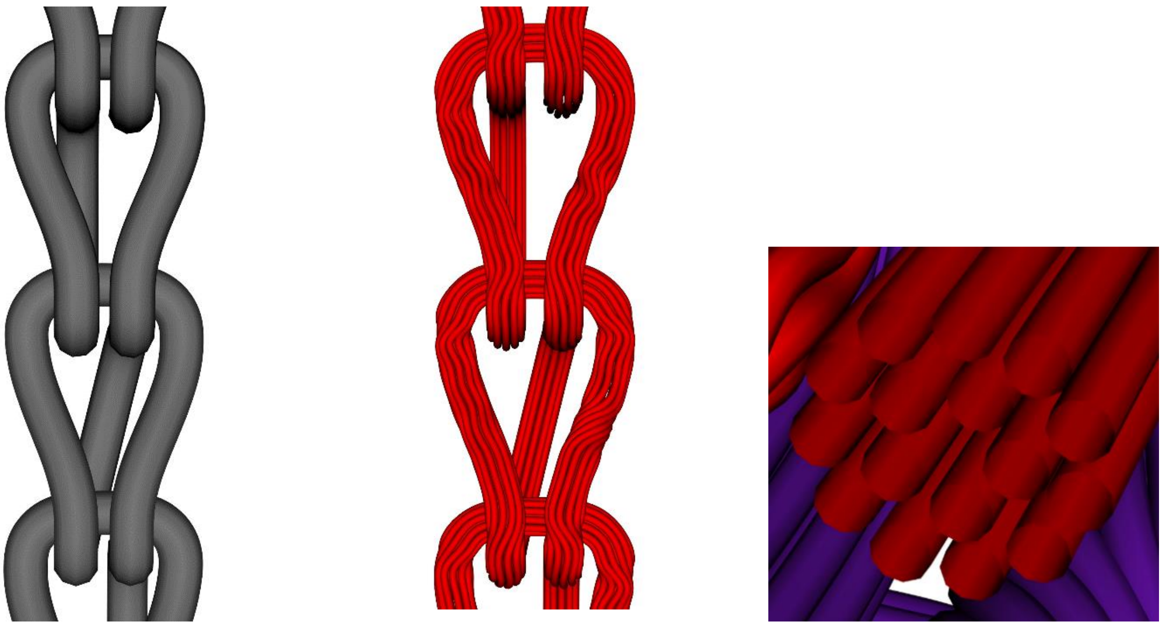
As the yarn cross section can be rotated around the yarn axis, for instance due to twist of the yarn, additionally to the normal and binormal vector, vectors p and q are used, which define the local coordinate system of each cross section. These vectors are rotated on an angle γ, which is determined by the yarn twist, applying rotation matrix R:

$$p(s) = R(s) \cdot t(s) \quad (4)$$

If the yarn cross section is defined as an arbitrary set of the centre points of each filament c_i, in a local coordinate system, based on the vectors p and q, the positions of these centres can be determined after applying the rotation:

$$c_{i^*}(s) = R(s) \cdot c_i(s) \quad (5)$$

Figure 3a presents loops of one yarn, created from geometrical model and modelled with constant cross section. Fig. 3b presents the same loop filled with 15 filaments based on this method and Fig 3c shows a view of a cross section of the filaments. As on the Fig 3b visible, there are some irregularities in the filament orientation, which will be discussed in the next section.



a b c

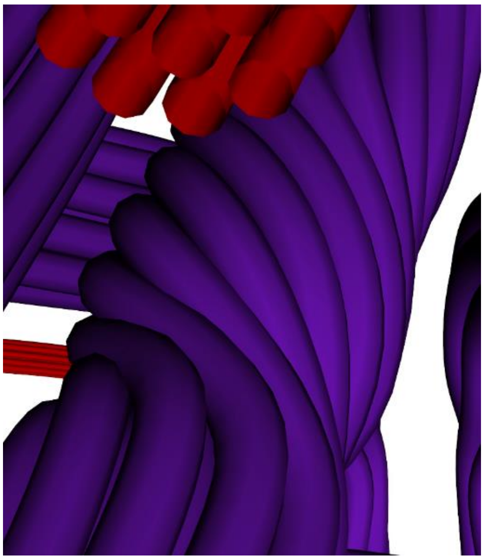
Figure 3: Modelled warp knitted loop (a), filled with filaments (b), view of the cross section (c)

TOPOLOGICAL PROBLEMS AND SOLUTIONS

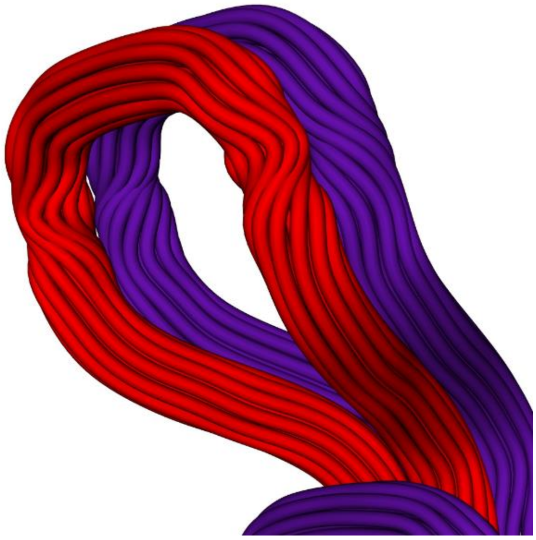
Each curve in the 3D space have some natural curvature and natural torsion. The torsion of the curve shows the change of the binormal rotation around the tangent and is as such not connected to the twist of the yarn, which has the 3D curve as axis. The twist is coming additionally to the torsion of the curve. The defects of the representation on the Figure 3b, is as well visible in figure 4b. At some places the orientation of the normal and binormal vector changes and this causes artificial twist of the filaments, which is caused only from the form of the curve. More drastically appears such effect in areas, where the radius of the curvature is too large and becomes indefinite. At such points the tangent vector can change its sign and the cross sections of two neighbour points become rotated at one complete revolution (Fig. 4a).

$$if\ t(s_i) \cdot t(s_{i-1}) < 0 \quad t(s_i) = -t(s_i) \quad (6)$$

Such effects can be improved by checking the sign of the tangent vector and in case it changes its sign (Eq. 6), a sign correction is applied and the resulting normal and binormal vector are calculated again after this correction.



a



b

Figure 4: Defects of the model, based on the torsion of the 3D curve

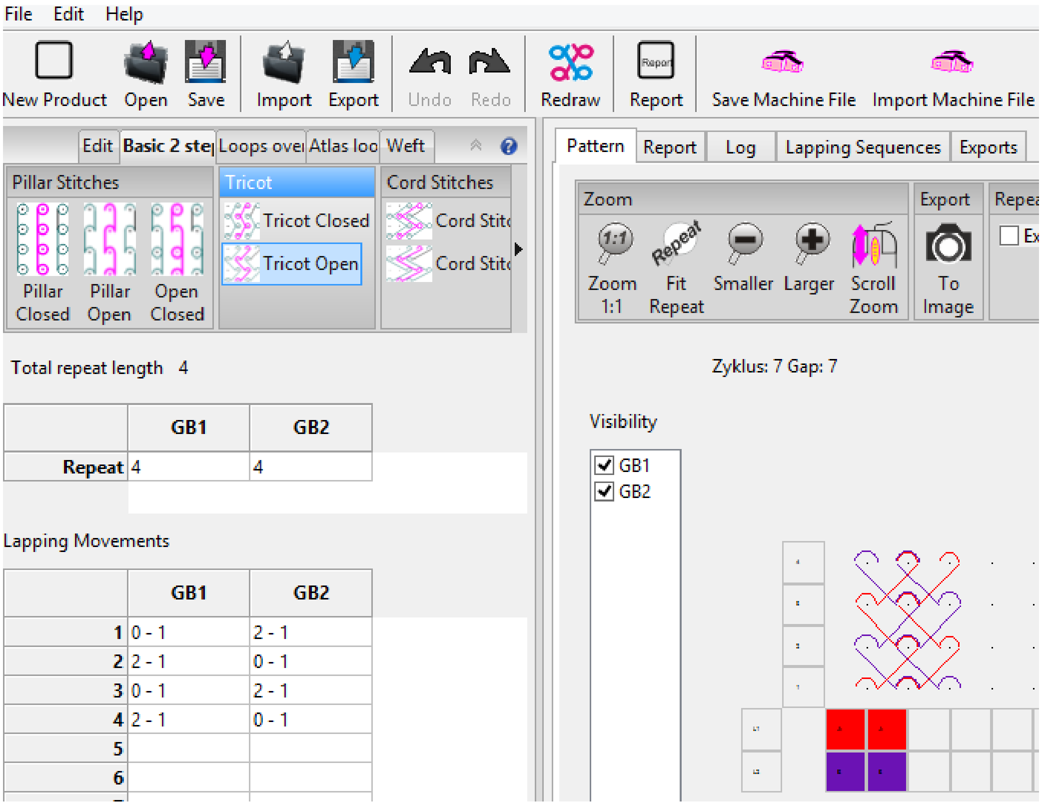


Figure 5: Graphical interface of the TexMind Warp Knitting Pattern Editor with the pattern

Figure 5 shows the graphical user interface of the TexMind Warp Knittign Pattern Editor, where the pattern data is prepared and the yarn data is defined (not visible on the figure). After calling the Loop3D software the geometry, presented on figure 6a is created and after calculation of the coordinates of each filament of each cross section point, the multifilament geometry is genearted (Figure 6b). The correction of the small artificial twist is not applied on this example. For this correction the rotation of the cross section should be corrected under consideration of the torsion of the curve, but this is point of a separated work.

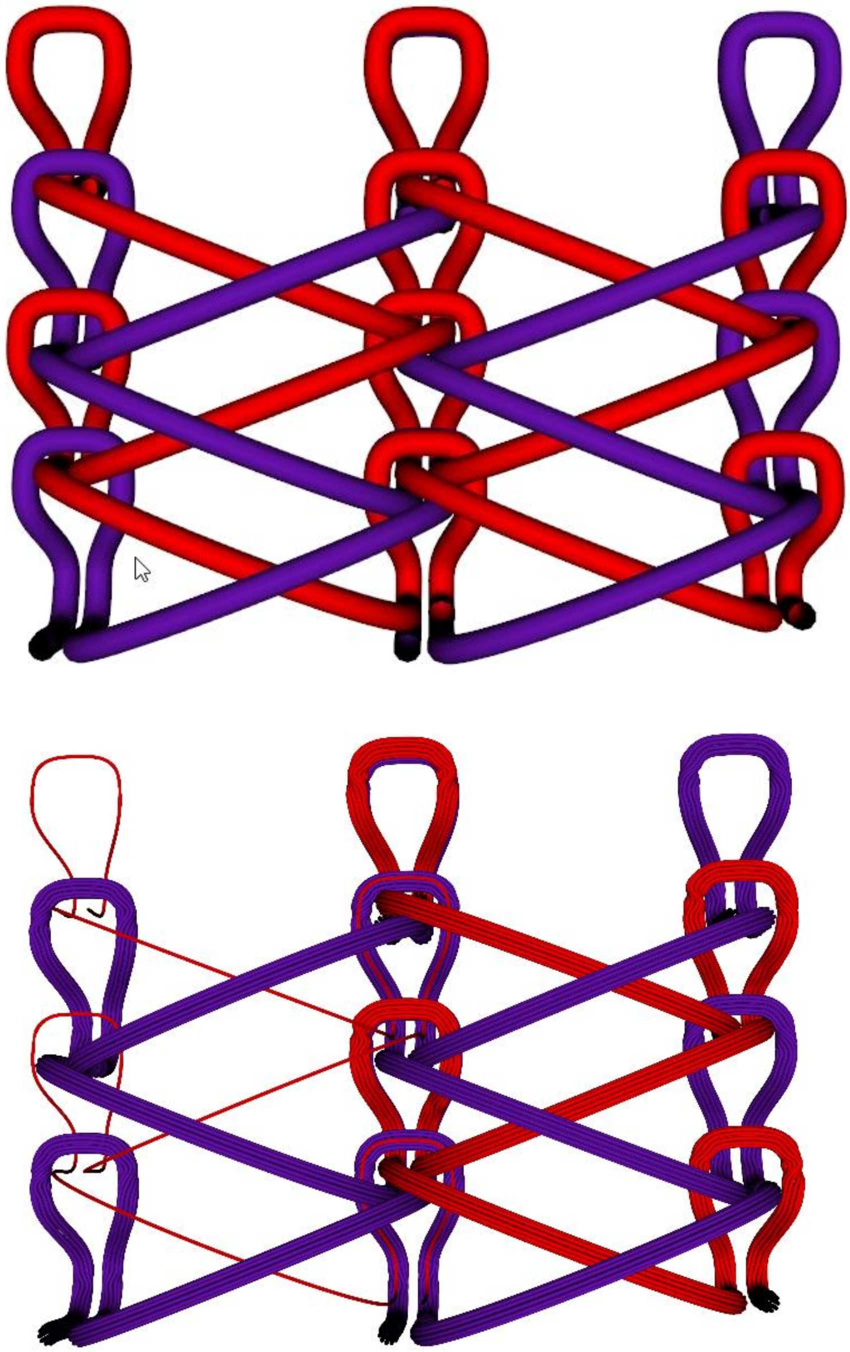


Figure 6: Double Tricot structure modelled at yarn level and at multifilament level

CONCLUSIONS

This paper demonstrates a method for calculation of the coordinates of single filaments within a yarn volume of warp knitted structures, which allows the creation of multifilament geometries of these structures. The influence of the natural curvature and torsion of the curve over the filament coordinates is demonstrated and the common method for its correction – changing the sign of the tangent vector is applied. The created 3D warp knitted structures based on multifilament yarns can be refined and investigated numerically using for instance the digital chain method, as demonstrated for single loops at yarn level.

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A STUDY OF THE FIBER MIGRATION IN YARN CROSS-SECTION FOR HEMP/POLYPROPYLENE BLENDS

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Abstract: *Three hemp type yarns blended with modified polypropylene were spun on a spinning machine which processes the fibers in wet condition: raw yarn, yarn spun from alkaline treated roving and yarn obtained from bleached roving. Yarns have been prepared to be sectioned and then investigated under the microscope. Different methods of zoning the yarn cross-section have been compared in order to study the fiber migration in the yarn cross-section. It has been found that the migration of modified polypropylene fibers has occurred mostly in the yarn core, while the hemp fiber were placed mainly to the exterior of the analyzed sections. This positively affects the characteristics of yarns and products made from them, because they will keep the touch and appearance specific to hemp type yarns, improving at the same time the yarn properties.*

Keywords: *fiber migration, spun yarn, hemp/polypropylene blending*

INTRODUCTION

Analysis of the way the fibers distributes in yarn cross-section is of great importance both in terms of the appearance that will have the finished product and of the surface characteristics that will be conferred [1,2]. In the case of a blending of fibers that have different physical-mechanical characteristics, such as the one analyzed in this paper, polypropylene and hemp blending, it is necessary to study the way in which the fibers migrate in the yarn cross-section. Thus, it is possible to determine whether the distribution of the fibers was done uniform, or if the fibers of a component tend to be located on the outward or inward of the yarn cross-section [3, 4].

Important effects on fiber migration have the coefficient of fiber friction, the length of the fiber, fineness, shape of cross-section, and fiber chemical type [1]. Short or coarse fibers are placed usually in the outer layers, and the long or fine fibers in the yarn core. Also, fibers that have the shape of cross-section circular and smooth tend to migrate to the core of the yarn and those with trilobal and rough shape are located mainly in the external layers [1].

Different image processing techniques have been applied in recent years to analyze the cross-section of yarns obtained from different blends of fibers [1,5]. These methods allow the calculation of central position, individual fiber boundary detection, features extraction and fiber distribution analysis [5].

EXPERIMENTAL

Three hemp type yarns blended with modified polypropylene were spun on a spinning machine which processes the fibers in wet condition: 37 tex raw yarn, 36 tex yarn spun from alkaline treated roving and 32 tex yarn obtained from bleached roving. Yarns have been prepared to be sectioned and then investigated under the microscope. Two different types of fiber cross-section forms could be differentiated, a rounded shape one for polypropylene fiber and a polygonal one for hemp fiber. The fibers of each component were counted and marked for the whole cross-section.

One of the methods used to assess the distribution of fibers in the yarn is the method Hamilton [1, 2, 3,4]. With this method the migration index (MI) was calculated which shows the percentages amount for radial displacement of fibers in the yarn cross-section. If MI = 100%, the fibers migrate outwards, if MI = -100%, the fibers are placed mainly in the center of the yarn and if MI = 0, fiber distribution in the cross-section of the yarn is uniform.

Derivation of the migration index

Method of calculating the migration index requires that the yarn cross section to be divided into five zones of annular shape, radius being divided equally. In the case of yarn that has two components, A and B, the fibers of each component from each zone are counted settling in this way the values a_1, a_2, a_3, a_4 a_5 and b_1, b_2, b_3, b_4 b_5. With these values the actual distribution is calculated as the product between the number of fibers and a zone bias value. The author of this method [3] considers that the central zone has the bias value of -2, the second zone the bias value of -1, the third zone the bias value of 0, the fourth zone the bias value of 1 and the fifth zone the bias value of 2. The zone bias value have been chosen to make the numerical calculation as simple as possible [3]. In these conditions, the fiber moments of the actual distribution corresponding to the two components will be calculated by the sum of the products of the fiber frequency and the zone bias value. Thus, the following relations will result:

$$M_{actual\ A} = 2(a_5 - a_1) + (a_4 - a_2) \quad (1)$$

$$M_{actual\ B} = 2(b_5 - b_1) + (b_4 - b_2) \quad (2)$$

The ideal moments or the moments that reflect the uniform distribution of the fibers of the two components in the yarn will be calculated with the following relations:

$$M_{uniform\ A} = [N_A / N_{total}]\ [2(n_5 - n_1) + (n_4 - n_2)] \quad (3)$$

$$M_{uniform\ B} = [N_B / N_{total}]\ [2(n_5 - n_1) + (n_4 - n_2)] \quad (4)$$

where:
N_A represents the total number of fibers of the component A;
N total - the total number of fibers;
N_B represents the total number of fibers of the component B;
n_1, n_2, n_3, n_4 n_5 - the number of fibers in the five zones of the cross-section.

By comparing the value of M_{actual} to the value of $M_{uniform}$ it can be appreciated in which zone, outward or inward, the fibers of the respective component are placed predominantly. Depending on this, it is estimated the possible number of fibers on each zone, for each component, being calculated the moments M_{inward}, for fibers that migrate to the yarn core and $M_{outward}$, for fibers that migrate to the sites nearest the yarn surface [3].
When fibers migrate to the sites nearest the yarn core, respectively when $M_{actual} < M_{uniform}$, the migration index, in percentage, has a negative value and it is calculated with the following relation:

$$MI = [(M_{actual} - M_{uniform}) / (M_{uniform} - M_{inward})]\ 100 \quad (5)$$

If $M_{actual} > M_{uniform}$, fibers migrate toward the yarn surface and the migration index, in percentage, has a positive value, being calculated with the following relation:

$$MI = [(M_{actual} - M_{uniform}) / (M_{outward} - M_{uniform})]\ 100 \quad (6)$$

RESULTS AND DISCUSSION

For all three types of yarns that have been analyzed, when it was examined the migration of hemp fibers, it resulted that the value of M_{actual} was major than the value of $M_{uniform}$, which means that the hemp fibers were distributed mainly in the outward regions of the yarn section.

For the calculation of the migration index of polypropylene fibers in yarn cross section, the same steps have been accomplished as in the case of hemp fibers. In all three cases, it resulted $M_{actual} < M_{uniform}$, which means that the polypropylene fibers will be distributed mainly in the core zones of the yarn section.

In the first stage, the migration index was calculated by the steps described above in the previous paragraph, being obtained the initial values of the migration index ($MI_{initial}$). Because the fiber densities and fineness in the case of the two components are different, it will be desirable to convert the fiber frequency to a volume distribution [3]. Therefore, the fiber frequencies for one component are multiplied with a correction factor given by the relation:

$$c = \frac{T_{dtexA} \cdot \rho_B}{T_{dtexB} \cdot \rho_A} \quad (7)$$

where:
T_{dtexA} is the mean length density of the fibers of the component A (25 dtex);
ρ_B - is the density of the fibers of the component B (0,847 g/cm^3);
T_{dtexB} is the mean length density of the fibers of the component B (4,167 dtex);
ρ_A - is the density of the fibers of the component A (1,5 g/cm^3).

Whence c= 3.387

Initial values and corrected values of the migration index are shown compared in Figure 1. Analyzing the graphical representation, we can notice that the equivalent correction based on relative length densities and densities has led to obtain slightly lower values of the migration index. In the cases of the raw and alkaline treated yarns, the fiber migration was closer to the ideal case of the uniform distribution of fibers in the yarn cross-section. For the bleached yarn, the migration index has indicated that a less intimate blending of two-component fibers occurred during the processing of fibers. This can be explained by the fact that after chemical treatment of roving, the hemicelluloses and pectin substances were partially dissolved, the hemp technical fibers being individualized to some extent, with some of them remaining bonded. It was also noted the importance of the washing after each step, for removing the bleaching products and the other auxiliary substances.

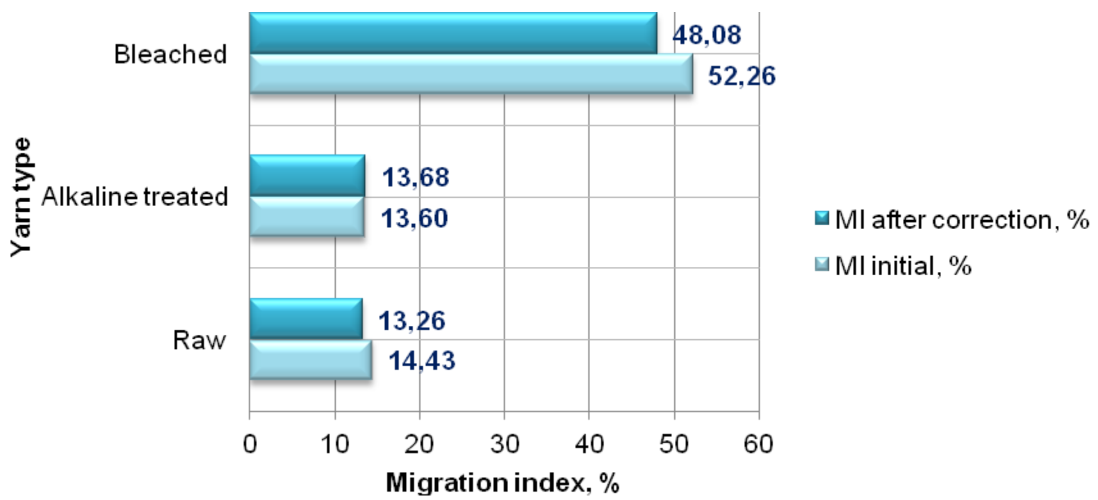

Figure 1: Initial values and corrected values of the migration index

Different methods of zoning the yarn cross-section have been compared in order to study the fiber migration in the yarn cross-section: division into five zones corresponding to equal increments in radius and concentric annuli of equal area [2,3,4]. The values of the migration index resulted after these two methods of concentric zoning have been applied, have shown that the division of the cross-section into five zones of equal area has led to slightly higher amounts of migration index compared to those exhibited by the yarns that have been divided into five zones corresponding to equal increments in radius, as shown in Figure 2.

The equal thickness method is preferred because it offers the possibility of investigating a smaller core zone compared with the other method which very much obscures any distinctive properties of the core, because in this case fibers up to some 45% of the way from core to surface are considered as core fibers [3]. Moreover, the equal area method led to a very thin outer zone for which it is more difficult to determine the correct frequency of fibers.

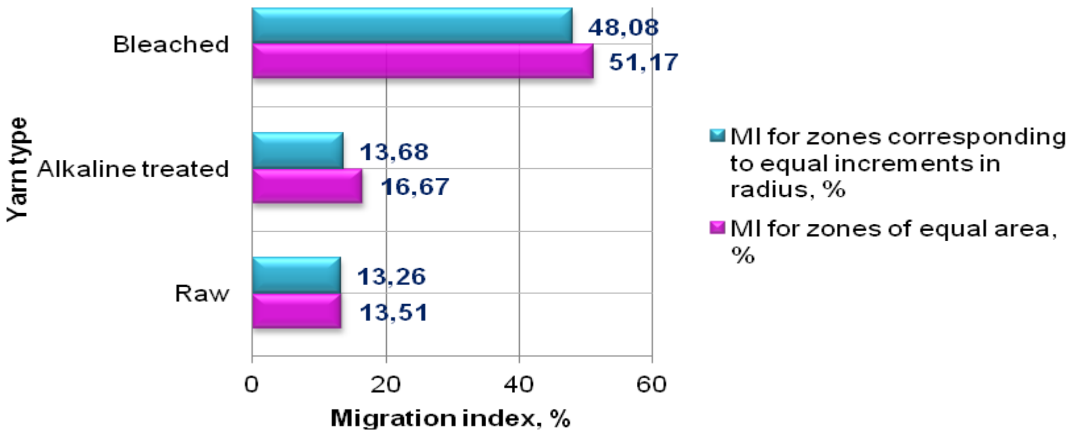

Figure 2: Migration index for two types of concentric zoning of the yarn cross-section: division into five zones corresponding to equal increments in radius and concentric annuli of equal area.

CONCLUSIONS

In the case of a blending of fibers that have different physico-mechanical characteristics it is very important to study the way in which the fibers migrate in the yarn cross-section. For a yarn wet spun from polypropylene and hemp fibers blending, it has been found that the migration of polypropylene fibers has occurred mostly in the yarn core, while the hemp fiber were placed mainly to the outward of the analyzed sections. This positively affects the characteristics of yarns and products made from them, because they will keep the touch and appearance specific to hemp type yarns, improving at the same time the yarn properties, especially elongation due to the presence in yarn composition of modified polypropylene fibers. It thus demonstrates that migration parameters that assesses distribution of fibers in the yarn cross-section is very important with respect to the end use of the yarn.

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META-TEXTILE STRUCTURES, A TECHNOLOGICAL CHALLENGE OF TEXTILE INDUSTRY

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Abstract: *The paper presents the elements that are necessary and sufficient to the understanding of the notion of multifunctional meta-textile structure. The first part of the paper presents a synthesis of the results obtained in the field of "invisible" metamaterials (optical cloaks, acoustic cloaks, thermal cloaks) and a mathematical model of an invisible multifunctional meta-textile structure taking into consideration the design of such a structure. The second part of the paper presents the theoretical concepts of transformations thermodynamics to exemplify the dynamic flow of heat around an object as if no object was there.*

Keywords: *multi-functionality, textile meta-structures, optical/acoustic/thermal cloak.*

INTRODUCTION

Advanced industrial technologies, directly or indirectly, exert their beneficial influence, generated by progress, in the fields of the social-economic life, in such a way that these fields seek to harmonize the development in view of a common benefit. Since, from the social and economic points of view, textile industry represents a major technology user; it is natural that it should try to address all challenges in a positive way. The benefit is mutual: technology identifies a user (*consumer*) that is directly interested, willing to make investments in order to adapt both the methodology and the manufacturing process to the new technical requirements, while the *consumer* (user) assesses the effectiveness of the envisaged investment, following that it should be recovered during application of the accepted flow (raw-materials-manufacturing process-trading).

Technological advances achieved over the past 25 years have led not only to great technologic results, but also to theoretical reconsiderations which were unimaginable 30 years ago. It is enough to mention here only two very conclusive examples, namely ***metamaterial.***

"The concept of metamaterials was first introduced in the field of electromagnetic (EM) materials. Here it came to mean a material whose effective properties arose not from the bulk behavior of the materials which composed it, but more from their deliberate structuring. Therefore, metamaterials sit at the intersection of two classical categories, materials and devices. Our definition of metamaterials in this review is somewhat broader than what conventionally defined as it includes all MNSMs regardless of a relative scale ratio between the characteristic structural length and the wavelengths of EM or mechanical waves. In the conventional (narrower) definition of metamaterials, the characteristic length scale of their structures is one or more orders smaller than the wavelengths"[2]

THE MATHEMATICAL MODEL OF THE EXTERNAL LAYER FORMED OF AN INVISIBLE METATEXTILE STRUCTURE [1-2]

2.1. The material point hypothesis

Each intersection between a warp yarn and a weft one is a distinct material point (figure 1), perfectly pointed out. This means that the two determined yarns have the same and only material point, as if they were connected. The mass of the material point results from the even distribution of the textile area mass on all over the material points above mentioned;

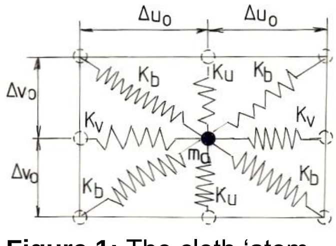

Figure 1: The cloth 'atom

2.2 The hypothesis of the elastic bonds

Each material point ("atom") is connected with at the most eight neighboring material points, two by two on each warp and weft yarn and with other four on biè (figure1).This connection is a perfect elastic bond when it is subjected to tensile stresses, following Hook's Law.

2.2 The hypothesis of the electrical properties of yarns.

The yarns are electro-conductibilities.

2.3 Equations of motion

$$\begin{cases} m\ddot{\mathbf{X}}_i = \boldsymbol{\phi}_{ij} + \mathbf{F}_i + \mathbf{F}_{\mathbf{i,em}} - \beta\dot{\mathbf{X}}_i \\ i = 1,2,\ldots N_m,\ j \in V_i \end{cases} \quad (1)$$

$\boldsymbol{\phi}_{ij} - elastic\ \ force$

$\mathbf{F}_i - exterior\ \ force$

$\mathbf{F}_{\mathbf{i,em}} - electromagnetic\ \ force\,(Lorentz)$

$-\beta\dot{\mathbf{X}}_i - damping\ \ force$

$V_m - N_m$ *the number of free nodes that belong to the texti le field*

2.4 Equations of Maxwell

$$\nabla\mathbf{E} = \frac{1}{\varepsilon_0}\rho \quad (2)$$

$$\nabla\times\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t} \quad (3)$$

$$\nabla\mathbf{B} = 0 \quad (3')$$

$$\nabla\times\mathbf{B} = \mu_0\mathbf{J} + \mu_0\varepsilon_0\frac{\partial\mathbf{E}}{\partial t} \quad (4)$$

2.5 Constitutives laws

$$\mathbf{D} = \varepsilon_0\mathbf{E} \quad (5)$$

$$\mathbf{B} = \mu_0\mathbf{H} \quad (6)$$

$$T_{ik} = \varepsilon_0\left(E_iE_k - \frac{1}{2}\delta_{ik}e^2\right) + \frac{1}{\mu_0}\left(B_iB_k - \frac{1}{2}\delta_{ik}B^2\right) \quad (7)$$

where:

$\boldsymbol{E}$ - electric field

$\boldsymbol{B}$ - magnetic field

$\boldsymbol{J}$ - current density

ρ - change density

ε_0 - permittivity of free space

μ_0 - permeability of free space

T_{ik} - tensor of tension

e - electric charge

δ_{ik} - Kronecker symbol

The mathematical model obtained links variable to the electromagnetic variable permitting the interaction between the textile structure and the surrounding electromagnetic field.
Equations are written for each node (linking point) of the textile (structure) network therefore depending on the density there can be thousands of equations with partial derivatives to which the boundary conditions are added. It is clear that the solution to such a huge system of equations can only be found by GRID networks specific methodology, the only methodology that can lead to an acceptable numerical solution.

MATHEMATICAL MODEL OF THE DEFORMATION OF AUXETIC WOVEN TEXTILE STRUCTURES
The mathematical model used for the study of the deformation of auxetic textile structures can be, as a matter of fact, considered an adaptation of Butoescu V. model [3] to auxetic textile structures in a GRID network. In comparison with the initial model, the fundamental difference is the fact that GRID network equations accept millions of numerical solutions, and at the same time, it presents particular challenges for error control and for other specific characteristics of this work method. The fact that grid networks are compatible with the calculation of matrices of such dimensions leads us to formulate the essential work hypothesis which is that in this case each connection point is biunivocally represented in the model, so that each “atom” point is presented with the material specific characteristics. Because the study used the values obtained for parachute fabrics, this model eliminates the hypothesis of the existence of “oblique” reactions. Because the model is detailed in [3], we shall underline the essential elements specific to auxetic woven structures that can be solved as grid networks and the methodology for grid network calculation.

3.1 Description of the mathematical model specific to these auxetic woven structures
Butoescu’s model [3] shall be adapted to the grid network work method. Therefore, the work shall be done not with fictitious yarns, but with the yarns in the woven fabric, in this case the warp and weft yarns and the connection points shall be considered mass points – points in which the mass of each fabric “atom” is concentrated. Furthermore, rigidities K_u and K_b depend on Poisson ratio. The elastic forces in the yarns are given by the [2] expressions:

$$\boldsymbol{\Phi}_{ij} = \begin{cases} \boldsymbol{K}_{ij}(\nu)\left(1-\dfrac{\left|\mathbf{X}_{ij}^{o}\right|}{\left|\mathbf{X}_{ij}\right|}\boldsymbol{X}_{ij}\right)\cdot\dfrac{\mathbf{X}_{ij}}{\left|\mathbf{X}_{ij}\right|}, & \boldsymbol{if}\quad \left|\mathbf{X}_{ij}^{o}\right| \le \left|\mathbf{X}_{ij}\right| \\ 0, & \boldsymbol{if}\quad \left|\mathbf{X}_{ij}^{o}\right| > \left|\mathbf{X}_{ij}\right| \end{cases} \qquad (8)$$

in which *i,j* are indices for the connection point situated at the intersection of the “i” weft yarn with “j” warp yarn. The index *j* takes values for the neighbouring nodes of *i* node rigidity values must be linked to Poisson ratio, corresponding to *ij* region in the system. $\mathbf{X}_{ij}$, is the position vector of *(i,j)* point and “0” index, indicates the initial position of a point. The equations of motion for point *I* are:

$$m\ddot{\mathbf{X}}_i = \boldsymbol{\phi}_{ij} + \mathbf{F}_i + \mathbf{F}_{\mathbf{i,em}} \qquad (9)$$

In which *i* takes values for all the network nodes and $\mathbf{F}_i$ is the external force acting in *i*.

3.2 Elastic equivalence of elastic membranes and certain textile structures [5]

There are many situations in which, in order to study certain characteristics (especially those related to elasticity and resistance) of the textile structures, we need to use numerical methods that evidence by means of calculations firstly, the “compatibilities” of the elastic behaviour of the studied samples.
This way we are led to the concept of elastic equivalence of two samples: when subjected to identical stresses, two geometrically identical bodies have identical behaviours. Thus, under identical loads we get the same results (tensions, deformations) for both. A concrete example is given by the walls of arteries in the human body – they are elastic and resistant walls that can be assimilated to an elastic membrane with similar properties. If there is a need to replace such arteries, one of the searched for characteristics is the elastic behaviour – a textile structure that, from an elastic perspective, behaves the same as the original artery. Once this concept is clear, we can work towards the proposed objective: a numerical model of the elastic behaviour of a membrane, a problem solved within the limits of the theory of elasticity by using dedicated products such as ABACUS, COMSOL MULTIPHYSICS. In the figure below the tension state is presented for two elastic membranes with opposite Poisson ratios – for the first case v is 0.3 and for the second case it is -0.3. We can now approach the problem of finding a textile structure that is elastically equivalent to the elastic membrane. It is a challenging problem, as the textile structure is a discontinuous medium, therefore using the above products is forced upon this problem (meaning that in many instances the discontinuity of the textile structure leads to errors). There is a need for a closer method to have a correct modelling of the textile structures. One of the methods is the model presented in this paper. The work methodology shall be presented in the following part of the study.

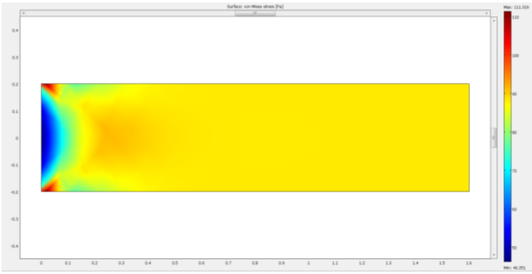

Figure 2: a) Conventional case

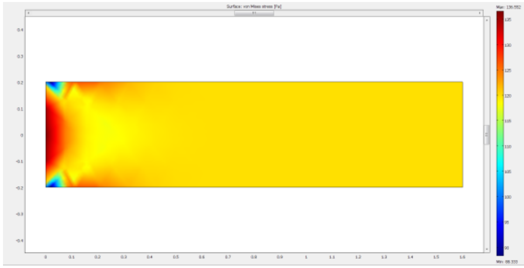

Figure 2: b) Auxetic case

RESULTS AND DISCUSSION

For calibrating the model, parachute samples type T40-200 with the following characteristics were used: mass 60 g/m^2; thickness 0.13 mm, D_u = 628/10 cm; D_b = 615/10 cm; the yarn used was PA 6, warp yarn fineness was of 4.5 Tex and the warp yarn diameter was of 88 µm . As regards the weft yarn the diameter is 86 µm, fineness 4.5 Tex. Textile sample is treated as a membrane that is numerically simulated and then we compare the values obtained by the first method (the one using COMSOL MULTIPHYSICS) with those obtained using GRID networks. Some calculations are presented in Table 1. As can be seen in COMSOL MULTIPHYSICS product simulation (column 3 and 5), the values obtained in the auxetic case (Fig. 3 b) are superior to those obtained in the conventional case (Fig. 3 a.). As regards the second method, a number of 628x615 points were used for the connection points. It can be seen that generally the values obtained by GRID processing are ranging around the values obtained by the conventional method.

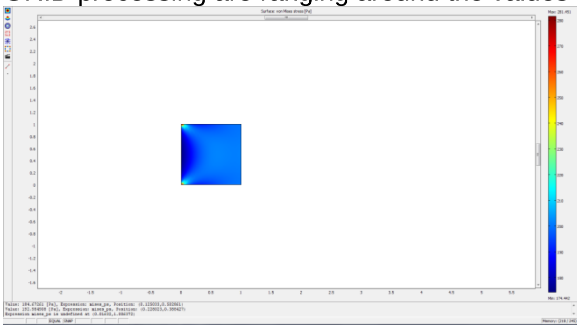

Figure 3: a) Conventional case

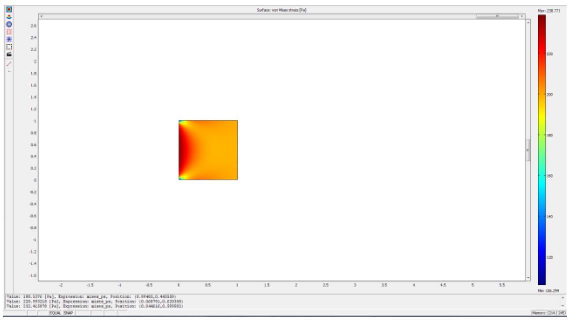

Figure 3: b) Auxetic case

We used the following values: density 1150 kg/m3 wire, 2e9 Young's coefficient [Pa] and the Poisson ratio is 0.2. Auxetic case was considered for the Poisson value -0.2.

Table 1: Values calculated by simulation on COMSOL MULTIPHYSICS and grid network

Coordinate x	Coordinate y	Conventional Von Mises [Pa]	Conventional Grid	Auxetic Von Mises [Pa]	Auxetic Grid
0.25	0.55	193.5	191.8	208.4	205.6
0.48	0.45	201.1	199.7	212	210.9
0.59	0.45	201.7	200.1	199	200.6
0.49	1	193.7	194	207	205.7
0.48	0	193.6	191.8	206	204.7
0.4	0	191.7	193.	207.2	205.3
1	0.46	201.4	200.5	198.53	200.7
0.01	0.01	282.2	283.1	278.1	276.5
0.08	0.62	212.5	213.1	229	227
0.04	0.6	226.7	227.1	232	231.4

4.1 Thermal cloak [6-17]

As similar to the invisible cloak and the acoustic cloak, the researchers are trying to design the thermal cloak. A first approach was the use of coordinate transformers. An interesting outcome is due to S. Guenneaux and his collaborators research within the German studies, which has been shown within the work [6]. The authors of the research design both an experiment device, as well as a model for thermal numeric simulation using Comsol. The results of the calculations are checked by the experiment measurements using a conventional of infrared thermal device (FLIR A320). Due to the experience in time, the authors have created a meta-material micro-structure with strong anizotrop nature from a thermal point of view.

They used relationships:

$$k_\theta = k_0 \left(\frac{R_2}{R_2-R_1}\right)^2 \geq k_0 \qquad (10_a)$$

$$k_r = k_0 \left(\frac{R_2}{R_2-R_1}\right)^2 \left(\frac{r-R_1}{r}\right) \leq k_0 \qquad (10_b)$$

where: k_0 is the heat conductivity of surrounding of the cloak, and (k_θ, k_r) azimuthal and radial components of the conductivity tensor $\overleftrightarrow{k}$ in the interval $[R_1,R_2]$.
The experiment device consists of a copper plate (see fig. 4 adapted after ref[6]) where same thickness rings were designed and the copper rings suffered some drilling of different holes so that each ring is anizotrop (from a thermal point of view).
The holes (which are white in fig. 4) have been filled with polydimetilxiloxane (PDMS), and the "i" metal section of each ring, indicated by f_i, allowed for a calculation of an efficient coefficient of thermal conductivity associated to the "i" ring (i,j=1-10 and $f_i \neq f_j$ for $i \neq j$) determined by the following relation $k_i=f_i k_{Cu}+(1-f_i)k_{PDMS}$. The following values have been used: k_{Cu}=394 W/(Km), k_{PDMS}=0.15 W/(Km), k_0=85W/(Km).

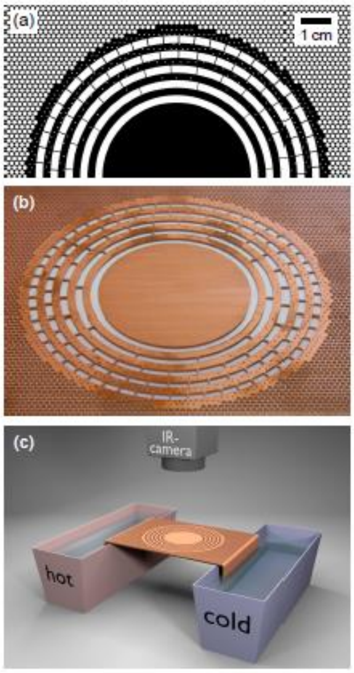

Figure 4: a) The black regions are bul copper, the white regions polydimethylsiloxane (PDMS) with heat conductivities of 394W/(Km) and 0.15W/(Km), respectively; b) the radial and azimuthal components of the effective local heat conductivity; c)scheme of experiment

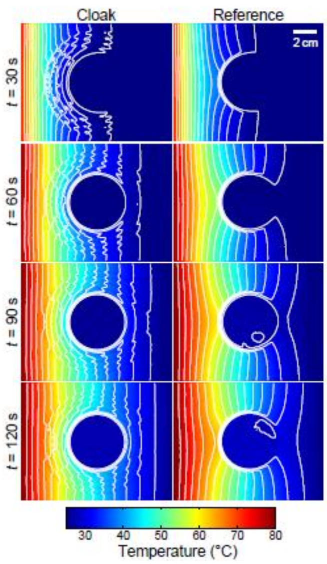

Figure 5: Measured temperature distributions at differences as indicate (Ref [6])

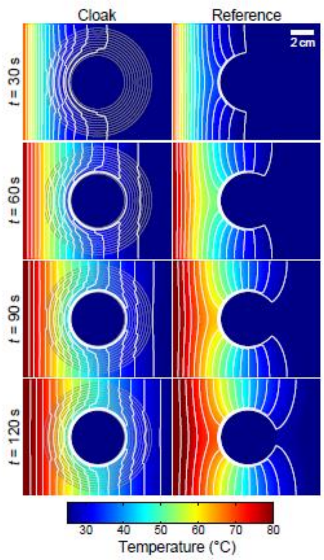

Figure 6: Calculated temperature distribution shown as the experimental in Figure 5

CONCLUSION

A hypothetical model of “multifunctional invisible” textile structure was presented. This structure is formed of two layers: an external one that ensures the “invisibility” of the textile structure as a whole and an internal one consisting of an auxetic structure. For the internal layer, a concrete case of design of such a structure will be presented (mathematical modeling and numerical results). For thermal cloak we use the theoretical concepts of transformations thermodynamics, and we realized a cloak that molds the dynamic flow of heat around an object as if no object was there.

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KNITTED HOMETECH PRODUCTS BASED ON STITCH TRANSFER TECHNIQUE

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Abstract: *A well-defined area of technical textiles is the Hometech, which must satisfy aesthetic criteria and comply with requirements regarding mechanical, biological, comfort, dirt resistance, and protection parameters. Of all textile technologies, knitting technology, is mainly used when making the Hometech articles due to specific properties of knitted fabrics and the possibility of production, depending on the needs and on the most complex three-dimensional shapes too. Out of all the structures obtained through knitting (flat or tubular jersey, shape or no-shape knitted panels, complete product made only by knitting), complex-shaped 3D knits, are widely used for Hometech articles. Fit loop transfer stitches also fall in the category of knitted structures used for manufacturing such items. The paper mainly focuses on the technique of transferring stitches when knitting with patterns, as well as when manufacturing knit-and-wear products designed for articles belonging to the Hometech category of textiles.*

Keywords: *hometech, yarns, knitting technology, knitted shape, stitch transfer.*

GENARAL ELEMENTS

Technical textiles are an expanding and changing sector in the global textile industry. Technical textiles have an increased functionality and are characterized by determinant properties with strict variation intervals, with extreme values [1]. These properties differ depending on the field of use, the most frequent ones being mechanical, biological and protection features. The notion of "technical textile materials" encompasses an extremely wide range of products of different types and made of various raw materials, used for many purposes.

Technical textiles, depending on the product characteristics, functional requirements and end-use applications have been classified into 12 segments: Agrotech (Agriculture, horticulture and forestry), Buildtech (building and construction), Clothtech (technical components of shoes and clothing), Geotech (geotextiles, civil engineering), Hometech (components of furniture, household textiles and floor coverings), Indutech (filtration, cleaning and other industrial usage), Meditech (hygiene and medical), Mobiltech (automobiles, shipping, railways and aerospace), Oekotech (environmental protection), Packtech (packaging), Protech (personal and property protection) and Sporttech (sport and leisure) [2]. These classification system developed by Techtextil, Messe Frankfurt Exhibition GmbH, is widely used in Europe, North America and Asia. Some examples of day-to-day use of technical textile products, are: Kitchen (Wipes, Floor Mops, Tea Bags, Coffee Filters), Clothe (Collar / Cuff Interlinings, Shoulder Pads, Waddings in Jackets), Shoe (Lining, Insoles, Toe Stiffners, Synthetic Uppers), Car (Carpets, Roof-liners, Insulations, Air Filters), Civil Engineering (Geotextiles in Roads, Railway Tracks, Soil Erosion, Slope Stabilization), Furnishing (Carpets, Vertical Blinds, Wall Coverings), Factory Dust Collection Filter Bags, Liquid Filtration, Clean Air Filters of AC systems; Hospital Masks, Gowns, Caps, Dressing, Bandage; Hygiene Baby Diaper, Sanitary Napkin, Wet Tissues, Bed Blanket, Quilts, Mattresses [3].

TEXTILE HOMETECH PRODUCTS

The new promise of technical textiles is generation of products (by combining the latest developments in advanced flexible materials with advances in process technologies) that eventually have a direct impact upon all sorts of consumer textile markets, including both clothing and furnishings. These are called "HOMETECH".

Hometech segment, one of the largest technical textile markets [Figure1], comprises of the textile components used in the domestic environment-interior decoration and furniture, carpeting, protection against the sun, cushion materials, fireproofing, floor and wall coverings, textile reinforced structures/fittings, filter products for vacuum cleaners. They are made of both natural and synthetic fibers.

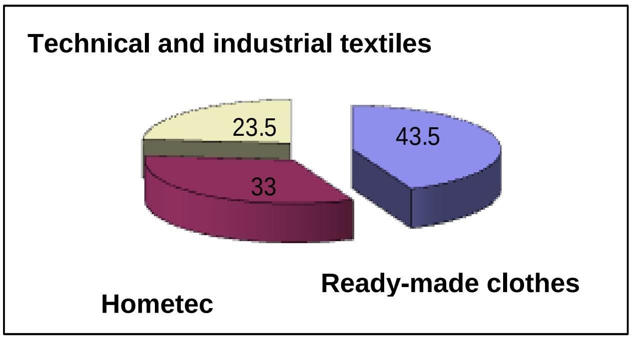


Figure 1: Textiles' market

Some of the highly useful applications of Hometech include [4], [5]: Fiberfil, Mattress and pillow components (Flanging and quilt backing, spring wrap), Carpet backing cloth (Jute & Synthetic - used as primary as well as secondary backing for tufted carpets), Stuff toys, Blinds, HVAC filters, Filter cloth for vacuum cleaners, Nonwoven wipes (floor mops), Mosquito nets

JERSEY FOR HOMETECH ARTICLES MANUFACTURED BY USING THE STITCH TRANSFER TECHNIQUE

When manufacturing Hometech articles, the decorative products branch represents a well-defined area of activity, as they have to meet a number of requirements, such as: aesthetic, comfort, dirt resistance, and safety when used criteria. From all the available textile technologies, knitting is particularly applicable when manufacturing decorations for both our home and public spaces, considering the possibilities they offer regarding knitting patterns, their specific elasticity, and the diversity of raw materials that can be processed.

For a knitted product, the nature of the finite product and the manufacturing process is determined by initial knitted fabric characteristics [6]. So, for the purposed goal, it is important to choose the optimal and appropriate variant, in terms of maximum economy of manufacture and suitable quality [7]. For obtaining finite knitted products, there are used different methods, like:

- "fully cut" knitted products. This method requires cutting and making the product from jersey, and about 40% of the original basic fabric may go as cut-loss;
- "stitch shape cut" knitted products (used in the case of rectangular knitted panel);
- "full fashioning" knitted products. These are based on knitting shaped panel. In this case cut-loss is eliminated and knitting shaped panel the components, of the knitted garment, must be only sewn together;
- "complete knitted products". They need no cutting and sewing process, and more they can be improved by integrating trimmings, pockets, buttonholes and other accessories.

Various structures can be used when making decorative articles; an essential role is played by the technique of stitches transfer that allows the accomplishment of highly diverse and complex drawings, but also of flat and spatial jersey shapes, complex-shaped 3D knits respectively.
The name of transferred stitch is a generic name, the stitch being not transferred as a whole, but only by its components. So, both bearded and latch needle weft knitting machines offer considerable scope for transfer of a full or a part needle or sinker loop onto an adjacent needle either in the same bed or in an opposing bed with the objective of achieving shaping, producing a design or changing the stitch structure [7]. Automatic loop transfer requires a specific arrangement of specially shaped needles and/or transfer points.
There are known four main types of transfer stitches:

- plain needle loop transfer stitches produced by transference from one needle to another in the same bed;
- fancy lacing stitches produced by modification of the plain loop transfer stitch;
- rib loop transfer stitches produced by transferring a loop from one needle bed to another;
- sinker loop transfer stitches.

The transfer of the structure elements can lead to the achievement of a wide range of knitted fabric concerning the covering capacity with many various effects. The improvements made to the flat knitting machine for the enlargement of the integrated systems (for knitting and transfer) and also for reduction of the yarn stress both for knitting and for transfer with consequences over improvement of the knitted fabric quality came to compensate the reduced productivity due to the insertion of the transfer stages.

Knitting's unique ability to manufacture shaped products offer appreciable economies in raw material by elimination of cutting waste as well as minimizing the time for the obtaining of the knitted product. There are three possibilities [6] for shaping knitted garments without cutting:

- by varying the number of needles in action in the knitting width (increasing or decreasing the number of the wale), based on stitch transfer technique;
- by changing the knitting construction (course shaping by inserting additional courses over part of the garment);
- by altering the stitch length (stitch shaping by adjusting the size of stitches in different part of the garment).

Depending on the final product shape, fabric requires widening or/and narrowing in different manner.

Considering the wide range of applicability that the Hometech products have, especially the ones that were manufactured by using the knitting technology, we selected decoration products in order to exemplify our research activities, such as: covers for various furniture parts (Figure 2), accessories and decorative articles (Figure 3), floor tiles decorations (Figure 4), bed sheets (Figure 5), decorative pillows (Figure 6), articles for room landscaping (Figure 7), decorative products for walls (Figure 8).

Figure 2: Covers for sofas, armchairs, chairs, stools, and tables

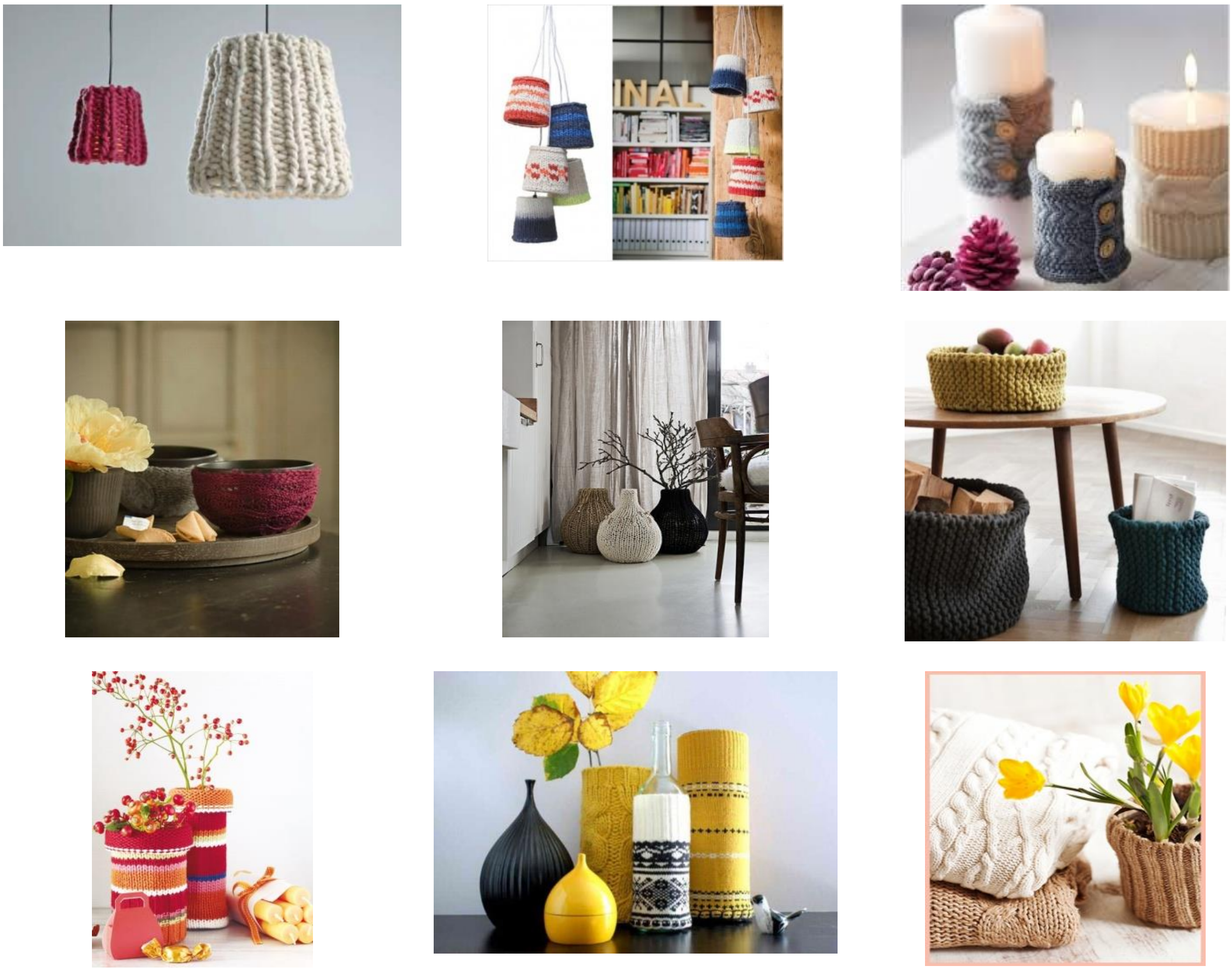


Figure 3: Covers for lamps, candles, vases, bowls, and plates

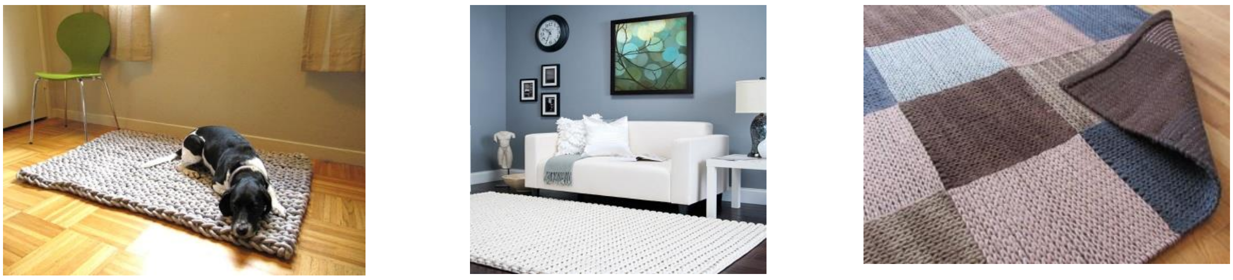


Figure 4: Carpets

Figure 5: Bed sheets, quilts

Figure 6: Pillows

Figure 6: Products for baby rooms

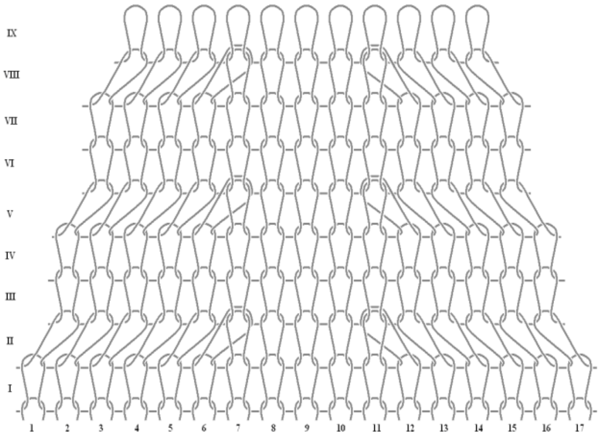
The technique of stitch transfer applied when defining flat or spatial contours, or when making entirely knitted articles, as well as structural designs, is highly used for manufacturing Hometech products (Figure 7)

a

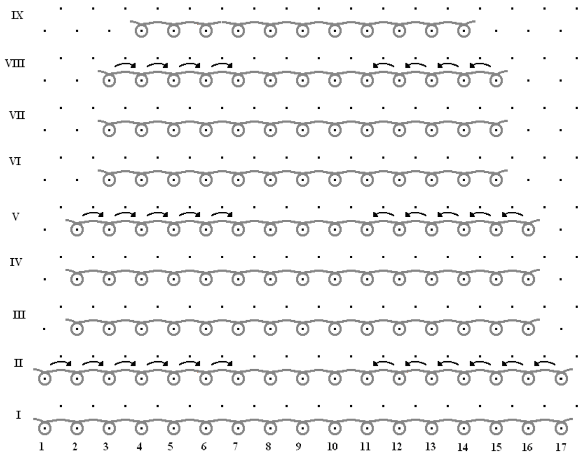
b

Figure 7: The technique of stitch transfer applied to Hometech products: for defining shapes (a), for structural design (b).

One of the solutions that was applied when defining shapes is based on the procedure of narrowing the fabric; Figure 8 exemplifies, structurally and technologically, a method of bilateral narrowing.



structural view



technical view

Figure 8: bilateral narrowing based on stitch transfer technique

When knitting Hometech articles, drawings based on stitch transfer are highly applicable. Below, a Hometech blanket is presented in order to exemplify this particular technique (Figure 9), which includes torsion-type designs carried out on automatic flat line machines with CMS control programme Stoll 530 [2], gauge 6.2.Some elements from the knitting programmer that was used to manufacture the product on the previously mentioned flat line machine, for various torsion versions that the product includes, are represented by: fabric view (Figure 10), symbol view (Figure 11), and technical view (Figure 12).

Figure 9: blanket

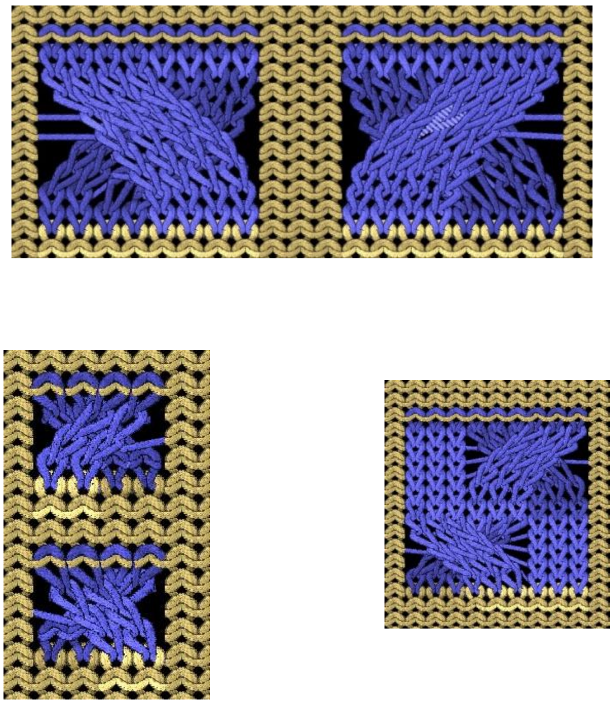


Figure 10: fabric view (stitch cables variants)

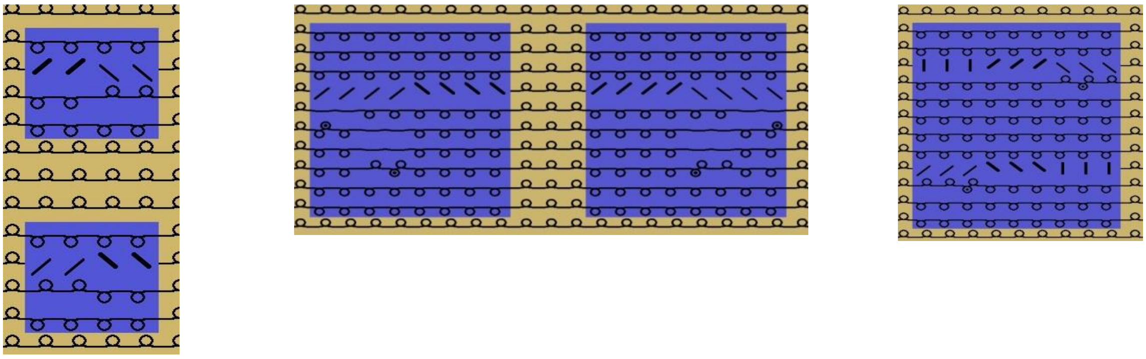


Figure 11: symbol view (stitch cables variants)

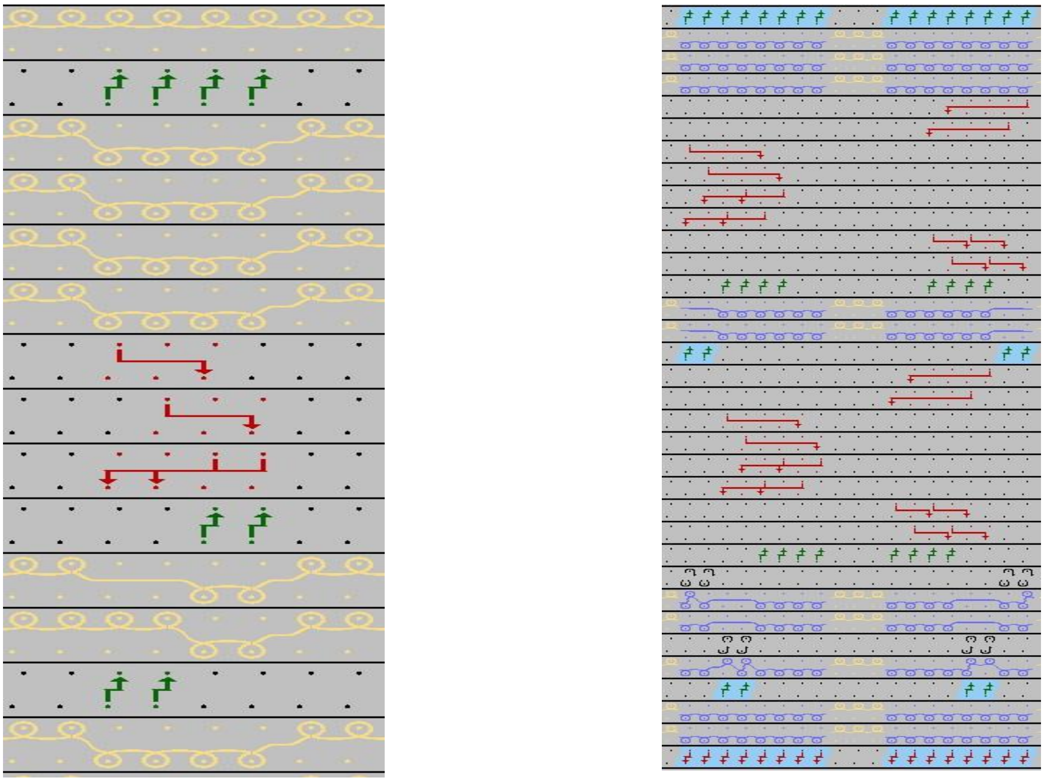


Figure 12: technical view (stitch cables variants)

CONCLUSIONS

The Hometech segment represents one of the largest technical textile markets, including the textile components used in the domestic environment-interior decoration and furniture, carpeting, protection against the sun, cushion materials, floor and wall coverings, and so on, made of both natural and synthetic fibers. Knitted Hometech products can be obtained by using: flat or tubular jersey, shape or no-shape knitted panels, complex-shaped 3D knits and complete products made only by knitting. Decorative articles that are included in the Hometech products category can employ various structures, from which the ones carried out based on the stitch transfer technique play an essential part. Such a technique allows the accomplishment of highly diverse designs as well as of knitted shapes that could be flat or spatial. The manufacture of articles with such complex structures and shapes becomes possible due to the use of flat line knitting machines with state-of-the-art electronic control devices.

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VOLUME POROSITY AND AIR PERMEABILITY IN KNITTING FABRICS

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Abstract: *Main aim of this paper is to find a suitable model that makes possible the prediction of air permeability of a Knitting fabric on the base of its constructional parameters. The methodology: As the constructional parameters of Knitting fabric are considered: gouge of twist factor, yarn count yarns, diameters (or fineness) of yarns and a type of weave structures. This research is focused on clothing woven fabrics of a cotton type. Two variants of so-called cumulative parameter of a Knitting fabric structure are defined and they are applied on the set of Knitting fabrics. Porosities evaluated from empirical analysis and basic knitting wefts structural parameters (kind of material, yarn diameters and loop length / gouge setts). The cotton single jersey of weft knitting constant sett of gouge and varying sett of weft and varying yarn fineness are used for predictive model building. the obtained results, this new (EMP-THE) Empirical Theoretical Model of Volume Porosity and air Permeability in knitting fabrics are created end evaluated by the combination of partial of samples, numerical without graphs and suitable criterion expressing the predictive ability, a correlation between calculated values of structural parameters and experimental air permeability values was evaluated. Conclusions, in the first step the principal component analysis of volume porosity and air permeability in knitting fabrics, leading of new factors to the design suitable for end-use.*

Keywords: *air permeability, Knitting, structure, porosity.*

1. INTRODUCTION

Volume is the amount of space occupied by an object or a material, then volume porosity is the amount of space occupied between loops of knitted fabric, or the amount of space occupied by a three-dimensional object or region of space between loops of knitted fabric, Porosity is the ratio of the total amount of void space in a material to the bulk volume occupied by the material. Fabric porosity is an important parameter in assessment of clothing comfort and physical properties of technical textiles.[15][10][9][14]. Several studies have been carried out to analyze the dimensional properties of knitted structures with prevailing these from Chamberlain (1926) [6], Peirce (1947) [19], Leaf and Glaskin (1955) [17], Doyle (1953) [8] and Munden (1960) [18]. These studies have presented either formulated geometrical models consisting of known curves, for example circular arcs and straight lines, or the results of measurements that have been carried out on a series of knitted structures (Demiroz and Dias, 2000) [7]. The present work focuses on the estimation of the geometrical characteristics of a single jersey knitted fabric structure supporting the maximum possible accuracy in order to ensure the numerical modeling success by new equations with experimental on contact analysis.

Weft knitted structure porosity

Plain weft knitted parameters structure such as the courses per unit length, wales per unite length and loops density, the effect of loops length, and yarn liner density on volume pore size as a basic elements of a knit fabric structure is the loop intermeshed with loops adjacent to it on both sides and above and below it.

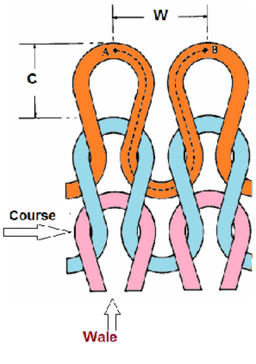

Figure 1. Representation of a plain weft knitted structure.[5]
Where: Wales/cm = 1/w=w , Courses/cm =1/C= c , Loop length = AB= /mm , Loops/cmcm2 =S

Then characterize a pore within loop, which is the unit cell of a plain knitted structure, between the fiber of the yarn in the loop, and the calculated from measurement of fabric thickness with a thickness gauge and yarn diameter as in the following:

$$R' = t/4 \quad (1)$$

$$\text{Since,} \quad R = \sqrt{R'\,R''} \quad (2)$$

$$R'' = R^2/R^1 \quad (3)$$

And loop length as the Peirce equation [19]:

$$l = 2/c + 1/w + 5.9\,d \quad (4)$$

Where;

$l = length\ of\ yarn\ on\ loop (cm)$
$c = number\ of\ courses\ per\ cm$
$w = number\ of\ wales\ per\ cm$
$d = dimeter\ of\ yarn\ (cm)$

S, the number of loop/cm^2 of fabric or loop density is defined as follows:

$$S = c\ x\ w \quad (5)$$

We can calculate volume of free space (cm^3) , inter-yarn, 1 cm^2

$$Fabric = 1x1xt - Sl\,\pi R^2 = t - SlSl\pi R^2 \quad (6)$$

Where *t* is fabric thickness, area of free space (cm2)in 1 cm2

$$Fabric = \frac{t - Sl\,\pi R^2}{t} \quad (7)$$

Since S is the number of loops in 1 cm2, the area of open space within one loop can be given as follows:

$$\text{Area of open space within one loop} = \frac{t - Sl\,\pi R^2}{tS} \quad (8)$$

The pores in a fabric are not circular, however, if the area occupied by a pore is transformed to that of a circle, one can estimate pore radius by the following:

$$Pore\ radius = \sqrt{\frac{t - Sl\pi R^2}{\pi t S}} \quad (9)$$

So loop length and yarn diameter incising pore size values decreases, As indicated by equation of The linear density (tex) of a yarn can be given as follows:

$$T = \frac{\pi d^2}{4} P_y 10^5 \quad (10)$$

Where: *T* is the yarn linear density (tex), *d* is the yarn diameter (cm) and ρy (g/cc) is the yarn, density. Peirce used a value of 0.909 (g/cc) for ρy for cotton yarn. And yarn diameter, *d*, can be shown to be as follows:

$$d = \sqrt{\frac{4T}{\pi P_y 10^5}} \quad (11)$$

When the knitted fabric is treated as a three-dimensional formation, void spaces (pores) can be situated in the fibers, between fibers in the yarn, and between loops threads in the fabric. For these last pores, the term “macropore” is also used. As textile materials, fabrics knitted structures, the most exactly determined inner geometric model of a porous structure in form of a tube like system, where each macropore has a cylindrical shape with a permanent cross section over all its length [16]. the density loops in knitted fabric is usually greater than the gouge density; the elliptical shape of the pore cross section is used to represent the situation of *compact force* [13], to compare woven fabric with porosity, a lot of models for description of porosity in woven fabrics distinction can be made among porosity between yarn, an inter-yarn porosity, and porosity between fibers inside yarn, an inter-yarn porosity, from the point of view of an air permeability evaluation. Permeability of porous materials depends very strongly on the morphological structure. Due to the complexity of the fiber architectures and the lack of an adequate mathematical model, many researchers continue to determine permeability experimentally.

The main aim of theoretical analysis of volume porosity and air permeability of textile materials is usually to find relationship between an air permeability and structure of knitted fabrics. A knitted fabrics structure is in this case usually represented by its porosity. For a determination of the porosity, a number of theoretical and experimental methods exist. then the porosity indicates how much air a knitted material contains of loops densities distribution for a description of physical properties of knitting fabrics throw a configuration of pores in knitting fabrics (the pore size, shape, arrangement etc.) are very important. We are develop a method to predict the volume porosity by equations analysis as a theoretical model, which used as empirical to predict the volume porosity and air permeability and radius of capillaries of weft knitted spacer fabric based on the geometrical parameters and they found that the porosity and capillary radius of weft knitted spacer fabric influenced by the number of spacer yarn. In this work which can be used to handmade calculate the porosity of plain weft knitted fabric is developed. Requires only few input parameters to generate 3D geometrical model of a plain weft knitted fabric. Comparisons of volume porosity of plain knitted fabrics are made between results obtained from experimental work.

2. MATERIALS AND METHODS

In this work a plain weft knitted fabrics made with different yarn (19.6, 14.7tex) of acrylic fibre, Twist factor 2.25, were used in order to evaluate the effectiveness of the developed. In case of staple fiber yarn intra yarn porosity was also considered in the calculation of porosity.

Table 1 shows the fabric specifications of plain weft knitted fabrics of circular knitting machine (Paolo Orizio), gouge 28/inch , Wales/cm = (1/w=w) = 10 per cm on machine were fabrics described. In a research, the porosity of plain weft knitted fabric is expressed laboratory of consolidation fund at Alexandria Egypt for and air permeability of textiles fabrics ASTM D737-96[4], and the Stiffness, weight, and Thickness tests have been carried out for textiles research labs, in faculty of Specific Education, Kafrelsheikh University, Egypt. According to ASTM D 1388 – Standard test method for stiffness of fabrics [2], and ASTM D3776 / D3776M – 09a Standard Test Method for mass per unit area (weight) of Fabric [3, 1], by using ElNashar Digital Tests Methods for weight, durability, stuffiness, strength and elongation for fabrics, ASTM D1777 – 96(2007) Standard Test Method for Thickness of Textile Materials [1], by using ElNashar Digital Thickness Test Methods

3. RESULT AND DISCUSSION

Modified 2D model of porosity, in knotting fabrics includes partly a 3D structure of pores. A various pores type does not show the same relationship between a projected and real effective area opened for the flow. The influence of the pores was described with loop basic unit cells.

Each type of knitting fabric can be described by the following pore type. The structure parameters of uncut loop (densities of loops, basic structure of loop; linear density of loop; degree of loop ratio of uncut the loops, material of loop. were carried out on single-jersey knitting fabrics, as shown in table (1) which were constructed according to the setting theory. All samples before the measurements were conditioned in accordance with standard. A correlation between porosity and air permeability of a fabric is very complicated because a structure of knitting changes by influence off machine (linear density) system is possible classified as a horizontal increase of the porosity, removing of free loops are interlaced very closely in single-jersey knitting fabrics, relative removing of yarns cause an increase of its porosity predominantly in a vertical direction. Flowing air cause a move of not interlaced parts of loop floats between vertical wales and the horizontal Courses increase of porosity can result in a considerable increase of air permeability, moisture permeability, and vapor permeability. Therefore an interesting material for different application such as garment and technical end-uses to determine knitted fabric porosity, several methods have been developed (optical methods or those based on liquid penetration, absorption, filtration, airflow, etc.). To find the diameters of warp pile cross-section, **d** the cross-section of yarn as indicated in the following equation:

$$d = 4.44\ (\sqrt{\text{Tex count/fiber density}})\ 10^{-3}\ \text{cm}. \quad (12) \quad [16]$$

Then, we can calculate the weight as the following:

$$W = \pi\ (d/4)\ L * \text{number of loop threads in knitted fabrics}. \quad (13)$$

Where: W = (weight), L = (length of loop).

3.1. PRESENTATION OF THE GEOMETRICAL MODEL

The main structural parameters of a single jersey fabric are the course-spacing, the wale-spacing and the thickness of the yarn. The rest of the geometrical parameters required for the complete description of the structure derive analytically from the geometrical parameters. Thus the yarns are represented as homogenous cylinders of constant diameter, with initial restricted contact area between them. in figure 1. And this equation gives us more fitting results, it calculates the volume porosity and inner porosity, especially when use the knitted cloth. This model was constructed to have a geometry complicated enough to see the effect of changing the medium location but simple enough to save computational time. Due to geometric symmetry, four different high-permeable medium locations were examined. The permeability of the Seaman high-permeable distribution medium was used in the simulations as the following calculate the knitted fabrics porosity construction % in regular constructors system with plain structure of knitted fabrics by using the flowing figure and equation:

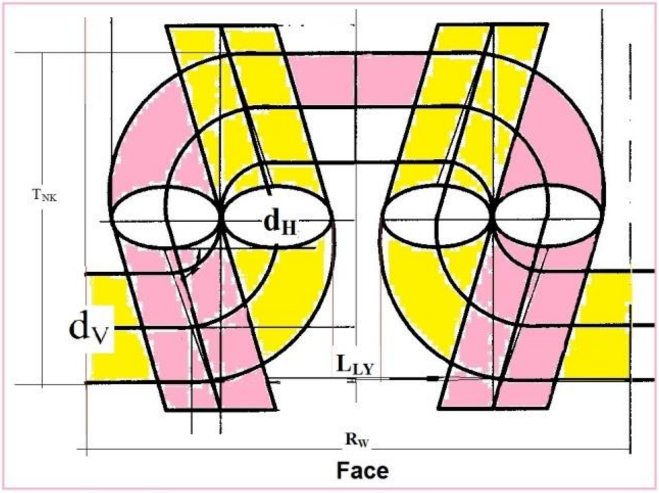

Figure 2. Representation New Model of a plain weft knitted structure.

We calculate volume porosity (V_p) and defined by the following equations**.**

$$VP = \frac{1000\pi[2d_v\, d_H\ \gamma 4T\, D_Y]10/2}{d_{NK}\, T\, \gamma \sqrt{[1-0.01\, C_{VH}]100}} + \frac{L_{LY}\, R_W}{N_{YR}} X \frac{1}{IFC} \qquad \textbf{(14)}$$

Where symbols description for equation:
V_P = volume porosity,
T_{NK} = thickness of knitted fabrics.
T: Yarn count in Tex system.
C : Crimp for knitted fabrics (vertical- horizontal).
D_y: Density of yarns/cm.
γ : *Scientific
d_V: Vertical Cross section for loop yarn.
(d_H) : Horizontal Cross section for loop yarn.
L_{LY} **:** Length of loop yarn "weft" extended between tow intersection in perfect repeat of knitted construction.
R_W : Width of repeat of loop "wale".
N_{YR} **:** Number of Crouse repeats for loop "weft".

***Scientific** (fiber) density for cotton (1.54)- viscose (1.46)-polyester (1.38) – Acrylic fiber density is 1.17 (g/cm3).
IFC**:** Integration factor construction [IFC (in regular structure) gouge) = 1**].**

IFC = Σ(α X W) / n (15)

Where: α: Balance factor of knitting construction. W: width of stripe (density). n : number of wale width tripes (density). Where: K= C n √ N. For direct system. C= is the constant for material, (0.04126 for Tex.). n = number of course threads per inch. N = yarn count.

3.2. CALCULATION OF THE LOOP LENGTH [11][12]

Due to the symmetry of the unit cell the length of the loop is received by the equation 12.

$$L = 4 \cdot arc(\Sigma M) + 4 \cdot arc(MK) + 2 \cdot arc(KP) \qquad (16)$$

Where $arc(KP) = 2\theta \cdot k/\sin\theta$ (17)

Basic parameters of a knitting fabric are: loop width Ωr, loop height Δr, loop length ℓpi,

$$\ell pi = \pi\Delta r - \Omega r \qquad (18)$$

Where ℓ is loop length [mm], Ωr is loop width [mm], Δr is loop height [mm]

$$p_1 = 2d\ p_i + d_2 \qquad (19)$$

$$p = 4d\ p_i + 3d_2 \qquad (20)$$

Where: p1, space between wale of loop, *P:* Widths repeat. And $d\ p_i$: is pile yarn thickness [mm].

The loop length is influenced by the yarn input tension, Knitting fabric take-down tension, loops interlacing velocity, materials friction in the loop zone, yarn structure and properties, yarn linear density, etc. The knitting fabric vertical density W: is defined by the loop density and the yarn input tension; it changes only slightly with the change of the yarn input tension for conventional yarns for elasticized. The vertical density of the knitting fabric changes with depth change. The loop length increases and simultaneously the vertical density are reduced. Volume porosity and air permeability depending on the materials relaxation process usually comprises shrinking of the plain knitting fabric, Dry relaxation begins immediately after exiting the loop interlacing zone when the tension applied to the loops during the knitting process is reduced. The relaxation takes some time, depending on the yarn material composition, the horizontal/vertical (wales and course) density and the structure of the knitting fabric, and loads applied to the fabric prior to relaxation.

The portion of the immediate shrinkage natural materials fabric is wet relaxed during wet after-treatment processes like bleaching and dyeing and additionally during the care process, e.g. laundering and steaming. Theoretically, a knitting fabric changes continually and perpetually tends to attain more stable state than the previous one. The changes are also influenced by the factors like temperature, relative humidity, pressure of materials etc. As the changes are not visible anymore the state is comply with the order. The main structural parameters of a plain knitting fabric are: the head of loop-spacing (P): Widths repeat, the knitting fabric vertical density (w) and the thickness of the loop yarn. The rest of the geometrical parameters required for the complete description of the structure derive analytically from them. The estimation of the geometrical parameters has been based on the assumption of the ideal cotton yarn of knitting fabrics. Thus the yarns are represented as homogenous cylinders of constant diameter for loop and ground, with initial restricted contact area between them. We consider initially the independent parameters c, W, d and in addition the: distance t as it is noticed in figure (2) Geometrical model of plain knitting fabrics structure. Due to the symmetry of the unit cell the length of the loop is received by yarn crimp ratio cross-section change is not neglected it may be assumed, that greater angel of contact will be connected with more important change of yarn cross-section from circular into approximately elliptical, due to the symmetry of the unit cell the length of the loop is received by the equation.

$$c = \frac{\pi(d)}{180\sqrt{d_{Vartical}{}^{2} + 2d_{horizantal}}} + (\pi\Delta r - \Omega r)\cos^{-1}\frac{d}{d_{Vartical}{}^{2} + 2d_{horizantal}} - 1 \qquad (21)$$

4. EVALUATION OF THE GEOMETRICAL MODEL

The evaluation of the geometrical model is based initially on the comparison of the experimentally defined loop length of a given fabric to the respective calculated by the geometrical model for the same main parameters (*c*, *w*, *D*). The main structural parameters of a fabric can be defined after a microscopic observation and the loop length can be measured using the crimp tester. Table 1 contains the main parameters, the measured loop lengths and the geometrically calculated loop lengths for eight randomly selected fabrics. The error between the calculated loop length and the measured one is considered as the indication of the accuracy of the geometrical model.

Table 1: Element of geometrical porosity and air permeability of a plain knitted loop

No.	count tex	Fiber density (g/cm3)	Loops /cm^2 =S	Wales /cm = (1/w=w)	Courses /cm = (1/C= c)	Thickness mm	Areal density (g/m2)	Air permeability	Volume Porosity %	Stiffness
1	19.6	1.28	2.25	13.5	15	2.48	145.12	56.3	19.7	41.8
2			3.2	12.5	14.5	2.68	127.37	62.2	18.3	39.8
3			3.8	11.3	14	2.97	95.20	65.4	17.1	37.6
4	14.7		2.24	13.5	16.5	2.55	125.7	57.3	20.2	40.8
5			3.2	12.6	15.5	2.83	111.12	63.5	21.6	37.8
6			3.8	12	14.6	3.2	87.12	67.3	22.9	41.8

These models were suggested includes partly 3-D structure of pores. A various binding type does not show the same relationship between a projected and real effective area opened to a flow. The modified 2-D model of porosity is based on idea that air flows around of yarns not only in a perpendicular direction. The flowing equation, has focused on the creation and the evaluation of a three-dimensional plain knitted fabric geometrical model. The precision of the geometrical model has been cross-checked by using geometrical and mechanical criteria. Especially the mechanical criterion is considering the success of the geometrical model taking in account the final results of the finite element analysis of the structure created. However more realistic models based on a better approach of geometry and material properties will be created in order to investigate the numerical analysis performance of the mechanical properties of knitted fabrics.

4.1. EVALUATION OF THE GEOMETRICAL MODEL

For detection of geometric characteristics of structure of plain knitted acrylic, the method of direct research of inner structure of fabric was used. It was done with help of analysis of soft of fabric samples, introduced in the individual parameters of bent plane knitted fabric were measured to the evaluation of the geometrical model is based initially on the comparison of the experimentally defined loop length of a given fabric to the respective calculated by the geometrical model for the same main parameters (*c*, *w*, *D*). The main structural parameters of a fabric can be defined after a microscopic observation and the loop length can be measured using the crimp tester. Table1 contains the main parameters, the measured and calculation loop lengths and the geometrically calculated knitted loop lengths for six group randomly selected fabrics. The error between the calculated knitted loop length and the measured one is considered as the indication of the accuracy of the geometrical model. Correlation between a structural parameters and air permeability experimental values for all fabrics the air permeability values were measured and relationships between experimental porosity and air permeability values and structural characteristics of knitted fabrics (determined according to method) were used for measuring of air permeability of knitted fabric. The all parameters of loop structure mentioned above were calculated and for all fabrics porosity and air permeability was measured. Apparently from the table1 and figure 3 that the specific volume of porosity and air permeability are shown constructional parameters of used fabrics and levels of loop. The specific volume is significantly influenced by behavior of the spaces in between structural characteristics values of porosity and air permeability in low level of loop and their deviations from experimental knitted fabrics air permeability values. Evident that in the cases of relatively “opened” fabrics the suggested method gives relatively good results. In the cases very dense fabrics the results (predicated values of knitted fabrics of porosity and air permeability) are not so accurate.

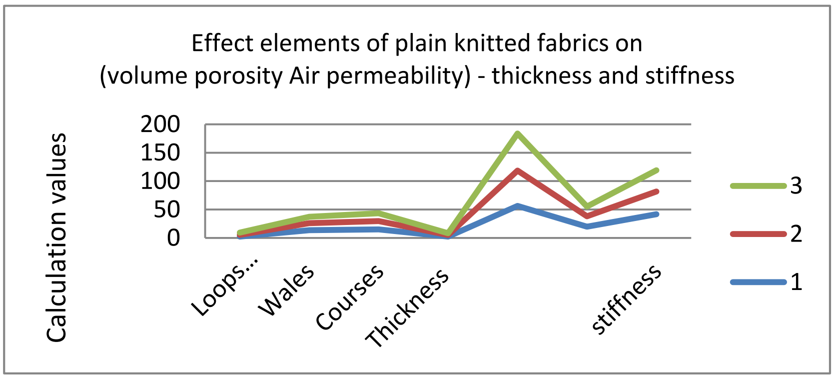

Figure 3: Coloration between elements of geometrical volume porosity and air permeability and stuffiness of plain knitted fabrics

5. CONCLUSION

The present work has focused on the creation and the evaluation of a three-dimensional plain of a warp pile woven fabrics structure fabric geometrical model. The precision of the geometrical model has been cross-checked by using geometrical and mechanical porosity and criteria. Especially the mechanical criterion is considering the success of the geometrical model taking in account the final results analysis of the structure created. However more realistic models based on a better approach of geometry and material properties will be created in order to investigate the numerical analysis performance of the mechanical porosity and properties of a warp pile woven fabrics structure fabrics.
The suggested process makes possible prediction of knitted fabrics porosity and air permeability value of plain knitted fabrics, which are characterized by their constructional parameters as are sett of wale and course yarns, diameters or fineness of loops of fabrics and by the type of structure. On the base of the area covering value is chosen suitable model for description of knitted fabric structure.

The porosity and air permeability value is predicted with use of chosen level and density. Two variants of cumulative parameter of a plain fabric structure were introduced. Knitted fabrics are the preferred structures in athletic wear in which demand for comfort is a key requirement. Heat and liquid sweat generation during

athletic activities must be transported out and dissipated to the atmosphere. A key property influencing such behaviors is porosity and stuffiness. Two parameters that characterize it are pore size and pore volume.
One of the objectives in this research was to come up with models that can predict interyarn pore size and pore volume for simple weft knitted structures, from fabric particulars, such as courses and wales count, yarn size, stitch density, thickness and other geometrical details of the fabric, which characterize the structure.

Such a model was developed that was based on the geometry of the unit cell of a single loop. The experimental work in this thesis involved using a set of 8 knitted fabrics that differed in course count and examining their pore structure and porosity related characteristics. The values of pore size and pore volume were calculated, those of pore size were measured with image analysis and fluid extrusion procedures, and the role of these in determining fluid holding and air and fluid transport properties were determined. The effects of course count and washing on stitch density, stitch length, fabric thickness and pore size are examined in detail.

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REGARDING SOME FACTORS THAT MAY INFLUENCE THE DATA ACCURACY IN THE SUBJECTIVE EVALUATION OF THE FABRICS HAND

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Abstract: *In this paper, a subjective evaluation of four cotton-type woven fabrics selected for curtains was conducted as a case study for fabric hand topic, in order to analyze data accuracy, considering the accomplishment of the blind evaluation by means of the heterogeneous panel of evaluators. The panel of evaluators consisted of six master students (three girls and three boys), taught about the human perception of the relevant mechanical characteristics of textiles by means of handle, and about the AATCC evaluation procedure rules. They have been selected to fit a specific profile assessor and afterwards, trained to precede the blind evaluation for quantifying their individual perceptions. In order to analyse whether or not, a heterogeneous panel of evaluators may be a factor that influences the data accuracy in the subjective evaluation, Kendall's coefficient of concordance was used for assessing the agreement/disagreement among assessors.*

Keywords: *woven fabric, comfort, hand, subjective evaluation.*

INTRODUCTION

In the nowadays interior decoration field, the choosing of fabrics for curtains could be considered a concrete topic. There are many factors involved in choosing fabrics suitable for curtains, (besides the price) among which we can mention: the room type, the window size, the fashion trends (the style of curtains, the heading type, the form of hanging) [1].
Aside from aesthetics and dimensions, the mechanical properties and the surface characteristics of the fabrics according to this specific end-use are very important; concerning the practical issues of the fabrics for curtains, the weight and the drape have to be considered as a main relevant for a "quality profile". Therefore, fabrics' designers could expect that interiors' designers or any other buyer (even without training in textiles) will select materials for curtains in order to mainly match their fashion-related demands and the quality by means of a simple visualization and handling, when purchasing the product [2,3]. Subsequently, the fabric handle is based on people's subjective preferences so yet again, the choosing of fabrics for curtains can be a different task to different people having different backgrounds [1].
The AATCC evaluation procedure established among others, that the panel should be formed as a homogeneous group (gender, age and interests, with similar preferences in fashion trends and design), [4]. Considering the previous work regarding the fabrics' subjective evaluations [5,6,7], in this paper, the difference was that the activity was performed within a heterogeneous panel of evaluators, consisting of six master students (three girls and three boys), taught about the human perception of the relevant mechanical characteristics of textiles by means of handle, and about the AATCC evaluation procedure rules.
As a case study for fabric hand topic, four cotton-type woven fabrics selected for curtains, have been subjected to a blind evaluation, to analyse whether or not the panel of assessors could be a factor that influenced the data accuracy. A statistical analysis by means of the Kendall's coefficient of concordance was applied as a measure of emphasising the agreement/disagreement among evaluators.

EXPERIMENTAL

2.1 Materials

In this paper, the subjective evaluation (blind) was carried out for an assortment of four fabrics selected for curtains. Table 1 shows the overall description of the selected fabrics.
According to the specified end-use of fabrics, will be manufactured:

- curtain made from medium weight cotton/polyester blend fabric (F1 and F4),

- curtain made from medium weight 100% cotton fabric (F3)
- curtain made from heavy weight cotton/polyester blend fabric (F2).

Table 1: Main characteristics of selected fabrics for manufacturing curtains

Fabric codification	**F1**	**F2**	**F3**	**F4**
Screen shot				
Raw material	33%Cotton/ 67%PES	50%Cotton/ 50%PES	100% Cotton	80%Cotton/20%PES
Mass per square meter	190 g/m^2	320 g/m^2	180 g/m^2	220 g/m^2

2.2 Methods

Subjective evaluation of fabrics selected for curtains

The subjective evaluations were conducted according to the AATCC Evaluation Procedure 5-2011, through two different approaches in order to achieve the sensory profiles of fabrics F1, F2, F3 and F4, selected for curtains.

1. by means of blind individual evaluation, with a trained panel of evaluators (six evaluators, Ev1 to Ev6);
2. by means of visualization and consensus within the panel on the fabrics hand profiles (subsequently to the blind sessions).

According to the AATCC Evaluation Procedure 5-2011, the fabric hand is described as tactile sensations perceived when fabrics are touched, squeezed, rubbed or otherwise handled [4]. The primary handle attributes are in compliance with this procedure and the panel of individuals have been trained under the mandatory rules, starting from the statement: “to standardize the conditions under which a fabric is evaluated for constituent elements of hand”. The AATCC evaluation procedure comprises rules and details about the subjective evaluation principle, the terminology, the limitations of the effective use of guidelines, the fabrics’ sampling, the evaluator preparation, the evaluation set-up, the grading of samples and also, a reference list of hand descriptors.

In agreement with the standardised procedure, the panel of evaluators should be a homogeneous group (gender, age and interests, with similar preferences in fashion trends and design). Contrary to the procedure, in this paper the assessment sessions involved a heterogeneous panel of individuals, consisted of six master students: three girls (Ev1 to Ev3) and three boys (Ev4 to Ev6).
The panel of students were trained to evaluate fabrics by means of blind handling and to quantify their individual perceptions. In order to achieve the evaluation of the fabrics hand by means of bipolar physical attributes, these were explained in connection with specific handling actions for evaluation of some mechanical and surface properties of fabrics [8,9,4,5,6,7], Table 2.
For quantifying their sensorial perceptions during fabrics handling, they were taught to use a rating scale that quantifies the intensity of each bipolar attribute from 1 to 10 on a subjective rating scale. Therefore, the entire evaluation was conducted on the basis of an evaluation sheet for bipolar attributes, see Table 3 [4,5,6,7].

Table 2: Handling for the human perception of physical attributes

Mechanical and surface properties	**Bipolar physical attributes**
Handling for the tensile properties	Stretchable/Unstretchable
Handling for the shear properties	Soft / Hard
Handling for the bending properties	Flexible/ Stiff
Handling for the compression properties	Thin / Thick
Handling for the surface properties	Smooth/ Rough
Handling for the weight properties	Light / Heavy

Table 3: Evaluation form for the bipolar attributes

Attribute	***1***	***..***	***5***	***..***	***10***	***Attribute***
Warm						*Cold*
Smooth						Rough
Thin						Thick
Flexible						Stiff
Soft						Hard
Stretchable						Unstretchable
Light	*lightest*		*medium*		*heaviest*	Heavy

Statistical concordance analysis within the panel of evaluators

The selected fabrics received grades reflecting the individual perceptions of the evaluators during fabric handling and were "interpreted" as experimental results. As a measure of emphasising the agreement /disagreement among the heterogeneous panel of evaluators, the data achieved have been processed according to the Kendall's test.
The Kendall's coefficient of concordance, W, is define by the equation 1, [10]:

$$W = \frac{12s}{k^2(n^3 - n)} \qquad (1)$$

s - sum of the quadratic deviations of the Ri values comparing with their mean R:

$$s = \sum_{i=1}^{n}(R_i - R)^2 \qquad (2)$$

Ri - sum of the ranks (considered according to each individual evaluator, for each fabric);
K - number of evaluators for the ranking classification of fabrics (in our case, k=6);
N - number of samples/fabrics, (in our case, n=4)

RESULTS AND DISCUSSION

Regarding the subjective evaluation of fabrics selected for curtains

The Figures 1a, 1b, 1c and 1d show the sensory profiles of the selected fabrics for manufacturing curtains, as results of both, the blind individual evaluations (Ev1 to Ev6) and the visualization and consensus within the panel on the fabrics hand (F_Panel, as a reference hand profile achieved subsequently to the blind sessions).

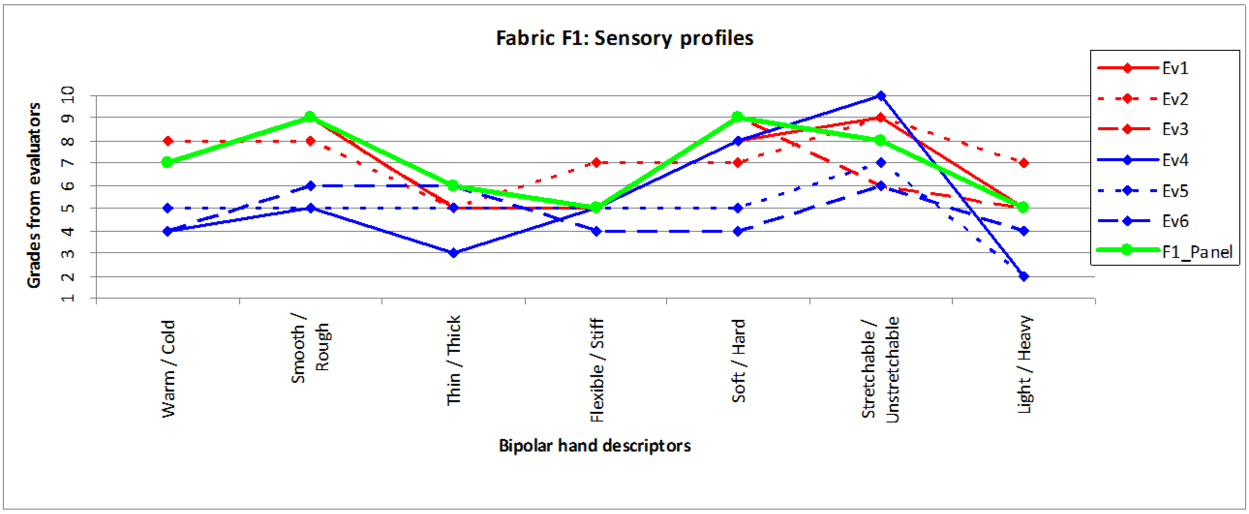

Figure 1.a.

The sensory profiles have three colours, red, blue and green:

- the "red" profiles show the results of the blind evaluation made by the girls (Ev1 to Ev3)
- the "blue" profiles show the results of the blind evaluation made by the boys (Ev4 to Ev6)
- the "green" profiles show the results of the visualization and consensus in panel, for each fabric (F1_Panel to F4_Panel)

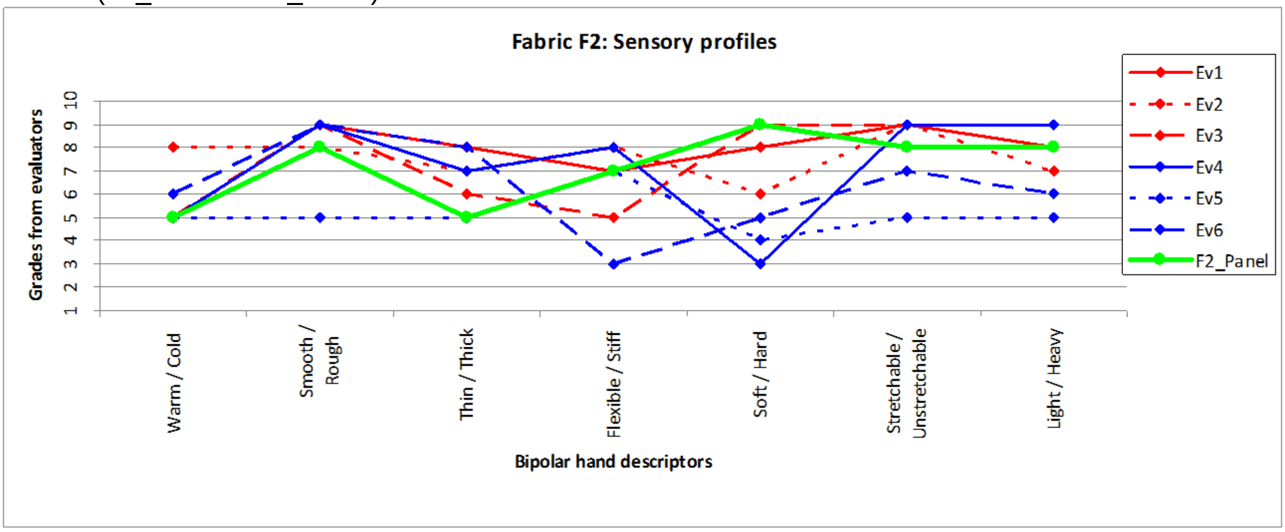

Figure 1. b.

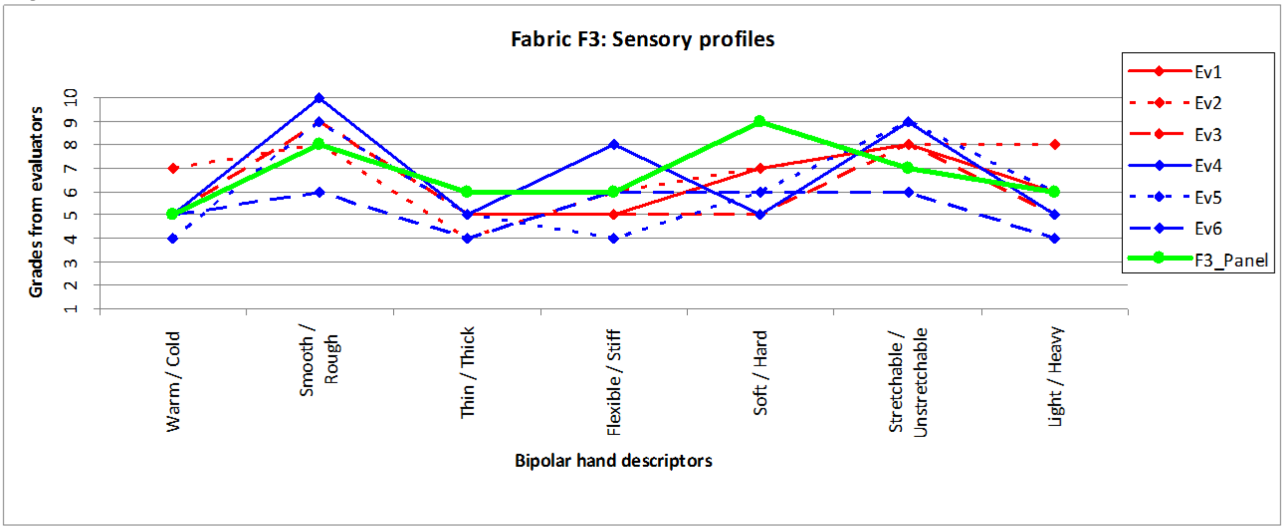

Figure 1. c.

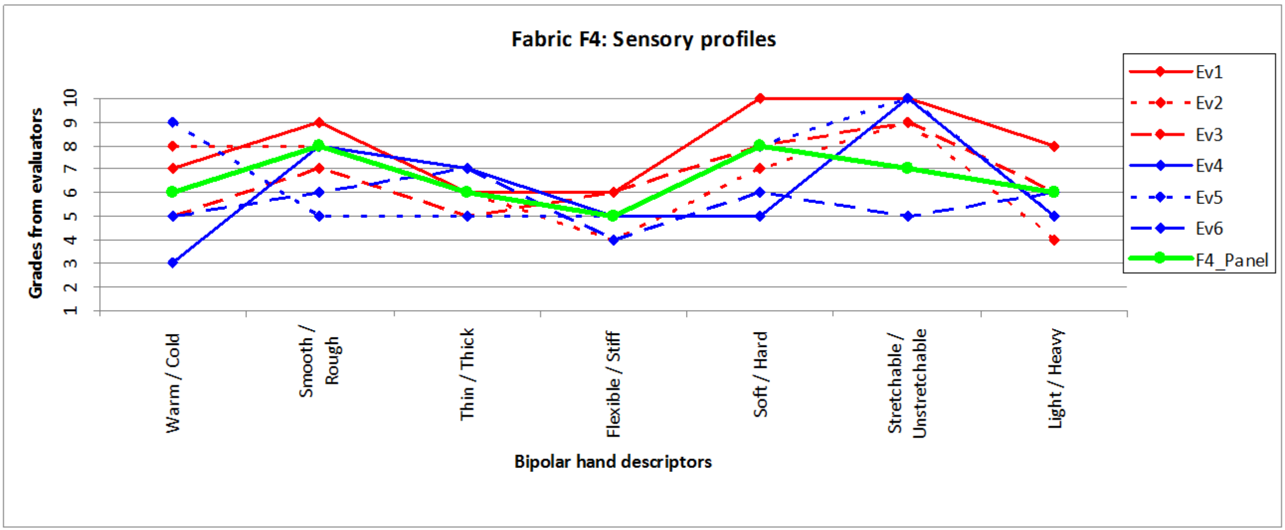

Figure 1.d.
Figure 1: Sensory profiles of fabrics F1, F2, F3 and F4 selected as suitable for curtains (1.a; 1.b;1.c; 1.d)

According to Figure 1, the evaluators' perceptions are divided and the accuracy of the blind subjective evaluation can be considered as moderate compared to the reference evaluation, achieved after the visualization.
Between the evaluations performed by girls (profiles in red color) and those performed by boys (profiles in green color), we can notice that the "red" sensory profiles fit in a smaller area of variation, being quite close to each other.
However, only by studying the sensory profiles, it is hard to predict whether or not the panel heterogeneity may be endorsed as a disturbing factor for the data accuracy.

Regarding the concordance analysis within the heterogeneous panel of evaluators

The results of the subjective assessments of the bipolar attributes for all fabrics, led to the sensory profiles configuration. Afterwards, the next step was to process these data in order to calculate the Kendal's coefficient of concordance, see Table 4.

Table 4: Kendal's coefficient of concordance for the panel of evaluators

Bipolar hand descriptors	Ri				R	s	*W*
	F1	F2	F3	F4			
Warm / Cold	35	34	31	37	34.25	18.75	0.104
Smooth / Rough	42	49	52	43	46.5	69	0.383
Thin / Thick	29	41	28	36	33.5	113	0.628
Flexible / Stiff	31	38	34	30	33.25	38.75	0.215
Soft / Hard	41	35	36	44	39	54	0.3
Stretchable/ Unstretchable	47	48	48	53	49	22	0.122
Light / Heavy	25	44	34	34	34.25	180	1

In the Table 4, it is shown that the values of Kendall's coefficient of concordance are different for all bipolar hand descriptors, fluctuating within the 0.104 -1 range.
The W values can be interpreted as follows, [10]:

- ✓ Kendall's coefficients values calculated from data corresponding to the given grades for Warm/Cold (W=0.104), Stretchable/Unstretchable (W=0.122), Flexible/Stiff (W=0.215), Soft/Hard (W=0.3), Smooth/Rough (W=0.383) and Thin/Thick (W=0.628), can be considered intermediate values (between 0 and 1), and indicate a lesser or higher degree of unanimity among the various responses of the evaluators from the heterogeounous panel, without being considered fully or almost accidental;
- ✓ Kendall's coefficient value calculated from data corresponding to the given grades for Light/Heavy (W=1), indicates that all the evaluators (girls and boys) have been unanimous when assesed this bipolar hand atribute.

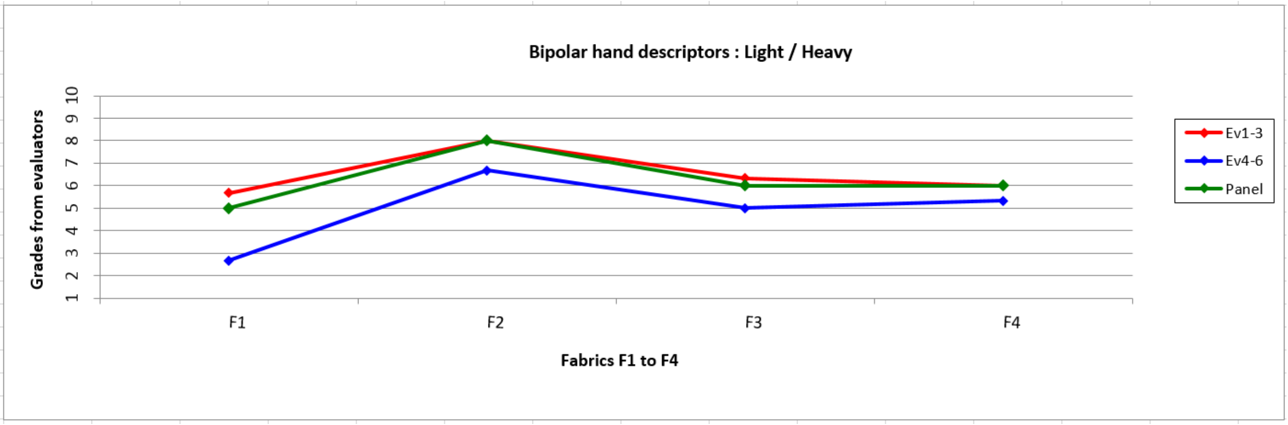

Figure 2: Sensory profiles of fabrics for Light/Heavy bipolar attribute

However, as it is shown in Figure 2, given the consensus assessment values for attributes Light/Heavy, there is a easy identifiable difference between the blind evaluations belonging to the girls and, respectively, boys, the former being much closer to the assessment in the panel consensus. These results are also in accordance with the values of mass per square meter of the four fabrics, as shown in the Table 1: F1(190 g/m^2); F2 (320 g/m^2); F3(180 g/m^2) and F4(220 g/m^2).

Based on the results presented above, we can conclude that, indeed, using a heterogonous panel for the subjective evaluation (not recommended by the AATCC procedure), may be considered as including a disturbing factor influencing the data accuracy.

CONCLUSIONS

The research in this manuscript was focused on emphasizing the requirements to comply with the rules and details about the subjective evaluation belonging to the AATCC evaluation procedure, when it comes to organizing a panel of evaluators for subjective assessment sessions of the fabrics hand.
As a case study for fabric hand topic, four cotton-type woven fabrics selected as being suitable for curtains, have been subjected to a blind evaluation. The handle activity was performed within a heterogeneous panel of evaluators, consisted of six master students (three girls and three boys), contrary to the requirement of the AATCC evaluation procedure rules. Based on the blind evaluations results, the sensory profiles for the four fabrics were generated and afterwards, a statistical analysis by means of the Kendall's coefficient of concordance was applied as a measure of emphasising the agreement/disagreement among evaluators. In spite of the continuously training sessions, the final results showed that the personal sensory perception is almost impossible to customize. Furthermore, have been highlighted differences within the panel, due to the assessment carried out by different gender of the evaluators, girls vs. boys.
In this case study, the inconsistency of the panel has been confirmed at the individual level for the subjective evaluation. For definitive results, it is recommended to conduct new evaluation sessions for other materials, also with heterogeneous panel, but consisting of a larger number of evaluators.

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KNITS INSPIRED BY THE ARCHITECTURE OF THE BUILDINGS

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The technical capabilities of the computerized flat bed knitting machines make them suitable for 3D structures production. The introduction of advanced CAD systems supporting complex surfaces has influenced many design fields such as: architecture, industrial design and engineering.
The presented project aims to achieve three-dimensional surfaces and textures by using building architectures, as source of inspiration. A range of knitted structures has been created, according to some specific knitting principles and to their visual construction having an appeal towards architectural motives. The fabrics were manufactured on the electronic CMS 530 E 6.2 and CMS 502 E 2,5.2 Stoll knitting machines, in the laboratory of the Faculty of Textiles, Leather and Industrial Management from Iasi, Romania. The *Bishop Edward King Chapel* architecture, Oxfordshire, UK, has been reproduced within a fabric with 3D cells, spread it uniform to the surface and obtained by using the partial knitting technique. The bridge of *Cultura en la Calle* from Spain, recycled with old tires, was successfully designed by knitting on the fabric surface, open applications, with partial knitting technique and adjusting the machine parameters correctly, especially the fabric take-down. The flexible stitch method was used to produce surfaces with alternative thicknesses within the same fabric, generating thus a 3D aspect, inspired by the façade of the pastry factory, *Usine des Calissons du Roy Rene*, from Aix-en-Provence, France. The project is completed by an original dress, with aran patterns, inspired by the *Infinity Column*, belonging to the famous Romanian artist, Brâncuși. When analyzing the production of knits on the electronic flat knitting machines, both advantages (fashionable to specific shape and size, absence of cutting and waste, availability of almost any type of yarns, easy patterning) and disadvantages (low speed process, reduced number of systems, complex and expensive equipment), should be considered.

Keywords: *knitted structures, knitting, building architecture, CAD-CAM systems.*

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RESEARCHES ON THE OBTAINING OF COMPOSITE MATERIALS BY USING THE BAST FIBERS AS REINFORCEMENT MATERIALS

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Abstract: *New composite materials are obtained by using polymer matrices of chemical fibers (polypropylene, polyester) and produced by reinforcement obtained from the hemp bast fibers. After forming the mixture of the two components, the pressure and temperature of the composite material is obtained. Shows superior mechanical physical properties of products made from wood fibers with various resins and not degas while using toxic by products, such as formaldehyde. These materials can be used in furniture, automotive, shipbuilding, etc.*

Keywords: *fibers bast, matrix, mixture, composite materials, analyzed physico-mechanical indices.*

INTRODUCTION

Composite materials can be defined as multi phasic systems resulted by combining of two or more different materials in order to obtain a higher performance compared with the separated components. The major advantage of composite materials is the possibility of modeling the properties and obtain in this way for a wide variety of materials, the use of which may be extended in almost all fields of technical activity. The main components of the composite materials are the reinforcing products (fibers) and the matrix [1-3].
In most instances, the composite material comprises a core matrix in which is dispersed an additional material in the form of particles or fibers.

The fibers provide strength and rigidity, and the matrix binds the fibers together, allowing the transfer of the tension between fibers and through the composite to outwards. The fibers used in composites because they were lightweight, rigid and resistant. Choosing the type of fiber that is used depends on the desired mechanical properties, the characteristics of the environment where they work and cost structure composite fiber reinforced composite materials with particles results by including more elements in the array of organic or inorganic nature [4-6].

Textile structures used as reinforcing agents for composites in the form of fibers and yarns, fabrics, braids, knits and woven, and the matrices used for their consolidation are those polymers.
An important feature of the composites reinforced with textile fibers is that they may exhibit anisotropic properties (e.g. strength, stiffness, thermal properties and moisture retention may vary in a ratio of 1 to 10 according to different directions) [7-11].

The properties of the composite structure are influenced by the nature of the fiber and matrix properties, ie bonds that are formed between the two basic components of the composite.
The major advantage of composite materials consists in the possibility of modeling properties and getting a very large range of materials, which using can be extended in almost all fields [12-15].

EXPERIMENTAL WORK

Obtaining composite materials was conducted according to the following steps:
In this study were used hemp bast fibers. The obtaining these materials comprise the following steps:
1. Obtaining a thin woven fabric that reinforces the punched (a slide). In this sense, it was mixed on a special card to varying degrees polypropylene and / or polyester recycled fibers and, hemp fibers. In obtaining the nonwoven were used several compositions by mixing: 0/100, 25/75, 50/50, 75/25 and 100/% (chemical fiber (%) / fiber bast (%)). The fibers were purchased from s.c.Taparo s.a.from Tg. Lapus.
2. Overlap multiple blades (1-8) followed by gentle pressure, is cut by cutting the model (product) wanted.

3. Heat treatment of consolidation in order to obtain the composite material. This treatment is performed simultaneously with the pressing of the mold material in two phases:
a. preliminary treatment to about 230-240^{0}C and a pressure of 150 atmospheres between the plates for 5 minutes;
b. the final treatment is carried out at 150 atmospheres for 10 minutes, after which the material is cooled and the resulting product can be used.
Scheme for the preparation of composite materials is shown in Figure 1.

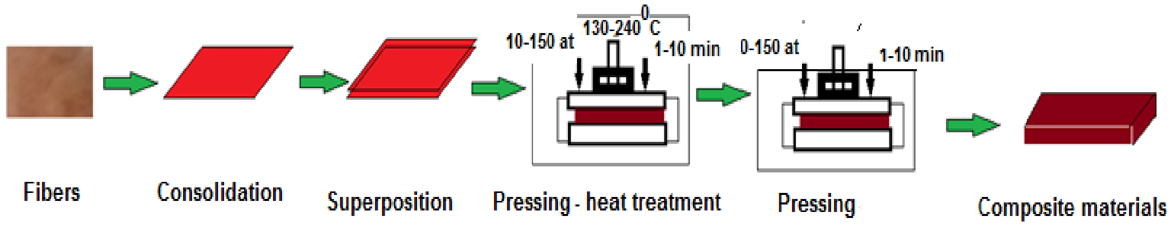

Figure 1: Scheme obtaining a composite materials

RESULTS AND DISCUSSION

The plates obtained in this way were evaluated by determining the physico -mechanical indices : elongation and tensile strength, the modulus of elasticity , compressive strength , resistance to exhaustion. Finally, the results were analyzed according to the used parameters in research (mixture composition, density, temperature and pressure of work, period). The best results were obtained by using polyester fibers and hemp.

3.1.Tensile strength

Analyze physical and mechanical indices were determined on a dynamometer electronic type STM- 466. The results are displayed both in the form of diagrams (figure 2) as well as tables.

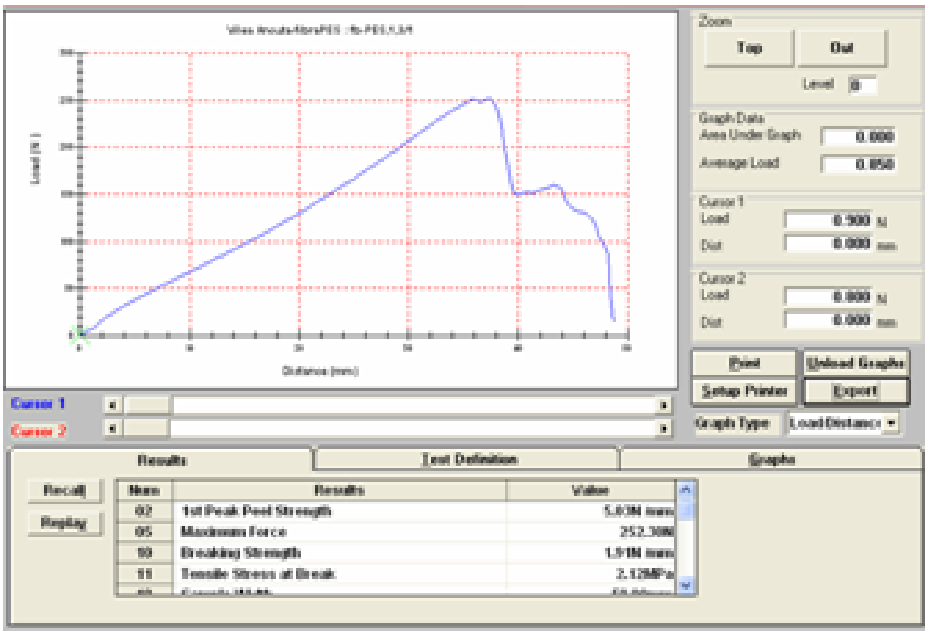

Figure 2: Recording data

Tensile strength was determined on strips of material 5 mm width and a length of 20 cm. The results are presented in Figure 3.
The analysis of these curves is observed that the physico-mechanical changes significantly depending on the composition of the mixture used to form the composite material. The tensile strength increases with the

amount of chemical fiber up to a certain relation between the two fibers, then has a tendency to decrease. From the graph that an optimal composition between the two fibers is between 50- 75% (chemical fiber / fiber hemp).

With regard to the two part chemical fiber matrix used, the graphic can be seen that the best results are obtained by using the polyester fiber.

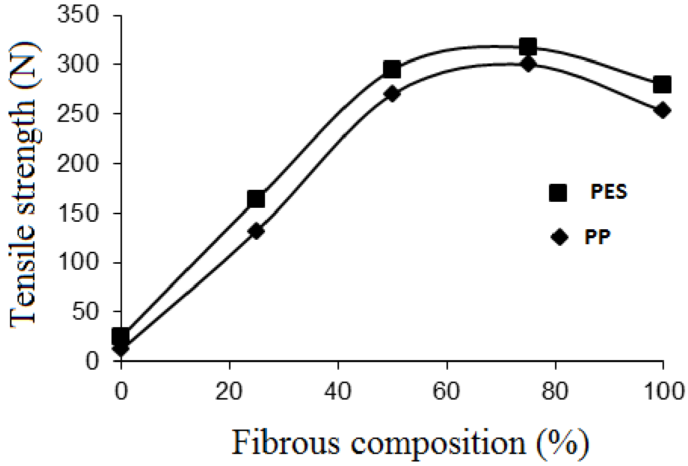

Figure 3: Breakthrough variation depending on the fiber composition (4 blades)

3.2. Elongation at break

Elongation at break shows a continuous decrease with increasing amounts of chemical fiber used. The composite materials obtained by using polypropylene fibers have an elongation at break higher than those obtained using polyester fibers. The decrease in elongation of the samples containing 100% chemical fiber can be explained by the fact that these fibers melt at temperatures of 230-240^{0}C and forms a hard and brittle with low elongation to break (Figure 4).

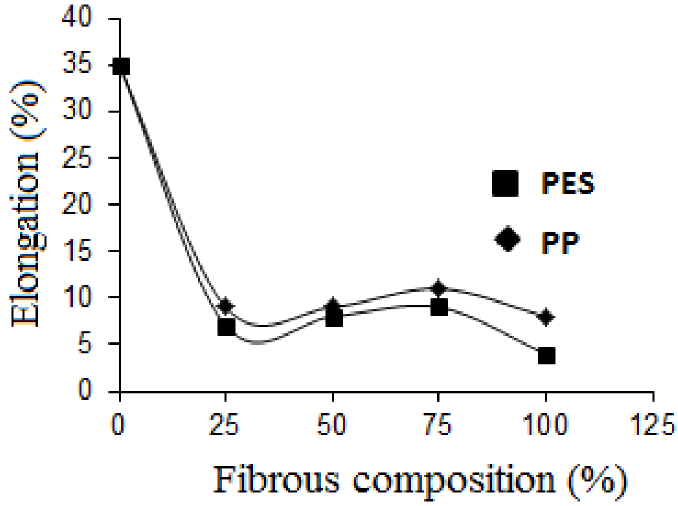

Figure 4: Elongation variation according decomposition fiber composite material (4 blades)

3.3. Influence number of layers used in the production of composite materials

As necessary, the thickness of the composite material may vary. Such materials can form multiple layers. The variation of physical and mechanical indicators of these materials are shown in Figures 5 and 6. They were used to obtain recycled polyester fibers of such materials.

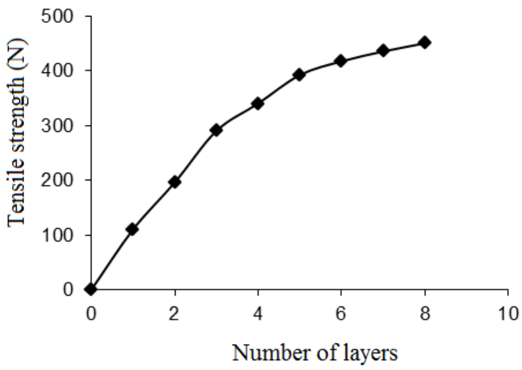

Figure 5: Variation of tensile strength depending on number of lyers

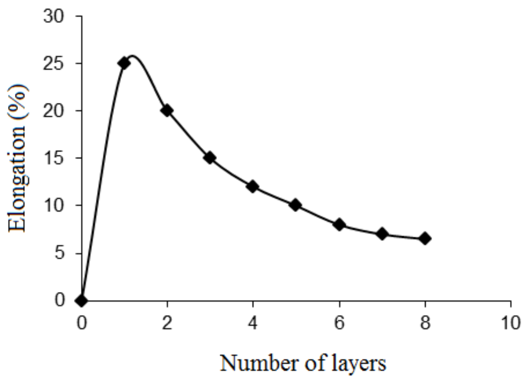

Figure 6: Variation of elongation depending on number of lyers

The composite materials obtained can be used in the manufacture of furniture items, successfully eliminating the fiber - wood products, in machine building (obtaining fittings, making various body parts) or in the plastics industry.

CONCLUSIONS

By using building products can be obtained various composite materials with multiple applications:
- Composite materials obtained using bast fibers can be use in the manufacture of furniture products eliminating successfully fibrous-wood products (PAL) used in large quantities in the furniture industry;
- By using recycled polyester fiber it can be obtained composite materials in the form of plates using different yarns;
- Plates obtained may have various applications in construction (decorative plates); in car construction or in the plastics industry;
- In this research, the best results were obtained using recycled polyester fibers compared to polypropylene fibers used as matrices in obtaining composite materials.

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RESEARCH ON THE COLD SIZING OF COTTON YARN WARPS TITLE OF THE PAPER (ARIAL, 14 PT, BOLD)

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Abstract: *The research aims at achieving a comparative analysis on the quality of cold sizes made by dilution with cold water, at ambient temperature, of a number of sizing polymers with relatively high concentrations and viscosities. The research outline includes specific indices used for characterizing the quality of polymers and sizes, which can be determined in laboratory conditions. The main specific indices for characterizing sizes and sizing films are: dynamic and conventional viscosity of the size, sizing strength and linear tenacity of yarns and sizing films, etc.*

Keywords: *cold sizing, indices of thread sizing, sizing films tenacity*

INTRODUCTION

Cold sizing of warps simplifies the process of preparing sizes and does not require heating them in the sizing tub. The chemical industry provides specific products for cold sizing, made of synthetic sizing and specific auxiliaries for warp sizing.

CHARACTERISTICS OF PRODUCTS AND COLD SIZING

The sizing preparation is made by slight heating of the sizing polymer or by diluting the polymer with water at room temperature. Table 1 presents the main features of cold sizing polymers used in the present research.

Table 1. Main characteristics of cold sizing products

Sizing polymer	Main characteristics of the sizing polymer					
	Base polymer	Ionic character	pH Values	Dry substance concentration in%	Dilatability	Physical state
Arcofil CS 20	Alcohol polyvinyl	non-ionic	4 -7	20	water-miscible	viscous liquid
Kemacol 25 LIQ	Alcohol polyvinyl	non-ionic	5 - 7	25	Soluble in cold water	viscous liquid
Dilerol 20 MP	Sizing organic lubricant	anionic	6 - 8	20	Hot water dilatable	viscous liquid

All polymers listed in Table 1 have the form of viscous liquids. "Kemacol 25 LIQ" has the higher viscosity and polymer concentration. Sizing of present polymers is obtained by dilution with water, at room temperature, except for the polymer "MP Dilerol 20" which requires the use of heated water for dilution during the sizing preparation process. Research has shown that sizing viscosity decreases with the decreasing of the concentration in dry substance of the sizing polymers. Table 2 shows the influence of sizing polymer concentration on the conventional viscosity, assessed by flow time, t_c, from the viscosity funnel of 100 ml of sizing.

Table 2. Conventional viscosity of cold sizing

Sizing polymer	Conventional viscosity by flow, t_c in s, at a concentration of:			
	K_f = 20 %	K_f = 15 %	K_f = 10 %	K_f = 5 %
Arcofil CS 20	155	31	14	5
Kemacol - 25	130	24	8	3
Dilerol - 20 MP	75	17	7	3

It has been found that sizes obtained by diluting the sizing polymers presented in this paper are efficient if the concentration in dry substance of the sizing polymers is between K_f = 10-20%. For example, in the case of using the "Arcofil CS - 20" polymer for sizing warp yarns of 100% cotton, with a fineness of 20 Nm - 27 Nm, the size concentration level is recommended to be of 14 - 17% dry matter. In this case sizing would achieve a conventional viscosity with a time flow of 30-70 s in the viscometer cup.
This cold sizing viscosity is comparable with the classic sizing viscosity that contains 6% starch and 2% "Size" product. On the other hand, classical sizes are used at temperatures of 70 - 75^o C. Classical sizes used at the above mentioned temperatures may have a conventional viscosity assessed by the size time flow in the viscometer cup that can be of 70-75s.
Cold sizes, with concentrations of dry substance of up to 10% inclusively, obtained only by dilution of the sizing polymer may present the disadvantage of insufficient coverage of the warp yarns with a sizing film, as a result of the low viscosity of such sizes. Sizing behaviour during their deposit on sizing yarns can be more correctly appreciated by analysing the sizing dynamic variation of the viscosity.
The disadvantage of classic sizing is well-known, based on natural starch, which is strongly thixotropic, as shown in Figure 1. The thixotropic nature of starch-based sizing leads to uneven deposition of sizing films on warps in relation to the time-use of sizing. The study of the cold sizing dynamic viscosity was done using the Rheotest2 viscometer. The calculation formulas of shear stress and dynamic viscosity, specific to the device are the following:

$$\eta_d = \frac{\tau_r \cdot 100}{\gamma_r} \quad (1)$$

$$\tau_r = z^\alpha \quad (2)$$

where:

η_d – is the dynamic viscosity, in cP;
τ_r - shear stress, dyne/cm^2;
γ_r- shear velocity gradient of the fluid, s^{-1};
z –constant of the working domain, z = 6;
α = 0 …100 – values on the measurement scale.

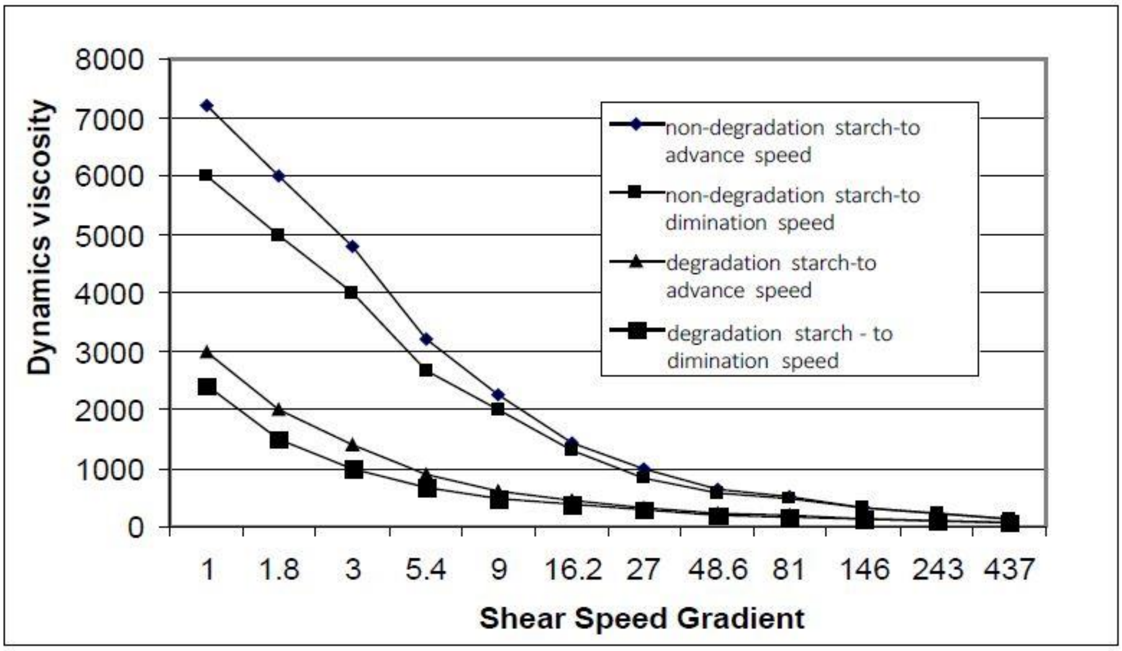


Figure 1. Thixotropic nature of starch sizing, at a warm temperature, evidenced by the dynamic viscosity

The experimental measurements for a cold sizing of Arcofil CS -20, with a concentration of 15%, led to the results shown in Table 3 and to the graphs presented in Figure 2. These experimental determinations show a linear increase of the shear stress with an increasing shear velocity of the gradient (fig.2). The decrease in the shear stress, with a decrease in the shear velocity of the gradient is also linear and overlaps on the growth curve. Similarly, downward and onward curves of the dynamic viscosity overlap, once with the variation rate of the shear velocity (fig.2), revealing the pseudo-plastic nature of these cold sizes. This feature of cold sizes ensure a greater uniformity of sizing, regardless of the sizing duration and speed.

Table 3. Sizing dynamic viscosity (k15%) of Arcofil CS – 20

α , τ, η_d	Sense γ_r	Measured or calculated features (α , τ, η_d), at γ_r values equal to:											
		1	1,8	3	5,4	9	16,2	27	48,6	81	145,8	243	437,4
α	+	1	1,1	1,2	1,8	2	3,5	5	7,8	11,5	20	32,5	58
	-	1	1,1	1,2	1,8	2	3,5	5	7,8	11,5	20	32,5	58
τ,	+	6	6,6	7,2	10,8	12	21	30	46,6	69	120	195	346
	-	6	6,6	7,2	10,8	12	21	30	46,6	69	120	195	346
η_d	+	600	366	240	200	133	129,6	111	95,8	85,1	82,3	80,2	79,1
	-	600	366	240	200	133	129,6	111	95,8	85,1	82,3	80,2	79,1

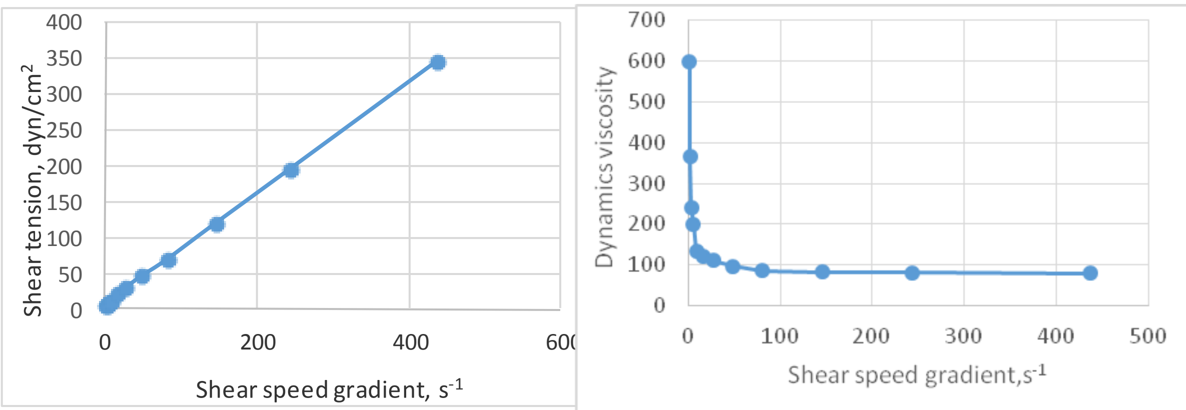


Figure 2. The variation of shear stress and dynamic viscosity according to the shear velocity gradient

STUDY OF COLD SIZING FORCES OF COTTON WARP YARNS

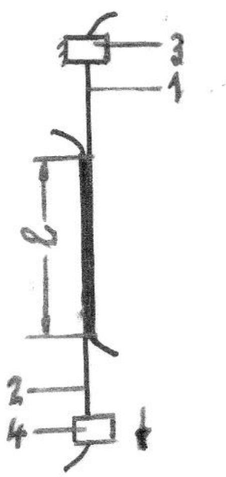


Figure 3. Yarn unstick through axial stretch on dynamometer

The study of sizing forces and stress of sizing polymers was performed by determining on a dynamometer the separating axial forces of the warp yarns nos. 1 and 2 that were cold sized with cold sizing on the distance "l", as shown in Figure 3.
The present research on sizing forces of threads was made on 100% cotton yarns with a linear density Tt = 45 tex and with a thread made of polyester and cotton mixture, with a linear density of Tt = 30 tex. The sizing length of the yarns is l = 5 cm. The yarn sizing force was defined by use of a dynamometer for threads. The axial stress of yarn sizing, τ_{if}, is determined by dividing the axial sizing force of threads, F_{i1}, to the length of by sized threads, l.

$$\tau_{if} = \frac{F_{i1}}{Ttn} \qquad (3)$$

where : τ_{if} – sizing axial stress, thread-specific, in cN/cm.tex;
F_{i1} –axial force of threads-separation per length unit, in cN/cm;
Ttn – linear density of the yarn, in tex threads.

To highlight the effect of sizing film-loading of yarns, on the sizing force of the sizing polymer, the sizing stress of the dry film is also determined according to the following relationship:

$$\tau_{if} = \frac{F_{i1}}{Ttn} \quad (4)$$

where:

τ_{ip} -sizing stress specific to the existing film on the thread, in cN/cm.tex
F_{i1} –axial force of separating yarns per unit length, in cN/cm;
Ttn - linear density of dry film on thread, in tex;

The linear density of the sizing film deposited on threads is determined by the following relationship:

$$Ttp = Tti – Ttn \quad (5)$$

where :

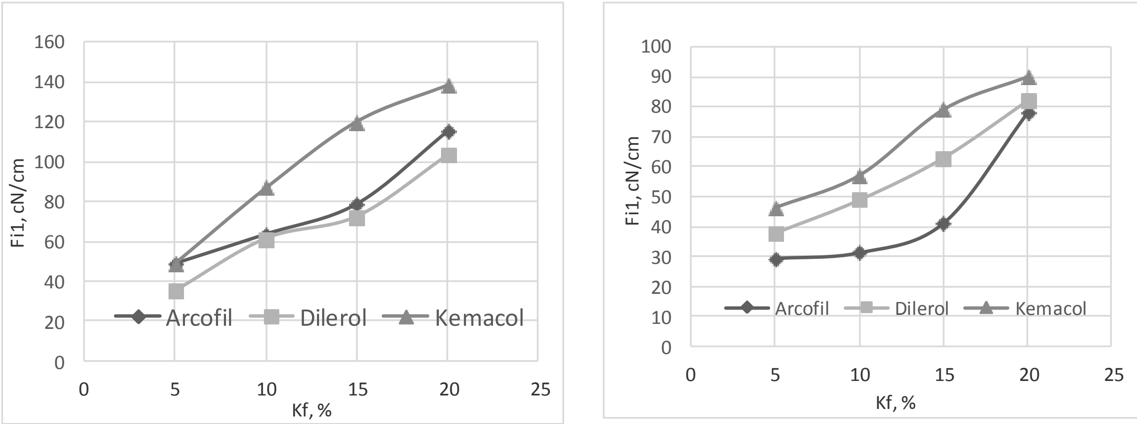
Ttp - linear density of dry film on the thread
Tti – is the linear density of the sizing yarn, in tex (film grams on a km of thread).

Table 4. Indices of cold sizing of cotton type yarns

Concentration of dry substances K_f, in %	Indices of cold sizing yarn									
	Tt=45 tex x 2, (100 % cotton)					Tt=30 tex x 2 (cotton + polyester mixture)				
	Ttî, tex	Ttp, tex	F_{i1}, cN/cm	τ_f, cN / cm.tex	τ_{ip}, cN / cm.texp	Ttî, tex	Ttp, tex	F_{i1}, cN/cm	τ_{if}, cN / cm.tex	τ_{ip} cN / cm.texp
Arcofil CS 20 liquid										
20	55,2x2	20,4	115	1,27	5,63	39,45x2	18,9	78	1,3	4,12
15	52,2x2	14,4	78,7	0,87	5,44	37,22x2	14,44	41,2	0,68	2,85
10	48,6x2	7.2	63,5	0,70	8,82	35,55x2	11,1	31,3	0,52	2.82
5	47.7x2	5,14	48,8	0,54	9,49	34,04x2	8.08	29,4	0,49	3.64
Dilerol 20 MP										
20	62,4x2	34,8	103,3	1.14	2,97	38,8x2	16,4	82,2	1,37	5,01
15	57,16x2	24,32	72,4	0,80	2,97	36,15x2	12,3	63	1,05	5,12
10	56,7x2	23,4	61,3	0,68	2,62	34,51x2	9,02	49	0,82	5,43
5	50,9x2	11,8	40,5	0,45	3,43	33,6x2	7,2	38	0.63	5,27
Kemcol 25 LIQ										
20	59,5x2	29	138,4	1,53	4,77	39,61x2	19,22	90,2	1,5	4,69
15	57,75x2	25,5	120,2	1,33	4,71	38,1x2	16,2	79,3	1,32	4,89
10	55,2x2	20,4	87	0,96	4,26	37,5x2	15	57,3	0,95	3,82
5	53,66x2	17,32	72	0,8	4,1	35,3x2	10,6	46,5	0,77	4,38

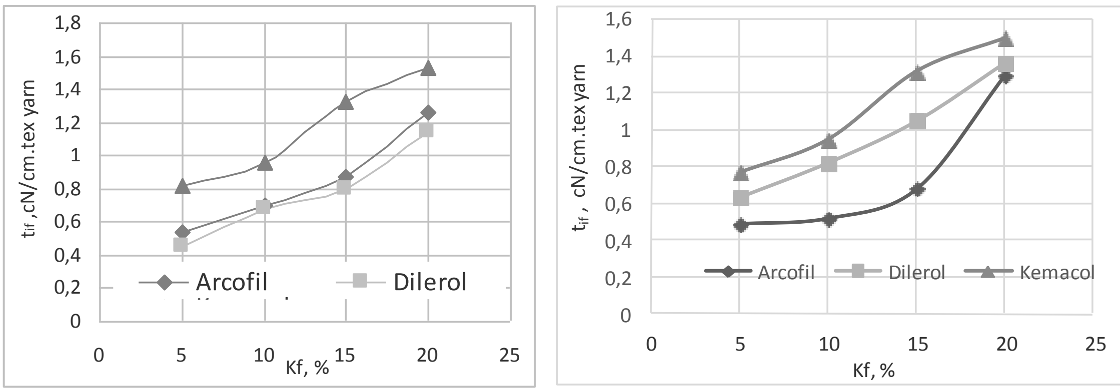
The linear density of the non-sized yarns (Ttn) is known. In order to determine the value of the linear density of the sized yarn from the sizing area (Tti) all the segments of thread separated from each variant were collected. According to the total length of these segments and to their mass determined by analytical balance, the tex values of the sized yarn (Tti) were calculated.

Based on the method of sizing mini-warp yarns doubled with contact insured during sizing and during their separation on the thread dynamometer, a number of specific indices on strength and linear sizing tenacity of polymers used at the yarn sizing can be determined. In the experiments the three sizing polymers studied in this paper were used. They were used with four different concentrations to size two cotton yarns. The results of the experiments are shown in Table 4 and are plotted in Figures 5 and 6.



a.Thread 45 tex, (100% cotton) **b. Thread 30 tex, (cotton + polyester)**

Figure 5. Variation of cold sizing force of threads at different concentrations



Yarn 45 tex, 100% cotton **b. Yarn 30 tex, cotton+ polyester**

Figure 6. Axial specific tenacity per tex yarn for measuring sizing strength dependent on size concentration

The sizing concentration and the type of sizing polymer significantly influence the sizing, film and, implicitly, the sizing threads features, as shown in Figures 5 and 6.

CONCLUSIONS

The main conclusions to be drawn on the sizing indices of yarns, based on the study of cold sizing indicators of threads when using polymers presented herein (Table 4) are:

- the "Kemaccol-25 LIQ" sizing - polymer has the greatest sizing force on threads, both for 100% cotton yarn, and for yarn made of cotton and polyester mixtures;
- it has been observed that the sizing force and tenacity of warp yarns have increasingly larger values, corresponding to the increasing concentration in dry matter of sizing, for the period analysed in this paper;
- it has been noticed that the sizing force and tenacity of cotton yarns are reduced in the case of the "Dilerol-20 mp" sizing polymer, at the increase of the proportion of the lubricating agents in the sizing recipes.

By using the concept of tenacity of the sizing film, one can make a comparative analysis of sizing polymers, regardless of the threads sizing concentration and loading. By analysing the average values of film sizing tenacity for sizing with the three variants of sizing polymers studied in this paper, the following conclusions are drawn:

- for the cold sizing of 100% cotton yarn the "Arcofil CS-20" polymer is recommended because it has the highest sizing tenacity of the sizing film (τ_{ip} = 7.34 cN / cm.tex, average value for the four concentrations of the product);
- the "Dilerol 20 MP" polymer is not recommended for the 100% cotton yarns, because it has the lowest average sizing tenacity (τ_{ip} = 2.99 cN / cm.tex, an average value for the four analysed product concentrations);
- the "Dilerol 20 MP" polymer is recommended for the cold sizing of polyester and cotton yarn mixtures, because the cold sizing tenacity of the film is τ_{ip} = 5.2 cN / cm.tex;
- the "Kemacol - 25 LIQ" polymer is efficient, both for the 100% cotton yarn sizing, and for the sizing of yarns of polyester and cotton mixtures as the average sizing tenacity of the film has values of τ_{ip} 4.46 cN / cm. tex for 100% cotton yarn, and τ_{ip} =4.44 cN / cm.tex for yarns of polyester and cotton mixtures).

Following a comparative analysis of cold sizing indicators of threads using sizing polymers studied herein and listed in Table 4 it results that the values of the concentration in dry matter of cold sizing must be generally higher (up to 10-15%) than the concentrations in dry matter of sizing obtained by the classic procedures, at a warm temperature, in order to ensure the viscosity required for the coverage and protection of the thread surface sized at the static and dynamic requests to which are subjected warp yarns during weaving.

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BENDING RIGIDITY OF YARNS AND KNITTED FABRICS MADE FROM BLENDS OF COTTON AND COTTONISED HEMP OR FLAX

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Abstract: *In this paper the results of a research regarding the effect of partial cotton replacement by cottonised flax or hemp on the bending rigidity of yarns and knitted fabrics are presented. Rotor spun yarns of 59 tex and 100 tex linear density from 30% cottonised flax/70 % cotton, 30% cottonised hemp/70 % cotton and 100 % cotton blends obtained on the cotton spinning system have been used to produce rib knitted fabrics on a manual flat knitting machine. The bending rigidity of yarns and knitted fabrics has been evaluated. Regardless the yarn linear density, the 100 % cotton yarns and knitted fabrics have the bending rigidity higher than cottonised flax/cotton and cottonised hemp/cotton yarns and fabrics.*

Keywords: *bending rigidity, cottonised hemp, cottonised flax, rotor yarn, knitted fabric.*

INTRODUCTION

The market share of natural fibres in global fibre consumption decreased during the last two decades from over 60% in 1990 to 40% in 2008 due to substitution in favour of synthetic fibres [1]. The Kyoto protocols on greenhouse gas reduction and CO_2 neutral production have initiated a transition from a fossil-input-based economy towards a bio-based economy. This change requires the substitution of synthetic fibres that are produced from fossil fuels by fibres produced from renewable (plant and animal based) resources. Among natural fibres, cotton is most widely used in apparel applications being characterized by good resistance to wear, fading, and pilling, good moisture absorption, resistance to moths, and dyeability [2]. Even if cotton is fully biodegradable and renewable raw material, its cultivation requires large amount of chemicals and water and therfore harms the environment. In comparison to cotton, flax and hemp are environmentally friendly, produce much higher yields per hectare and can constitute an alternative to cotton fibres in apparel applications.

One of the most important factors which affect the handling and comfort of apparel is the fabric bending rigidity that depends on knit structure, density and yarn bending properties [3]. The bending characteristics of yarn together with its strength, elongation at break, and frictional properties also influence the knittability. During knitting, the yarn bends in the form of loops to form stitches. Therefore, the yarn bending rigidity affects the yarn knittability and the quality of final knitted products [4].

The aim of the present study is to evaluate the effect of partial cotton replacement by cottonised flax or hemp on the bending rigidity of yarns and knitted fabrics for apparel applications. To this end, rotor spun yarns of 59 tex and 100 tex linear density from 30% cottonised flax/70 % cotton, 30% cottonised hemp/70 % cotton and 100 % cotton blends obtained on the cotton spinning system have been used to produce rib knitted fabrics on a manual flat knitting machine. The bending rigidity of yarns and knitted fabrics has been evaluated.

MATERIALS AND METHODS

The rotor-spun yarns from blends of 30% cottonised flax/70 % cotton and 30% cottonised hemp/70 % cotton have been obtained on the cotton spinning system using a purpose-developed double carding technology [5]. Instead, the all-cotton yarns were spun using standard spinning mill procedures and practices. In order to maintain a good spinning stability, the twist of cottonised flax/cotton and cottonised hemp/cotton blended yarns was adjusted up to 30 % higher than the twist of all-cotton yarns.

All tests were performed after the samples were kept in standard atmospheric conditions (20 ± 2°C and 65± 2% RH) for 24 hours. The yarn diameter has been measured on a Leica MS5 Microscop (2.5 x magnification) using Mesdan Video Analyser software. The tensile properties of yarns have been determined on a TINIUS OLSEN H5 K-T tensile tester according to EN ISO 2062 standard. The modulus of elasticity has been calculated from the load-elongation curve according to literature specifications [6]. Assuming the yarn to have a circular cross-section, its bending rigidity can be calculated with the following formula:

$$R_y = E \cdot I \tag{1}$$

where:
R_y – yarn bending rigidity [N·mm^2];
E - modulus of elasticity [N/mm^2];
I - axial moment of inertia [mm^4].

$$I = \frac{\pi \cdot D^4}{64} \tag{2}$$

D - yarn diameter [mm].

The yarns have been converted into 1 x 1 rib knitted fabrics on a manual flat knitting machine characterized by one negative feed system, two needle beds and E 10 gauge. The bending rigidity of knitted fabrics has been determined on a METEFEM FF-20 apparatus according to STAS 8392-80 standard. In order to characterise the fabric bending, this apparatus uses the principle of cantilever deformation in textiles. The fabric is made to deform under its own weight as a cantilever, and the cantilever length required to produce a deflection angle of 41.5^0 is measured. The bending rigidity of the fabric in the wale and course directions is calculated with the following formula [7]:

$$R_{w(c)} = m \cdot \left(\frac{l}{2}\right)^3 \tag{3}$$

where:
$R_{w(c)}$ - fabric bending rigidity in the wale and course directions, respectively [mg·cm];
m - sample mass [mg/cm^2];
l - length of sample bent at 41.5^0 under its own weight [cm].
The bending rigidity of the knitted fabrics (R_f) is calculated with the following formula:

$$R_f = \sqrt{R_w \cdot R_c} \tag{4}$$

RESULTS AND DISCUSSIONS

The yarn diameter is an important characteristic because it influences both the settings of technological parameters in further yarn processing and the comfort and appearance properties of textile products. The values of yarn diameter, modulus of elasticity and bending rigidity are presented in Table 1.

Table 1. Yarn properties

Blend type	Yarn linear density [tex]	Yarn diameter [mm]	Modulus of elasticity [N/mm^2]	Yarn bending rigidity [N·mm^2]
100 % cotton	100	0.5925	60.269	0.3647
	59	0.4224	98.783	0.1543
30/70 cottonised flax/cotton	100	0.6149	48.067	0.3373
	59	0.4217	71.728	0.1114
30/70 cottonised hemp/cotton	100	0.6209	38.724	0.2825
	59	0.4261	49.02	0.0793

As can be seen in Table 1 the diameters of yarns of 100 tex that contain cottonised flax or cottonised hemp are higher than the diameter of 100 % cotton yarn even if the twist of these yarns have been adjusted up to 30 % higher than the twist of all-cotton yarns. It is known that the higher the twist, the higher the degree of yarn compactness and therefore the smaller the yarn diameter. However, the yarns of 100 tex that contain cottonised flax or cottonised hemp have a higher twist and a higher diameter than all-cotton yarns. This might be due to the higher torsional rigidity of flax and hemp fibres which during yarn formation prevents the compacting of fibre strand. Regardless the yarn composition, the diameters of yarns of 59 tex have similar values.

For each yarn linear density, taking into account the values of modulus of elasticity, the decreasing hierarchy of yarns comprise: 100 % cotton yarn, cottonised flax/cotton blended yarn and cottonised hemp/cotton blended yarn. This hierarchy can be explained by the fact that the cottonised flax and hemp fibres we used were coarser and more variable in fineness than cotton and had a higher percent of short fibres.

Due to the influence of modulus of elasticity, the bending rigidity has the highest value for all-cotton yarns and the lowest value for cottonised hemp/cotton blended yarn. The finer yarns of 59 tex have a lower bending rigidity than the yarns of 100 tex.

During knitting process the yarns are subjected to bending depending on knit structure, density and yarn characteristics. The bending rigidity of knitted fabrics in the wale and course directions is presented in Table 2. Because all fabrics have been knitted in the same conditions, the main factor that influences the bending rigidity of knitted fabrics is the bending rigidity of yarns. As is the case with yarns, the bending rigidity of knitted fabrics in both course and wale directions decreases from all-cotton fabrics to cottonised flax/cotton and cottonised hemp/cotton fabrics. The bending rigidity in the wale direction is much higher than the bending rigidity in the course direction. This might be due to the fact that the course density is higher than the wale density.

Table 2. Bending rigidity of knitted fabrics in the wale and course directions

Blend type	Yarn linear density [tex]	Bending rigidity in the course direction [mg·cm]	Bending rigidity in the wale direction [mg·cm]
100 % cotton	100	161.176	1361.024
	59	26.244	184.786
30/70 cottonised flax/cotton	100	124.864	1237.742
	59	25.952	177.285
30/70 cottonised hemp/cotton	100	119.218	1249.936
	59	18.424	174.96

The overall bending rigidity of knitted fabrics is presented in Figure 1. Regardless the yarn linear density, the 100 % cotton knitted fabrics have an overall bending rigidity higher than cottonised flax/cotton and cottonised hemp/cotton fabrics. The knitted fabrics obtained from yarns of 100 tex are stiffer than the knitted fabrics obtained from yarns of 59 tex.

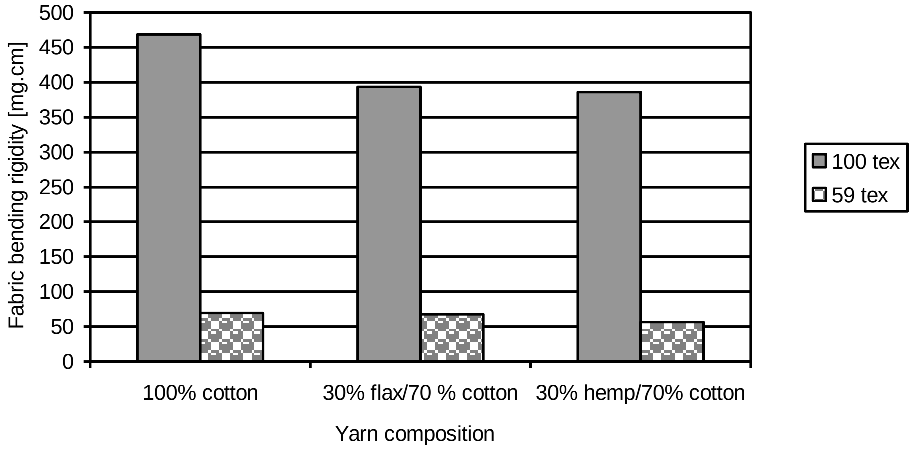

Figure 1. Bending rigidity of knitted fabrics

CONCLUSIONS

Cotton is the most used textile fibre in the world in apparel applications but its cultivation is environmentally destructive. Flax and hemp instead have several green advantages over cotton and can constitute an alternative to cotton fibres.
The aim of this research work was to study the effect of partial replacement of cotton with cottonised flax and hemp on the bending rigidity of yarns and knitted fabrics as important factor which affects the handling and comfort of apparel.
Based on the results of this research, the following conclusions can be drawn:

- Adding cottonised flax and hemp to cotton blends leads to a decrease of yarn bending rigidity due to the decrease of the modulus of elasticity.
- Regardless the yarn linear density, the 100 % cotton knitted fabrics have an overall bending rigidity higher than cottonised flax/cotton and cottonised hemp/cotton fabrics.
- A decrease in yarn linear density causes a decrease in yarn and fabric bending rigidity.

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RESEARCH ON ELASTIC BEHAVIOUR OF TECHNICAL TEXTILES

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Abstract: *The paper proposes a method for analyzing the knotted fabrics structure and a manner of finding the value of force that presses a cylindrical body over a part of man (wrist, ankle, etc).*
This may help an engineer to design a better smart fabric (knotted fabric). The paper gives some information about the characteristics and fabric properties, including also their behavior at their various demands,when they are used to protect some special parts of the human body, as wrist or ankle. The elements that characterize the internal structure of the fabrics are defined by the basic structural parameters, fineness, density of yarns and the weave, that determines the mutual position of the yarns of those two systems, yarns positional stability, distribution of the tensile forces on the parts of the fabric,and the pressure an the circular area. Studying the behavior of a cuff (of a smart glove) is important because all the sensors or transmitters fixed in it have a strong connexion with both textile and skin of the body.

Keywords: *smart technical textiles, knotted cuff, tensile force, intelligent glove, transmitters, textile sensors.*

INTRODUCTION

Technical textiles is a distinct field of research and development which, in the last twenty years, has been focused more on the functionality of a fabric than its aesthetics. When we talk about technical textiles, we talk about yarns, fabrics, knotted fabrics used in different areas like clothing, bedding, sports, healthcare sector, agriculture [1].
Smart textiles can study and analyzes man and his environment and how they react in an appropriate way. On the other hand, they are very well suited for protective applications. The advances in transmitters for monitoring, textile sensors and textile-based actuators are used to obtain the new smart textiles. The working principles of them and some solutions for integration of electronic components can be applied successfully if the unobtrusive and reliable devices are reliable both for the user and for the diagnostician [2]. The unification between textiles and electrics it's possible because electrics need conductive structures.
On the other hand, industrially knittable and weavable filaments and yarns are the basics for the integration in approach that is put forward as a concept for successful production of smart textiles. We are interested in smart textiles for mechanical sensoring which, based on piezoelectricity and capacitive techniques, can give an electrical output as these embrace such basic quantities as position, movement, speed, acceleration, elongation, forces, pressure, and vibration [3].

Smart textile may be also the healthcare textiles which are specifically designed or produced for a wide variety of uses in the healthcare sector. These products can be derived from natural and artificial materials composed of fibers, hairs, yarns, or polymers. The product functions are analyzed in terms of pressure distribution and adaptation of compression textiles to individual therapeutic and anatomical situations [4]. Smart fabrics and interactive textiles are the newest area of research, with many potential applications in the field of biomedical engineering. Sensors integrated into textiles in contact with the body have the ability to capture many useful physiological signals. Some of the signals can be measured using smart textiles and the application of this technology. Future trends in this area of research involve knowledge regarding technology development [5]. The sportswear and sports footwear industries are among the foremost innovators in the clothing and textile sector [6]. Because we have not to hurt the human body, we must study the role of skin quality and function in the interaction with textiles, in particular clothing and bedding. We have to analyse, the typical cutaneous reactions to the mechanical stress. There are new developed techniques able to measure the possible irritating mechanical factors of fabrics and textiles to induce irritation on skin [7]. Knotted fabrics are formed using a variety of techniques, in order to manufacture by hand or by machine a translucent or open fabric. For example the new glove designs were based on the findings of subjective hand discomfort assessments for this type of work or travel and aimed to match the glove thickness to the localised pressure and sensitivity in different areas of the hand as well as to provide adequate dexterity for fine manipulative tasks [8]. When working with a knitted fabric, we must also take into account the specific properties of these fabrics like capacity to unstring and roll the margins. The presence of the twisted margins causes difficulties in the manufacturing process [9].

EXPERIMENTAL

This part is to be used in making an intelligent glove, able to be used both in sport and medical field. This glove is made of three layers of fabric capable of providing, through the outer fabric characteristics, infiltreting of water in the glove and through interior fabric features, the transfer of water vapors from the inside to out. There are inserted the pressure, temperature and acceleration transducers to measure, monitor and ensure a constant temperature of the hand, the transfer of moisture and the waterproof capability of gloves. This glove will have a display able to show us some information about existing pulse and blood oxygen value. This intelligent gloves may do issues like: heating the hand, in case of hypothermia; sanguine pulse detection; start vibrations in the area between the thumb and forefinger; display value of blood oxygen. It can transmit this information via GPRS.
Because the sensors and transducers are secured in the cuff of the glove, for the beginning, it will be studied the behavior of the cuff made of a knitted fabric. Cubic elastic cuff (circular figure/shape) is made of elastomer and cotton. There is analyzed the value of the exercising force (pressure) on the circular area, so the force done by the cuff on a part of the body, like wrist, ankle, etc. The most important element, in this case, is the behavior of cuff at a requested deformation. On a cuff of glove, fixed between two bars fastened by the dynamometer clips, is applied a tension (Figure 1). On one side of the cuff, there are traced two parts: one, by 10 mm, on the cuff circumference and another, by 30 mm, on the cuff direction (perpendicular to and at the middle of the request distance). The cuff is stretched and for a certain strength, the longitudinal deformation is measured, being seen like a contraction (the circumferential direction of cuff and transverse deformation on the direction cuff, like a contraction .

RESULTS AND DISCUSSION

The experiment shows that the clamping force is determined by strength in the direction of circumferential cuff. There are obtained values for strength, longitudinal elongation and transverse contraction (Table 1). In the second experience, the cuff is laid on a conical surface and there are measured the two deformations at different diameters. Now it can be appreciated how much force there is in the the cuff for a certain deformation of it (Table 2).

We noticed:

Fm	the tensile force of the cuff
F	the tensile force on a flank of the cuff
Lo	The initial length between the bars centers
Lmo	The initial length of the cuff (lmo=30mm)
l10	Length of a 10mm benchmark , on direction of cuff circumference, upon we apply tensile force
Lm	cuff width, upon we apply tensile force
C	Cuff contraction
Al10	elongation of a 10mm benchmark
AL	Cuff elongation

AL =((L-L0)/L0)*100= ((π*Ro-pi*R)/pi*R)*100=((Ro-R)/R)*100

C= ((lm-lm0)/lm0)*100

Where

L - length of the cuff on direction of cuff circumference, for a tensile force

L0 - The initial length of the cuff (66 mm)

Ro	circle radius equivalent of the wrist
R	Maximum of circle radius of the wrist
π*R	Semi-circumference of the wrist

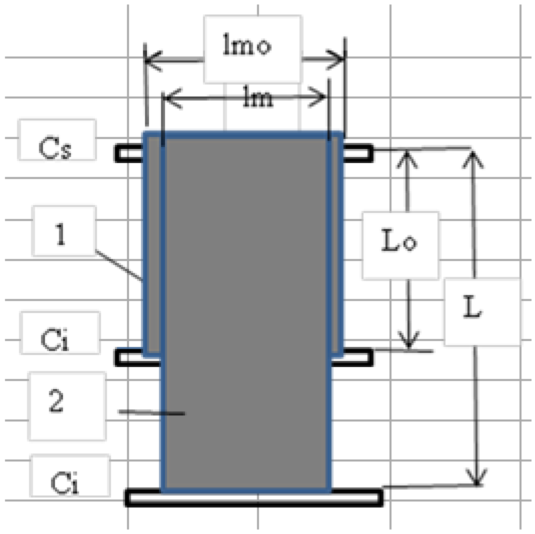

Figure 1: Principle scheme of measurements: Cs - uppe clamp; Ci – lower clamp; 1 – initial cuff; 2 – requested cuff

Table 1: Deformations of cuff according to the tensile force

Fm (cN)	F (cN)	L (mm)	AL (%)	Lm (mm)	C (%)	l10 (mm)	Al10 (%)	TT*R (mm)
0	0	66	0	30	0	10	0	33
20	10	70	6	30	0	10	0	35
30	15	74	12	28	-7	14	40	37
45	22.5	78	18	28	-7	14	40	39
56	28	83	25	27	-10	15	50	41.5
70	35	88	33	27	-10	16	60	44
90	45	92	39	26.5	-12	17	70	46
100	50	98	48	26	-14	17	70	49
115	57.5	103	56	26	-14	18	80	51.5
125	62.5	104	57	25	-17	20	100	52
136	68	107	62	25	-17	21	110	53.5
146	73	111	68	25	-17	21	110	55.5
158	79	112	69	25	-17	21	110	56
170	85	115	74	25	-17	21	110	57.5
190	95	117	77	24.5	-19	22	120	58.5
200	100	121	83	24	-20	22	120	60.5
210	105	123	86	24	-20	23	130	61.5
221	110.5	123	86	23	-24	23	130	61.5
240	120	135	104	23	-24	25	150	67.5
253	126.5	136	106	23	-24	25	150	68
273	136.5	142	115	22	-27	26	160	71
285	142.5	142	115	22	-27	26	160	71
300	150	142	115	22	-27	26	160	71
323	161.5	144	118	22	-27	26	160	72
342	171	150	127	22	-27	26	160	75
383	191.5	150	127	21.5	-29	26	160	75

Notice:

-L max -165 mm, the fabric stretches after this value.

-thickness cuff in a free state = 1.65mm

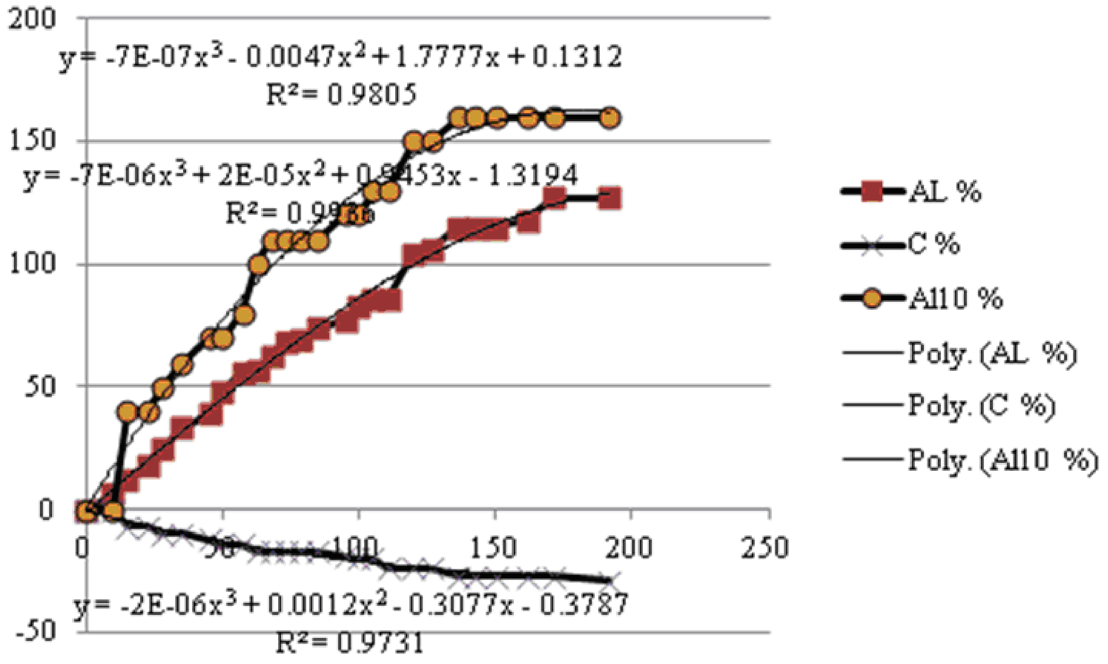

Figure 2: Variation of elongation and cuff contraction depending on force

R,from this ecuation,shows me how close are the experimental values to the theoretical values. R^2=0,9731 shows me that there is a good correlation between the values.

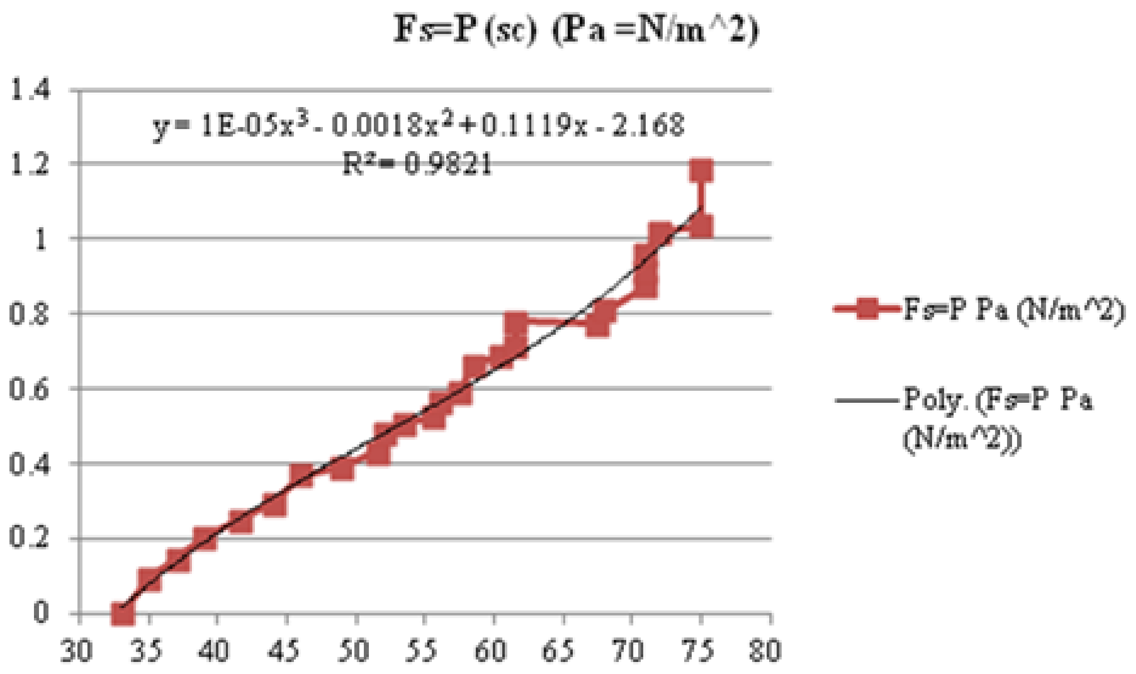

Figure 3: Variation of specific force (pressure) depending on the size cuff

Where: Fs – specific force; P – pressure; Sc – Semi-circumference of cuff (mm)

Table 2: Deformation characteristics of the cuff

TT*R (mm)	F (cN)	Fs=P Pa (N/m^2)	Lm (mm)	S (mm^2)	Fs =P (cN/mm^2)	Pa (N/mm^2)	Pa (N/m^2)
33	0	0	30	990	0	0	0
35	10	0.095238	30	1050	0.009524	9.52E-05	0.095238
37	15	0.144788	28	1036	0.014479	0.000145	0.144788
39	22.5	0.206044	28	1092	0.020604	0.000206	0.206044
41.5	28	0.249888	27	1120.5	0.024989	0.00025	0.249888
44	35	0.294613	27	1188	0.029461	0.000295	0.294613
46	45	0.369155	26.5	1219	0.036916	0.000369	0.369155
49	50	0.392465	26	1274	0.039246	0.000392	0.392465
51.5	57.5	0.429425	26	1339	0.042942	0.000429	0.429425
52	62.5	0.480769	25	1300	0.048077	0.000481	0.480769
53.5	68	0.508411	25	1337.5	0.050841	0.000508	0.508411
55.5	73	0.526126	25	1387.5	0.052613	0.000526	0.526126
56	79	0.564286	25	1400	0.056429	0.000564	0.564286
57.5	85	0.591304	25	1437.5	0.05913	0.000591	0.591304
58.5	95	0.662829	24.5	1433.25	0.066283	0.000663	0.662829
60.5	100	0.688705	24	1452	0.068871	0.000689	0.688705
61.5	105	0.711382	24	1476	0.071138	0.000711	0.711382
61.5	110.5	0.781195	23	1414.5	0.078119	0.000781	0.781195
67.5	120	0.772947	23	1552.5	0.077295	0.000773	0.772947
68	126.5	0.808824	23	1564	0.080882	0.000809	0.808824
71	136.5	0.87388	22	1562	0.087388	0.000874	0.87388
71	142.5	0.912292	22	1562	0.091229	0.000912	0.912292
71	150	0.960307	22	1562	0.096031	0.00096	0.960307
72	161.5	1.019571	22	1584	0.101957	0.00102	1.019571
75	171	1.036364	22	1650	0.103636	0.001036	1.036364
75	191.5	1.187597	21.5	1612.5	0.11876	0.001188	1.187597

Clamping force for various diameters of the cuff, is determined by the strength of cuff, at a certain deformation (Figure 2). To determine the pressure tightening, the clamping force is reported to cuff area, which is modified by contraction (Figure 3). From the graphic I can find the value of the force which presses on a cylindrical shape/body, when I know the value of deformation. Knowing the value of force that presses a cylindrical body over a part of man (wrist, ankle, etc) helps me to design the fabric (knotted fabric).

CONCLUSIONS

When we talk about technical textiles, we talk about yarns, fabrics, knotted fabrics used in many fields of activity. Smart textile may be also used in the healthcare area.

They are specifically designed or produced for a wide variety of uses in this sector.

The product functions are analyzed in terms of pressure distribution and adaptation of compression textiles to individual therapeutic and anatomical situations.

Smart fabrics and interactive textiles are the newest area of research, with many potential applications in the field of biomedical engineering.

When we use an elastic technical textile like knotted fabrics, we have to remember that the tensions, which are introduced by the knitting process, tend to be free when we remove the fabric from the machine and fabric occupies a position characterized by minimal power.

Because we add the sensors and another electronic devices in the cuff of the glove, we must study carefully the behavior of the cuff on we apply a tensile force on it. The value of force that presses a cylindrical body over a part of man (wrist, ankle, etc) helps me to design the fabric (knotted fabric)

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EXPERIMENTAL RESEARCHES ON THE PROPERTIES OF NONWOVEN MATERIALS FOR MEDICAL USE

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Nonwoven textiles industry provides a wide range of materials obtained through different technologies, with different applications, among which the medical field too. Given the intended field of application, it is interesting to know since the laboratory stages, which are the structural and functional physical-mechanical characteristics that answer requirements imposed by it. The present paper presents the results of researches conducted on nonwoven textile materials made of cellulosic fibers (cotton, viscose and bamboo type regenerated cellulose). This research underlines those properties (weight per square meter, thickness, absorbency) recommending the use of nonwoven textile materials, with full compliance of all limitations in the medical field, replacing traditional materials in this way (gauze, cotton, etc.

Keywords: *textile, nonwoven materials, cellulosic fibers, medical field*

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MODELING OF THE TENSILE PROPERTIES OF THE GEOTEXTILES USED IN ROAD CONSTRUCTION

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Abstract: *In the article was conducted a study on the tensile properties of the nonwoven polypropylene geotextiles used for the rehabilitation and construction of roads. The determinations were carried out in accordance with SR EN 10319: 2015 Geosynthetics- Wide-width tensile test. Processing and statistical interpretation was made using the IBM SPSS Statistics 19 using the regression and correlation method. With this program was studied the dependence between the dependent variable y - breaking force, F [N] and an independent variable x - mass, M [mg]. Using the regression and correlation method aims to identify the existence of the link between the dependent variable and independent variable, determining the intensity of the relationship and establish the meaning and form of the link between the two variables. Regression analysis surmises the approximation of the regression model, estimation and testing of the regression model parameters and the correlation shows the degree to which a variable is dependent on another variable (or other variables).*

Keywords: *geotextiles, roads, tensile properties, regression method, corelation*

INTRODUCTION

In order to determine a dependency relation between two sizes of interest called variable we use the regression and correlation analysis. By using the correlation analysis are estimated the connections between various factors and the state variable and based on statistical criteria are detained factors and interactions that have significant influence. Through regression analysis aims to determine the experimental error, checking the significance of regression equation coefficients, checking the model concordance and the determination of the error calculation of the state variables [1-4]. Regression shows how a variable is dependent on another variable and the correlation shows the degree to which a variable is dependent on another variable [5-8].
Characterization of the geotextiles by tensile properties indicators requires particularities of the product determined by the structure of the material and the test conditions (testing system, specimen size, the initial state of the specimen, prestressing) [9].
The most widespread use of the nonwoven geotextiles belongs to the polypropylene material. Polypropylene is used as raw material for its chemical stability and the price / weight ratio Geotextiles have significant role in road construction because it provides the desired properties, such as strength, durability and a special behavior to chemical agents (chemical resistance). Polypropylene is used as raw material for its chemical stability and the price / weight ratio this gives the material the advantage that at a thickness equivalent to another polymer to be more resistant. [10], [11]. One of the main advantages of nonwoven geotextiles is that the production process is carried out continuously from raw material to finished product and, implying lower production costs and labor. Geotextiles have a significant role in building roads providing desired properties such as strength, durability and a special behavior to chemical agents (chemical resistance) [12].
The paper presents a study of the tensile properties of polypropylene geotextiles made for road works.

EXPERIMENTAL

Checking the tensile properties of the polypropylene geotextiles was done by dynamometer testing in accordance with EN ISO 10319: 2015 on the dynamometer H5K-T Tinius Olsen software computing QMAT Textile Research Laboratory TEXTILEXPERT in the Engineering and Design Textile products department of the Faculty of Textile-Leather and Industrial Management. Experimental data obtained were processed statistically using regression and correlation method.
Through the IBM SPSS 19.0 statistical processing was aimed identifying the existence of the link between the two variables, dependent and independent through graphical method which involves building the correlation curve and establishing the regression model, estimating the model parameters and test their

significance. Nonwoven polypropylene geotextile was analyzed longitudinally following the correlation and regression of variables "mass M [mg]" and "F breaking force [N]".

RESULTS

Experimental data processing was done by grouping the data and determining the frequency, the calculation of statistical descriptive indicators (Descriptive Statistics), the calculation of estimated coefficients (Estimates), confidence intervals of coefficients (Confidence Intervals), calculating statistics R, R2 and table Anova, modification of the determination coefficient and testing the significance of change to adding each block of variables (R squared change).
In table 1 - Descriptive Statistics there are the statistical parameters calculated for each variable in which is observed the homogeneity values of the two variables

Table 1: Descriptive Statistics

	N	Min	Max	Mean	Median	Std. Dev.	CV	Variance	Skewness		Kurtosis	
									Statist.	Std. Error	Statist.	Std. Error
M [mg]	30	835	1281	1064.24	1057.15	145.64	16.61	21211.49	0.92	0.43	-1.41	0.83
F [N]	30	329.6	596	445.37	434.25	73.96	13.69	5470.78	0.38	0.43	-0.73	0.83

Analyzing the data in Table 1, we obtain information about each variable independently analyzed. Skewness indicator is used in the analysis of the distribution of a series of data to indicate a deviation of the empirical distribution in relation to a symmetrical distribution around the mean, and the indicator Kurtosis is used in the analysis of the distribution of a series of data to indicate the degree of flattening or sharpening of a distribution. Thus, it can be seen that: the dependent variable "F [N], the breaking force" is characterized by an average value of 329.6 N and variance 5470.78; Skewness indicator sk = 0.38, sk> 0 indicates that the distribution is skewed to the left, with more extreme values to the right; Kurtosis k = -0.73, k <0 indicates a platikurtical distribution, a distribution flatter than a normal, with values spread out over a longer interval around the mean (Figure 1). The probability for extreme values is less than for a normal distribution. The value of the coefficient of variation obtained, CV = 13.69%, reflects the fact that mean is strictly representative, that shows a homogeneous collectivity.

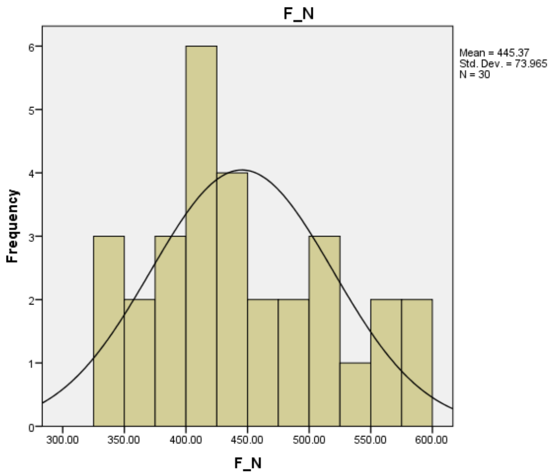

Figure 1. Histogram and the normal distribution curve for breaking force

Independent variable "M [mg] mass" is characterized by an average of 1064.24 and a variance of 21211.49; skewness Sk = 0.92, sk> 0 indicates that the distribution is skewed to the left, with more extreme values to the right; Kurtosis k = 1.1415, k <3 shows a leptokurtical distribution, sharper than a normal a distribution; having more concentrated values around the mean and thicker tails which means higher probabilities for extreme values.
Graphic representation as histograms (Figure 2) is another way of checking the normality of a distribution by viewing graphical differences between an empirical and theoretical distribution (Gauss). It is noticed that the

distribution is below a normal curve with a slight elongion to the left (sk> 0) and in terms of vaulting there is a platikurtical tendency (k <3) meaning that the results are scattered toward the mean. The value of the coefficient of variation obtained, CV = 16.61%, reflects the fact that mean is strictly representative, that shows a homogeneous collectivity.

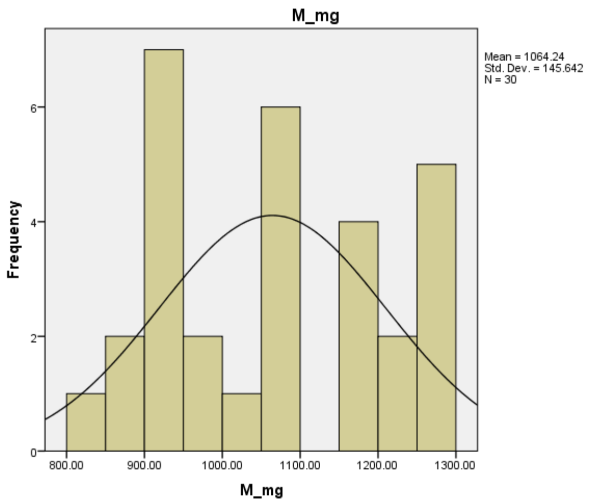

Figure 2. Histogram and the normal distribution curve for mass

Choosing the best model regression and correlation for the two studied variables, using SPSS, can be achieved through interpretation of the most important results in Output, shown in Table 2 and from the corelogram point cloud (scatter diagram or Scatterplot - Fig. 3).

Table 2: Model Summary and Parameter Estimates

Dependent Variable: F_N

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	,848	155,921	1	28	,000	-52,266	,468		
Logarithmic	,834	140,477	1	28	,000	-2971,417	490.855		
Quadratic	,864	85,448	2	27	,000	587,684	-,750	,001	
Cubic	,865	86,458	2	27	,000	340,991	,000	,000	2,463E-007

The independent variable is M_mg.

From Table 2 it is observed that for each regression model it is found in columns Model Summary the ratio of determination (R Square) and its testing with test F and in columns Parameter Estimates the regression equation coefficient.
Based on the R Square from the Model Summary it will decide the best regression model, respectively as R Square is closer to value 1 the regression model that is more appropriate. Thus we see that the highest value for R Square of all the regression models are registered to Cubic function - the function of 3 degree (R Square = 0.865), the Quadratic function - the function of 2 degree (R Square = 0.864).
To choose the best regression model the following conditions must be meet concomitantly:
- a great R Square value
- a value in the ANOVA analysis for the Sig F smaller than 0.05
- Sig. t values for the coefficients of the independent variable from the equation to be below 0.05.

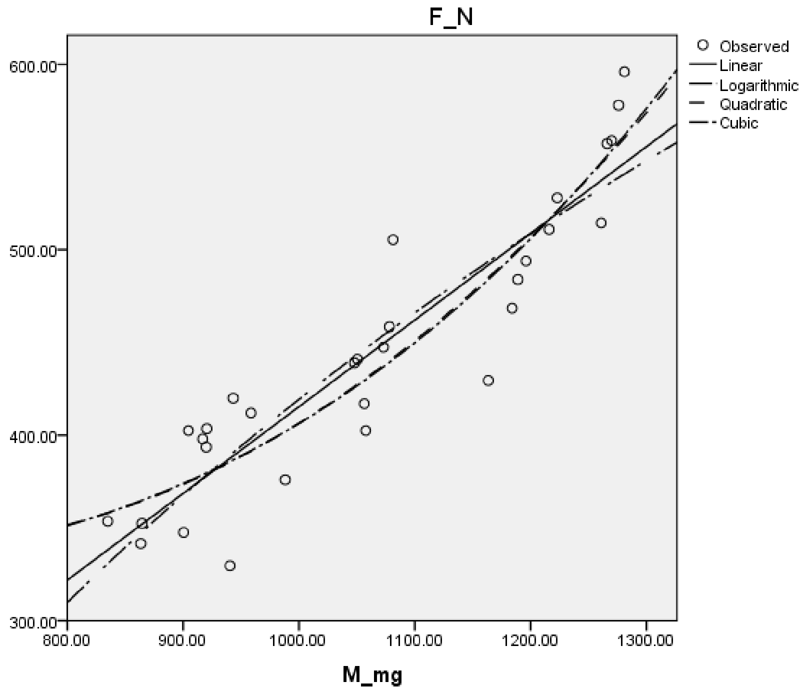

Figure 3. Chart dispersion or Scatter Plot for regression models

After analyzing the regression models it turns out that the best model is the LOGARITHMIC one. So the results are analyzed in Tables 3, 4 and 5.

Table 3: Model Summary for the Logarithmic model

R	R Square	Adjusted R Square	Std. Error of the Estimate
,913	,834	,828	30,687

The independent variable is M_mg

From Table 3: Summary Model are obtained information about the regression coefficient (R = 0.913), the determination coefficients (R Square = 0.834; Adjusted R Square = 0.828) and the standard error of the estimated coefficient (30.687). To verify the adequacy model is applied Fisher's test, as shown in Table 4.

Table 4: ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	132285,368	1	132285,368	140,477	,000
Residual	26367,150	28	941,684		
Total	158652,519	29			

The independent variable is M_mg

The imposed condition for the adequacy of the model is that the $F_c > F_T$. The value from the standard tables of the F test is chosen depending on the degrees of freedom contained. Meaning $F_{(1,28)} = 4.20$ [2]. The mathematical model is appropriate because, the condition imposed ($F_c = 140.477 > F_{(1,28)} = 4.20$) is meet.

Table 5: Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
ln (Mass)	490,855	41,414	,913	11,852	,000
(Constant)	-2971,417	288,335		-10,305	,000

The values shown in Table 5 column Unstandardized Coefficients B, used the write the regression equation for the LOGARITHMIC model:

$$F = a + b \times \ln M \qquad (1)$$

were:
F – represents the breaking force of the geotextile, N;
a, b – constants;
M – mass of the geotextile, mg.

So, the best regression equation for the two variables is written as follows:

$$F = -2971{,}417 + 490{,}855 \times \ln M \qquad (2)$$

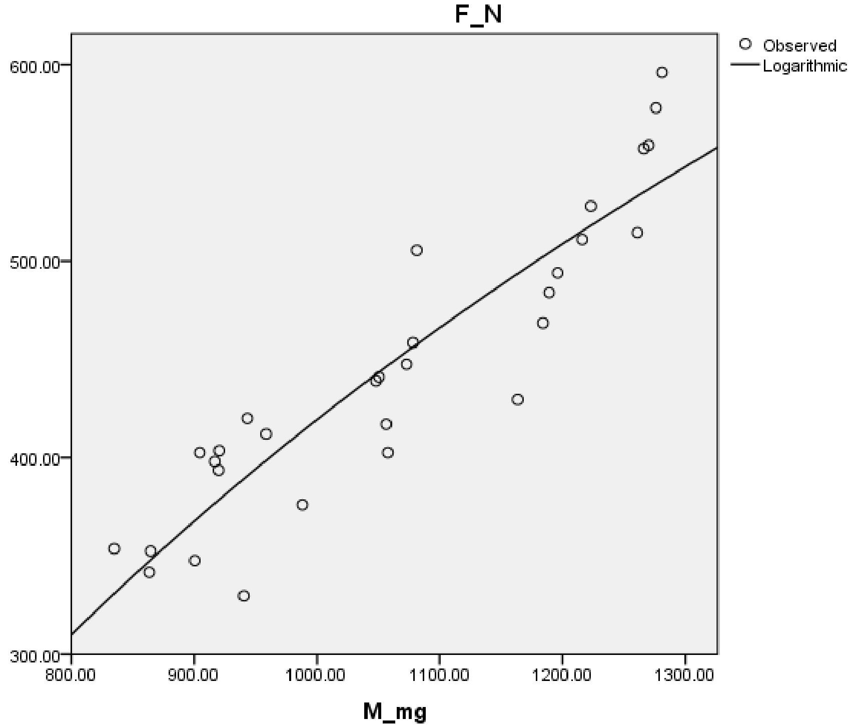

Figure 4. The graphic representation for the LOGARITHMIC Regression

DISCUSSION

Analyzing the tables of the LOGARITHMIC model remained into account we can say that it is the best regression model because the R Square is high (0.834) and the degree of significance of the F and t tests has the value Sig. 0.000 <α = 0.05.
The value of the correlation coefficient R = 0.913 confirms the existence of significant positive link between mass and breaking force of the polypropylene geotextile, used in road construction. A more accurate idea gives us the coefficient of determination R Square = 0.834. It tells us that 83.4% of the "breaking force" variation is explained by the variation of the variable values "mass". We infer that the remaining 16.6% of the variation is explained by the breaking force of other variables unknown at this stage.

CONCLUSIONS

To determine the relationship of dependence between the two sizes of interest, dependent variable and the independent variable was necessary regression and correlation analysis. The accuracy of the predictions that were developed was given be the correlation coefficient between the two variables.

After the statistical processing, the coefficient of asymmetry Skewness obtained for the independent variable sk> 0 (sk = 0.92) shows that the distribution is skewed to the left that is, it shows more extreme values to the right; flattening coefficient Kurtosis k = 1.1415, k <3 shows that the distribution is leptokurtica, sharper than the normal distribution.

The asymmetry coefficient of the dependent variable Skewness sk = 0.38, sk> 0 indicates that the distribution is skewed to the left, thus highlighting more extreme values to the right; Flattening coefficient Kurtosis k = -0.73, k <0 indicates a platikurtica distribution, the distribution is flatter than normal.

Following the fulfillment of the imposed conditions, getting a great R Square value, a value of the safety factor for the F test (in ANOVA analysis) Sig <0.05 and for the t test Sig. <0.05, the regression and correlation model that was obtained was the LOGARITHMIC.

The determination coefficient R2 identifies that the variation of the dependent variable "breaking force" is explained by the variation of the independent variable "mass" in proportion of 83.4%.

This strong and positive link between mass and breaking force of the nonwoven geotextile is evidenced by the correlation coefficient R = 0.913.

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Section 4: Intelligent textiles

ASPECTS REGARDING THE CAUSAL SYSTEM OF INTERACTIVE TEXTILES IMPLEMENTATION CONCEPT

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Abstract: *The Textile and Clothing Sector has been subject to a series of radical transformations over recent decades, companies have improved their competitiveness by reducing or ceasing the mass production of simple products, and concentrating instead on a wider variety of products with higher value-added.*
Multidisciplinary strategy elaboration for the interactive/ smart textiles development is required in terms of design research (environment & communication), physiology (human) and textile technology (e-textiles).
The Textile and Clothing Industry has all opportunities through the products that can be developed, to become a positive force of society. It depends largely on the education and research system and on the business environment to transform the textile systems into instruments that improve the everyday life of people and to create benefits to the industry and environment.

Keywords: *smart textiles, interdisciplinary research, higher value-added products.*

INTRODUCTION

1.1 The general framework for sustainable development of the Textile & Clothing Sector

In the global market competition, the chances of economic success of a country are based on the offer specialization and concentration of efforts in education-research and development business environment to key areas with competitive advantages, resources and skills.

At EU level the mentioned issues are the "engine" of innovation and sustainable development laying the basis of multidisciplinary cooperation based on causal systems.

In the implementation of the Europe 2020 strategy, the causal system includes economic, social, technological, educational objectives and general development support objectives [1] determined by (material, efficient, formal, final) causes and correlated by direct or reversely positive reactions. Objectives are based on priorities (sustainable, intelligent, inclusive growth,) which is based on flagship initiatives (An agenda for new skills and jobs, European platform against poverty, Europe of efficient resources, an integrated industrial policy for the globalization era, a union of innovation, Youth on the move, Digital Agenda for Europe) [2-5].

Smart growth involves developing an economy based on knowledge and innovation; sustainable economic growth is based on promoting a more efficient economy in terms of greener and more competitive resource use, greener and an inclusive growth ensures the promotion of an economy with a high rate of employment, able to ensure economic, social and territorial cohesion [6-9].

The Textile and Clothing (T&C) Sector is an important part of the European manufacturing industry, playing a crucial role in the economy and social well-being in many regions of Europe. [10]. In 2015, the overall size of the Textile & Clothing Industry in the EU-28 represents a turnover of 169 billion € and investments of around 4 billion €. Thanks to a revival of the EU activity, the 174,000 T&C companies still employ over 1.7 million workers. EU external trade was more dynamic than the previous year with 45 billion € of T&C products exported and 109 billion € imported from third markets.

The EU T&C Industry is a leader in world markets. EU exports to the rest of the world represent more than 30% of the world market while the EU Single Market is also one of the most important in terms of size, quality and design. The sector accounts for a 3% share of value added and a 6% share of employment in total manufacturing in Europe. Companies with less than 50 employees account for more than 90% of the workforce and produce almost 60% of the value added [11].

The sector has been subject to a series of radical transformations over recent decades, companies have improved their competitiveness by reducing or ceasing the mass production of simple products, and concentrating instead on a wider variety of products with higher value-added.

The trend towards higher value-added products needs to be continued in order to strengthen the competitiveness of theT&C Sector and the educational system in the field.

EXPERIMENTAL

2.1 Smart textiles – the engine of textile-clothing sector development

The use of new innovative methods to produce textile fibers and many other textile products in different sectors such as medicine, science, architecture, aerospace, transport and automobile have opened up several avenues for foreign investors to exploit the textile market and cater to the needs of the market.[12, 13]. The European Textile sector is especially proactive in undertaking research work for the development of new and innovative products. Not many smart textile products are found on the consumer market yet, but multiple applications are about to enter the market (ambient assisted living, health monitoring, sport and outdoor, well-being, fashion, protective function and safety, automotive and aviation industry, home textile, technical textiles and civil engineering.

At international level, smart textiles are the main dynamic innovation factor, namely [14]:

- provide the textile sector a strong position on the international market;
- contribute to the social inclusion of labor force;
- represent a new field that involves knowledge both in the field of textile materials and the manufacturing processes.

According to the report published by the Transparency Market Research "Smart and Interactive Textiles Market - Global Industry Analysis, Size, Share, Growth, Trends and Forecast, 2014-2020, smart textiles and interactive textiles were valued at 1.53 billion USD and have a forecast of 3.82 billion USD value in 2020. As regards CAGR index, the growth in 2014-2020 is 14.0%.
For the period 2016-2026 as regards e-textiles market, CAGR index (fig.1) records different values depending on the intended use. [15]

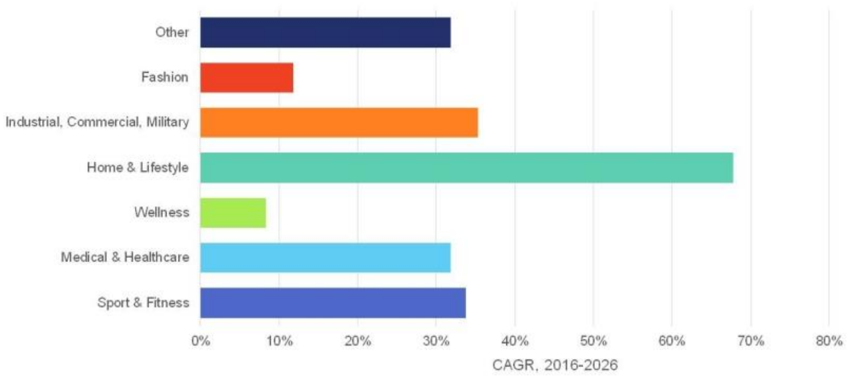

Figure 1: Forecasts of the CAGR index during 2016-2020

The use of smart textiles as wearable devices (sensors or actuators) must satisfy a number of requirements to guarantee the results and adequate response to the user [19]:
- *Reliability, robustness, and durability*. Environments where sensors must operate vary and users are non-specialists who are not necessarily aware of the technical limitations of use.
- *Appearance /discrete character of textiles*. Smart textiles must be integrated into the daily life of users, therefore their appearance should match individual preferences and to be as discrete as possible.
- *Communication.* Sensors and measuring devices must be able to transfer information to a specific CPU memory, preferably using a fully automatic system, or at least to be light enough so that it would not represent a burden for the user.

- *Zero maintenance and error recovery.* A key issue for health monitoring is self-calibration, ie finding ways to ensure that the sensor performance does not deteriorate over time. Calibration and accuracy are two topics that are fundamental (Teller, 2004).

- *Adaptation.* The measures of wearable sensor systems and confidentiality of data obtained are two issues with respect to the user which have to be considered in the development of smart textiles applications.

Advantages of the creation and development of such industries are: reduced consumption of raw materials; environment protection; possibilities of application in different areas of use with impact on the development of economic environment; the use of a specialized workforce; assuming government involvement in creating conditions for the development of an industry-friendly environment for companies using advanced technologies and professional training activity of labour force required in the field; it is the future of traditional industry; it ensures international scientific cooperation.

The development of the field of smart textiles involves efforts which are based on a number of issues, such as:
- product complexity due to the combination of "high-tech" components and textile materials;
- multidisciplinary character of technologies involved;
- difficulties related to the production on an industrial scale;
- products must be resistant to wear and maintenance (cleaning) treatments;
- products should not affect comfort;
- development of new measuring techniques and their standardization.

The success of the field is conditioned by: identification of the types and sub-categories of technical textiles and smart textiles, understanding the manufacturing technology, properties and functionalities, identification of solutions for practical implementation considering the available information in the field.

The supporting factors in the field are: consumer demands for smart clothing; miniaturization of electronic components; rapid decrease in the price of wireless sensors.

2.2 Elements of causal system for implementation of interactive textiles

The market of smart textiles has a complex structure dominated by multidisciplinarity, research and innovation, eco-design. In textile processes, different disciplines meet – physical chemistry, bio-technology, materials science and process engineering [16].
Smart textile is defined as a new garment feature which can provide interactive reactions by sensing signals, processing information and actuating the responses. Similar terminology such as interactive clothing, intelligent clothing, smart garment and smart apparel is used interchangeably representing these types of clothing [17].
The development of textile and apparel sector is a prevalent phenomen for all the concerned stakeholders. Education is widely accepted as one of the leading instrument for promoting economic development. Knowledge-based competition within a globalizing economy is prompting a fresh consideration of the role of higher education in economic development and growth [18].

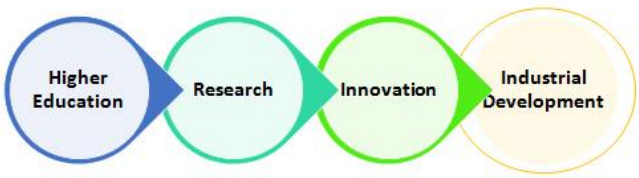

Figure 2: The innovation chain [18]

Re-engineering Education and Training with effects on the research activity requires:
• ensuring that learning as one moves from one level to the next one is seamless;
• improving the articulation between levels and types of education and training;
• building and extending necessary knowledge and expertise to support the textile and related industry in their need to develop a strong international position:
• strengthening the link between research and enterprises through the priority promotion of RDI activities in economic sectors with growth potential;

• lifelong learning, a continuous process with flexible learning opportunities, linking learning and skills acquired in formal institutions with development of skills in non-formal and informal contexts, particularly in the workplace.

CONCLUSIONS

- Smart clothing is understood as an object of interdisciplinary research from different disciplines. It is very important to establish the research area of the product as well as the way in which other disciplines define product-integrated intelligence based on various research paradigms.
- Elaboration of multidisciplinary strategy for the development of interactive/smart textile systems is required in terms of research design (environment & communication), physiology (human) and textile technoloy (e-textile).
- Recent trend towards open innovation has resulted in increasing flows of knowledge and new types of cooperation between research and business environment. Education and Training 2020 strategy (ET2020) clearly defines as priority to establish a close relationship between research, education and innovation- the three sides of the "knowledge triangle".
- Textile & Clothing Industry has all opportunities through the products it can develop, to become a positive force of society. It depends largely on the education - research system and business environment to transform textile systems into tools that improve the everyday life of population and that bring benefits to the industry and environment.

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Section 5: Functional textiles and clothing

TEXTILE CONCEPTS FOR RADIATION PROTECTION

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Abstract: *This paper gives an overview on different types of radiation and textile concepts for protection against them. The main idea of the concept is based on a functional component which is able to absorb or reflect the radiation. A summary of suitable functional components will be given for different types of radiation. Also the suitable combination of function and fiber will be part of the presentation. Special examples are given for the fields of EMI-shielding (electrosmog), light management and X-ray protection. In fact, there are many fields of interesting applications for functional textiles with radiation protective properties. This is as well related to many potential products in the field of clothing, home textiles and technical textiles.*

Keywords: *X-ray, UV/IR-protection, electrosmog, effect pigment coating, composite fibers.*

INTRODUCTION

The term electromagnetic radiation summarizes a broad range of very different types of radiation, from X-rays, to UV- and infrared radiations to microwaves and radiowaves. Usually the different types of radiation are summarized in the electromagnetic spectrum as function of wavelength. The types of radiation are defined usually by their wavelength, frequency or photon energy [1,2]. A rough overview is given in the following table 1. The relation of photon energy E to the frequency ν and the wavelength λ of a radiation is presented in formula 1. The photon energy is also named as the energy of one quantum of light. This relation contains two further constants, as the Planck constant h=6.63 10^{-34}Js and the speed of light c=2.99 10^{10} cm/s. In summary it is clear that with increasing frequency also the photon energy is increased while the wavelength is decreased [1,2].

$$E = h\nu = hc/\lambda \qquad (1)$$

In most cases the contact of humans with radiation is unwished, because of potential health risks. The potential health risk is strongly related to the energy impact of the radiation, so radiation with lower frequency is in most cases more dangerous. Beside the influence of radiation on living organism also its influence on materials has to be mentioned. A prominent example is here the destruction of aramid fibers under the influence of UV-light. With this background there is a demand for protection against radiation and the use of textile materials can be a significant part of a protective concept. Due to this the current presentation will summarize several textile applications useable for effective radiation protection. The idea behind radiation protective applications is quite simple. For each type of radiation certain compounds are known which are able to absorb or reflect this radiation. These compounds with functionality of radiation protection have to be applied into or onto textile materials. Table 1 gives a rough overview on different types of radiation in order of the range of wavelength which are defined for this radiation. The reasons for protection against the radiation and some related potential applications are given. Also some functional component with radiation protective properties are given as examples. In fact, to reach a suitable radiation protection, this functional component has to be applied to fibers or textiles.

Table 1: Overview on different types of radiation, their wavelength and issues related to protection

Type of radiation	Range of wavelength [nm]	Reason for protection & potential applications	Protective functional component
Radiowaves, microwaves / electrosmog	> 10^6	EMI-shielding, protection of electronic devices and identity	Electric conductive materials (e.g. elementary metals or carbon in conductive form as graphite)
Infrared radiation /	780 - 10^6	Heat management,	IR-reflective materials, as e.g.

IR light		camouflage	metals or special metal oxides
Visible light / Vis	400 -780	Optical protection	Dyes or colour pigments
Ultraviolet radiation / UV light	10 - 400	Prevention of sun burn, skin cancer / protection of UV sensitive materials	Organic UV-absorbers (e.g. Tinuvin); inorganic UV-absorbers (e.g. TiO_2 ; CeO_2 or ZnO)
X radiation / X rays	< 10	Prevention of radiation damages and cancer	Components containing heavy chemical elements, as lead, $BaSO_4$ or Bi_2O_3

Beside the type of functional component it is also a significant parameter, in which kind the functional component is combined with fiber or textile. An overview on different ways of combination is presented in figure 1. The simplest case is of course, if the fiber is self-functional, that means the fiber material by itself is able to absorb or reflect radiation. An example would be a metal fiber for protection against microwaves and radiowaves. For synthetic fibers or regenerated fibers it is as well possible to embed the functional component as additive in the spinning process. Also the coating of the fiber or textile and the traditional finishing with functional compounds is possible (Figure 1). The type of combination chosen strongly influence the effectivity of radiation protection. In fact, a strong correlation of concentration of functional component to the reached function can be expected. For this, of course the self-functional fiber has the highest concentration and is in the ranking the one with the best radiation protection.

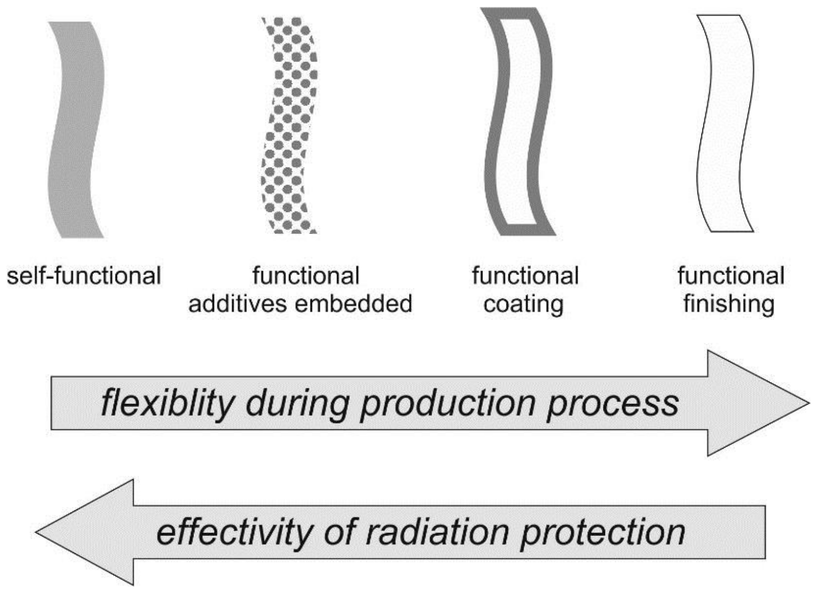

Figure 1: Schematic drawing showing the different combinations of functional radiation protective component in combination with the fibers.

Nevertheless, another parameter has to be introduced describing the different combinations given in figure 1. This parameter could be named “flexibility during production process” and is not defined easily compared to the radiation protection. However, this parameter has also a certain relation to the final cost of the product. Compare for example the self-functional copper fiber with a polyester fiber modified during spinning with some copper particles. The production process of the copper doped polyester fiber is obviously less demanding and also less cost intensive compared to the preparation of the copper fiber. However, the copper concentration in the polyester fiber is lower, so of course its radiation protective properties will be as well lower. Another example is here the comparison of regenerated cellulosic fiber which can be modified with UV-absorbers during the spinning process or by finishing process on the already prepared fiber. Of course, the modification of an already available simple viscose fiber by an UV-absorber in a wet finishing process can be simple performed, if the product is demanded. For this, this type of application is of high flexibility and the proposed costs are expected to be lower. However, compared to the cellulosic fiber with the spin-doped UV-absorber, the concentration of UV-absorber after the finishing application is less, so the protective function against UV-light should be also smaller.

APPLICATIONS FOR RADIATION PROTECTION

Following three topics will be discussed as applications for radiation protection. Different textiles useful for protection against electrosmog, UV-light, IR-light and X-ray are introduced. Also, a short view on their concepts of realization and properties are given. These examples are related to current work performed during recent years at the Hochschule Niederrhein and can of course not cover each possible application developed worldwide.

2.1 EMI-shielding

EMI-shielding is a popular phrase related to the shielding of microwaves and radiowaves. This types of radiation contain high wavelength and low photon energy, so the dangerous effect on human health is expected to be low as well. Nevertheless, due to the broad use of broadcasting, mobile phones and other devices of modern live, this radiation is present almost everywhere and each person is effected by significant amount. For this, in public discussion also the term "electrosmog" is used. The negative impact of electrosmog onto human health is still in discussion but without a dough electrosmog protective clothes have a certain marketing potential. Another significant aspect is the protection of electronic devices or data which can be damaged or stolen by use of radiowaves. An example is here the takeover of electronic car opening systems, which is a recently reported safety issue. The ability of EMI-shielding of a material is related to its electric conductivity. Simple applications can be the introduction of metal fibers into a non-woven material. In recent experiments metal effect pigments are used for coatings onto textiles to realize electric conductive fabrics [3]. For this purpose special useful metal pigments are systems containing of a copper core and a silver coating. These pigments are distributed under the name econduct pigment by the company Eckart (Altana). The coating onto textile substrate is easily possible in combination with a polyacrylate or a polyurethane binder system. In this way realized conductive coatings are also able to shield against microwaves and electrosmog. The effectivity of shielding is increasing with pigment concentration in the coating and the coating thickness [3]. The textile application is possible and for example shown on protective devices for credit cards [4].

2.2 Light management

The term light management is a summary of treatment of three different types of light – IR-light, visible light and UV-light. Of course for UV-light mainly the protection aspect is important. However, for IR-light and visible light beside the protection in some applications also to collection of radiation is of interest. IR-light is also named as heat radiation and the protection against IR-light could be also understood as heat protection. However, in some situations it is also more useful to collect heat instead of be protected against it. An example could be the so-called "winter situation", where remaining sun-light should be caught and collected into the buildings to keep them at convenient temperature. For this, it is more suitable to talk about "light management" instead of "light shielding".
The simplest case is the UV-protection reached by use of organic and inorganic UV-absorbers, for example both type of absorbers can be applied together on textiles by using a sol-gel coating system [5]. An as well effective tool for radiation protection is the use of coatings containing effect pigments. These anisotropic plain pigments have excellent reflection and absorption properties for UV- and IR-radiation. An overview on some metal effect pigments is shown in figure 2. These pigments can exhibit a size of up to 20 micrometers while their thickness is in the range of several nanometers. They can be also understood as microscaled mirrors with can be used for the effective reflection of light. In figure 2, two different kinds of metal effect pigments are presented – aluminium pigments and gold bronze pigments. The aluminium pigments are uncoloured and contain high reflection properties against UV- and visible light. They are used mainly to manipulate the infrared reflectivity of a material. The gold bronze pigments are coloured and originally used for production of coating for design and colour effects. They are made from different copper alloys and depending on the alloy composition the colour shade of the gold bronze pigment can differ in a broad range. Possible colour examples are copper red or golden yellow [4,6].

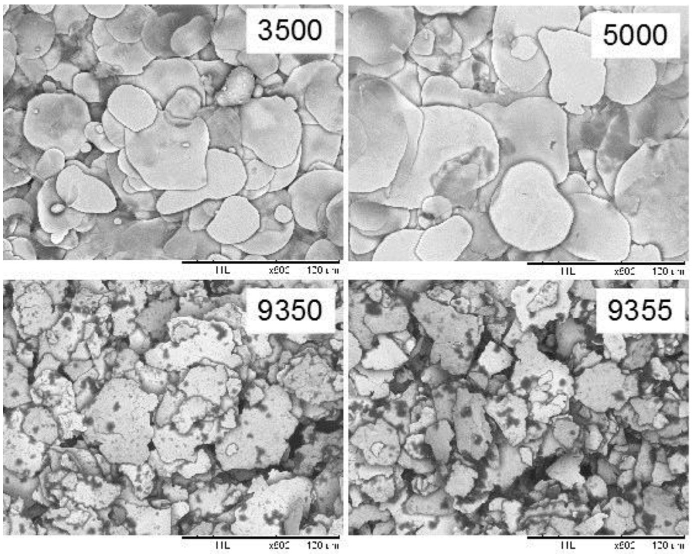

Figure 2: Size and shape of some metal effect pigments (Shinedecor product type from company Eckart/Germany). Types 3500 and 5000 are aluminum flakes; types 9350 and 9355 are gold bronze flakes. Images taken by SEM on the dried pigment pastes.

In current investigations metal effect pigments and interference pigments are used in acrylate and polyurethane binder systems as coating onto textile. The interference pigments are Iriotec pigments supplied by Merck and are consisting of different metal oxide combinations. The radiation protection of metal pigment coatings can be improved by combination in a double layer system including titanium dioxide white pigments [4,6].

The figure 3 shows a concept for a multilayer coating for textile for light management purposes. The aim is to develop a textile material with three different functions – UV absorption, visible light transparent and IR reflection. The application is clearly a window coverage as home textile, which gives the costumer a certain protection against UV- and IR-light and immediately the visible light can transfer inside the room, so an additional lightening is not required. The concept presented in figure 3 contains three coatings applied step by step. The first applied base coating contains small titanium dioxide pigments as UV-absorber and has also the function to even the textile structure for the next applied effect coating. The second effect coating contains anisotropic effect pigments with strong IR-reflective properties but low UV-absorption. To gain an optimal reflection property, the horizontal arrangement of the effect pigments onto the textile substrate is necessary. This horizontal arrangement will be supported by the previous base coating. The third coating is a thin protective top-coating without any optical active component. The aim of the top-coat is the protection of the effect coating, to reach improved abrasion and washing stability.

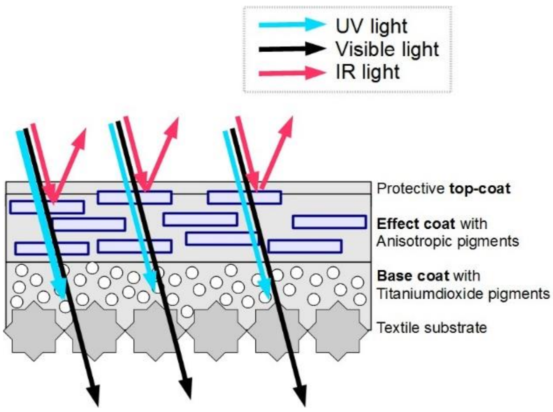

Figure 3: Schematic drawing of a multilayer concept for an UV/IR-protective textile with transparent properties for visible light.

2.3 X-ray protection

In comparison to the shielding of other types of radiation, the shielding against X-rays is especially demanding, because X-rays exhibit high photon energy. For this, thicker layers of absorbing material are necessary to reach a significant reduction in X-ray intensity. A simple coating or finishing application including X-ray absorbing compounds are not effective enough. Suitable X-ray protective textile materials were realized by combining inorganic X-ray absorbers (e.g. barium sulphate, barium titanate, barium zirconate or bismuth oxide) into fibres of regenerated cellulose. By use of the lyocell process, cellulose fibres with contents of 20% to 30% X-ray absorbers were developed [7,8]. An example of such a cellulosic fiber containing barium zirconate particles as X-ray absorbers is shown in figure 4. In this electron microscopic image the areas containing heavy chemical elements as barium are depicted brighter. By this, it can be seen that the embedded $BaZrO_3$ particles are equally distributed in the cellulosic fiber. The prepared organic/inorganic composite fibers can be used for yarn and fabric production. Yarn production from staple fibers by ring spinning is possible. Fabrics can be produced by weaving or knitting [7; 8]. The effectiveness of those materials are determined by transmission measurements and X-ray tomography. An example for such a measurement is given in figure 5.

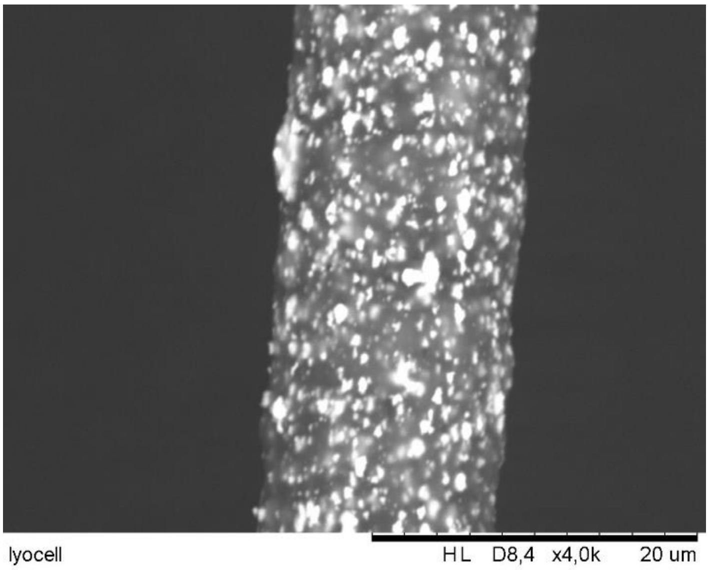

Figure 4: Cellulosic composite fiber with barium zirconate as X-ray absorbing component. Picture recorded by scanning electron microscopy SEM with a magnification of X4000.

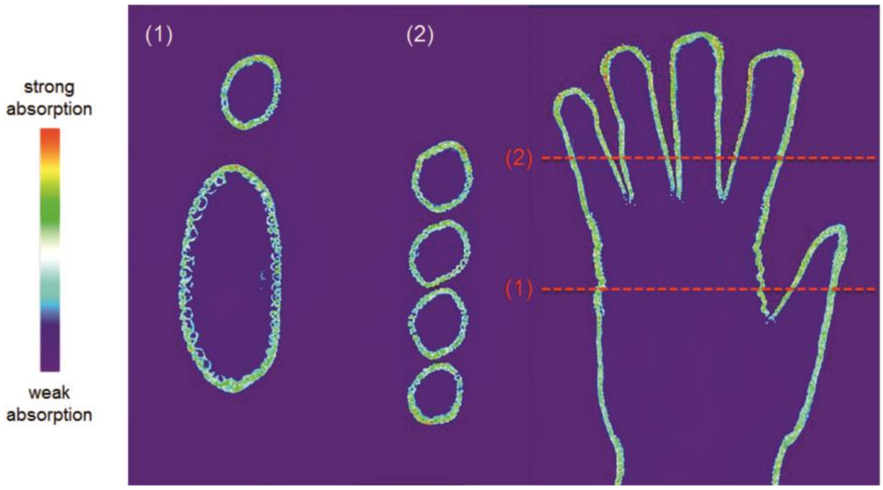

Figure 5: X-ray tomography investigation on a glove prepared with organic/inorganic composite fibers. The inorganic component is $BaSO_4$ and Bi_2O_3 as X-ray absorbers.

SUMMARY AND CONCLUSIONS

The realization of radiation protective textiles is possible with manifold methods using functional components with absorptive properties and/or reflective properties. For each type of radiation a certain functional component has to be used. The combination of different suitable component in one application can lead to an enhanced protection.

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FUNCTIONAL KNITTED FABRICS FOR UV PROTECTION CLOTHING

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Abstract: *Thanks to continued concern over global warming and people’s propensity to be outside when the weather is nice, there is great potential for UV protective fabrics and so there is growing demand for casual and active apparel which can block the sun’s rays without hindering the wearer’s enjoyment of outdoor pursuits. Fabrics with higher levels of sun protection should therefore have a competitive edge in an increasingly health-conscious age. Clothing, as an ideal means of protecting the skin from UV rays, are often realized by knitted fabrics, generally preferred for summer and outdoor because of their exceptional comfort owing to fabric openness, air permeability and elasticity. The paper deals with some general elements concerning UV protection factor, a general view on factors affecting the UV protection of knitted fabrics and on some solutions to added performance for UV protect, to apparel products.*

Keywords: *ultraviolet protection factor, knitted fabrics, stitch types, knitted structure.*

INTRODUCTION

With increase in depletion of ozone layer, due to emissions from the earth’s surface, there is steady increase in the amount of UV rays reaching the earth, and, because an excessive exposure to these radiations leads to detrimental effect, it is highly significant to protect the skin. Clothing is the most basic and generally the best solution to protect the body from the sun’s harmful ultraviolet rays (UVR), given that people need to work, travel and sometimes play outside. For people who spend a long time outdoors, because of their work, such as builders, gardeners, farmers, low enforcement officers, industrial cleaners or waiters, to use special UV protection clothing are very necessary For these people, that work eight hours or more in the sun, doctors warn that their risk of developing skin chance is twice as high that of those employees who do not work outdoors. The sun damage done to every exposed part of the body is cumulative over the lifetime, continually adding risks of premature skin aging and skin cancer. So, UV protective fabrics are generating more and more interest, and in the clothing sector, UV protection clothing is particularly in demand.

GENERAL ELEMENTS CONCERNING UV PROTECTION FACTOR

UV Protection is one of the newer innovations just beginning to gain momentum in performance apparel for the outdoor and fitness market. The UV spectrum present in the sunlight has shorter wavelength ranging from (280÷400) nm. Based on the range of wavelength, the UV radiations are categorized into three areas [1]:

- the UVA radiations (320÷400 nm) – have longer wavelength, which penetrate the skin more deeply, degrading the skin’s elasticity and causing premature ageing;
- the UVB radiations (290´÷20 nm) - have shorter wavelength, which penetrate the top layers of the skin, causing sunburn. On excessive exposure, UVB also accelerates skin aging and can cause damage to eyes, and are the main cause of skin carcinomas. UVB are about 1,000 times more effective at causing sunburn than UVA.
- the UVC radiations - have shortest wavelength and are the most injurious to the skin, but they hardly reach the earth’s surface.

In nature, the UV levels are different [2]:

- in the shade, the UV level is reduced by more than 50%, but near to a reflective surface (e.g. snow, water, white surface, sand, etc.), the UV level increase considerable;
- in the water, reflection and scattering of UV rays can increase UV exposure by 25%, and, even at half a meter under the water, the body is exposed to about 40% of surface radiation. The amount of radiation that penetrates the water depends on a combination of factors such as: UV levels at the time, water clarity (the clearer is the water, the more radiation will pass through), angle of the sun (more directly overhead the sun is, more UV rays will get through the water), etc.

- at higher altitudes UV is stronger as there is less atmosphere to filter it. For every 300 meters in altitude, UV increases by 4%.
- snow acts like a mirror to UV, increasing overall exposure by up to 80%.

Ultraviolet Protection Factor (UPF) refers to the degree of protection of the clothing covering the human skin, from ultraviolet radiations. With other words, it indicates how much longer the wearer of the UV protection clothing can stay in the sun without damaging their skin. UPF is calculated as the ratio between the time duration to cause skin redness with the textile material, and without the textile material, under constant exposure of solar radiations. The basis for the calculation is what is called "the natural protection time of the skin", that varies greatly depending on the individual skin type. As example, a skin type 1 (a person with red or blond hair, blue eyes and a very pale complexion) has a natural protection time of about 5 to 10 minutes, and, any exposed to strong sunlight longer time, without protection, result in dangerous sunburn. If such a person is protect by a textile material with UPF 60, the exposed time in the sunlight is by sixty times longer, without causing any skin damage (60 X 5 min = 300 min to 60 X 10 min = 600 min).[3]

The UPF scale range is from 0 to 50+, the minimum protection established by the American Dermatology Association being UPF15. From this minimum value, for each individual, to determine the proper amount of protection it must be take into consideration: the skin sensitivity, family history of cancer, current medications being used, etc. In high-UVR regions, clothing worn outdoors should have, in general, a UPF of 50+. This would include, for example, workshirts, high-visibility shirts and vests, swimwear and rash vests (which usually should exceed UPF 50+ by a considerable margin because their UPF decreases when wet), fishing clothes and police uniforms. The current Australian/New Zealand Standard has three major protection categories, shown in the Table 1 [4].

Table 1: UPF ratings and protection categories

UPF Rating	Protection	% UVR Blocked
15, 20	Good	93.3 - 95.9
25, 30, 35	Very Good	96.0 - 97.4
40, 45, 50, 50+	Excellent	more than 97.5

FACTORS AFFECTING THE UV PROTECTION OF KNITTED FABRIC

Clothing, as an ideal means of protecting the skin from UV rays, are often realized by knitted fabrics, generally preferred for summer and outdoor because of their exceptional comfort owing to fabric openness, air permeability and elasticity. The UV rays incident on the fabric is absorbed, reflected or transmitted, and the higher is the transmission of UV rays through the fabric the lower is the protection offered by the fabric. In this idea, the degree of protection of skin from UV rays, by a knitted fabric, largely depends on a number of factors.

- *Cover factor* or *weave density* – i.e., how much of the fabric is actually fiber and how much is open space, through which UVR can pass. This is the most important protective factor of fabrics because the tighter is the knit the smaller are the holes and the less UVR can get through.
- *Fibers.* Fabrics can be made from many types of fibers, including cotton, wool, and nylon, most of fibers naturally absorbing some UV radiation. Natural fibers have lower UV absorption than synthetic fibers; grey cotton offer greater UV protection than bleached cotton, because of the presence of natural absorbers pectin, wax etc., and wool has the greater UPF among natural fibers. Synthetic fibers such as polyester, lycra, nylon, and acrylic are more protective than bleached cottons (because their chemical structure boost their sun protection), and shiny or lustrous semi-synthetic fabrics like rayon reflect more UV than do matte ones, such as linen, which tend to absorb rather than reflect UV. In studies done in Australia, lycra/elastane fabrics were the most likely to have UPF of 50 or higher, followed by nylon and polyester [5]
- *Yarn structure*: Twist of the yarn relates to the packing density of the fiber in the yarn structure. This corresponds to the air space within the fabric structure hence contribute to the transmittance of the UV rays through the fabric. The yarn twist becomes one of the major determinants of UPF especially of knitted fabrics as it affects the porosity of the fabric.
- *Construction of the fabric*. The construction of the knitted fabric determines whether the amount of open area in a fabric changes when tension is applied. Generally: knitted fabrics with elastomeric fiber Lycra offer better protection owing to decrease in fabric porosity; warp knitted fabrics, because them stable structure that do not stretch like weft knitted fabrics, shield about 80 per cent of incident

solar radiation. Concerning the correlation between construction of the knitted fabric and UPF, studies reveal that [1], [6]:

- stitch type and its influence on UPF: tuck stitches increase the space between wales and increase the fabric pores so contribute to decrease in fabric UPF; miss stitch tightens the fabric and reduces the fabric openness so increase the fabric UPF. Increase in the ratio of tuck with respect to knit, decreases the UPF, and increase in ratio of miss with respect to knit, increases the UPF.
- knitted fabric structures and UPF: single knit fabrics made of knit and tuck stitches are open hence offering lower protection. Single knit structures with knit and miss stitches offer maximum protection than other structures. Double knit structures like Rib, Interlock, Milano and Cardigan show that all the double knit structures offer higher ultraviolet protection than single knitted fabrics owing to their heaviness and thickness. Off them, Interlock fabric has maximum UV protection owing to its compact, stable structure with less elasticity.

- *Fabric thickness*. As fabric thickness increases, the measured protection increases because thicker fabric absorb more UV rays.
- *Tension* or *stretch***.** More stretch lowers UPF rating. Stretching a knitted fabric will normally cause a decrease in UPF rating as the space in the fabric open up. Loose fit garments offer increased air space between the skin and fabric, which reduces the transmission of UV rays to the skin.
- *Color*. Un-dyed fabric provide a very low sun protection, Most of the clothing is dyed in attractive or functional colors. Many dyes absorb UV, which helps reduce exposure. Darker colors, because they use more dye, absorb more UV radiation and provide better protection than lighter colors, including whites and pastels, that reflect visible light, but let the UV radiations to passes through the fabric to the skin. Bright, vivid colors, such as red can also substantially absorb UV rays, the more vivid is the color, the greater is the protection.
- *Moisture* Content Wet fabrics have lower UPF because of scattering of UV rays by water molecules. For example, the UPF of a thin white cotton T-shirt may decrease from 5 to only about 3 when wet.

KNITTED PRODUCTS FOR UV PROTECTION

Referring to protection against UV radiations, because most people forget to put on sunscreen and much less to re-apply it when needed, sun protection apparel is very necessary. Because sun protective clothing is meant to be worn in the hot summer sun, while working out, running, biking, playing golf or just “sitting” on the beach, the style of these products must ensure:

- a loose-fitting design that tends to give better protection against UV;
- a greater cover of the skin:
  - a long sleeved shirt, instead a T-shirt, with a high neckline or collar to shield the back of the neck
  - shorts or skirts that come to the knee
  - long pants instead shorts
- the used of a double layer of fabric, at the shoulders or other areas with a high UV exposure, constructed with a lightweight material that gives the wearer superior comfort and coolness as well as added sun safety;
- the insertion of mesh areas in side or beck vents, as well as under arms to increase air circulation.

Referring specially to working clothing that provides UV protection, it has to be able to be washed lots of times, why until now it was always made of thick fabrics that make it physiologically uncomfortable. In odder to determine more people to include this type of clothing in their working wardrobe, and so to protect themselves from the negative effects of UV radiations, it must be taken into account wearer's comfort. So, it is currently trying to develop work clothes with an adequate UV protection for a full day, and at the same time they should be, visually, functionally and comfortable to wear like light normal working or leisure clothes. In these idea, to improve the level of UV protection factor, the wearing comfort and durability of protective clothing, in recent years have been developed special fibers with built-in UV protection, that contain titanium dioxide which reflects and/or absorbs harmful UV radiation that does not reach the skin, being at the same time lightweight and comfortable to wear.

Based on the functionality offered in performance knitted fabrics that has fulfill the increasing demands of consumers, at the Hohenstein Institute [7] has been developed a textile product (a shirt), with a special cut, including different knitted structures with different characteristics, placed in specific areas of the body (Figure 1):

- A dense knitted fabric, on exposed areas - like the shoulders, that offer an especially high UV protection (UPF 80) and with a very hard mechanical wearing;

- A stretch knitted fabric, on the back and sleeves, that by its increased density provides protection from the sun, but in the same time make the shirt comfortable to wear and easy to take on and off;
- Light and open knitted structure, in special zones, like – under the armpits and around the stomach, that deals with sweat production, the garment becoming breathable and pleasant to wear.

Figure 1: UV protective knitted clothing

Another used sun protective product is the arm sun protector sleeves. very useful for cyclists, fishermen, golfers, gardeners, or those long summer drives in the Sun, that like having one arm resting on the window ledge. These products must fit snuggly around the arm from the hand up to the bicep area to stop UV damage.

Figure 2: Knitted arm UV protector sleeves

To added performance, for UV protect, to apparel products for children, outdoor apparel, activewear (i.e. tennis, golf, and running apparel), and swimwear, appears to be an increasing interest, so;

- have been developed specialized fibers, like Sun Modal fabrics, with UV absorbent properties;
- during the manufacturing process can be added chemical additives such as UV absorbers and UV blockers. These advances in technology have created a new wave of sun protection fabrics that are sophisticated, lightweight, cool and easy to wear. In addition, most UV blocking performance fabrics provide consistent UV, wet or dry, while the standard t-shirt loses about 50% of its sun blocking ability

when wet. Finally, unlike lotions or creams, the sun block in fabrics doesn't need to be reapplied every two hours.

- Chemical treatments: Dyed fabrics offer more protection than un-dyed fabrics and it is also found that as the depth of shade of fabric increases, UPF also increases. Studies also show that the structure of the dye molecules plays a major role in UPF of fabrics. Bleaching process lowers the UPF of cotton fabrics as it removes natural absorbers. Optical brighteners reflect UV rays hence cater to better protection. Cellulose, widely used in bio-polishing of knitted fabrics removes protruding fibers from the fabric surface. It is found that the enzymatic treatment increased the UPF of the knitted fabrics.

UV protection in fabrics can be incorporated into the yarn, or it can be applied to the surface of the fabric as a finish. It is known that light colored textiles reflect both visible and invisible rays of sunlight, meaning both heat and light, but dark colored textiles absorb both types of rays and therefore absorb heat. Coldblack® [8] is a finishing technology designed particularly in the case of darker colors in all types of textiles, clothing and products that are exposed to sunlight over extended periods, preventing the textile from heating up and ensuring protection from UV rays, (it can make the blacks reflect 80% sun lights - including UVA and UVB), based on an unusual features: absorption and reflection (Figure 3). This technology guarantees a minimum UPF 30 protection when applied to any textile in any color without affecting the look or feel of the product, and is applied very successfully in the sports and outdoor areas, as well as in workwear for wearers who are severely exposed to the sun and engaged in hard physical work.

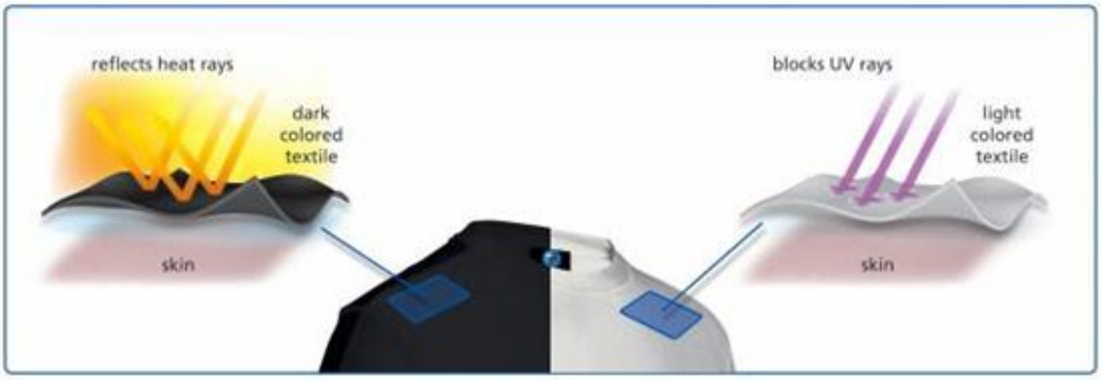

Figure 3: Effects of applying Coldblack technology

CONCLUSIONS

In the clothing sector, sun protection clothing and UV protection clothing are particularly in demand, they acting as a 'second skin' for human, and providing a durable protection against harmful UV radiation. Knitwear in the form of daily wear is an indispensable form of clothing in summer because of their exceptional comfort owing to fabric openness, air permeability and elasticity. The UV rays incident on the fabric is absorbed, reflected or transmitted, and the degree of protection of skin from UV rays, by a knitted fabric, largely depends on a number of factors including: fiber types, yarn characteristics, fabric construction, coloration, wetness (rather than just the moisture absorbed into the fibers), the stretching that may occur in clothing. Regarding weft-knitted fabrics, many researches were focused on them knitting construction, (the stitch types - knit, tuck, and miss, and the knitting structure - single knitted fabrics and double knitted fabrics) as a major factor that influence the UV protection.

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INOVATIVE TEXTILE PRODUCTS WITH ELECTRICALLY CONDUCTIVE YARNS

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Abstract: *Nowadays there are a wide range of electrically conductive yarns (metallic yarns, yarns made of conductive polymers, polymeric yarns with a high level of conductive particles - carbon, silver, etc.) that can be used in functional textile products. In areas of use of electrically conductive yarns are including innovative textile products that concern both comfort and health of ordinary people and those with certain motor disabilities. In this group can fit innovative products for heating and for improving neuromuscular disabilities. The particular structure of electro conductive yarns allows an optimal integration as heating elements or neuron-stimulating electrodes within the textile, because them advantages, in being used in specific textiles technologies (knitting and sewing), as extensibility and flexibility, especially because they are supplied at the same time with a conventional textile yarns. The papers deals with some functional heating products made by electrically conductive yarns, using two textile technologies: knitting and sewing.*

Keywords: *Conductive yarns, heating, disabilities, knitting, sewing.*

INTRODUCTION

The changes that occurred in the textile industry caused by consumer demands for comfort and performance, the advanced technology that influences the innovative production processes, as well as the need to satisfy safety, health, aesthetic and ecological requirements, have determined a constant increase of the textile products offer and implicitly the development of the innovative textile market. One development direction consists in manufacturing a range of products with electro conductive properties based on the use of electro conductive yarns.

FIELDS OF USE FOR INNOVATIVE TEXTILE PRODUCTS THAT CONTAIN ELECTROCONDUCTIVE YARNS

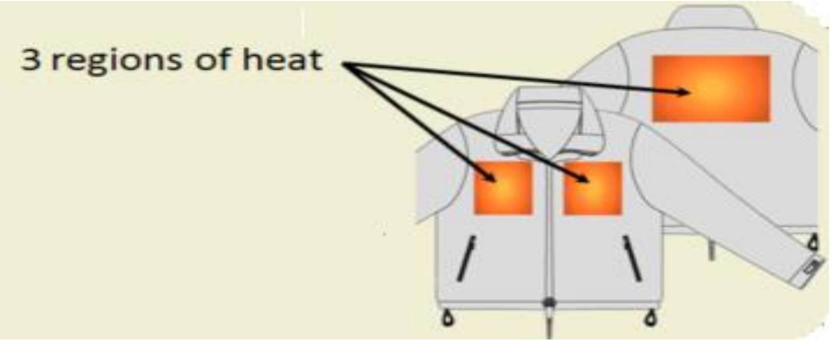
Innovative textile products with guided functionality are based on the use of electricity integrate fibers, yarns or electro conductive materials [1] in their structure, from carbon micro fibers, filamentary metallic yarns, carbon nanotubes, all the way to conductive polymer yarns and polymeric yarns with a high level of conductive particles. In the category of electro conductive yarns there also are the yarns made of synthetic fibers coated with various metals, such as: silver, nickel, copper, gold, or tin. They combine the resistance of the textile thread with metal conductivity, and the resulting yarns can be processed by using various textile technologies, along with classic textile yarns.

Electro conductive yarns can be used in order to manufacture innovative products with various functionalities; two main fields of use are apparels with heating function [2] and the articles that achieve electro stimulation for people with neuromotor deficiencies.

Apparels that embed heating electro conductive yarns have multiple uses:
- For satisfying the requirements imposed in order to ensure thermal comfort during every day, leisure, or sportive activities, which take place at low temperatures;
- For ensuring the necessary thermal conditions so as to carry out various activities and medical interventions;
- In order to raise the quality of life of people suffering from motor/neuromotor disabilities, be they temporary or permanent [3].

Within the category of heating apparels, several types of products (vests, jackets, gloves, sweat suits, gloves, and so on) that ensure heating through electro conductive yarns (that are embedded or not in the textile structure from which the product is made) have been manufactured; these products have a high electrical resistance, powered by a battery. Here are some representative examples of such types of products:

- Heated racket/vest (Figures 1 a) – ActiVHeat [4] that uses a technology based on a multilayered ensemble (Figures 1 b), powered with the help of a battery, which conveys the heat generated by a layer of carbon micro fibers placed in the chest and back areas.



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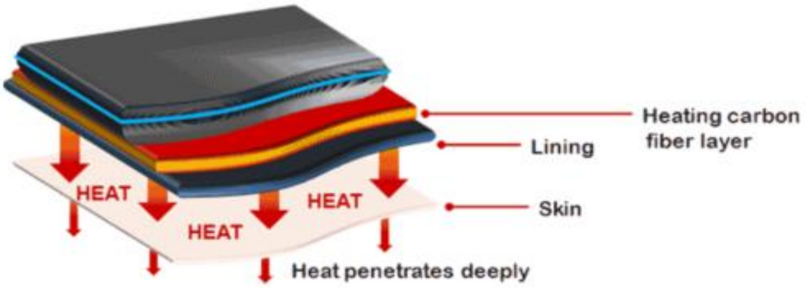

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Figure 1: ActiVHeat heated jacket

- Undershirt-type of undergarments (Figure 2) – The WarmaX Company [5], embedding polyamide electro conductive yarns placed within the product in the lumbar and kidneys areas, powered by a rechargeable battery.

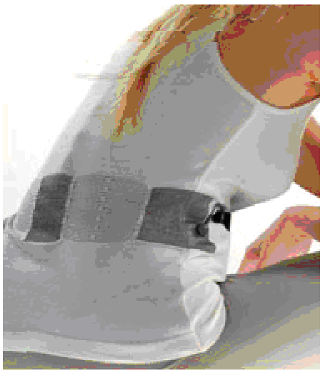


Figure 2: Undershirt containing heating electro conductive yarns

- Heated lining for gloves (Figure 3), made by Warmawear Company [6], designed for various activities (skiing, horse riding, motorcycle racing, cycling, walks, and lucrative activities) but also for people suffering from Reynaud's condition.
- Socks for heating (Figure 4), perfect for outdoor sports during cold weather (skiing, sledging, football).

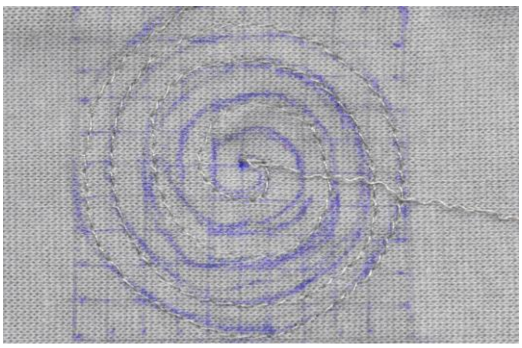
Figure 3: Heated lining for gloves – Warmawear company

Figure 4: Heating system for *Toasty Toes Warmarwear Heated Socks* [6]

The use of electro conductive yarns in order to manufacture some innovative textile materials that improve, from a different perspective, the life quality of people suffering from various neuromotor deficiencies, is based on the functional electro stimulation technique. Electrostimulation represents the excitation of muscle nerves through electric impulses, defined as a complex process that entails physiological effects.

Electric stimulation can be carried out depending on the strategy of electrode placement, meaning that one can use surface or embedded electrodes [7]. Conventional textile electrodes that belong to the category of surface electrodes and which integrate electro conductive yarns were made until recently as independent electrodes that must be placed and fixed on stimulation areas [8].

The current tendency (due to inconveniences and limitations caused by the use of conventional electrodes [9]) is to manufacture some electrodes made of electro conductive yarns and integrated through various textile technologies within electro stimulation apparels [10]. In this category we have textile electrodes (Figure 5) that embed electro conductive yarns made by using sewing (Figure 5a) or knitting (Figure 5b) technology.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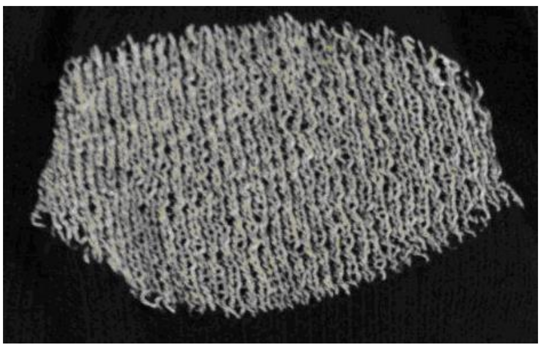
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Figure 5: Types of electrodes made by using sewing and knitting technologies

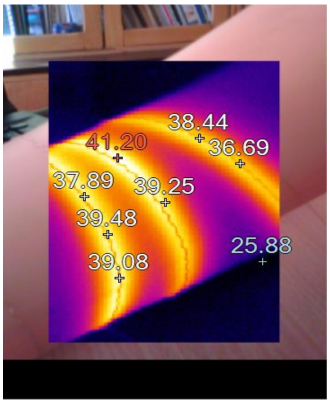
INNOVATIVE TEXTILE PRODUCTS FOR HEATING, MADE OF ELECTROCONDUCTIVE YARNS

Heating apparels have a wide range of use that includes: exterior garments, footwear, undergarments, socks, gloves, articles for protecting the head, bed sheets, covers for automotive or office chairs, medical products (beds, bed sheets, pillows, mattresses), protection clothing, and work equipment.

In the field of clothing articles, the materials made of electro conductive yarns are increasingly used in order to manufacture some heating apparels that must meet a number of specific requirements [11], such as:

- Clothing requirements (the heating system must be easy to embed in the structure of the product, visually undetectable, comfortable upon wearing, and it must also meet the design requirements of the product);
- Safety requirements (it must not cause burns when in contact with the wearer's skin);
- Technical requirements (such products must be functional, offer resistance upon wearing or handling, ensure the wearer's independence, to provide a minimum of retention of smells emanated by the body by using adequate raw materials or due to subsequent treatment) – thus ensuring an increase of the uninterrupted wearing time and decreasing the frequency of product cleaning;
- Thermal requirements (maintaining the expected temperature during a specific period of time and proving good behavior during repeated heating).
- Maintenance requirements (the possibility of being washed manually/in the washing machine without deteriorating the fabric);
- Requirements regarding an adequate positioning within the product of the specific heating area(s).

In order to manufacture some heating textile products, we have first and foremost tested several types of electro conductive yarns, considering their functionality as heating elements as well as their workability when using the knitting and sewing technologies. Thus, after excluding the yarns that did not meet the imposed functionality requirements and which were confronted with frequent tears and damaged parts of the textile processing equipment during the manufacturing process, the selected product was the Shieldex® electro conductive yarn 117/17 dtex 2-ply HC+B plated with silver, with the final fineness of 300 dtex. This yarn proved to be highly recommended from the point of view of its heating properties (Figure 6), and at the same time due to its possibilities of processing by using the knitting and sewing technologies, because of its specific elasticity and workability properties.



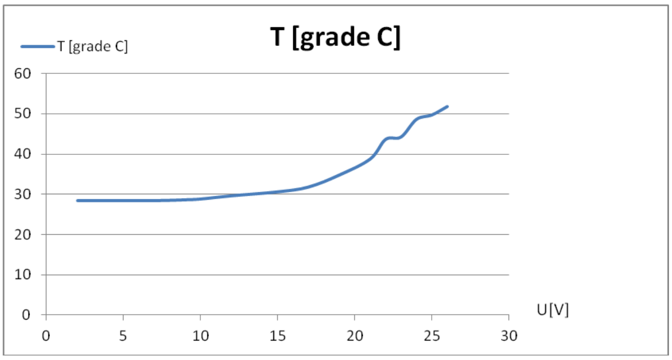


Figure 6: A thermal image of the Shieldex® yarn and the correlation of the tension-temperature parameters

The knitting technology contributes to the achievement of certain textile products where the electro conductive threads are easy to insert.

In order to be able to knit conductive threads, one has to consider aspects such as thread friction, mechanical strength, resilience and flexibility because most of them are more rigid than conventional textile threads. Electro conductive threads that are more rigid than conventional textile threads imply the use of a rougher knitting machine, as well as the adequate adjustment of the knitting parameters.

The knitting insertion technology applied to electro conductive threads has a number of advantages because the final product will be flexible (especially if it is fuelled through a conventional textile thread at the same time), and also extendible. Furthermore, the integration of the conductive threads inside the structure can be carried out at the same time with the knitting process. It also provides the necessary space in order to incorporate more electronic elements that are essential for the constitution of the heating system.

The sewing technology for manufacturing heating apparel, must take into account the following aspects:

- the type of electro conductive yarn used, with adequate sewing properties;

- the width of the stitch;
- the surface covered in stitches;
- the textile support.

During the second stage, we designed and manufactured various heating textile products that were subsequently tested so as to meet the following requirements: to achieve heating at the temperature demanded by its destination; an adequate consumption of electricity provided by portable power sources (batteries/accumulators); an electric tension that is adequate for portable power sources. To this purpose, the testing equipment that was used included: a power source with adjustable parameters (Umax = 40V, Imax = 5A), ampere-meter, oscilloscope, infrared thermal vision camera (Fluke Ti125).

Two products belonging to this group of heating textile articles are presented below:

- ❖ **Product 1** is a shoe (Figure 7) made of single jersey, containing cotton yarns plated with simple elastic yarns, covered in polyamide yarns. The electro conductive yarn is sewed at the surface of the product by using the Uberdeck sewing machine with two needles and three yarns; it is powered from the inferior covering yarn distributor. The electro conductive yarn accomplishes a series electric circuit. The assessment of the functionality of the product is outlined in Figure 8 which illustrates its heating capacity.

Figure 7: Shoe

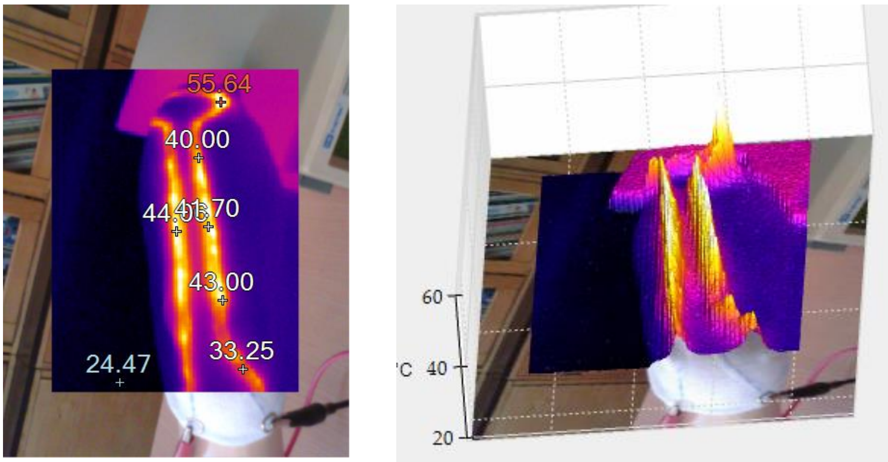


Figure 8: Illustration of the heating process of the shoe

- ❖ **Product 2** is a stocking (Figure 9) manufactured by using the Sangiacomo knitting machine 3"3/4, 160 needles, 14 E, 1 system. The electro conductive yarn is inserted through knitting on half of the stocking circumference, placed in the sole area; the yarn is alternatively knitted every two rows (area A) and as longitudinal stripes on two diametrically opposed directions (area B). The assessment of product functionality is outlined within Figure 10 that demonstrates its heating capacity.

Figure 9: Shoe

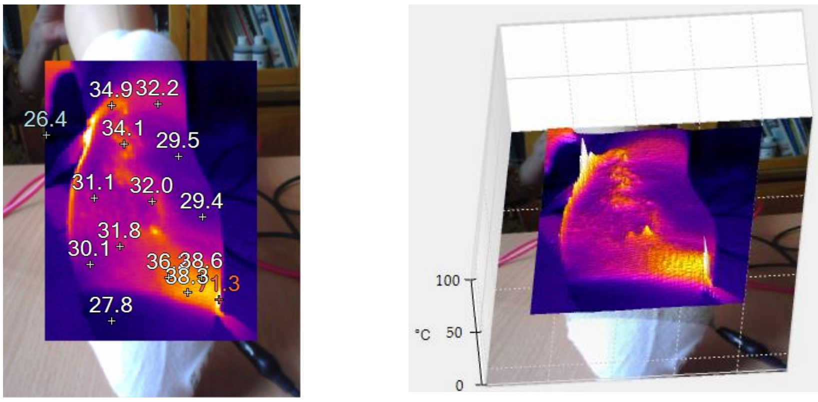


Figure 10: Illustration of the heating process of the sock.

CONCLUSIONS

The use of electro conductive yarns for developing some innovative textile articles was based on the improvement of product functionality (ensuring specific thermal insulation through which one can adjust and maintain comfort when circumstances change), and on the creation of new functionalities (articles designed for electrically stimulating people who suffer from neuromotor deficiencies). The heating textile products that use electro conductive yarns imposed onto such yarns properties that are specific to insertion (knitting) and application (sewing) technologies of attaching/embedding them onto/in textile surfaces, thus allowing the passage from *passive* to *active thermal insulation*. Such type of products must meet a series of requirements, not only clothing requirements, but also specific ones, such as: safety, workability, functionality, reliability, imposed by the embedded electro conductive structures.

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PERSONAL PROTECTIVE EQUIPMENT FOR EMERGENCY RESPONDERS

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Abstract: *Emergency workers are exposed to a combination of many different risks and there may be many possible consequences for their safety and health. The use of specific personal protective equipment (PPE) according to the given risks is of great importance in preventing adverse health effects among emergency workers. The hazards that rescue teams are exposed, particularly in emergency operations, are at the same time multiple and complex. The aim of this research was to develop PPE for emergency operations in extreme weather conditions that ensures: (a) protection against multiple hazards, (b) physiological comfort, ergonomic design and enhanced mechanical parameters, and (c) extended service life. To meet this objective new textile knitted/nonwoven structures have been developed by incorporating high amounts of man-made cellulosic fibers with non-encapsulated PCM content and design and manufacture of PPE prototypes for emergency operations in extreme weather conditions ensuring an adequate level of protection as well as a high comfort.*

Keywords: *emergency responders, personal protective equipment, multiple hazards, comfort.*

1. INTRODUCTION

Emergency workers comprise large professional groups ranging from career and volunteer fire-fighters, police officers, emergency medical staff (paramedics, emergency medical technicians, doctors and nurses) to psychologists. In major disasters, rescue workers, technicians from large relief organisations, additional medical staff, military personnel, antiterrorist forces, body handlers, clean-up workers, construction workers, and numerous volunteers are involved. Depending on the emergency/disaster site, emergency workers need specialisation for instance in water rescue, mountain rescue or rescue from heights. Emergency workers' priorities are to protect human life, property and the environment, and their most common fields of action include: everyday emergencies (road accidents, crime scenes, gas explosions, fires); natural disasters (floods, storms, fires, earthquakes, volcanic eruptions); industrial accidents (involving hazardous materials, such as in the nuclear and mining sectors); transport accidents (major car crashes, plane crashes, rail accidents); terrorist and criminal attacks (bomb attacks, gas attacks, shootings); massive public events (negative events during concerts, sport events, demonstrations). Emergency workers are exposed to a combination of many different risks and there may be many possible consequences for their safety and health. The use of specific personal protective equipment (PPE) according to the given risks is of great importance in preventing adverse health effects among emergency workers [1].
The aim of the project are to develop PPE that ensures: (a) protection against multiple hazards, (b) physiological comfort, ergonomic design and enhanced mechanical parameters, and (c) extended service life. The hazards that rescue teams are exposed, particularly in emergency operations, are at the same time multiple and complex. The main protective properties required and targeted within project are protection against: wetting and water permeation, extreme temperatures, microbial contamination, fire and associated heat, UV radiation, static electricity, etc. Because many different hazards may occur simultaneously in a specific situation, the research is focus on the development of protective textiles, by combining various functionalities in order to obtain multi-protective clothing [2]. In this context, in the structure of the PPE will be integrated innovative high-performance materials, obtained by using fibers and surface treatments for specific functionalities. This paper is focused on PPE for emergency operations under extreme weather conditions.

2. EXPERIMENTAL

From the analysis of the types of aggression for which protection must be ensured there were identified the performance requirements imposed by the specific European standards that were translated into properties required for manufacturing materials and constructive design parameters of PPE: a multilayer structure: inner layer – mainly taking over the sensorial and thermophysiological comfort functions; outer layer – having a barrier function for the risk factors in the work environment (cold, bad weather, mechanical aggressions, etc); intermediate layer encompassing the system of enabling the thermal insulation function.

2.1 Materials

Phase change materials (PCMs) can be used to reduce thermal stress and provide improved thermal comfort for wearers of protective clothing. PCMs are characterized by their ability to absorb energy when they change from a solid to a liquid state and to release heat as they return to the solid phase. PCMs used in clothing go through the phase change at temperatures close to the thermally neutral temperature of the skin, 28–32°C. During the phase change, the temperature does not change, and thus PCMs can stabilize body temperature[3].
As part of the project there were used Cell Solution Clima fibres, a PCM (Phase Change Material) micro composite of the latest fiber manufacturing generation with thermo-regulating features purchased from Larsen Production ApS. Via direct spinning paraffin is embedded in highly crystalline and tear-resistant Cell Solution functional Lyocell fibers during this patented process [4].
For emergency operations under extreme weather conditions the garment structure and materials used for the PPE prototype include:

- a knitted thermoregulating undergarment made of yarns from Tencel regenerated cellulose fibres incorporating PCMs that melt at 28-32°C
- a 2 piece garment jacket/trousers consisting of a 2-layer structure:
  - a needle-punched nonwoven made of cellulosic fibers with non-encapsulated PCM, Cell Solution Clima 6,7 dtex /60mm, 70 J/g, quilted between two layers of knit 62% Coolmax /36% PES Micro/2% Lycra as inner layer for thermal insulation;
  - an outer fabric 100% PES coated with PU film, breathable, with a mass of 192 g/m^2

2.2 Prototype design

For emergency operations under extreme weather conditions a two pieces garment configuration (jacket and trousers) was designed and manufactured (Figure 1).

Figure 1: PPE for emergency operations under extreme weather conditions

To ensure the performance requirements imposed there were considered the following technological design features of the PPE: a) use of technologies with fewer operations due to: fully tailored details (cuffs, collars, pocket bands, details of the trousers slit, etc.); transfer of tucks into the constructive lines, providing also a degree of freedom in specific movements; b) selecting the correct fineness of sewing needles and thread depending on the structural features of the fabric and the type of ensemble; c) appropriate selection of the types of machinery and ensembles that would provide high standards on the stitch resistance.

3. RESULTS

Highlighting the thermoregulation properties of nonwoven made of 100% Cell Solution Clima fiber was performed by OMPG Rudolstadt laboratory by means of Dynamical Differential Calorimetry (DSC) – Analysis according to DIN 51007. The results of measurement are presented in Figure 2

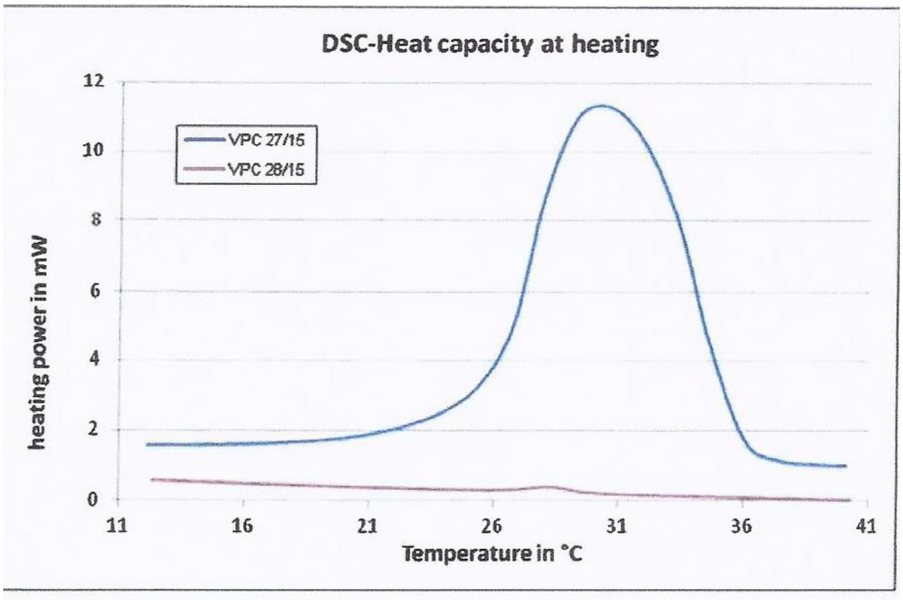

Figure 2: DSC - Heat capacity at heating

The blue curve VPC 27/15 (sample 100% Cell Solution Clima nonwoven 340 g/m^2) is characterized by a distinctive signal in the temperature range from 21 to 36°C. In this temperature range the occurring phase change of the embedded paraffin requires a large amount of additional energy for heating the material. The red curve of VPC 28/15 (sample standard material) shows a small deviation from the linear course at 27°C.

Thus sample VPC 27/15 is found to remain colder for a longer time period as compared to sample VPC 28/15, which is caused by its additional latent heat storage capacity. Additionally absorbed heat is then released on cooling and significantly retards material cooling. With this sample 1 possesses a distinctive thermos-regulating behavior. The latent heat of nonwoven sample detected is 80 J/g.

PPE for emergency operations under extreme weather conditions has been tested in accordance with the SR EN 342:2004 (EN 342:2004) + SR EN 342:2004/AC/2008 (EN 342:2004/AC/2008) „Protective clothing. Ensembles and garments for protection against cold' and SR EN ISO 13688:2013 (EN ISO 13688:2013) "Protective clothing - General requirements". The following European and international standards were also considered: SR EN ISO 9920:2009 (EN ISO 9920:2009) "Ergonomics of the thermal environment. Estimation of thermal insulation and water vapour resistance of a clothing ensemble" and SR EN 14058:2004 (EN 14058:2004) " Protective clothing. Garments for protection against cool environments" – partly for Thermal and Evaporative Resistance.

Performances of the manufactured PPE are in accordance with standard specifications:

- SR EN 342:2004 (EN 342:2004): 4.1 (General, ergonomics), 4.3 (air permeability within the limit of class 3 - below 5 mm/s), 4.6 (tear resistance above the value required of 25 N for the outer material).
  It has the following protection characteristics against cold:
  - The ensemble of materials has a thermal resistance ≥ 0,25 m^2 x° C /W, determined in accordance with the method of EN ISO 31092, in conformity with the recommendations of EN 14058 for clothing against cold;
  - Model provides an intrinsic (basic) thermal insulation calculated according to SR EN ISO 9920:2007 (EN ISO 9927:2007) of minimum 0,5256 m^{2}x°C /W (3,39 clo) per unit of product (without the undergarment).
- The outer fabric has the following characteristics of resistance to surface mechanical actions**:** tensile strength in both directions over of 1,000 N – corresponding to class 6 in accordance with SR EN 14325:2004 (EN 14325:2004) and stitch resistance: over 75 N – corresponding to class 3 in accordance with SR EN 14325:2004 (EN 14325:2004).
- SR EN 13688:2013 (EN ISO 13688:2013) – all requirements (ergonomics, aging, sizes).

4. CONCLUSIONS

The aim of this research was to develop PPE for emergency operations in extreme weather conditions that ensures: (a) protection against multiple hazards, (b) physiological comfort, ergonomic design and enhanced mechanical parameters, and (c) extended service life.
To meet this objective new textile knitted/nonwoven structures have been developed by incorporating high amounts of man-made cellulosic fibers with non-encapsulated PCM content and design and manufacture of PPE prototypes for emergency operations in extreme weather conditions ensuring an adequate level of protection as well as a high comfort.
PPE for emergency operations in extreme weather conditions meets the essential health and safety requirements for use as protective clothing against the cold (at least 8 hours to -7ºC or for an hour up to -20°C, the wind speed is below 0.5 m/s and is worn over undergarment in activities with little effort), protection against superficial mechanical aggressions (abrasion, tear, etc.).

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ANIMATION OF 3D HUMAN SCANNING DATA – EXTRACTING THE SITTING POSTURE FOR A BETTER UNDERSTANDING OF THE GARMENT DEVELOPMENT FOR WHEELCHAIR USERS

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Abstract: *Due to the special particularities of the body, people with disabilities have different needs regarding garments. To better understand the development of the trousers for wheelchair users from the constructive point of view, an animation of the human body in a 3D programme is needed. In this way we can see what kind of modifications the garment has on different poses and sizes.*
For this research we got scanning data of women bodies in different sizes and fit them with a human template in 3DS Max Autodesk programme. After merging the template and the scanning data, we succeeded to save different postures of the lower part of the body. These being obtained, we could export the new data in other 3D programmes for pattern making, in order to create the proposed garment directly on the surface. The 2D patterns were created in an automatic way by a flattening procedure.

Keywords: *wheelchair users, scanning data, pattern design, flattening procedure.*

INTRODUCTION

In the context of health experience, a disability is any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being.
Paraplegia due to a spinal cord injury results in an impairment in motor or sensory function of the lower half of the body. The condition occurs due to damage to the cellular structure of the spinal cord within the spinal canal. The area of the spinal cord which is affected in paraplegia is either the thoracic, lumbar, or sacral regions of the spinal column. [1]
Wheelchair users' motor limitations lead to the dependency on this technical aid. In addition to lower limb, they may affect different body parts (and to different extents) and autonomic physiological functions. Moreover, they are often accompanied by sensory losses in affected body parts and, in some cases, to further skeletal and cognitive disorders.
The use of unsuitable off-the-shelf clothing, footwear and orthotics by these collectives share a number of inter-related comfort, health and safety problems that often lead to social exclusion and dependent living. These problems are mostly resulting from a lack of functional properties (mechanical or physiological) delivered by materials used in its construction, and from a poor adequacy of product patterns to users atypical body shapes, postures or movements. [2]
Garments for a sitting position should meet certain needs for the body dimensions and postures. In this manner, for paraplegic persons there should be some design considerations referring to ergonomic comfort in the sitting position and include functional requirements due to their limitations. Some specific requirements for these special garments should be:
- Fitting : Need of loose fitting in the neck, chest, abdomen, bottom and legs. Need of longer leg lengths and longer back of shirts, sweaters, jackets and coats.
- Usability : Need of specific openings to facilitate the put on / take off process.
- Freedom of movement : Wheelchair users have limitation in their movements: garments must not increase these limitations. The areas where users feel more movement restriction due to garments are the back, shoulders and arms**.** [3]

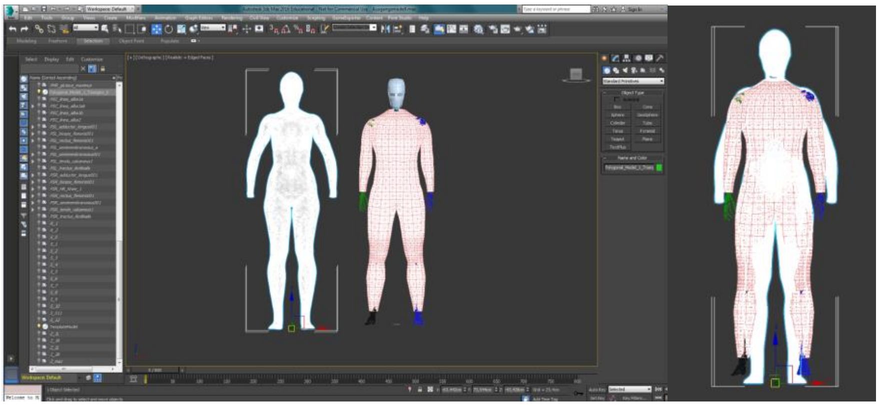
With the development of the technology of virtual reality and the network technology, the research and application of realistic 3D human body model have been more and more important in the virtual reality system. At present, there are mainly two methods to obtain high quality 3D human body models: 1) obtaining

3D human body models by using some 3D modeling software, such as Rhinoceros 3D, Poser, Maya, 3D Max; 2) obtain geometric data from the human body surface by using the 3D scanner. [4]
Our objective is to reconstruct the body shape and fit the animation control structure in order to directly obtain a fully animate body model. The method is based on fitting a human template model to the scanned data that we have. The template we use was developed by Christine Meixner and is described in detail in [5].

EXPERIMENTAL

1.1 Human Body model alignment – fitting the scanning data together with the template model

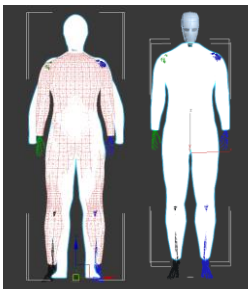
Nowadays many different 3D scanning methods are available for digitizing 3D human body models. This method is characterized basically by the fact that the measuring is made on the image of the subject by scanning and not on the body. These methods have the advantage that they immobilize for a short time the person, they allow taking plan or spatial images from which it can be taken the information about the measures and conformation of the body. The collected data can be integrated into a CAD system and can be improved in designing systems, where it can be mixed the advantages of custom designing with textile industrial fabrication.
In order to better understand the development of the trousers for wheelchair users from the dimensional and constructive point of view, an animation of the human body in a 3D programme is needed. In this way we can see what kind of modifications the garment has on different poses and sizes.
For this research we got scanning data of women bodies in 36, 38, 42 and 44 sizes and fit them with a human template in 3DS Max Autodesk programme. (Figure 1)



a b
Figure 1: a- Import of the scanning data **b-** Template Model fitting

1.2 Model Merging

In order to obtain the right dimensional characteristic of the scanning data, the next step is to merge the template model together with the scanning, by running the scripts specially designed for 3dS Max programme. So, after running the *ScaleMusclesDynamic* and *ScalePelvisWidth* scripts, the alignment in the right position of the template and converting the surface into *Editable Mesh* is possible. (Figure 2).



a b
Figure 2: The human template after running scripts –a , and alignment -b

1.3 Skinning animation

The skinning method is controlling the movement or deformation of the body skin. This section analyzes the skinning animation by controlling deformation of the skin mesh, the muscles and the bones which are generally placed inside the skin mesh. The running of the skin scripts ensures the correct animation of the human body in the end. After running *AdaptTemplateSkin*, it is necessary to improve the surface skin using other scripts (*DivideTemplate, AdaptTemplateSkin, AddSkin, ReadWightData, CalcAndSetDiividedWeights*) in order to have an animation with a better mesh refinement. [5] (Figure3)

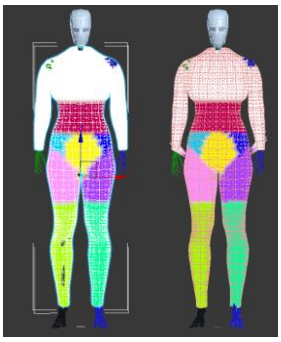


Figure 3: Mesh improvement after skinning animation

The examples of animation of real-time model are shown in Figure 4.

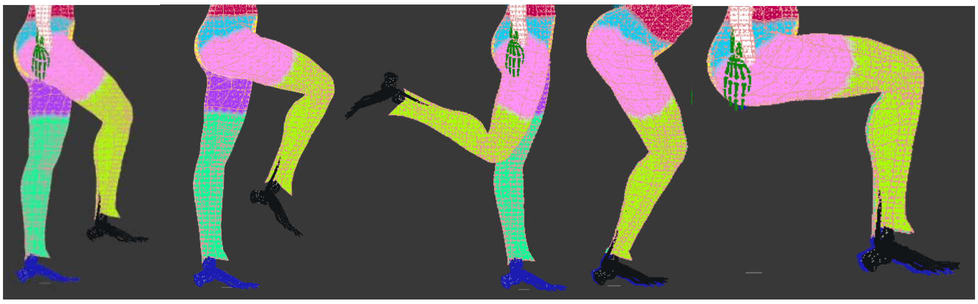


Figure 4: Animation of the human template

After merging the template and the scanning data, we succeeded to save different postures of the lower part of the body (Figure 5). These being obtained, we could export the new data in *Geomagic Studio12* to repair and finish the meshing area. After this we can export the final data in *DesignConceptAuto* from Lectra in order to create the proposed garment directly on the surface (Figure 6). The 2D patterns were created in an automatic way by a flattening procedure (Figure7). By sewing the patterns we can see in the end the necessary modifications for the trousers in different positions.

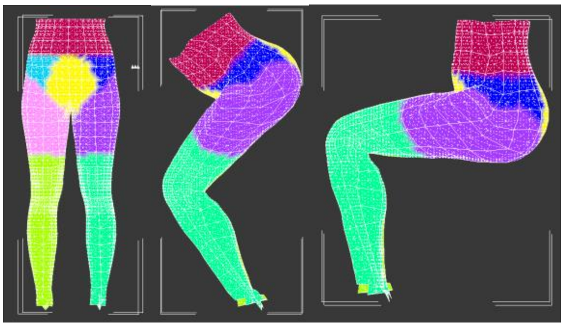
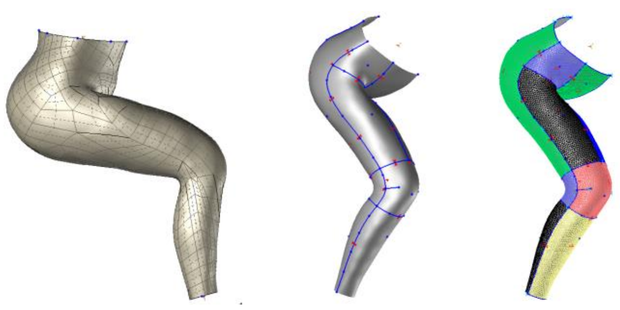


Figure 5: Postures of the lower part of the body



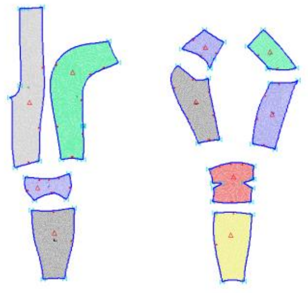


Figure 6: Creating patterns in DesignConceptAuto **Figure 7**: Patterns flattening

DISCUSSION

The ready-to-wear clothing industry has difficulties understanding the basic needs of the population with disabilities due to the uniqueness of almost every type of physical disability and the difficulties in producing clothing to fit body types that vary from industry standards.
It is true that 3D scanning methods used for the virtual prototyping of garments are more familiar these days, but it is a very difficult area when we are talking about paraplegics sitting in a wheelchair. The proposed method of animating the human body in a 3D programme is proved to be efficient in obtaining an adequate body posture of the scanning data. In the end, creating the garment and the 3D-2D flattening procedure gave us a good view upon the modification that has to be done in creating trousers for people sitting in a wheelchair. In order to see that a few trials in sewing different models of the trousers had to be done.

CONCLUSIONS

Through this study we tried to show a new and efficient way in creating garments for people with disabilities, according to their personal needs and dimensions. Although it is still necessary for research in this matter, the animation of the the human body in the 3D programme it is proven to be efficient. The 3D-2D design method is marking out a good view about the dimensional changes the fabric has and it's necessary characteristics in the garment construction.

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ELECTROMAGNETIC PROTECTION FUNCTION OF WOVEN FABRICS WITH METALLIC YARNS

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Abstract: *Since ancient times, clothes occupied an important role for humans, ensuring protection against environmental factors. Nowadays the protection against electromagnetic fields has become a topical problem. Numerous studies conducted in various fields of research try to find solutions to protect the human body against electromagnetic radiation. In this paper, electromagnetic protection function of textile structure is shown through a comparative study of a medieval chain mail shirt and a woven fabric with metallic yarns. Woven fabric with Bekinox yarns were woven on a weaving loom - ARM PATRONIC B60. Electromagnetic shielding effectiveness was analysed in the 8.7GHz frequency domain. According to experimental results excellent electromagnetic shielding properties were shown.*

Keywords: *electromagnetic protection, electromagnetic shielding, shielding effectiveness, woven fabric, Bekinox yarns.*

INTRODUCTION

Since ancient times, clothes occupied an important role for humans, ensuring protection against environmental factors.The way that the clothes has evolved over time is an issue which cannot be ignored in the study of individual evolution, of requirements and also of society.
With the evolution of society many changes regarding functions that clothes have to fulfill occurred (e.g. utility functions, informational aesthetic functions) [1], [2], [3].
The clothes have to fulfill increasingly more complex functions responding to the protection and beauty requirements and also harmonize the body.
Thus, clothing has been and is in constantly evolving, and the design and its design should take into account a number of very important factors.
Nowadays the protection against electromagnetic fields has become a topical problem. Numerous studies conducted in various fields of research try to find solutions to protect the human body against electromagnetic radiation.From electromagnetic fields exposure, some people can feel headaches, fatigue, nausea, dizziness, or some even become physically sick. Without proper electromagnetic shielding protection the people that are sensitive to these waves may never feel better. In recent years there are a lot of studies about effects of electromagnetic fields on cellular level; DNA, RNA molecules, some proteins, and hormones, intracellular free radicals, and ions are shown [4]. It was indicated in epidemiologic evidences elaborated in the past ten years a start of an increased risk, in particular for brain tumor, from mobile phone use [5], [6].
Lately the electromagnetic shielding technology suddenly becomes a necessity.
In recent years a large number of researchers have begun to make studies about fabrics having electromagnetic protection function [7], [8].
In this paper, electromagnetic protection function of textile structure is shown through a comparative study of a medieval chain mail shirt (Figure 1.a,b) and a woven fabric with metallic yarns (Figure 2).


Figure 1.a: Medieval chain mail shirt (front view) **Figure 1.b:** Medieval chain mail shirt (back view)

Figure 2: 12-End Satin with Bekinox yarn in warp

In the entire world engineers and scientists suggest the development of a range of textile materials that incorporate various types of threads, obtained by applying different techniques regarding textile materials for the electromagnetic protection [7], [8], [9].

FUNCTIONAL TEXTILES AND CLOTHING

The destination of clothing products defines the functions of product and they must be satisfied.
Although 2,300 years (fourth century BC) have passed since they were created and the time of war has passed the medieval chain mail shirt is still used nowadays by researchers and divers to offer them protection against shark bites.
The growth oh the number of devices we have to use every day (eg: Cell Phones, Cordless Phones, Laptops, Tablets, Smart TVs, PCs, Microwave Ovens, Routers) puts us in a real danger by exposing us to electromagnetic radiations that can have a serious impact on our health.
Even though we are surrounded by electromagnetic fields the "old" chain mail shirt can still show it's protection functions by electromagnetic shielding properties.
Yet this type of armor has drawbacks such as: the difficulty of manufacture,increased weight, high production costs. And because of that new ways to keep the shielding effectiveness of the medieval chain mail shirt while reducing it's weight in the same time must be found.
In this study the shielding effectiveness of woven fabric with Bekinox yarns is compared with the shielding effectiveness of a medieval chain mail shirt.

MATERIAL DESCRIPTION AND THE CHARACTERIZATION OF THE ELECTROMAGNETIC SHIELDING EFFECTIVENESS OF THE MATERIALS

Electromagnetic protection function of clothes is shown through electromagnetic shielding properties comparative study of a medieval chain mail shirt (Figure 1.a,b) and a woven fabric with metallic yarns (Figure 2).
The medieval chain mail shirt is made of 2mm diameter galvanized wire and consists of over 20 thousand links. It can weigh more than 7-8 kg depending on the body size.
Woven fabric with Bekinox yarns were woven on a weaving loom - ARM PATRONIC B60. The woven fabric used for this study has 180 Bekinox yarns/10 cm and a 12-End Satin weave structure.
Both medieval chain mail shirt and woven fabric have been tested in the 8.7 GHz frequency domain using the "free-space" method [10] to characterize the shielding properties of the electromagnetic field of these.
The medieval chain mail shirt and the woven fabric have been disposed midway between the antennas, with parallel yarns to the direction of polarization of the antennas field (Figure 3.)
.

Figure 3: "Free-space" measurement technique

Measurements were made when the material was placed halfway between antennas. The measurement results show a shielding effectiveness (SE) of around 58 dB for the woven fabric with Bekinox yarns [11], [12] and SE>58 dB for the medieval chain mail shirt.

CONCLUSIONS

The destination in the design process for clothing products indicates the product functions. For the functional textile and clothes they must perform specific functions. Conventional textile materials are not suitable for this purpose, but their modification and transformation in composites or other type of structures can be useful.
The use of metallic yarns in this study indicates complete electromagnetic shielding so in this case a new function is accomplished by woven fabric and also for the medieval chain mail shirt.
Measurement results show that both medieval chain mail shirt and woven fabric have excellent electromagnetic shielding properties.
The medieval chain mail shirt can successfully satisfy the electromagnetic protection function like the woven fabric that has the same properties.

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3D FOLDABLE KNITTED STRUCTURES FOR SOUND ABSORPTION

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Abstract: *Noise or unwanted sounds represent an increasing threat to human health because they have side effects and may cause deterioration or hearing loss, sleep disturbances and harm to mental health. This urgent problem can be solved by the reduction of noise using sound insulating materials. Sound can be isolated in two ways: by absorption or by diffusion. For the absorption, the polyurethane (PU) foams are most commonly used while for the sound diffusion, various panels have been designed. Noise reduction using textiles is becoming increasingly interesting for the market because of its important effect on living comfort. At the same time, in the field of interior design the importance of ecological and sustainable materials increases. Within the presented research, different 3D flat weft knitted fabrics were produced from various materials. After knitting and relaxing, they were treated by various finishing agents for hardening. Their sound-insulating properties were tested and the suitability for new designed interior multi-purpose decorative and functional objects was assessed.*

Keywords: *sound absorption, noise management, knitting, foldable knitted structures, hardening.*

INTRODUCTION

During recent years, the subject of noise has received increasing amount of attention to the scientists, technologists and public as a whole. For a healthy and a pleasant environment, controlling the sound hazards is an important issue. There is a medical evidence, that the human body will take sound as "pollution" if the ambient sound levels exceeds 65dB. This sound pollution leads to significant health problems including hypertension, dizziness, depression, sleep disturbance, hearing loss, decrease in productivity/learning ability/scholastic performance, increase in stress related hormones and most commonly, loss of hearing. Therefore, unwanted and uncontrolled noise should be reduced using noise barriers and noise absorbers. Properly designed textile materials may be considered as noise control elements in a wide range of applications, including wall cladding, acoustic barriers and acoustic ceilings [1, 2, 3].
Noise refers to the irregular and chaotic sound which disturbs people's work and impairs people's health. There are two main methods to control the noise pollution. One is the control of the noise sources, that is, to make the big vocal sound inaudible through a small device or equipment; the other one is to use a variety of noise reduction materials with special structures [4].
Therefore, achieving a pleasing environment can be obtained by using various techniques that employ different materials. Fibrous, porous and other kinds of materials have been widely accepted as sound absorptive materials. Sound absorbing materials are commonly used to soften the acoustic environment of a closed volume by reducing the amplitude of the reflected waves. Absorptive materials are generally resistive in nature, either fibrous, porous or in rather special cases reactive resonators. [5]. The number of products that include a low noise level design increases daily. However, apart from the design itself, it is frequently necessary to use techniques that lower the level of noise in the product or industrial application [6]. Curtains and room dividing panels can also be used as interior textiles with sound absorbing performance. The application of curtains as sound absorbers for room acoustical purposes has several substantial advantages: curtains are relatively cost effective, lightweight, flexible, easy to manage and they enable variable room acoustics [7].

SOUND ABSORBING TEXTILES

Many natural and man-made raw materials have been used as sound absorbers. Wool is a natural fibre from which textiles can be made for acoustical purposes. While wool has historically been used in acoustical applications, there has been little direct study of the fundamental acoustical properties of wool and its optimum uses. Wool is by comparison a much more pleasant material to work with and there are no significant hazards associated with ingesting fibres. Wool is primarily useful as a sound absorber, having broadly similar properties to other fibrous materials such as rock wool or fibreglass. However, wool can also

be used for isolation of vibrations, for instance in isolating linings of timber-framed walls to improve sound insulation. Wool can be used in a wide variety of acoustical applications, though it is more suited to uses whenever lower flow resistivity is either an advantage or is not important. In applications where its vibration-isolating properties can be used in conjunction with its sound-absorbing properties, such as stud walls, wool can offer significant advantages. Wool has good acoustical properties and is well suited to may applications It is a safe and pleasant product to use and can be used as a substitute for other materials where desired [8].
In the last years a greater attention for environment and public health has stimulated the research and development of many new material s for noise control as alternatives to the traditional ones. These materials can be divided into two main categories:

– natural materials: cotton, hemp, sheep wool, flax, clay, etc.
– recycled materials: rubber, plastic, cellulose, carpet, etc.

Sustainable materials are in many cases comparable to traditional ones as far as thermal and acoustic performances. Though for many products physical properties have not been deeply analysed and not yet certified, they have already reached a technical and commercial maturity; in Italy, for example, many sustainable materials are listed in official Prices lists for public tenders [9].
In the research, different three-dimensional flat weft knitted fabrics made of different materials were examined for their sound-insulating properties. The purpose of the work was to select the optimal raw material, the optimal knitted structure with optimal structural parameters and high aesthetic value.
The objectives of the research were:

– to examine the link between the structure, fabric's structural parameters and sound-insulating potential,
– to show examples of finished sound insulation products (i.e. room dividing panels, wall decorative textiles, curtains, etc.).

FOLDABLE KNITTED STRUCTURES

“Collapsible” as a noun was a neologism first used in a book entitled Collapsibles. Collapsibles are objects that, in one way or another, fold out for action and fold up for storage. Collapsibles are ubiquitous. They exhibit two opposite states, one folded and passive and one unfolded and active. They grow and shrink, expand and contract, according to functional need. To qualify as a true collapsible, an object must be repeatedly collapsible and expandable. Collapsibility can be achieved by many ways: by compression, hinging, sliding, etc., and also by folding and creasing. Creasing means folding an object along preset lines instead of wrinkling randomly [10].
One of the most famous ways of creasing and folding is Japanese technique called origami. It has been an inspiration for many industrial and interior designers. Origami-inspired folding is often used in textile design and production as well. It can be performed by various techniques. Woven and nonwoven textiles usually exhibit creased or folded look achieved by sewing or finishing. On the other hand, knitted products can be designed by integrating creases and folds directly into the knitted structure. Creased or folded knits can involve a wide range of structures from simple ribs and pleats to more complex 3D structures. Links-links knitting enables manufacturing of very aesthetically intriguing structures which are flat-knitted but crease and fold after relaxation, forming various textures and spatial patterns. Foldable knitted structures could replace embossed rubber foam which is often used as sound insulating material. They could be available in various colours and textures.

EXPERIMENTAL

Trying to visually mimic morphological structures found in nature on one hand, and inspired by origami technique on the other, foldable links-links structures (Figure 1) were designed for various purposes, sound absorbing materials being one of them. They could be used as flexible sound absorption panels or decorative folding screens.
Most of the research reported in the literature used two methods for measuring acoustical properties of fabric materials: the impedance tube method and acoustic chamber method. The impedance tube method uses rather small test samples, it is faster and generally reproducible, while for the acoustic chamber method large reverberation rooms and large test samples are used.
In the impedance tube method, sound waves are confined within a tube. Thus, the test sample needs only to cover the circular cross-section area of the tube. The sample is fastened to one end of tube, and the loud speaker that can emit sound waves of well-defined frequencies is attached to the other end of the tube. The emitted waves travel through the tube and are reflected back from the sample. The reflected waves are received by the microphone. The received waves by the microphone are pictorially shown on the

oscilloscope screen. The proportion of sound absorbed by test fabric is then calculated using equations 1 and 2.

$$\alpha = \frac{I_i}{I_r} = \frac{|p_i|^2 - |p_r|^2}{|p_i|^2} = 1 - |R|^2 = 1 - \left(\frac{n-1}{n+1}\right)^2 = \frac{4n}{(1+n)^2} \quad (1)$$

$$n = P_{max}/P_{min} \quad (2)$$

Where α = sound absorption coefficient; I_i & I_r = intensities of incident and reflected waves respectively; P_i & P_r = pressure of incident and reflected waves respectively; R = reflectance factor; n = standing wave ration which is the ratio of the maximum to minimum pressure of the sound wave; P_{max} & P_{min} = maximum and minimum values of sound wave pressure respectively as shown on oscilloscope screen [11].

Figure 1. Foldable knitted structures designed for sound absorbing panels

Figure 2. The impendance (Kundt) tube

Knitted samples were produced from various yarns, including 100% wool and 50%wool/50% PAN as basic yarns, and 100% nylon filament which was added to basic yarns as reinforcement thread. 100% wool samples were designated – W, 100% wool samples with added nylon thread – W+N, 50%wool/50% PAN samples – PW and 50%wool/50% PAN samples with added nylon thread PW + N.

For the finishing of knitted fabrics two hardening agents were used: Tubicoat A 41 (CHT, Bezema, Switzerland) and Beaippret liquid (CHT Bezema Switzerland). The samples finished by hardening agent Tubicoar were designated – T while the samples treated with Beaippret were designated – B.
The thickness and the mass/unit area of the knitted samples were also measured.

RESULTS AND CONCLUSIONS

After finishing, the handle and aesthetic look (change of colour, colour uniformity, dimensional stability) of the samples were evaluated by a survey. The results of the survey revealed that the knitted structure 1 and the Tubicoat (concentration: 40%) finishing exhibited the best handle and aesthetic appearance. Therefore, these selected samples were prepared for the sound absorption testing. The sound absorption coefficient was compared to the commercial woolen felt sound insulation performance.

The thickness and the mass/unit area of the knitted samples compared to woolen felt are presented in Table 1. The sound absorption coefficients of the knitted structures 1 made of various yarns and finished by Tubicoat hardening agent are shown in Figure 3. The sound absorption coefficients of the samples W and PW+N compared to woolen felt are shown in Figure 4.

Table 1. Thickness and the mass/unit area of the knitted structures 1 made of various yarns and finished by Tubicoat hardening agent, and woollen felt as a comparative material

	knitted structure 1					woollen felt
	PW	PW+N	PW+T	W	W+N	
thickness (mm)	17,40	17,16	17,14	16,04	15,91	11,60
mass/unit area g/m2	1086	1714	1587	1270	1607	997

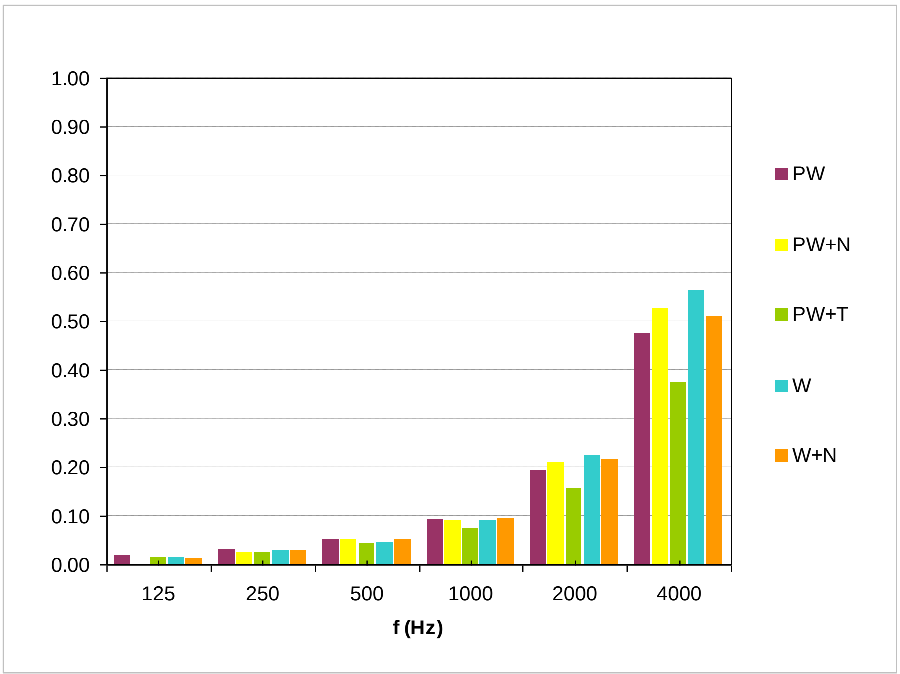

Figure 3. Sound absorption coefficients of the knitted structures 1 made of various yarns and finished by Tubicoat hardening agent

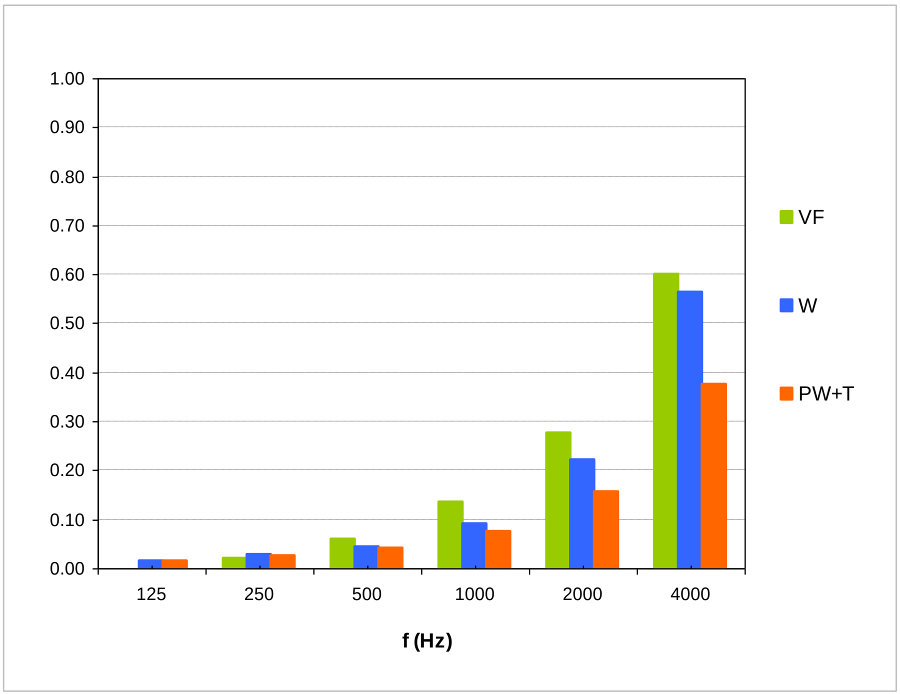

Figure 4. Sound absorption coefficients of the samples W and PW+N compared to woolen felt

The results showed that the 3D knitted foldable structure 1 can be used as sound insulating material as it exhibits good sound absorption properties. Further interesting and attractive foldable structures can be developed for sound insulation with similar thickness, compactness and mass/unit area. Woolen structure showed the best acoustic properties, followed by woll/PAN structure reinforced with nylon filament. 100% wool structure with added nylon thread and 50%wool/50% PAN structures also exhibited good acoustic properties. Hardening agent significantly reduced the sound absorption coefficient. Incorporating nylon into knitted structure improved the stiffness of the structure; it decreased the sound absorption coefficient in the case of woollen structure and increased the sound absorption coefficient in the case of wool/PAN structure.
The simulation of the possible use of the foldable knitted structures, finished by a hardening agent is shown on Figures 5 and 6. The knits can be mounted in an extendable frame, used as curtains or pull-walls. They can also be designed as sound diffusors mounted on walls or ceilings.

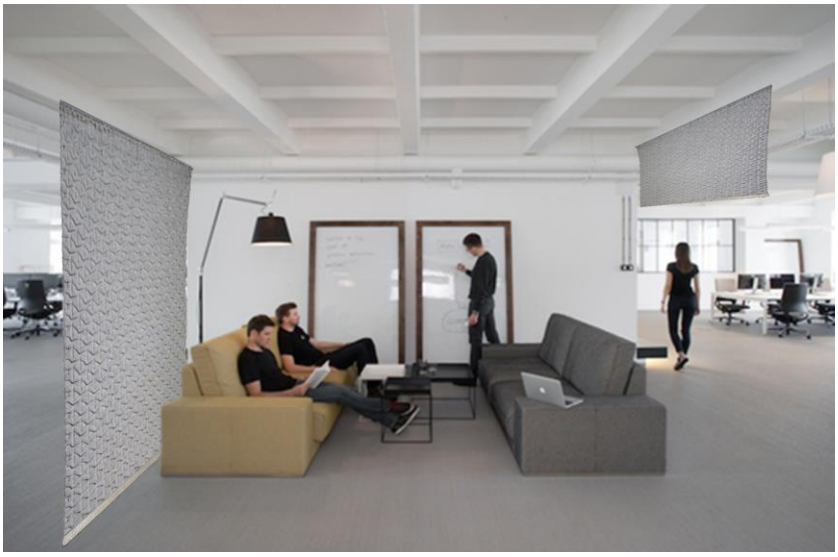

Figure 5. Sound absorbing curtains made of foldable knitted structure

Figure 6. Room dividing panel made of foldable knitted structure

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MICROENCAPSULATED EUCALYPTUS OIL FUNCTIONALIZED

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Abstract: *Plants derived chemicals (Mahesh, 2008) can be highlighted as efficient antimicrobial solutions for functionalization of textile materials, with high efficiency and reduced footprint on environment components (Kalemba, 2003). The aim of the study was the obtaining and characterization of antimicrobial textiles functionalized with encapsulated eucalyptus oil. Two textile materials (white (T1) and camouflage-dyed (T2) 68% cotton-32% polyester, Kivanc Tekstil, Turkey) were treated by dip coating (as chemical finishing) and cyclic capsules spray coating (as sanforization) with eucalyptus oil (Eucalypti Aetheroleum, Hofigal, Romania) filled melamine capsules (Inotex, Czech Republic). Presence of functionalized treatment (eucalyptus oil filled microcapsules) on the surface of the materials was qualitatively assessed by GC-Headspace (DB-35MS, J&W, 35m length, 0.25mm interior diameter capillary column), highlighting presence of eucalyptus oil components on obtained chromatograms, with eucalyptol identified as main component (91.921-95.842%) followed by limonen (2.851-5.622%) and terpinen (1.307-3.087%). Fibers and microcapsules morphology was assessed on a Quanta 200 (FEI) Scanning Electron Microscope, in low vacuum mode, GSED (Gaseous Secondary Electron Detector) detector and 10kV filament voltage, which allowed highlighting of presence of microcapsules on the surface, with very good treatment coverage of the fabric and good dispersion of microcapsules along the fibers, when compared to control. Determination of wetting capability of the obtained materials was quantified by assessment of contact angle by mediation of five measurements on each side of treated materials. Due to hydroxyl groups from the structure of cellulose, the initial material is highly hydrophilic. After the deposition of the functionalized of the materials (eucalyptus oil filled melamine capsules), some of the functional groups are blocked thus leading to slightly hydrophobization of the material, more pronounced for T1 material (undyed material). Physical-chemical analysis revealed good treatment of the selected materials with microencapsulated eucalyptus oil functionalized textiles which can be used as efficient bio-active barriers*.

Keywords: *Plants extracts, antimicrobial textiles, antifungal, bioefficiency.*

INTRODUCTION

Modern improvement in living standards and environmental awareness dictate the rapid development of multifunctional textiles, with antimicrobial properties, that include finishing with synthetic and natural chemical agents. Plants derived chemicals [1] can be highlighted as efficient antimicrobial solutions for functionalization of textile materials, with high efficiency and reduced footprint on environment components [2]. The aim of the study was the obtaining and characterization of antimicrobial textiles functionalized with encapsulated eucalyptus oil.

Materials and methods

Two textile materials (white (T1) and camouflage-dyed (T2) 68% cotton-32% polyester, Kivanc Tekstil, Turkey) were treated by dip coating (as chemical finishing) and cyclic capsules spray coating (as sanforization) with eucalyptus oil (*Eucalypti Aetheroleum*, Hofigal, Romania) filled melamine capsules (Inotex, Czech Republic). Presence of functionalized treatment (eucalyptus oil filled microcapsules) on the surface of the materials was qualitatively assessed by GC-Headspace (DB-35MS, J&W, 35m length, 0.25mm interior diameter capillary column). Fibers and microcapsules morphology was assessed on a Quanta 200 (FEI) Scanning Electron Microscope, in low vacuum mode, GSED (Gaseous Secondary Electron Detector) detector and 10kV filament voltage. Determination of wetting capability of the obtained materials was quantified by assessment of contact angle by mediation of five measurements on each side of treated materials.

Results and discussions

GC-Headspace analysis highlighted presence of eucalyptus oil components on obtained chromatograms, with eucalyptol identified as main component (91.921-95.842%) followed by limonen (2.851-5.622%) and terpinen (1.307-3.087%) (Figure *1-2*).

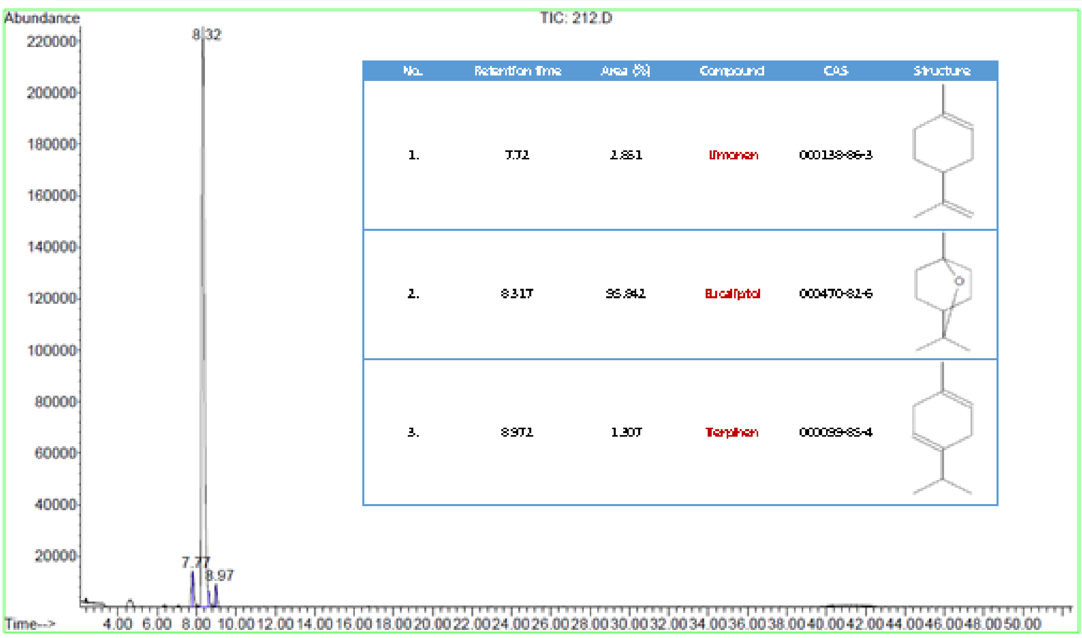

Figure 1. T1 GC-Headspace chromatogram with elemental quantification

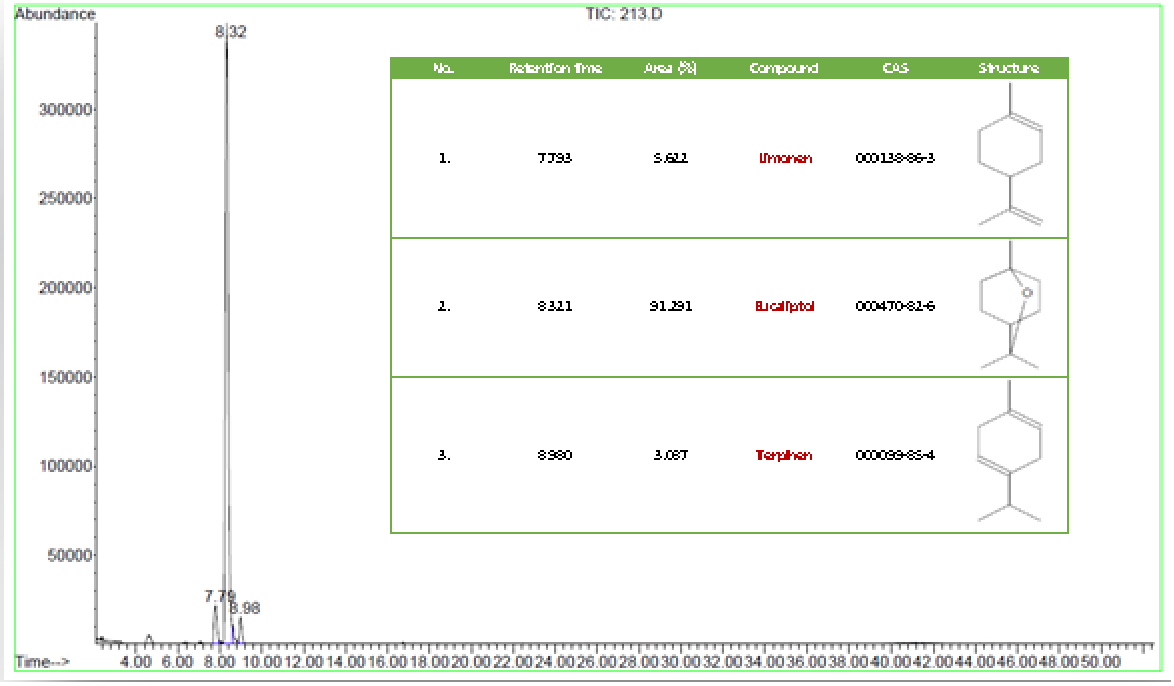

Figure 2. T2 GC-Headspace chromatogram with elemental quantification

Scanning Electron Microscopy analysis allowed highlighting of presence of microcapsules on the surface, with very good treatment coverage of the fabric and good dispersion of microcapsules along the fibers, when compared to control *(*Figure 3-5).

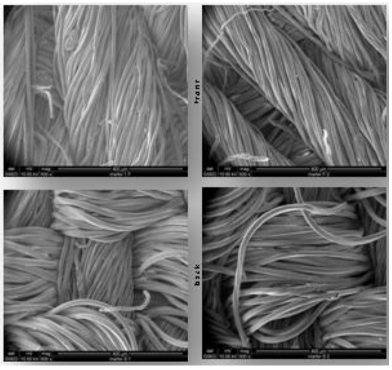

Figure 3. Control SEM analysis (front and back, 500x)

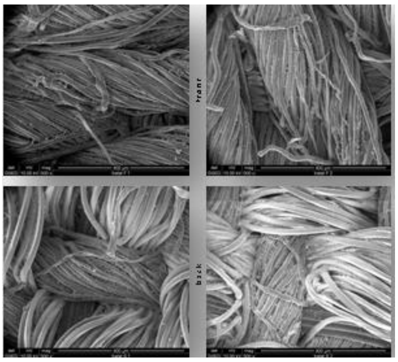

Figure 4. T1 SEM analysis (front and back, 500x)

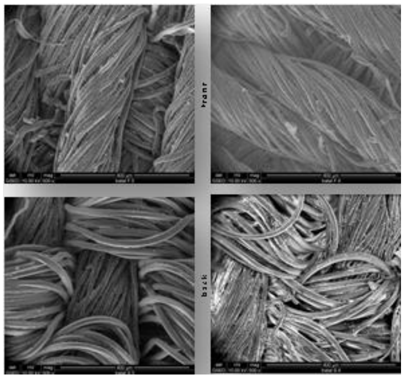

Figure 5. T2 SEM analysis (front and back, 500x)

Control material is highly hydrophilic due to hydroxyl groups from the structure of cellulose. After the deposition of the functionalized of the materials, some of the functional groups are blocked thus leading to slightly hydrophobization of the material, more pronounced for T1 material (undyed material), backed up by contact angle analysis (Figure 6-7*)*(Table*. 1*)*.*

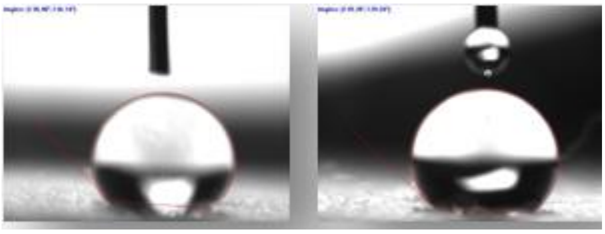

Figure 6. Contact angle for T1 (front and back)

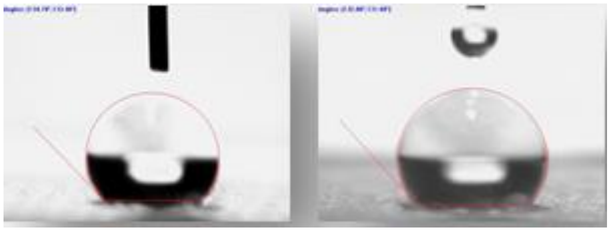

Figure 7. Contact angle for T2 (front and back)

Table 1. Contact angles average values

Sample	Left angle (°)	Right angle (°)
Control (*untreated material*)	0	0
T1 (*undyed material-front*) *under 10 seconds*	134.36	134.50
T1 (*undyed material-back*) *under 12 seconds*	138.94	139.14
T2 (*camouflage-dyed material-front*) *under 6 seconds*	129.68	129.38
T2 (*camouflage-dyed material-back*) *under 6 seconds*	131.02	131.88

CONCLUSIONS

GC-Headspace analysis allowed highlighting of presence of eucalyptus oil treatment on the surface of the textiles, backed up by SEM analysis which showed very good coverage with functionalized melamine microcapsules reported to surface area. The results can promote functionalized textiles with encapsulated plant extracts as efficient solutions regarding textile industry's demand of bio-active barriers as prevention and control methods

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Section 6: IT applications

INTERACTIVE GARMENT BLOCK DESIGN FOR DISABLED PEOPLE OF SCOLIOSIS TYPE USING VIRTUAL SIMULATION

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Abstract: *This paper introduces a co-design based method for garment design for physically disabled people with scoliosis. A parameterization process is first performed on a scanned 3D body for creating a digitalized model of the human body, permitting simulation of the consumer's morphological shape with atypical physical deformations. A basic garment block wire-frame aligned with body features is then established based on the defined feature points of the human body. Based on the deformed wireframe, a 3D expandable garment block is modeled. Customized 2D and 3D virtual garment prototyping tools are applied to create customized garment products based on the general concept of co-design by running the sequence Design–Display–Evaluation–Adjustment using the garment design process and design knowledge, which have already been applied to normal body shapes successfully.*

Keywords: *Disabled people, atypical morphotype, virtual reality, collaborative design process, sensory evaluation, garments block*

INTRODUCTION

Disabled people constitute an important part of the world population. Physically disabled people represent quickly increasing consumer market with special needs in terms of personalized products such as clothes, footwear and furniture. However, although the customization need for disabled people is immense, the related market is still covered by limited producers offering marginally functional and in most of the cases completely dull and unattractive products. In fact, the customized requirements of this target population increase the complexity of product development process thus leading to unaffordable prices. High prices along with reduced quality and limited diversification constitute important barriers for adapted products.
From the view of ergonomics, in the design process for the human oriented garment, human body should be regarded as a core consideration. In this process, a garment is designed to satisfy the wearer's requirements, in terms of physical comfort, psychological comfort and beauty. In spite of both the potential market and technological availability, the needs of disabled consumers are not adequately covered. For these customers, a good garment means that the wearing of the garment is comfortable, pleasant to the eye, and gives the wearer a feel of self-confidence. These needs cover both functional and social aspects. The functional needs deal with comfort, protection, medical care and so on, while the social needs are mainly concerned by fashion trends, personal preference and social dignity requirements. In order to satisfy customers, the most important need to ensure is an appropriate garment fit (Hong et al. 2016).
Scoliosis is a three-dimensional deformation of all or part of the spine (cervical, thoracic or lumbar) causing twisting of one or more vertebras and causing a distortion of the thorax, abdomen and paravertebral areas (close to the vertebrae). The figures of the disabled people don't fit into the standard sizes, used for garment design and production, which are available in the stores. The styles of the current garments are not properly designed to solve the problem caused by deformation, making these disabled people appear different from the others in his/her social group. Adapting ready-to-wear (RTW) garments is always required for the disabled, but the design solution of the adaption not only takes time for production and delivery but also cannot ensure a good comfort and fit. There is a huge gap between the supplied products in the market and the demands from the customers. The traditional 2D garment design process and related design knowledge, developed for the normal body shapes cannot fully meet the requirements for the deformations related to scoliosis. Finding a tailor seems a good solution but it is not available for all the customers.
3D body scanning is an important technology for the apparel industry, because a digitalized human body can be readily obtained, from which the 3D garment can be created to ensure fit. The garment is a 3D shape made from two-dimensional pattern to cover the complex geometry of the human body. In this study, a fit-ensured garment block has been discussed, because of difficulties in obtaining complex styled garment in 3D. 3D block contains all basic and necessary dimensions of a human body, and the flattened 2D pattern

can be regarded as the basic pattern of the customer, with which all kinds of garments can be developed to satisfy the wearer for various styles.

Collaborative design is the process of setting up an organizational structure where designers and customers work together. The design solution and result of this process is acceptable for both designers and customers. The basic element of collaborative design is an Internet-based visual platform showing interactions between the product, the designer and the customer. Collaborative design provides more possibilities for human oriented design, which provides more specific requirements of fit, comfort and aesthetics. Based on the interaction between designer's knowledge and customers' requirements, ideal design solutions of the desired product can be easily obtained within a short time(Lim, Istook and Cassill 2009).

The application of computer aided design technology (CAD) is blooming rapidly in fashion industry. The CAD applications can be roughly divided into two categories: 2D-to-3D and 3D-to-2D approach. 2D-to-3D approach is the conventional application of CAD technology, using the size table of standard body measurements. In the 2D-to-3D approach, 2D patterns are sketched manually, and later assembled through a virtual sewing procedure to produce realistic draping simulation. However, it cannot produce precisely fit garment for individual customers. 3D-to-2D approach is a 3D virtual garment design method, permitting to realize and validate design ideas and principles within a very short time. It speeds up the product development process and shortens the time from design and production to the market of fashion products.

In this context, a new collaborative design based 3D-to-2D CAD method seems to be the unique way for designing customized garments that can be accessible to find technical solution, permitting the industrial production and fitting the deformation of human body. To overcome the technical limitations presented previously, it is proposed in this paper to implementation new virtual reality-based design methods for an adapted 3D garment block and its corresponding 2D block patterns. As the design of a primary garment, a garment block can be further designed and extended to garment products of the same category (T-shirt, vest, jacket) with various styles, which contents different design ideas and allowance values. The proposed method can be applied to create fit-ensured mass-customized apparel products for the disabled people with scoliosis.

The proposed virtual 3D garment block and its corresponding 2D patterns should fulfil the following requirements: (1) the 3D virtual garment is constructed to align with the human body feature lines, so that the wearing ease values can be controlled and distributed for different wearing purposes, (2) the seam and style lines of the 3D virtual garment are constructed to follow the body contour (the spine, front and back center lines etc.) and facilitate the flattening process, (3) the 3D virtual garment can be adjusted to be flattened without distortion of the design information, satisfying textile properties and manufacturing constraints, and (4) the proposed garment block and its corresponding 2D patterns should fully consider the physical disfigurement of the customer as well as the fit problems.

SIMULATION OF THE CUSTOMIZED GARMENT DESIGN

The simulation process and method, following that of traditional garment prototyping and draping in reality, which can effectively ensure the ideal garment shape fit performance of the desired garment, is introduced.

- Simulation of the human body model

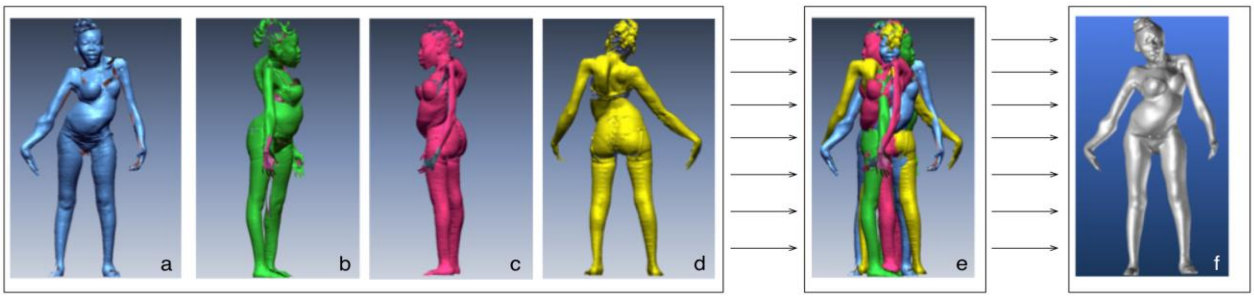

Figure 1: From the scanning results to the digitalized human body model

At this step, data on a body shape are acquired using a 3D scanner and the software ScanWorX of the Human Solutions Company. This method first takes various scanning pictures in different views for the same consumer with the same posture (Figure 1-a, b, c, d) during the 3D scanning procedure. Each of these pictures, taken with the same reference axis of the 3D scanner from different views, can be regarded as 1/4 of the full scan result. Then, the data from the scanned body shape are imported to another software, called RapidForm, permitting to edit and correct the defects of the 3D meshed object. Using the RapidForm

software, these four pictures (Figure 1-e) are combined, rotated and merged in order to generate one complete 3D virtual human body model (Figure 1-f).
By using this reference axis, the corresponding positions of different images or different views in order to generate the unique virtual human body model can be easily found. The proposed method will permit to automatically generate the digitalized 3D human body model. The mesh of the 3D shape is then re-triangulated using RapidForm software.(Wang, Wang and Yuen 2005) The holes that are invariably made as a result of scanning are filled. Irregular forms generated as a result of filling holes, like near the hands and feet, are removed. A plane is used to cut the feet to make it parallel to the X-axis. The body form is smoothened using a smoothening tool. It is ensured that all holes (near hair and armpit area) are filled. Normally the holes will be in the hair and armpit and in small size. Plain planes are created to repair the holes. As the sizes of these holes are small and the wearing allowance will be designed in future operation, plain planes will be created to fill the holes. A special function of RapidForm is applied to mesh the surface of the body model with 600-700 facets. With this procedure, the body made of point clouds will be transferred into small facets. These facets can be regarded as the sub surface of the body, which can be modified. The number of the facets will determine the quality of the virtual body surface. If the precision of the virtual body is not high enough, more facets can be added to meet the desired precision. The 3D body model modified by RapidForm is then imported into Design Concept. The result obtained in DesignConcept is the final digitalized human body model, from which a 3D garment can be created. Using the DesignConcept software, the 3D surface of the body shape can be modelled and simulated.
The operation of 3D scanning permits to directly obtain the 3D body shape, on which 3D draping of a virtual garment can be realized. The detailed body measurements will not be necessary. Different from the traditional pattern making method, which is based on the accurate measurements of body shape, the proposed method using the simulated human body model, serving as the individual mannequin, ensures the 3D customized garment design.

- Establishing reference planes

At this step, following the design process of the traditional garment design method, several reference planes, related to the feature points of the desired garment, will be established. These reference planes will permit to the location of the feature curves and feature points of the human body, in order to simulate the body shape information. But, different from that of normal people, the quantity and orientation of the reference planes are different because of the deformation (Figure 2). In this context, the definition of these reference planes should follow the following principles: (1) following the traditional 3D real draping method, (2) satisfying the requirements of the disability, (3) meeting the requirement of better observing the human body.
Based on these principles, different XY planes are oriented in the 3D space in the design process to help to cut the body and create the morphological curves (the morphological curves are curves in Figure 3-a). By adjusting the inclinations of the XY planes, the morphological curves can then be adjusted visually. The yellow axis between the feet is perpendicular to the ground. The red axis between the feet is parallel to the ground. All the subsequent red axes made on the body are parallel to the ground (Figure 3-b). Since the legs of the woman are more or less similar to those of normal people, all the axes between the legs are parallel to the floor.

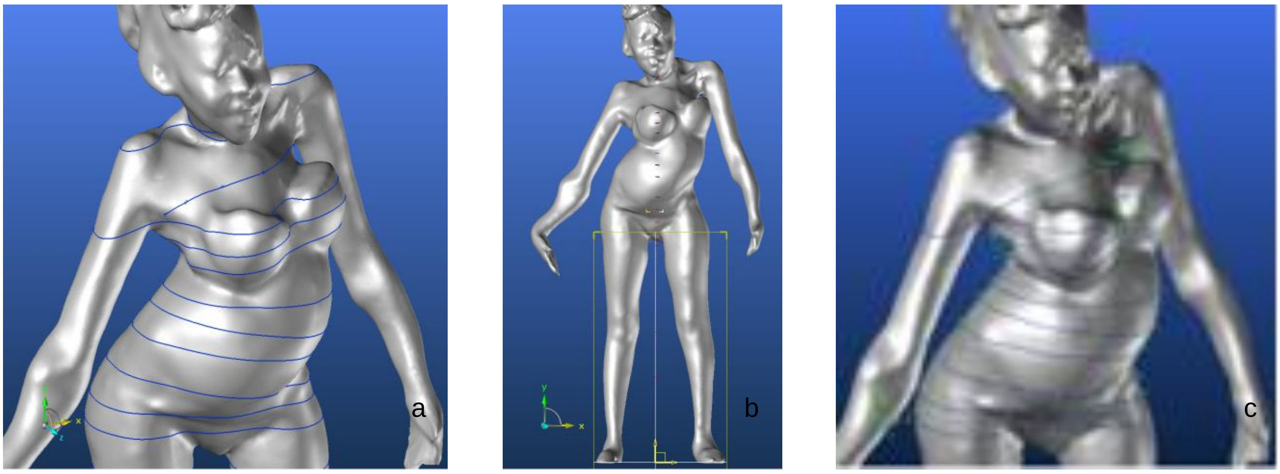

Figure 2: The morphological curves of the customer and the subsequent red axes for establishing the morphological curves

A set of special planes is defined following the shape of spine in the position of waist, hip and breast, which are important positions for garment design. Considering the irregular shape of the body and hyperbolic-curvature of the spine, more planes close to those defined initially are defined in order to ensure the reference planes can fully simulate the shape of the human body. As shown in Figure 6, three such planes are made in the waist region, one being on the waist, one above and another below it; three planes are made in the chest area, one running through the bust points, one below and another above it; other three planes are made on the hip region. These planes are defined in the *DesignConcept* software taking the reference of on the ground floor. The distance between the plane and the ground floor can be adjusted and tested until the numbers of the planes and distances are qualified enough to modeling the shape of the human body.

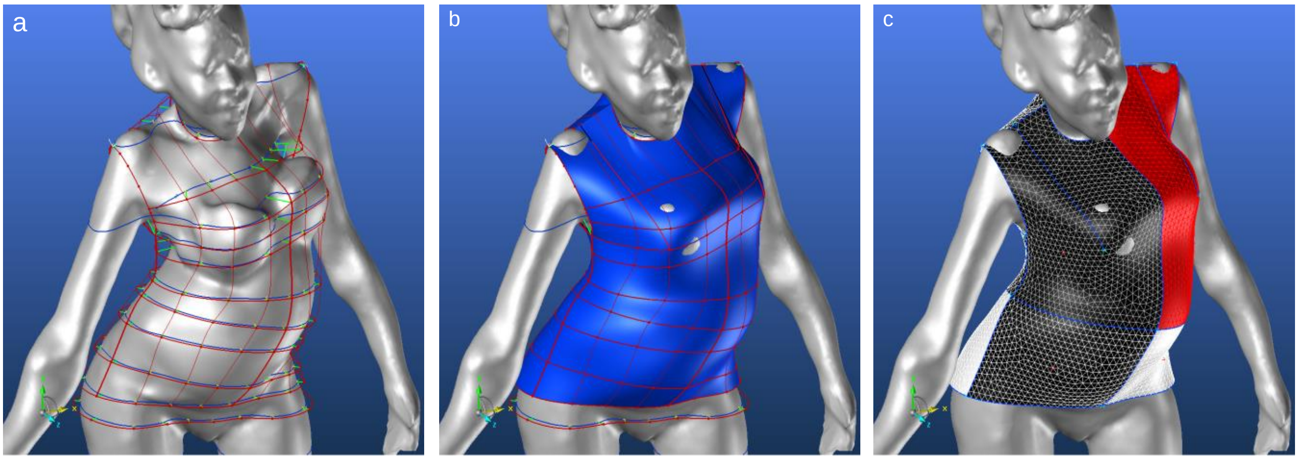

Figure 3: Names of the fit points and fashion points

➢ Feature points definition, ease distribution and wireframe formation

Using the defined reference planes, the feature curves of the human body can be easily obtained to simulate the body shape information of the customer. Based on these feature curves, the feature points of human body can be determined. The design knowledge and 2D pattern making knowledge are both applied in this process for determining feature points of human body, using an interactive design process. The designer first locates these points by his/her professional experience. Several modification operations are performed repeatedly until the final positions of these points on the curves are acceptable for both designers and customers. Same as the identification of the reference planes, more points are added than what the designers will do for normal people in order to make the result more accurate.

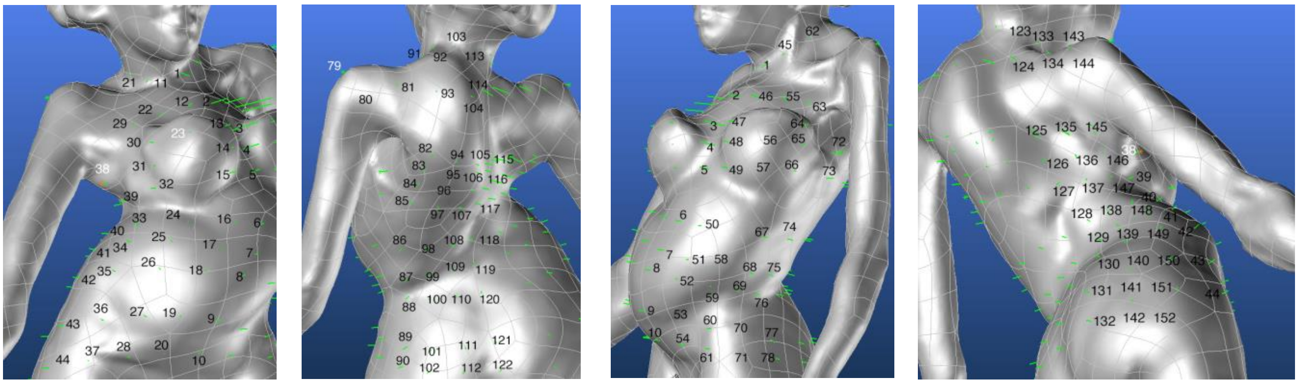

Figure 4: The wireframe of the garment surface and the meshed garment surfaces

Referring to the relationship between the feature points of the human body and those of the garment in the research carried out in another study, the fit points of the human body should be distinguished from the non-fit points. The fit point refers to the points on the garment surface that exists no wearing ease between the garment and the human body, while that of the non-fit point exists wearing ease. The non-fit feature points on the garment surface will be determined by the non-fit points of the human body by adding some values of wearing ease, in order to show desired fashion and comfort effects. A wearing ease represents the distance between the body and the garment. Figure 7 shows the defined fit points and non-fit points. The points marked with white color are the fit points while those with black color are the non-fit points.

In our study, a technical method is developed for generating values of wearing ease. The Normal lines of the non-fit points on the human body will be applied to the corresponding feature points of the garment surface. Their lengths of these Normal lines take values from the desired wearing ease given at different positions. The lengths, representing the value of wearing ease, can be adjusted by the designers in the 3D environment, according to the wearing purpose desired both by the wearer and designer. Design knowledge and 2D pattern making knowledge of the designer will be used for the determination of the wearing ease value. Besides, the directions of the normal lines can also be adjusted based on the simulation result in the following process (the green lines in Figure 7). Using this method, the consumer's requirements are fully considered not only at functional level but also at aesthetic level, which ensures the wearer and the designer to set up a compromise between desired fashion requirements and comfort feeling for different wearing purposes.
Table. 1 shows a number of representative wearing ease defined by designers and pattern makers with their design knowledge and 2D pattern making knowledge for different wearing purposes.

Table 1: Wearing ease distribution for different wearing purposes

Purpose	Fit points label			
	22	26	46	71
Basic fitting (mm)	30	8	30	10
Sports (mm)	40	16	40	18
Home (mm)	35	13	35	15
Dinner (mm)	32	10	32	12

After this step, all the feature points of the desired garment block are determined. For determination of the feature curves defining the structure of the garment, the feature points of the garment are linked together in horizontal and vertical directions, in order to guarantee that garment patterns follow in the both horizontal and vertical directions correctly. In this process, the 2D pattern making knowledge will provide inspiration and reference. These curves are neck and armhole curves, princess lines and so on. Finally a wireframe of the garment block surface can be obtained (Figure 8-a).

- Developing 3D garments and 2D block patterns

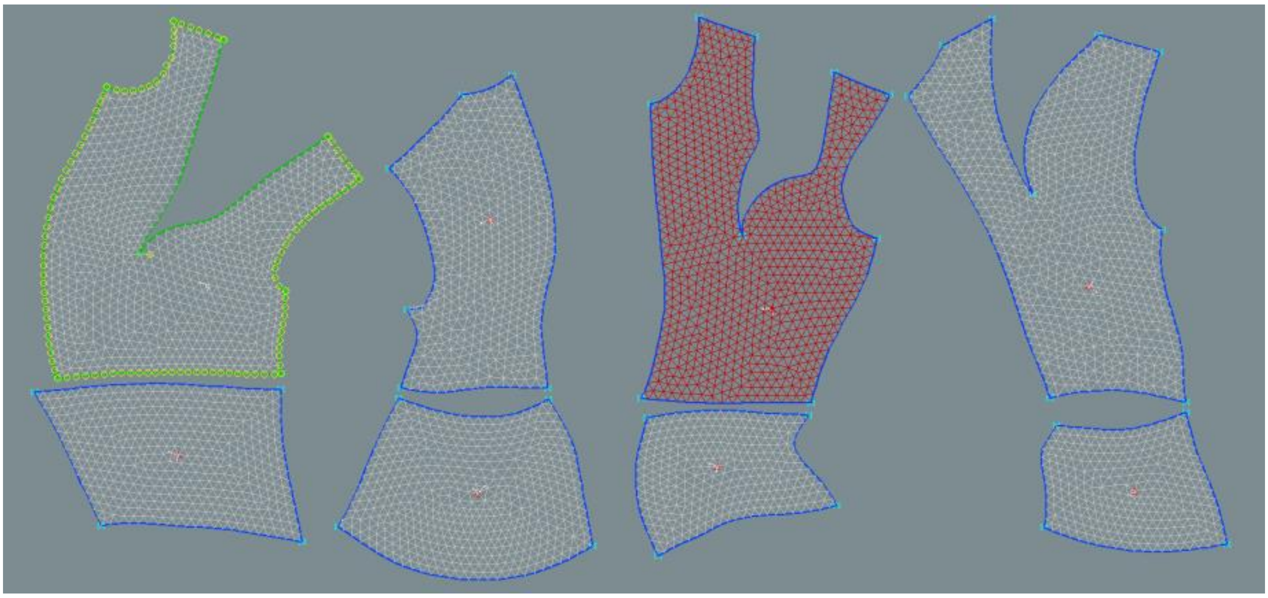

Figure 5: 2D patterns generated from the 3D garment block

The wireframe of the garment block is then modeled by triangulating and assembling different parts bounded by the deformed wireframe (Figure 8-b and Figure 8-c). The technical method is the same as the creation of a digitalized human body model using the *RapidForm* software. The number and size of the mesh is determined by the designers using several experimental adjustments until the final result is acceptable for the flattening operation. As the fabric information will be given in the virtual try-on section, there will be no specific requirement for the number and size of the mesh. The meshed garment block surface can then be applied to generate with the flattening operation to obtain the corresponding 2D pattern. The generation of

flattened 2D pattern also strictly follows the principle of the classical 2D pattern design knowledge. Darts, folds, opening, fabric direction (Warp and Weft direction) and other important 2D pattern design elements should be fully considered. Then the meshed virtual garment surface is divided into 4 parts: right front, left front, right back and left back (Figure 9). Eight different surfaces are generated: 4 in the front and 4 in the back. Then the 2D patterns can be flattened automatically and easily.
To make sure that the final result can be applicable for industry, the flattened 2D pattern is then input into the *Modaris* software for adjustment in order to satisfy the desired practical properties used in apparel industry. Then a customized garment block and corresponding 2D patterns with the proposed method can be generated and applied for industrial use.

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CONCLUSION

In this study, a visualization-based method is proposed for simulation customized 3D garment and generation corresponding 2D block patterns for physically disabled people of scoliosis type. The simulation process and method for the garment design follows that of traditional garment prototyping and draping in reality. A simulation process is performed from a scanned 3D human body for creating a digitalized human body model to ensure the identification of the feature points on the human body surface. Then the feature points on the body surface are discussed and classified with wearing ease for desired fit of the garment based on the parameterized model. A basic garment wireframe aligned with body features is then established based on the defined feature points of the human body. Based on the deformed wireframe, a 3D expandable garment block is simulated. In this process, Customized 2D and 3D virtual garment prototyping tools are ensured to create customized products based on the concept of from reality to simulation and visualization, which can be further applied to the design automation to create fit-ensured mass-customized apparel products (the top body type) for the disabled people with scoliosis. The experimental results show that the proposed method is easier to be implemented and can generate patterns with satisfactory fit.

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HEURISTIC ALGORITHM FOR OPTIMIZATION OF MANUFACTURING PROCESS BY BALANCING A PRODUCTION LINE FROM A TEXTILE COMPANY

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Abstract: *The flexible manufacturing system is a system adaptive to the market conditions, oriented to the production process profitability and characterized by typological diversification. It generates many complex optimization problems in operational management and research in the field is present with numerous algorithms and techniques that are trying to provide solutions to these problems. In this context, the paper presents the problem of production flow balancing for a jacket with 75 execution phases executed on 5 types of machines by 10 parts of the product, defines the objective function with the restrictions and create a tool to generate the quality solutions with the algorithm based on a greedy method, hybridized with a correction component for move phases from a station to another in a certain system of operational rules. The basic and the correction algorithms take into account the precedence restrictions, the production rhythm, type of phases, types of machines on which these are executed, and the sequence of the parts that compose the product. The results are analyzed, commented and explained in relation to the existing production flow and then be highlighted positive elements and original features of this algorithm.*

Keywords: *greedy algorithm, flow sheet optimization, production line balancing.*

INTRODUCTION

The stage of flow sheet optimization by balancing is an integrant part of any technological process [2], [3]. The importance of this stage increases in direct proportion with the increase of technological systems complexity and the decrease of the times for their design and decision [4]. Given the increased interest for this optimization stage, numerous algorithms included in specialized software have been developed in the specialized literature. These algorithms can be classified in two large categories: exact algorithms (branch&bound method, dynamic programming method) that supply optimum solutions for balancing problems in an a time increasing exponentially with problem dimension, and the class of approximate (heuristic algorithms) that supply good quality solutions in a time independent on the problem dimension. The target of this work is to balance a technological line from textile field for the realization of a jacket with the diminution of the down times between different processing stages, by developing an algorithm that takes into account the dynamic character of the processing line and the variable character of the human resource.

PROBLEM INTRODUCTION AND THE MATHEMATICAL MODEL FOR ITS CODIFICATION

Let's consider the manufacturing process of a specific female jacket which includes 75 operation phases, for which one knows:

- execution time, type of machine and type of component for each phase
- execution precedences; figure 1 presents a "window" from the previous operation/predecessors graph. The following information are registered in each node of the graph:
  - phase number
  - type of machine that executes the phase- there are five types of machines:
    - ms- simple machine
    - mc- sewing machine
    - ma – delivery machine
    - msp - special machine
    - ml – working machine
  - phase execution time (min. and sec.)
  - product component that includes the execution phase.

For instance, phase 52 is executed on a sewing machine (mc); it has execution time of 3 minutes, belongs to component 8 and has 6 direct predecessor (phases 42, 43, 45, 47, 32, 41).

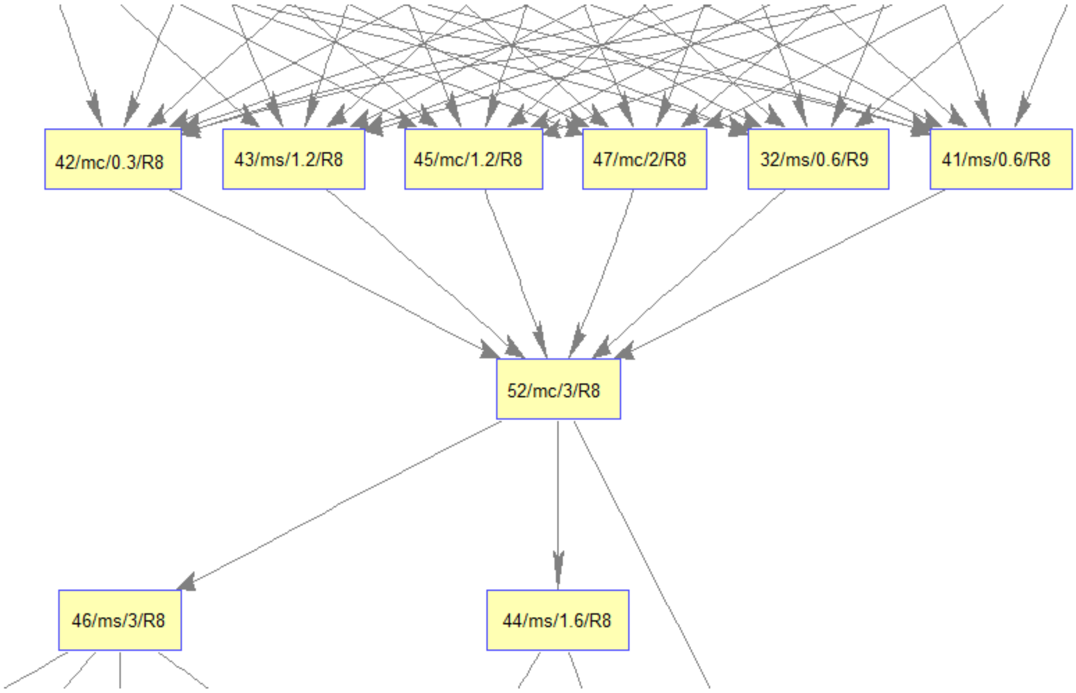

Figure 1: Detail from the graphs of technological process with execution precedences

- execution rhythm (C given in min. and sec.)

One knows the phases distribution per machines and one desires an improvement of the existing situation.

The **mathematical model** which defines this problem is the following:

Input data:

- Let's $F = \{f_1, f_2, \dots, f_n\}$ be the process execution phases.
- Each phase is given a fixed time t_i, a real, strictly positive number $t = (t_{f_1}, t_{f_2}, \dots, t_{f_n})$.
- Production rhythm is given by the constant C>0.
- Predecessors graph is known and it complies with the specificity of the technological process.
- One knows the types of machines on which the *n* phases are executed $m = (m_{f_1}, m_{f_2}, \dots, m_{f_n})$, where $\forall m_{f_i} \in \{m_{tip1}, m_{tip2}, m_{tip3}, m_{tip4}, m_{tip5}\}$, where:
  - m_{f_i} = type of machine on which the *i* phase of the technological process is executed
  - for the studied technological process, there are 5 types of machines.

The **objective function** *f* of the problem is the number of machines on which the technological process can be executed. If one denotes with $M = (M_1, M_2, \dots, M_p)$ a solution of the problem, where *p* represents the number of machines, then the objective function to be optimized is $f(M) = f(M_1, M_2, \dots, M_p) = p$. This form of the objective function results in a direct deduction of the optimization measure applied in each stage of the greedy method that we want to design. Thus, in order to deduce the optimization measure, we consider the **Total Unutilized Capacity** (*TUC*) [2] of all the machines for the solution $M = (M_1, M_2, \dots, M_p)$:

$$TUC(M_1, M_2, \dots, M_p) = \sum_{j=1}^{p} \left(C - \sum_{i \in M_p} t_i \right) \quad (1)$$

The expression (1) can be mathematically reduced to the following relation:

$$TUC(M_1, M_2, \dots, M_p) = pC - \sum_{i=1}^{n} t_i \quad (2)$$

Because in the relation (2) only the value *p* is variable, it follows that, the *TUC* value is minimal only when the value of *p* is minimal.
Therefore, the problem consists in determining the minimal number of machines on which the *n* phases of execution, such that:

- each phase is completely placed on one machine
- the sum of the times of phases assigned to a machine does not exceed its rhythm:
-

$$\sum_{i \in M} t_i \leq C \quad (3)$$

- the phases precedence is complied with.

A heuristic algorithm hybridized with a correction method was used as optimization method.
All the input data are explicitly presented in [1].

OPTIMIZATION ALGORITHM FOR THE PROBLEM OF THE FLOW BALANCING

The optimization algorithm is based on a greedy-type method, its solution entering a correction algorithm.
The **first greedy-type algorithm** is executed by a number of times specified in the input data and it presents the following structure:

Step 0:

- initialize with *C* the available times for each of the 5 types of working machines- current stations $W_i|_{i=1,...,5} = C$ (where W_i is the time available for the working machine i)
- initialize with empty set each type of machine

$M_i = \emptyset \,|_{i=1..5}$ (there is no phase initially assigned per machines).

Step 1:

- determine the phases without predecessors and randomly choose one of them (let this be f_c); assign this phase to the type of machine it belongs $f_c \in M_{m_{tip\_c}}$ (where m_{tip_c} is the machine type corresponding to the phase fc)
- update the time available for the current machine: $W_{m_{tip\_c}} = C - t_{f_c}$

Step 2:

- as long as $card(F) \neq \emptyset$ (there are unassigned phases, mathematically characterized by the fact that the set *F* contains at least one element), perform the following steps:

Step 2.1: determine the available phases

- $A = \{f_i, f_i \in F | pred(f_i) = \emptyset\}$ - the set A contains those phases which do not have predecessors.

Step 2.2: if $\exists f_k \in A$ with the property $t_{f_k} < W_i|_{i=1..5}$, then:

- assign the phase f_k to the current working machine, $f_k \in M_i$
- update the weight of the current working machine $W_i = W_i - t_{f_k}$
- remove the phase f_k from the set of unassigned phases $F = F \setminus \{f_k\}$

else

Determine a phase f* with the property that its execution time is the longest of the phases which do not have $f^* = \max_{f_i \in A} t_{f_i}$ predecessors and execute:

$M_{m_{f^*}} = \emptyset$ (initiate with the empty set the set $M_{m_{f^*}}$)

$W_{m_{f^*}} = C - t_{f^*}$ (update the working time on machine $M_{m_{f^*}}$)

$f^* \in M_{m_{f^*}}$ (attach the phase to the current working machine $M_{m_{f^*}}$)

$F = F \setminus \{f^*\}$ (eliminate the assigned phase from the set *F*).

End.

The solution of the algorithm is a topological sorting consisting of process phases disposed in the sequence of their assignation per machines within the flow sheet.

Elaboration of the correction algorithm

Step 1: set the trial threshold of phases shifting from one station (machine) to another station (machine) (establish a threshold of 20% of the machines number from the solution- decreasing ordinates in terms of available time)
Step 2: within the limits of the trials number, execute:
Step 2.1: consider the station phases with the longest time available and try to move them into another station upward or downward, keeping to the rhythm and restrictions of the previous one and the machine type.
Step 2.2: if one finds a host station (machine) which respects the conditions, then:
- move the phase
- update the time of host stage occupation
- update the time of starting station occupation;

Step 2.3: assess the available times and, if there are times per stations equal to the rhythm, then delete those stations from the solution.

EXPERIMENTAL VALIDATION OF ALGORITHMS

4.1. Situation existing at the company [1]:

The synthetic data of the flow sheet for this product are as follows:
- Total working time: 117 min 02”
- Rhythm: 117’ 02”: 21 persons = 5.57 min/person
- Persons: 21
- Rhythm time: 5 min 57”

Table 1 specifies the rhythm overrunning.

Table 1: Rhythm overrunning

Stations	Execution time	Overrun %
6	5.8	101%
14	5.8	101%
12	6.0	102%
17	5.8	101%
20	6.4	110%

4.2 Analysis of the solutions supplied by AGAC

Algorithms application was performed under the following conditions:
- the main algorithm was executed 100 times, maintaining the best solution, which is transmitted to the correction algorithm;
- the correction algorithm was applied on a number of trials equal to 20% of the number of stations supplied by the main optimization algorithm.

Table 2 presents the results of the application of this greedy algorithm with the correction algorithm (AGAC) and greedy algorithm without the correction algorithm (AG). In the columns, the production rhythm was increased by 10%, 20%, 30% and 40% respectively, in order to notice the evolution of the station number (increase/ decrease or down-time) in terms of the working line rhythm.

Table 2: Results of application of greedy algorithm with/ without AC

	Rhythm	C	C+0.1*C	C+0.2*C	C+0.3*C	C+0.4*C
Nr. of work-station	AG (AG fara AC)	29	26	26	24	24
	AGAC (AG cu AC 20%)	28	26	25	24	24

In Table 2, one can notice that one obtains the best solution for a 30% increase of the rhythm; for a further increase of the rhythm, the algorithm can no longer improve the number of working station. The AC influence can also be noticed in the solution quality for the rhythms C, C+0.1*C and C+0.2*C through the diminution of the number of working stations; along the last two columns, the AC influence on the solution quality is null, as this can not improve the solution.
Table 3 presents the composition of the best solution.

Table 3: Composition of the best solution

Station/machine	Execution phase								Machine type	Unutilized Time (min) reported to 1.3*C
1	1								1	0
2	29	34	23	25	6	11			4	0.798
3	31	24	26	33					3	5.038
4	17	16	35	2	50				2	4.698
5	3	7	9	38					4	-0.902
6	0	27	36	37	30	10	14	39	4	1.798
7	40	18	13						4	1.198
8	20								5	6.598
9	12	28	4	49	5	8			3	0.698
10	56	21	48						4	4.598
11	22	15	19	47	45	42			3	2.298
12	43	32	41						4	5.398
13	52	55	59						3	2.098
14	44	58	51	53					4	-0.302
15	46								4	4.798
16	54	57							5	1.998
17	62								5	4.398
18	68	66	70						2	4.038
19	60	61	65	64	69				4	-0.602
20	67	63							4	1.598
21	71								5	6.898
22	72								2	6.998
23	73								5	6.798
24	74	75							2	0.298

In the last column of the Table 3, the positive values represent available times per working machines, and the negative values represent rhythm overrunning, which results in flow sheet delays.

This is not the optimal solution (the best solution is 16 work-station in this example) but it is achieved in a very short time, without the need for high computing resources.

CONCLUSIONS

Both the AG and AGAC algorithms supply good quality solutions in a short time, being useful in situations with frequent changes of products on manufacturing line.
The algorithms are also flexible from an economical standpoint, as they efficiently balance the solution in terms of the number of stations and the desired manufacturing rhythm.
The difference between the two solutions (the existing one and that supplied by AGAC) derives from the fact that in reality, the graph of the precedence conditions was relaxed by eliminating certain restrictions.

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FOAMS DEPOSITION PROCESS CONTROL ON TEXTILE MATERIALS

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Abstract: *At classic sizing, the consumption of energy, chemicals and labour is very high and is costly. The modernizations of sizing process brought up to this technology on the trend of increasing the sizing bath's concentration and the pressing pressure, the water ratio of the warp cannot be reduced when the warp gets out from the sizing bath. Increasing the speed of work and saving energy consumption can be achieved by using unconventional sizing technologies such as sizing foam. Non-woven materials are consolidated in the bath in which the foam produced in various chemical substances. They can be those used in the warps, with a series of economic and technological advantages (reduced consumption of substances and energy, etc.) Foam can be deposited on textile material using a deposition head. Technological parameters of deposition and height control of the foam layer can be controlled by a process computer.*

Keywords: *foam sizing, warp, nonwoven, open source software.*

INTRODUCTION

The heating energy consumed in the classical sizing technology becomes more and more expensive. With all modernizations brought up to this technology on the trend of increasing the sizing bath's concentration and the pressing pressure, the water rate of the warp cannot be reduced when the warp gets out from the sizing bath, under 60-70%. The decisive leap in saving the sizing energy and in increasing the work speed can be taken only by using unconventional sizing technologies such as foam sizing.

Using chemical foams in warps bath sizing or the consolidation of non-woven textiles, presents a series of economic and technological advantages. In many cases, the height of the foam layer deposited on the material is determined using an equalization scraper, as in Figure 1. Deposition of the foam head has a certain feed flow rate, which can be set by the computer according to the characteristics of the fabric and the foam. For computer control of the process of foams depositing are necessary the relationship calculations of height and flow foam of head foams layer deposition.

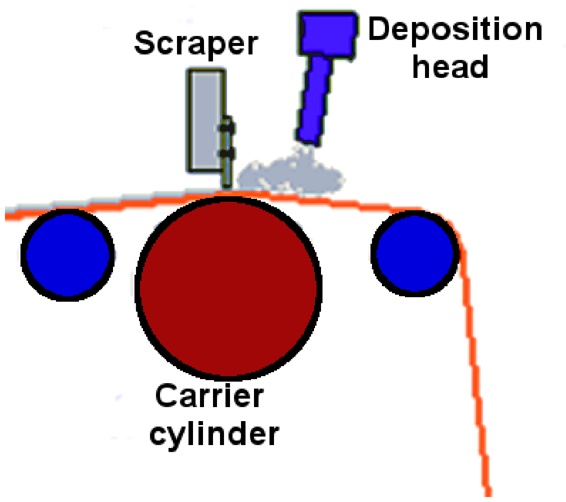

Figure 1: Foam deposition scheme

1.1 Specific concepts

Great researchers [1; 2; 3; 4; 5] settled this technology and showed the main requirements of the sizing foams and of their technical application's alternatives. The sizing foams are described by specific parameters, such as: - concentration K_s and foam viscosity η_s, foam density ρ_s, foam constancy, etc. The technical parameters of foam deposit refers to foam coat height h_s, warp speed v_u, the deposit roller's speed v_d, etc. The deposit technical parameters are determined by the sizing foam characteristics and warp characteristics (warp-set, yarn gauge, technological warp load in active sizing substances, etc.).

This paper will present some studies relating to connections between technological deposit parameters for foam and the warp and foam's characteristics.

1.2 The height of the foam layer

The height (h_{sp}) of the foam layer (Figure 2) is determined on the basis of equality of foam technological required loading (I_{tsp}) and achieved mechanical loading application system (I_{msp}).

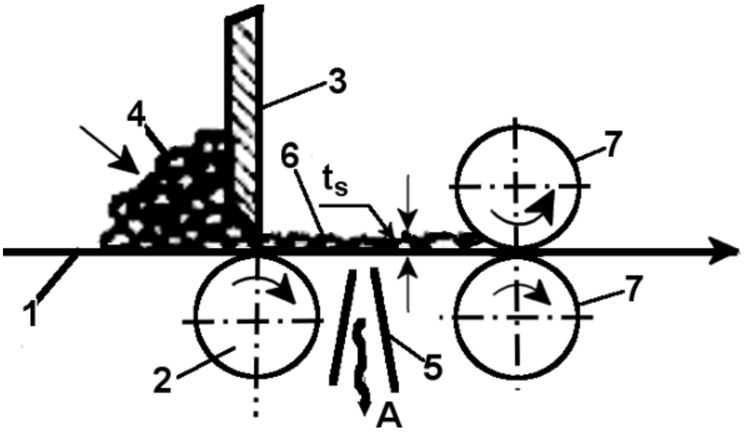

Figure 2: Calculation scheme

1 - textile material; 2 - cylinder support material; 3 - blade (scraper) equalization; 4 - roll of foam; 5 - suction device; 6 - the foam layer; 7 - cylinder pressure for breaking the foam; h_{sp} - the height of the foam layer.

Shall be used the following calculation relations:

$$I_{tsp} = \frac{I_{ts}}{K_{sp}}100 \; ; \; I_{msp} = \frac{m_{sp}}{m_m}100 \; ; \; m_{msp} = v_{sp} \cdot \rho_{sp}; v_{sp} = h_{sp}; \quad m_{sp} = h_{sp} \cdot \rho_{sp};$$

$$I_{msp} = \frac{h_{sp}\ \rho_{sp}}{m_m}100; \; I_{tsp} = I_{msp}; \; I_{tsp} = \frac{h_{sp}\ \rho_{sp}}{m_m}100 \; ; \quad \frac{h_{sp}\ \rho_{ps}}{m_m} = \frac{I_{ts}}{K_{sp}}$$

$$h_{sp} = \frac{m_m\ I_{tsp}}{100\ \rho_{sp}} \text{ or } h_{sp} = \frac{m_m\ I_{ts}}{K_{sp}\ \rho_{sp}} \qquad (1)$$

In relations above the notations were used:

I_{tsp} – technologically recommended foam loading, in%;
K_{sp} – foam concentration, in %;
I_{ts} – the treatment substances loading after drying, recommended technologically, in %;
I_{msp} – foam loading mechanical made by machine, in %;
m_{sp} – the mass of foam deposited on m^2, in kg/m^2;
m_m – the mass of textile material, in kg/m^2;
V_{sp} – foam volume deposited per 1 m^2 of material, în m^3;

ρ_{sp} – foam density, in kg/m^3;
h_{sp} – height of foam layer.

The relationships (1) for the height of the foam layer, specify the conditions necessary technological for foam deposition process, depending on the mass of textile material, foam characteristics (ρ_{sp}, K_{sp}) and technologically recommended loads (I_{tsp}, I_{ts}).

In figures 3a, b, c, d, e, it can trace the influence of different characteristics of foam and textile material on foam layer height deposited on the material.

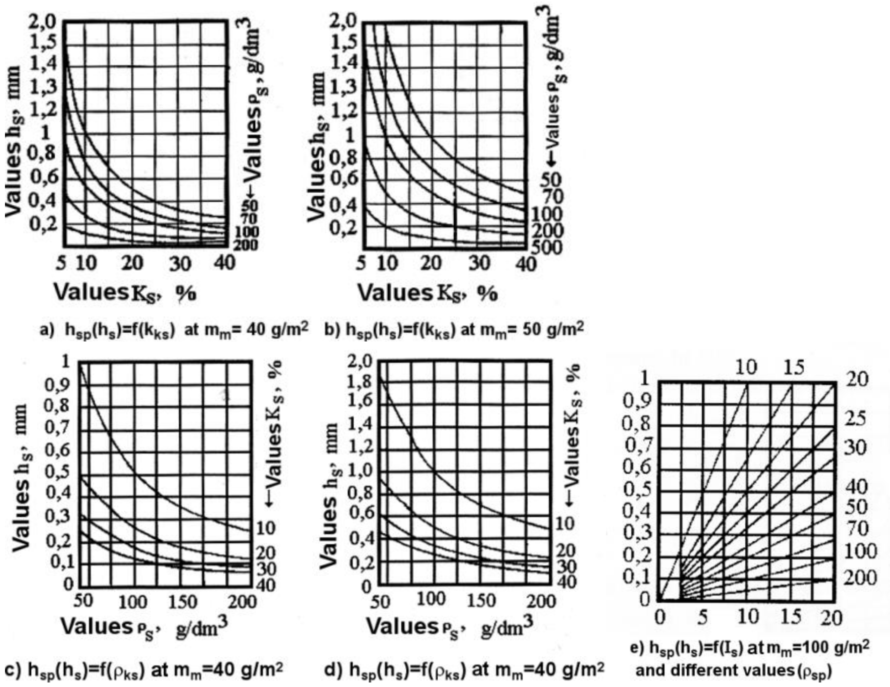

Figure 3: Relations between the height of the foam layer, the foam characteristics (K_{sp}, ρ_{sp}) at different masses of some warps
$h_{sp}(h_s)$ – the height of the deposited foam layer; $K_{sp}(K_s)$ – foam concentration; $\rho_{sp}(\rho_s)$ – foam density;

1.3 Deposition head flow

In addition to determining the height of the foam layer is necessary the determining the flow of the foam deposition head, figure 1. The flow of deposition head must ensure the amount of foam deposited depending on the mass and velocity of the fabric. This flow is determined by the relation 2:

$$Q_{asp} = h_{sp} \cdot H \cdot v \cdot \rho_{sp} \qquad (2)$$

where:

Q_{asp} – the flow deposition of foam on fabric, in kg/min;
h_{sp} – the height of foam layer (layer thickness) required to be deposited on material, in m;
H – the width of textile material, in m ;
v – speed of fabric, in m/min;
ρ_{sp} – the volumetric density of foam, in kg/m^3 or in g/dm^3 .

On the basis of relations (1) and (2) the flow for deposition of foam can be determined with relation 3:

$$Q_{asp} = \frac{m_{mt} \cdot I_{ts} \cdot H \cdot v}{K_{sp}} \quad \text{or} \quad Q_{asp} = \frac{m_{mt} \cdot I_{ts} \cdot H \cdot v}{1000 \cdot K_{sp}} \quad \text{if } m_{mt} \text{ is expressed in g/m}^2 \qquad (3)$$

The feed flow with foam (Q_{asp}) is influenced by the characteristics of the material (m_{mt} and H), the loading with substance treatment, technologically necessary, after drying of the material (I_{ts}), the speed of the material (v) and the concentration of foam in the dry treatment (K_{sp}).

EXPERIMENTAL

Computing relations for the height of the foam layer deposited on the material and flow of the foam deposition head can provide more precise control over this type of technology for loading with consolidating substances of non-woven, or other substances for treatment. In the Table 1 can track the calculated values of layer height and flow deposition of foam (deposition head feed flow) to achieve the technology desired loading of the active substances.

Table 1: The height of the foam layer and deposition head flow

Textile material	m_{mt}, g/m^2	H, m	v, m/min	I_{ts}, %	K_{sp}, %	ρ_{sp}, g/dm^3	h_{sp}, mm	Q_{sp}, kg/min	Q_{sp}, dm^3/min
Nonwoven	400	1,5	6	15	40	90	1,66	1,35	15,0
Nonwoven	500	1,5	6	15	40	90	2,08	1,68	18,66
Warp	100	2,0	40	10	30	50	0,66	2,66	53,20
Warp	150	2,0	30	10	30	50	1,0	3,0	60,0
Warp	200	2,0	20	10	30	50	1,33	2,66	53,20

The results obtained from calculations lead to values that it might meet in the industrial exploitation of machines that would use the deposition of bath foam. More precise control of such a technological variant it might be achieved by introducing a sequence program of the computer of the machine, to satisfy the above technological relations. Computer control scheme of the height of the foam layer deposited on the material and flow deposition of the foam it can follow in Figure 4.

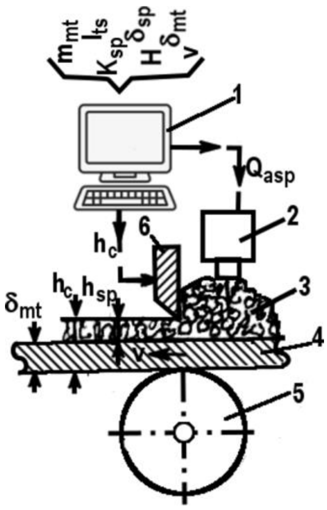

Figure 4: Computer control principle of the foam layer thickness and flow deposition head
1 – computer; 2 – foam deposition head; 3 – deposited foam on material; 4 – textile material; 5 – supporting and conducting cylinder of material; 6 – the scraper for calculate height (h_c) of scraper, towards supporting cylinder of material; δ_{mt} – thickness of textile material; h_{sp} – thickness of deposited foam layer; h_c – the positioning height of the scraper towards the cylinder 5; Q_{asp} – the foam flow of deposition head; m_{mt}; I_{ts}; K_{sp}; ρ_{sp}; H; δ_{mt}; v – initial technological data.

After the introduction in the computer 1 (Figure 4) of all data required in relations (1) and (3), it will establish and command the feed flow of the foam deposition head (2), and height (h_{sp}) foam layer deposited on the material. The height (h_c) for controlling the position of the scraper (6) relative to the cylinder (5), must take into account the thickness of the fabric (δ_{mt}). The control height will be:

$$h_c = h_{sp} + \delta_{mt} \quad (4)$$

where:

h_c – the distance between the adjusting scraper of the height of the foam layer and the support cylinder (5) for textile material, in mm;
δ_{mt} – the thickness of textile material, in mm;

RESULTS

Based on data from sizing foam of textile material (warp or non-woven textiles) and the relations previously established, a software was developed to calculate foam flow of deposition head and foam layer height. For this purpose was used the Scilab open source software, Figure 5.
Scilab is a programming language associated with a rich collection of numerical algorithms covering many aspects of scientific computing problems. From the software point of view, Scilab is an interpreted language. This generally allows to get faster development processes, because the user directly accesses a high-level language, with a rich set of features provided by the library. The Scilab language is meant to be extended so that user-defined data types can be defined with possibly overloaded operations. Scilab users can develop their own modules so that they can solve their particular problems. From the license point of view, Scilab is a free software in the sense that the user does not pay for it and Scilab is an open source software, provided under the Cecill license. The software is distributed with source code, so that the user has an access to Scilab's most internal aspects. Most of the time, the user downloads and installs a binary version of Scilab, since the Scilab consortium provides Windows, Linux and Mac OS executable versions. Online help is provided in many local languages. From the scientific point of view, Scilab comes with many features. At the very beginning of Scilab, features were focused on linear algebra. But, rapidly, the number of features extended to cover many areas of scientific computing.

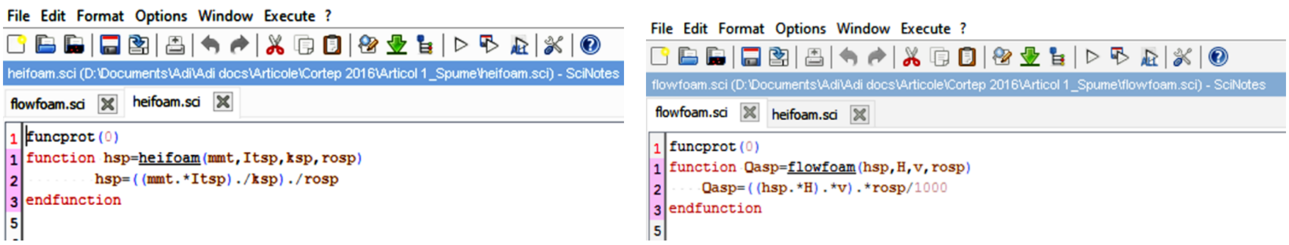

Figure 5: Scilab functions created for calculating the position and flow of foam scraper

These functions have been used for developing a script necessary to calculate the values that can be used for command of a foam sizing machine by means of a computer process, figure 6.

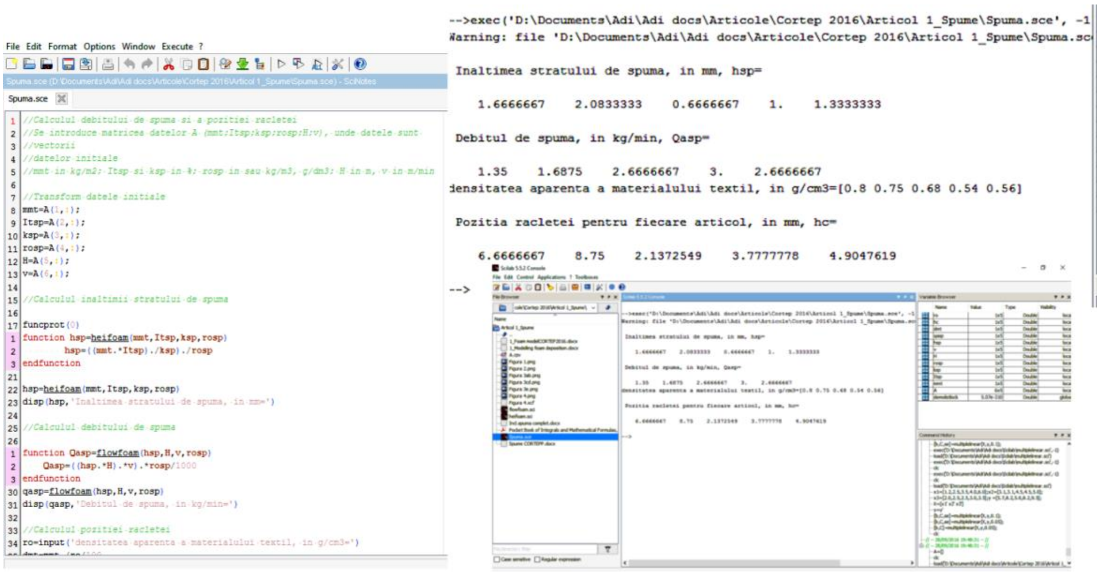

Figure 6: The script file and results

This script file can be used to calculate parameters necessary for good foam sizing for several textile materials: the height of the foam layer (h_{sp}) flow foam of deposit head (Q_{asp}), according to initial data, such as: the mass of textile material (m_{mt}), foam concentration (K_{sp}), foam density (ρ_{sp}), technologically recommended foam loading (I_{tsp}), etc.

CONCLUSIONS

At classic sizing, the consumption of energy, chemicals and labour is very high and is costly. This paper has analysed the possibility of computer aided control a process of foam sizing.

The decisive leap in saving the sizing energy and in increasing the work speed can be taken only by using unconventional sizing technologies such as foam sizing.

Using chemical foams in warps bath sizing or the consolidation of non-woven textiles, presents a series of economic and technological advantages.

Deposition of the foam head has a certain feed flow rate, which can be set by the computer according to the characteristics of the fabric and the foam.

For computer control of the process of foams depositing are necessary the relationship calculations of height and flow foam of head foams layer deposition. On the basis of these relations it was developed a script, based on Scilab software for calculating the flow of foam and the height of the foam layer of deposit of the textile material. This script can be used to control the process of foam sizing.

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Section 7: Machinery developments

MACHINE CONFIGURATIONS FOR MULTILAYER BRAIDED STRUCTURES WITH COMPLEX CROSS SECTIONS

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Abstract: *This work presents a numerical investigation of the possibilities for production and simulation of braided products with complex cross sections and arbitrary thickness.*
Previous investigations with the use of simulation software TexMind Braiding Machine Configurator show that with the help of the simulation software it is possible to create configurations for braiding machines with large number of horn gears in custom arrangements for the production of complex single layer braided structures like T- and double-T-profiles. This work presents an extension of this investigation with the goal to create profiles with multiple layers on the walls in order to have greater thickness. The investigation shows, that the possibilities for carrier arrangements are directly connected to the topology of the tracks and for the design of multilayer braided structures (interlock braids) with multiple tracks and interlacements between the individual layers, more empty places in the arrangement are required. For the cases, where a suitable machine configuration and carrier arrangement for such structures is found, a simplistic 3D geometry of the braid is generated.

Keywords: *braiding, modelling, profiles with complex cross section, interlock braids.*

INTRODUCTION

Three-dimensional braided preforms offer outstanding structural features and properties to composites. Besides others these are no delamination behaviour, improved impact and damage resistance and excellent torsional strength [1]. The manufacturing of braided preforms through cutting and draping and moulding of multilayer two-dimensional braided fabrics into specific shapes is well developed and widely used. As well as the radial braiding, that becomes very popular as a form of tubular braiding for the covering of mandrels of different forms, also known as overbraiding. The braiding of solid three dimensional preforms with complex cross sections is more difficult and the manufacturing of such profiles in a single processing step is, in the contrary, less developed. Only single reports and patents about production of larger solid braids are known in the literature [2], [3]. An extended, very detailed overview of the development of the 3D braiding technique can be found in the recently published chapter of A.E. Bogdanovich [1]. Some steps of the development of 3D maypole braiding machines are reported in [4], [5], [6] as well as Cartesian braiding [7], and hexagonal (lace-type) braiding [8].
The 3D maypole braiding offers high flexibility for the braiding process and one well-known example for this braiding technique is the 3D maypole braiding machine build by August Herzog [6]. The machine has a setup of horn gears with four slots, which are arranged side by side in a rectangular distribution and each switch and horn gear can be controlled individually. This technique gives a high flexibility but is too expensive. In the patent literature and some conferences machines can be found with horn gears, placed in special configuration, different from tubular or flat, so that special forms can be produced. In [2] some initial states of software of the company TexMind are reported, which allows emulation of the machine configuration with arbitrary placement of the horn gears. The algorithms and next development of this “Braiding Machine Configurator” are reported in [9].
The current paper presents numerical experiments, performed with the actual version of the TexMind Braiding Machine Configurator [10] with the goal to determine possible configurations of horn gears for custom maypole braiding machines, which are suitable for the production of profiles with complex cross sections. On several patents for paths of such machines the carriers are seldom given. Their arrangement for complex paths is not a trivial task, but in the current case this can be solved using simulation and checking each configuration.

SIMULATION OF BRAIDING MACHINE FOR L-PROFILE

For the design of three-dimensional maypole braiding machines custom configurations of horn gears and suitable carrier arrangements for the production of complex cross sections have to be implemented. In the first step the configuration of a standard flat braiding machine is taken as basis and in the second step the track is extended with additional horn gears for the modelling of the complex profile shapes. Figure 1a demonstrates the configuration of a flat braiding machine that is enhanced for the production of a L-profile. As explained in [9] this arrangement won't be possible to be implemented in a classical 3d braiding machine with rectangular arrangement of four slots horn gears, because the carriers will crash after turning the moving direction around the outer horn gears 1 or 6. In order to solve this problem the end horn gears have to be adjusted and need one more slot, so they have to be in the case with five slots (Figure 1b). The full carrier arrangement with "1 full -1 empty" can be realized and the generated braid for this configuration is shown in Figure 2.

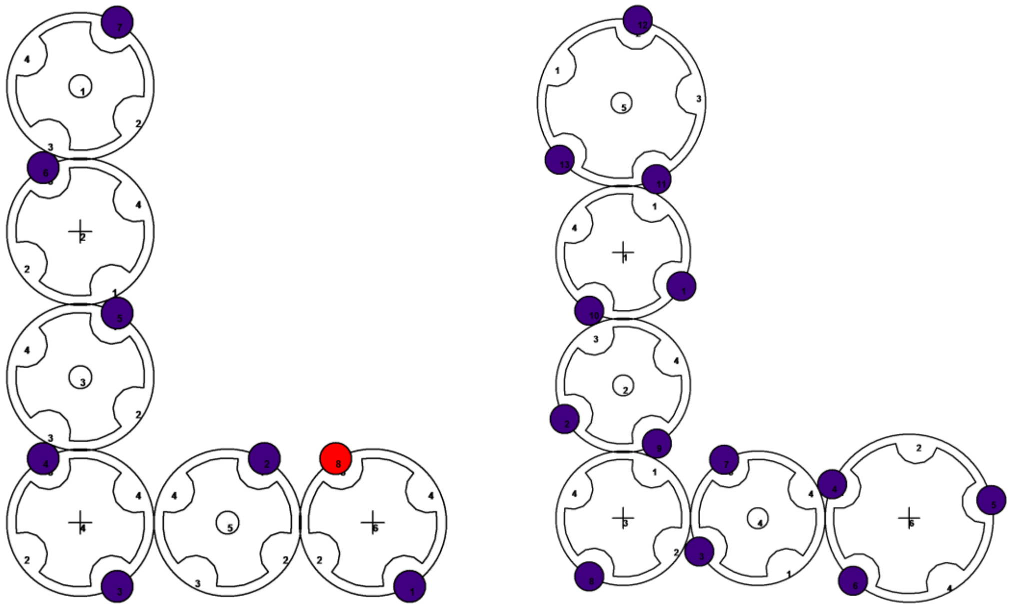

Figure 1: a) Not possible and b) possible configurations of horn gears for production of L-profile

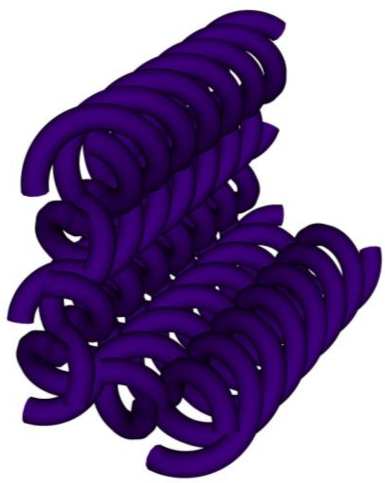

Figure 2: Simulated braid for the configuration of figure 1b

SIMULATION OF BRAIDING MACHINE FOR DOUBLE-T-PROFILE

The modelling of braiding machines for the production of profiles with more complex cross sections like a double-T-profile requires more adjustments in the configuration. Figure 3 demonstrates the machine set up with four turning gears with one more section at the outer ends. Anyway the carrier arrangement “1 full – 1 empty” is not suitable, as it will come to a collision at the middle horn gear, where the carries come together from two directions.

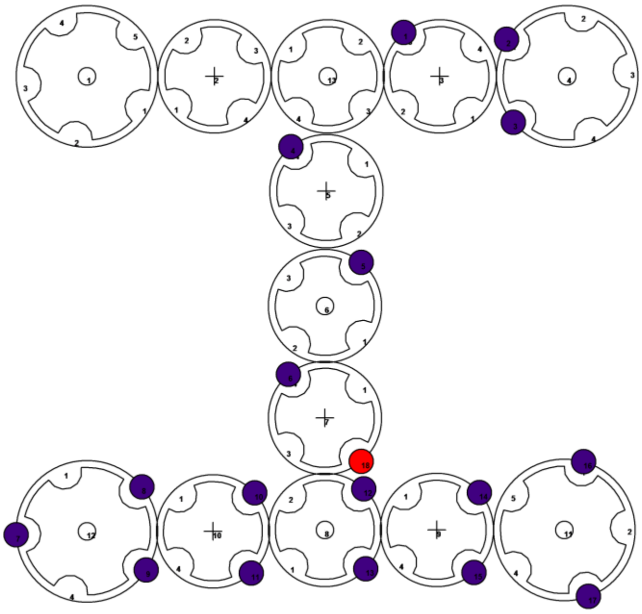

Figure 3: Configuration “1 full – 1 empty” will lead to collision

There are two opportunities to solve this problem. First – with an adjustment of the middle horn gears more empty places can be provided at the critical point, if horn gears with five slots are used, so that the full carrier arrangement can be realized (figure 4a). Second – without making changes for the horn gears, the carrier arrangement has to be adjusted. A partial carrier occupation with “1 full – 3 empty” will be suitable for the production (figure 4b).

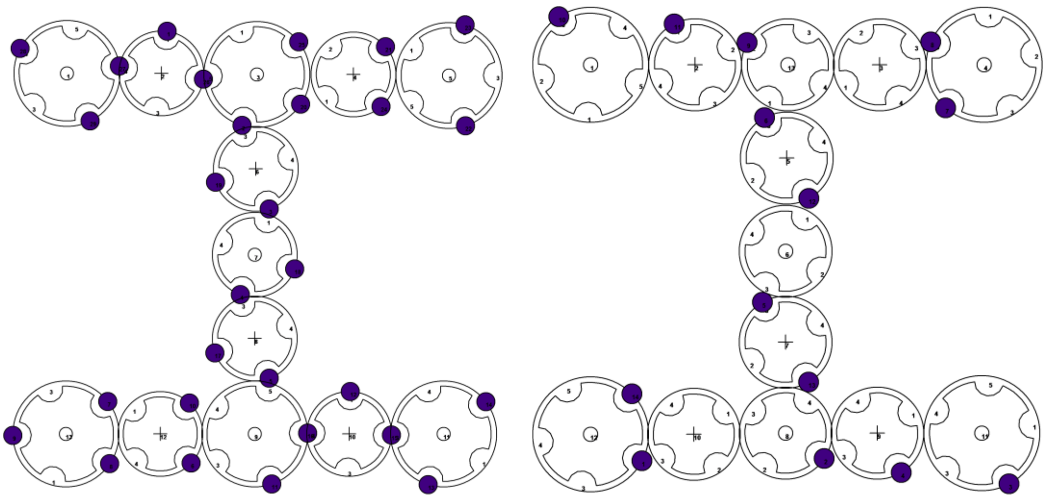

Figure 4: possible configuration a) with adjustment of horn gears b) with adjustment of carrier arrangement for production of double-T profile

Changing of middle horn gear, full carrier arrangement with “1 full – 1 empty” is suitable for the production. Other opportunity is the adjustment of the carrier arrangement. As more empty places are required along the track, a partial carrier arrangement with “1 full – 3 empty” can be realised for the braiding process. Anyway the two different options have influence on the structure of the braided profile. In figure 5 the simulated braided profiles of both machine designs are shown. The full carrier arrangement will lead to a braiding structure with floating length of one (figure 5a). The structure of the braided profile will be different with a partial carrier arrangement (figure 5b). In [11] two disadvantages are disovered, that will arise, using "1 full – 3 empty" carrier arrangement for the braiding of the profile. First - through the partial carrier arrangement there are less number of carriers available for the braiding, so for the production of profiles with required dimension double more gears and respectively machine size are required compared to the case "1 full – 1 empty". Second - as shown in Figure 4b the pattern will be with a floating length of one like a plain braid. Consequently the yarns have the largest possible undulations at the interlacement points. As well known, carbon, glass and basalt fibers have significant lower properties in crimped state, so this should be taken into account and investigated before building such machine.

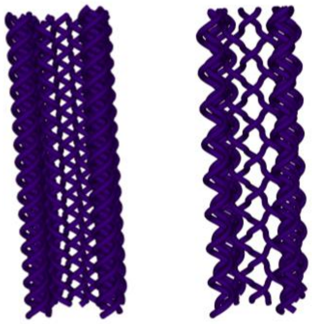

Figure 5: a) Simulated braid for configuration "1 full – 1 empty" b) Simulated braid for configuration "1 full – 3 empty"

MODELLING OF BRAIDING MACHINES FOR MULTILAYERED PROFILES

The realized configurations with one column of horn gears will produce thin walled braided profiles, which are based on a one thin flat structure. For the production of solid three-dimensional profiles with thicker walls, possible arrangements of braiding machines with two or more columns of horn gears should be investigated. Ideas of such configurations are reported in several works and patents like from Brookstein et al [13], Uozomi et al [14], Temple [15], Akiyama, Hamada et al. [16] and more. In several of these technical drawings and patents the carrier arrangement is not specified explicitly, because at that time it was not possible to simulate this behaviour on computer adequately.
Figure 6 shows a possible configuration of a braiding machine for the production of a double-T-profile with two columns of horn gears in the middle section of the profile.

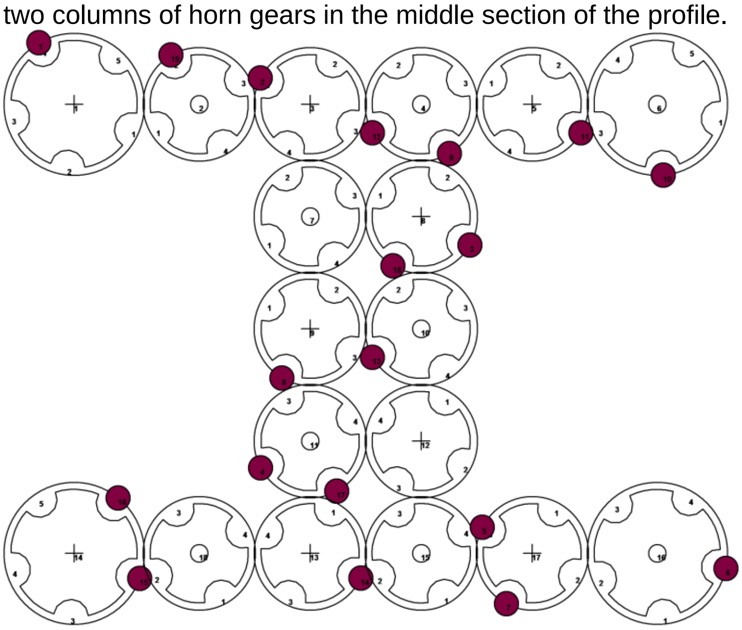

Figure 6: Possible configurations for production of double-T-profile with two columns of horn gears

The horn gear configuration of this cross section leads to a complex track for the carriers so that their arrangement has to be investigated as it is not a trivial task to avoid collisions. The numerical experiments shows that a partial carrier arrangement with "1 full – 3 empty", which provides more empty spaces along the track, will be suitable for the braiding process. Figure 6 shows the generated structure of three-dimensional braided profile.

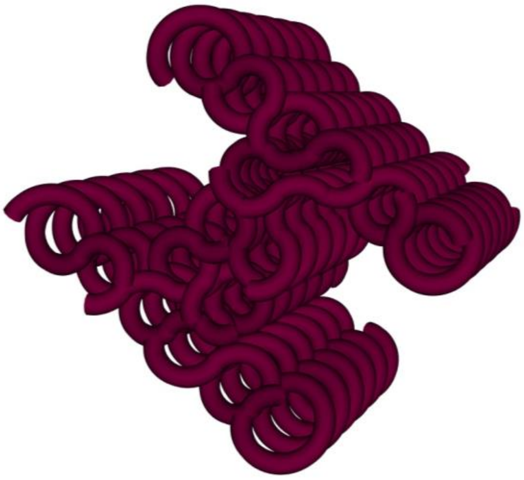

Figure 7: Simulated braid of the configuration of figure 6

DISCUSSION

The realized machine configuration will produce a double-T-profile with greater thickness of the middle section. For an increase of thickness of the entire profile it is necessary to place addition horn gears at the top and bottom section of the double-T as well. Previous investigations show, that a turning gear with more slots has to be placed at the end of the track, where the carriers turn their moving direction. The implementation of contacting points to additional connected horn gears at the top part of the profile needs further investigation, as it can be seen in Figure 8, that the slots of the different sized horn gears don't match in the right positions so that the carrier transfer won't work properly in this position.

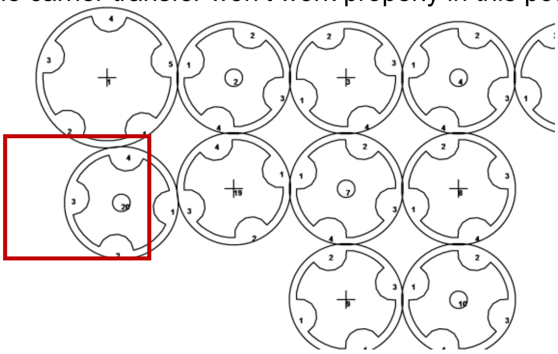

Figure 8: Placement of additional horn gear for increase of profile thickness

The numerical experiments demonstrate the common engineering approach of developing new products using trials and errors. It makes clear, that even using a simulation software, the design of machine configurations and the carrier arrangement for complex cross sections is not a trivial task and systematic rules for the modelling of such configurations should be developed. From another point of view, the simulation software allows the performing of a large set of virtual tests and could help with the development process of systematic rules and equations for possible configurations of horn gear based braiding machines and their carrier arrangement.

CONCLUSIONS

Within this paper numerical investigations about the design of custom maypole braiding machines for the production of braided products with complex cross sections were presented. Machine configurations for single layer braided shapes like L- or double-T-profiles were found but the check of the motion with the software "TexMind Braiding Machine Configurator" shows that the carrier arrangement is not a trivial task and that adjustments of the configurations have to be applied before a suitable machine design can be implemented. It was found, that is possible to enlarge the middle section of the double-T-profile with an additional column of horn gears in order to produce braided profiles of greater thickness with interlacements between the single layers. The investigation shows that the complex paths of the cross section requires more empty places and a partial carrier occupation with "1 full – 3 empty" can be applied for the braiding process. The simulated 3D geometries of the braids can be used for evaluation of the machine configuration and as well for approximated estimation of the properties of the structures.

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ADAPTING SPINNBAU- HERGETH INSTALLATION FOR THE PRODUCTION OF NONWOVEN TEXTILE MATERIAL WITH LOW .

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Market in Romania, and not only, has become a major consumer of non-woven textiles and demand is not only quantitative, but qualitative and especially with wide range of technical features - functional. To meet this demand in the market, profile companies can do acquisitions of new installations, option that entails substantial financially effort not always possible or with their own efforts to achieve changes in own installation. In the present work it is shown how to adapt the installation Spinnbau-Hegeth for production of nonwovens with a mass of 40 g./m^2,material now imported. Existing installation is designed to achieve mass nonwovens with over 100 g./m^2 from fiber 7den density length . Was used two versions of nonwovens fiber mixtures with fibres 4 den density length , and was made the material with the average weight of 40 g/m^2.

Keywords: *fibre, polyester, nonwoven, installation.*

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Section 8: Fashion design and product development

MULTI-FUNCTIONAL HARNESS/CONTAINER EQUIPMENT FOR PARACHUTES

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Abstract:
"This work was done on NUCLEU program, INOVA-TEX-PE, implemented with the ANCSI support, project no. 26N / 16 34 03 01"
The aim of the research is to achieve a multifunctional harness / container assembly for parachutes, adaptable to a wide range of canopy types and packing volume. The container is designed to take over and maintain main and reserve parachute canopies in a folded stage. Container / harness assembly is the safety system of the parachutist; it controls the deployment and opening of parachutes.
Currently the sizes of reserve canopy parachute and main parachute canopy compartments are manufactured in accordance with the volume of folded canopies. One of the proposed innovation for to develop the multifunctional container, consist in adjusting the container side panel in three positions adequate with the three packing volume of the parachutes. The harness is adjustable on the parachutist body and incorporated into the container.

Keywords: *main container, reserve container, harness, main parachute, reserve parachute*

INTRODUCTION

The Harness/Container equipment is intended for parachute jumpers. The Container / harness equipment is the safety system of the parachutist. The container controls the deployment and opening of canopies and the harness connects the parachutists with canopies. The container is designed to take over and maintain main and reserve parachute canopies in a folded stage.
The main components and subassemblies of container are specific with the type of parachutes connected to the container [1]. Containers for sport parachutes have two compartments, the bottom compartment for main parachute and its subassemblies and the upper compartment for reserve parachute and its subassemblies [2]. Sports containers have distinct requirements for main parachute compartment and reserve parachute compartment. Currently the sizes of reserve canopy parachute and main parachute canopy compartments are manufactured in accordance with the volume of folded canopies. For example, the Aerodyne ICON is produced in 7 sizes, certified under TSO C23d. The ICON container sizes, the reserve and main canopy sizes and accepted volume are presented in the table 1, [3].

Table 1: The ICON container sizes and the accepted volume for reserve and main canopy

Size	Reserve volume (m^3)	Max accepted volume (m^3)	Main canopy volume (m^3)	Max accepted volume (m^3)
I2	0,0014-0,0016	0,0045	0,0013 – 0,00132	0,0053
I3	0,0016-0,0018	0,0048	0,0016-0,0020	0,0060
I4	0,0018-0,0022	0,0056	0,0019-0,0022	0,0064
I5	0,0022-0,0026	0,0063	0,0022-0,0026	0,0068
I6	0,0026-0,0032	0,0078	0,0026-0,0032	0,0076
S7	0,0028-0,0037	0,0080	0,0034-0,0037	0,0083
S8	0,0032-0,0037	0,0080	0,0037-0,0040	0,0086

Another example is Quasar container. If the symbol is Q3/2, the container sizes would be 0,0051m^3 for the reserve parachute, and 0,0048m^3 for the main parachute [4].

The Icon harness is produced the following sizes, table 2.

Table 2: The Icon in harness sizes

Icon type	Size
A	XXSpecial
B	XSmall
C	Small
D	Medium
E	Large
F	XLarge
G	XXLarge
H	XXXL Special

The innovation consist in developing a multifunctional container with adjustable variable compartments volume that allow the hosting of different sizes of main and reserve parachutes. The harness is adjustable on the parachutist body.

EXPERIMENTAL

For achieving the target of the project, the variable volume of parachute compartments, we designed the container with adjustable side panel in different positions adequate with the variable packing volume of the main parachutes and adjustable flaps side of the reserve container.
The container compartments must include the bags for opening the parachutes. In these bags, type "Free Bag", the parachutes are folded and are extracted from the container by the pilot chute.
The shape of the D-bag is a truncated pyramid for the reserve and parallelepiped shape for the main parachute.
The bags volumes are calculated with formulas:

- Parallelepiped bag:

$$A_B \cdot H \quad (1)$$

- Truncated pyramid:

$$H/3(A_B+Ab+\sqrt{(A_B \cdot Ab\ )} \quad (2)$$

Where:
A_B - the big base area in cm^2
A_b -small base area in cm^2
H –height, cm
We designed two sizes of bags both for the main parachute and for the reserve parachute.
The harness was designed to be adjustable on the parachutist body and incorporated into the container. The harness layout is presented in figure 1.

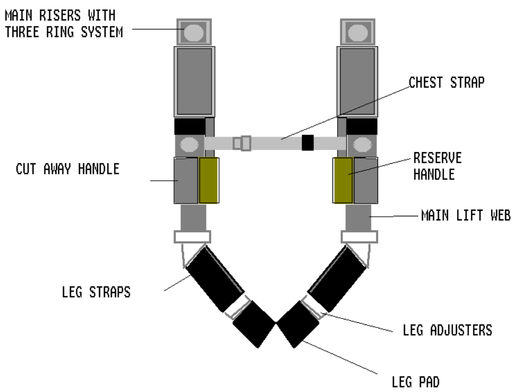

Figure 1: Harness of Multifunctional container

The materials used in the manufacture of equipment container / harness are standardized as materials for parachutes.

We used in the container manufacture, CORDURA fabric 1000 denier, with resistance to water, abrasion, and dirt and for other decorative pieces, CORDURA 500 denier. The technical characteristics are presented in table 3.

Table 3: Technical characteristics of Cordura fabric

N	Technical characteristic	Cordura 1000	Cordura 500
1	Chemical composition	Polyamide 6.6	Polyamide 6.6
2	Weaving	Cloth 1/1	Cloth 1/1
3	Weight , max., g/m^2	335	239
4	Tensile strength ,min., daN, Warp/Weft	319/232	224/209
5	Tear resistance , min, daN, Warp/ Weft	31,7/33,5	10,5/10,1
6	Hydrostatic pressure resistance, mm col. apa	400	3950
7	Abrasion Resistance (Martindale), no. cycles	Over 100000	Over 100000

Technical characteristics of tapes and webbing in conformity with PIA–W-4088, PIA-W-27265, used for harness and container are presented in table 4.

Table 4: Technical characteristics of the tapes and webbing

Type /characteristics	Type I	Type I a	Type II	Type IV	Type VII
Width, mm	14 ±0,03	19±0,03	26±0,03	76±3	43±1.5
Thickness, mm	0,6-1,0	0,6-0,9	0,6-1,0	0,6-1,0	1,5-2,5
Weight,max. g/m	8,5	10	13	37	73
Tensile strength, min, daN	250	300	300	900	3000
Color code	-	-	-	-	Yellow line on each side
Weaving	Twill 2/2	Twill 2/2	Twill 2/2	Twill 2/2	Double woven fabric
Application	Reinforcement tape	Container binding	Container fabric	Extension and reinforcement	Harness for sport parachutes

The novelty consisted in designing the container with adjustable volumes that can be used with parachutes that have different sizes.
This was done by varying the surface of the container sidewall with a cord and loops on both sides, figure 2. This allowed obtaining two volumes for the main parachute.

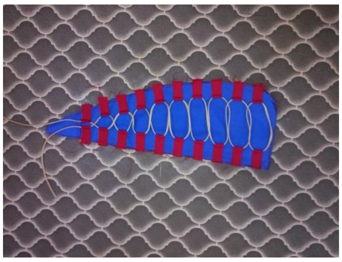

Figure 2: Sidewall of the container

In order to obtain a variable volume for the reserve parachute we used the same method, cord and loops mounted on the flaps side of compartment dedicated for the reserve parachute, figure 3.

Figure 3: The panel of reserve parachute compartment

RESULTS AND DISCUSSION

The multifunctional experimental model of container made according to the proposed innovations is represented in the figure 4.

a) b) c) d)

Figure 4: The multifunctional container- Experimental model; a) Front view; b) Back view; c) Side view; d) Inside view

The obtained results are:

- The main parachute container can be used for 2 parachute volumes: one volume with min. 5651cm^3 and max. 6224cm^3 and the second volume 6798cm^3 and max.7207cm^3;
- The reserve parachute container can be used for 2 parachute volumes: one volume with min. 4750cm^3 and max. 5487cm^3 and the second volume min. 5897cm^3 and max. 6388cm^3.

The verification that confirms us the correspondence between compartments volumes and parachutes volume is the Force of pin extracting. This must not be less than 2.2daN and no more than 9.8daN in the direction perpendicular to the direction of opening.

CONCLUSIONS

Manufacturing the harness/container assembly for parachute was made using specific materials, experimental model was made with materials that meet military technical standards.
The results of testing and verification on the ground showed:

- The innovation applied at the designed and manufacturing of the assembly confirmed the expected results: the volume of container is variable, it can be used with two different volume of the main and reserve parachutes;
- Some changes must be applied to the design of the prototype for a better aesthetical aspect and closing of the container;
- Adjusting the side panel of the container will be only half length (5 loops instead of 10), the remainder of 5 loops were redundant since the container is already adjusted by the reserve compartment.

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CONSTRUCTIVE DESIGN OF MODELS WITH ARCHITECTURAL FORMS

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Abstract: *There is a growing concern of designers to approach avant-garde and three-dimensional forms of architectural inspiration in their fashion creations. For a long time there is a bi-univocal connection between architecture and fashion, which originates in the fact that both have in the spotlight the man to whom they provide protection and shelter and highlight the personality, aspirations, culture and imagination.*
Architecture offers the most diverse forms that can be important sources of inspiration for designers. Thus, shapes as triangle, exemplified in the family of models studied, is used in unusual combinations (random and/or repetitive, with its original form preserved or reinterpreted, it is part of other geometric shapes bi and three-dimensional as the rhombus, the pyramid and polyhedron).
From the ever closer relationship between fashion and architecture, this study presents the results of a research which is focused on the creation and constructive design of clothing models with three-dimensional forms of architectural inspiration.

Keywords: *fashion, architecture, architectural clothing, constructive modeling, form of clothing.*

INTRODUCTION

Fashion has been an important part of human life since the dawn of human history. Fashion was, is and will be a method of differentiating people by using it as a way to display an image, which may or may not correspond to reality, presenting real assumed, show outright concealment willful or creating a diversion by what the carrier wants to communicate to those around him: information on membership of a social class, religious or political beliefs, preferences in music or art, material condition or just want to be different or one step or more ahead others.
Fashion consumers of any kind are becoming more knowledgeable and "educated" (correctly informed or manipulated) through channels of media and want increasingly more to express the uniqueness, individuality, preferences, with image that shows through clothing, footwear and accessories they wear, the hair styling, make-up and other ways of differentiating (tattoos, piercings or other "extravagances").
Consequently, fashion designers, becoming more experienced, have a difficult but pleasant task to overcome existing limits of imagination and technology it develops each collection season after season.
In this context, the use of sources of inspiration for the creative act is a challenge for designers of clothing and may result in innovative forms of consumer demanding, eager to amaze in various occasions.
Starting from the statement of the famous Coco Chanel: "Fashion is architecture: it is a matter of proportions" [5], can be seen that fashion and architecture have much in common though the differences between the two are obvious and can be summarized thus: fashion can often be ephemeral and superficial, using soft and fluid materials whereas architecture is considered monumental and permanent using solid and rigid materials. However, both the architect and the designer use geometry to generate patterns, to create structures, design lines and shapes. Regardless of differences in size, scale and materials used, the point of origin for both fashion design and architecture is the human body, both activities are in place to protect and provide shelter, while providing a means of expression identity purely personal, political, religious or cultural.
While fashion designer and architect create objects that differ in size and nature of the used materials, their creative processes can be strikingly similar. Both begin with a flat two-dimensional medium, and converting it to create complex three-dimensional shapes. The same trends prevailing aesthetic, ideological, theoretical basis and technological innovations have influenced each other, resulting in garments and buildings that share structural or stylistic qualities that have resulted from the joint creative impulses. While designers in both areas researched result of their work for inspiration from each other and for certain technical strategies. Fashion designer vocabulary was enriched with architectural terms derived from being applied to clothing (architecture, built, sculptural, deconstruction etc). And architects also borrowed and adapted their strategies in product design with terms from clothing and fashion vocabulary such as draping, weaving, folding, pleating and printed surfaces and materials [3].

The aesthetic design of the two areas is evaluated using the elements (line, shape, texture, color, etc.) and principles (unity, balance, proportion, rhythm, etc.) of design (Bauhaus practices)[3]. The architecture relates to the construction of a medium whose structure is entirely self-sustaining. Some fashion items are designed in a similar way but designed as a medium for the human body rather than a place within human beings live and work. These garments are made with real rigidity or just forms with visual perception of rigidity that exist separately from the body. Rigidity is created by using a material that supports fabric or from which clothing is made either directly on clothing.
The term of 'sculptural fashion', part of architectural fashion, is often used in fashion items and refers to those creations that have the elaborate and three-dimensional look of a sculpture and where attention to details is prominently.
Clothing inspired by architectural fashion is characterized by:
• Using fabrics as a building material that generate both hard and round lines;
• Carrying oversized proportions and exaggerated angles;
• Obtaining silhouettes with emphasis on structure, shape and pattern;
• Using of major pleats, folds, pinning, layering, surface texture and three-dimensional designs;
When using this approach, the structure of the garment is identified as having architectural design.

In Figure 1 are shown examples of clothing creations and the inspiration source [6].

Figure 1: Architecture inspired designs

The study intends to approach the relationship that exists between architecture and fashion, developing models of clothing inspired by the architectural structure and constructive design of the proposed models.

Developing and constructive design of models with stylistic elements taken from architecture

In accordance with the objectives of the study, here were developed models of clothing that are characterized by stylistic elements that are taken from arhitectural fashion. It will develop models for jacket product belonging to women, spatial models with surfaces obtained by using the polyhedron of various sizes located throughout the surface of a product item (bodice) or only on certain surfaces of the elements (upper bodice, ending sleeve).
Figure 2 presents the structural elements of buildings that were the inspiration in developing models of clothing. The dominant sources of this inspiration is the presence of geometric figures, the combination of triangles as basic element in obtaining three-dimensional effects that can be found on fabrics, knits as well as freestanding elements in different areas of clothing products.

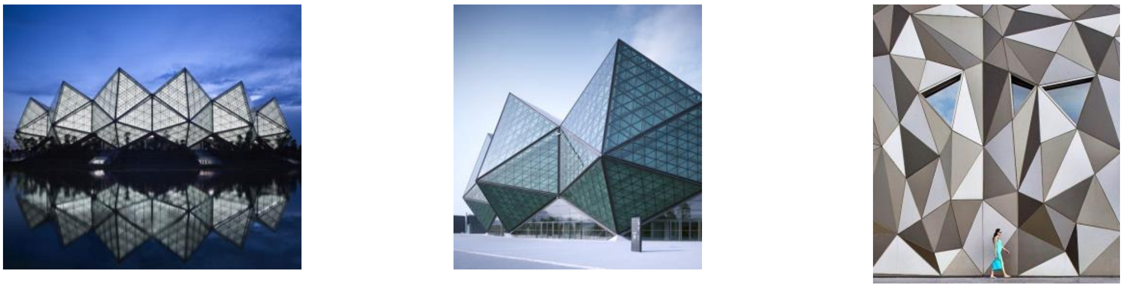

Figure 2: Architectural structures used as inspiration source in the creation of clothing [7]

Figure 3 indicates the developed sketches of models which are having three-dimensional shapes, placed at the top of the bodice, all over it, on termination of sleeve element, on the shoulders or on the back. Depending on the designer's desire these structural elements can be placed in other regions of the clothing.

Figure 3: Viewing designs.

The particularity of stylistic elements present on developed models, geometric figures that are based on the triangle, allows the constructive resolution of these models after a specific algorithm, with the following steps:

• basic geometric pattern design for the product type from fitting model;

• identifying the element of product or the area taken from it that will require modification of dimensions and shape;

• establishing dimensional increase for getting the spatial shape imagined by designer;

• going through the geometric modeling of initial surfaces;

• shaping the final forms of geometrical patterns, the projected polyhedra, which, after assembly, lead to three-dimensional shape of the model.

It exemplifies on the bodice of "Jacket for women" product, the stages of constructive modeling to be completed in obtaining from the form of 2D flat pattern the 3D shape model.
According to the specified algorithm in the first stage is projected the base pattern for "jacket for women" on average values of size with the main dimensions of body height (H), bust perimeter (P_b) and hip perimeter (P_{hip}) to standardized values (H = 174cm, P_b = 92 cm, P_{hip}= 100 cm) [1].
From the base pattern will be processed, in accordance with models particularities, bodice face completely, upper bodice face or bottom of the sleeve.
As the working method used to design the surfaces of the polyhedra which will increase the initial area of the models is similar, regardless of the position of this stylistic product element, will be the first model to illustrate the stages of transforming flat initial surface bodice in shaped space.
Definitive patterns of developed models are obtained in similar stages, difference from one model to another division lies in how the item initially splitting is correlated with polyhedra surfaces that will be placed in model.
It exemplifies for the reference model (model 1) the work stages of transforming the flat surface of the base pattern in a three-dimensional pattern for the model.
The first step is preparing the initial pattern (Figure 4) as follows:
• takeover of the base pattern bodice;
• transfer of bust dart within waist dart;
• positioning the division for the introduction directions at the top of the bodice to the surface that will be projected polyhedra, according to the model;
• positioning point P which connects with all the points that separate the selected surface;
• shaping the final form of the parts placed under polyhedra area.

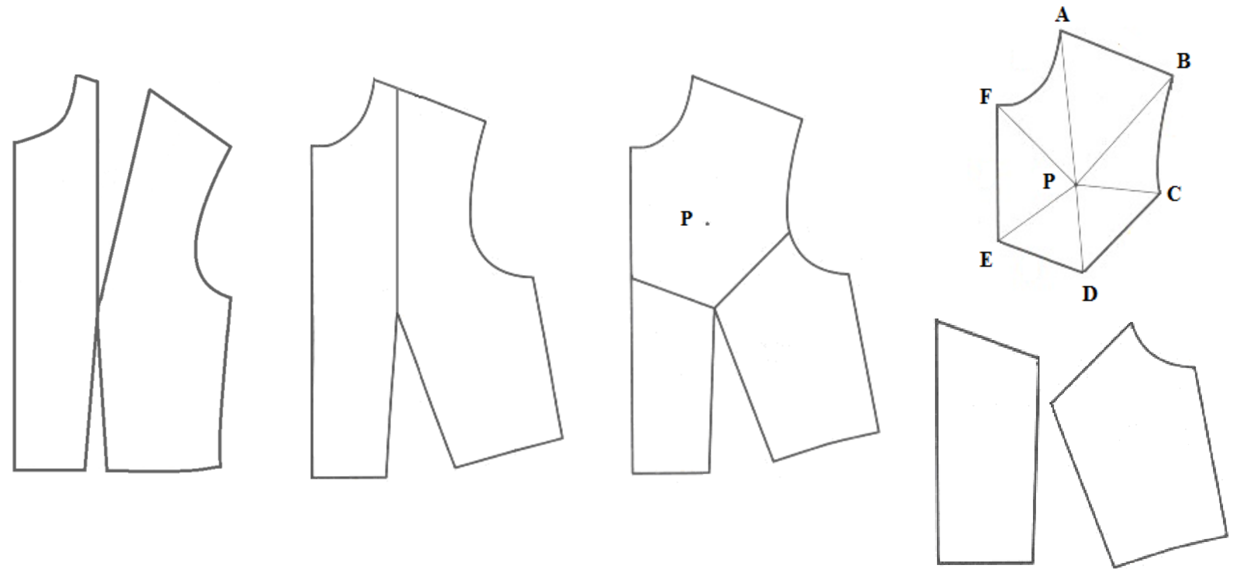

Figure 4: Preparing bodice

It is seen from Figure 4 that the surface of the base pattern that will change in order to obtain the spatial shape, was divided into six "triangles", each of which will be processed separately upwards inner sides baseline (Figure 5) as follows:
• sets a variable value P' which will allow to increase the inner sides of triangles and thus will determine the final prominent area consists of polyhedra (designed model was considered P P' = 6 cm);
• is copied each inner side of the triangles contained inside surface that is processed (AP, BP, CP, DP, EP and FP) and is projected at a height of PP '= 6 cm, is given new increased dimensions of the inner sides (AP', BP', CP', DP', EP ' and FP');
• joining triangles thus obtained in the initial order;
• it establishes the assembly line of the piece, according to the desire of the designer.
After the stitching between the two contours will get spatial form of the surface of the upper bodice.

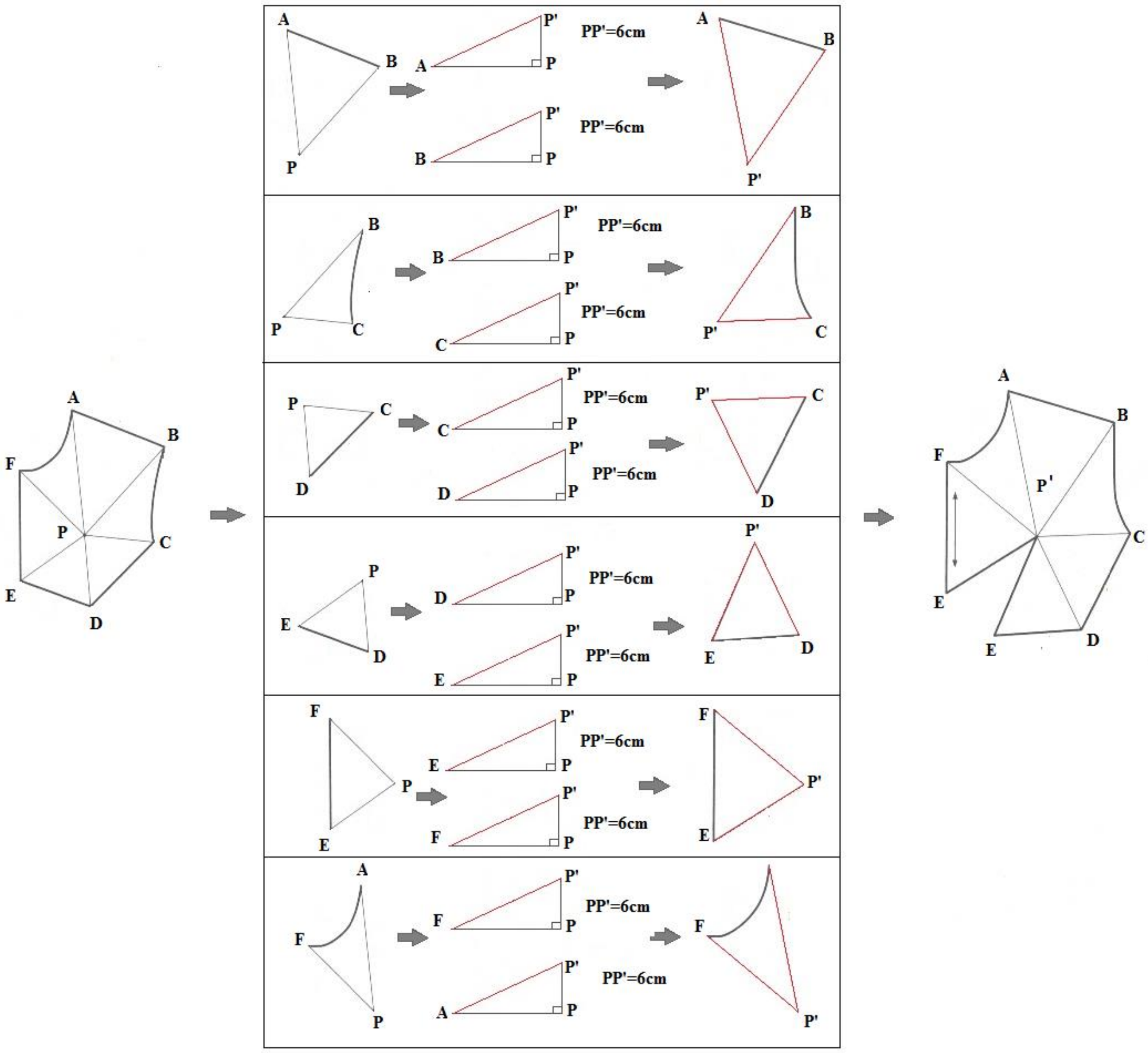

Figure 5: Surfacing initial form to obtain spatial model

This principle has been applied on the model 2 for which the Figure 6 shows preparation of the bodice, the final form of the parts that have been obtained by applying the algorithm introduced in model 1 and the prototype resulted in manufacturing the model [4].

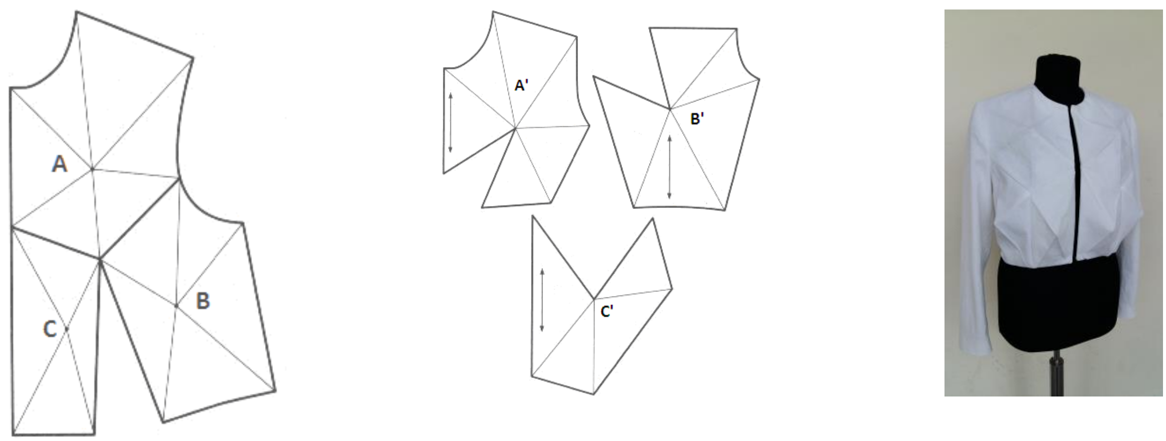

Figure 6: Viewing the stages of processing prototype for model 2

CONCLUSIONS

This piece of work is a study that aimed to identify stylistic connections that exist between architectural structures and clothing.
It was found that in the current fashion designers elaborate woven, knitted structures and clothing products which are inspired by architecture.
Models were developed for jacket product type belonging to women, models are showing on the upper bodice, all over the bodice or sleeves ending geometric shapes that are based on the triangle forms taken from architecture. These stylistic elements are present on various facade buildings, have a spatial form obtained by using specific architectural constructions techniques.
After the study of documentation was found that the volume of apparel products can be obtained by constructive processing of geometrical figure, through use of techniques known in descriptive geometry.
Models were developed following specific steps of constructive design that allowed resizing initial triangles in which the splited surface with stylistic elements are taken from architecture. The way in which the supplementation aspect of their initial triangles was conducted and shaped led to obtaining spatial surfaces that give volume and novelty to patterns.

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THEORETICAL CONSIDERATIONS REGARDING THE PROCESS OF DESIGNING PROTOTYPES OF CUSTOMIZED GARMENTS

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Abstract: *The overweight male persons have several problems when they need to buy clothes, such as pants. The stout persons are forced to purchase these products designed and manufactured in a customized manner because they are not able to find them in the mass production. The overweight male customer has 2 possibilities of wearing pants: one in which the level of the waistline of the pants is positioned above the bell prominence and another one in which the waistline of the pant is located bellow the belly prominence. In the first case, the person must fix the pants on the human body with belts or braces, while in the second one, the persons must wear belts. As a matter of fact, it is very important to know the difference between them and what alterations must be made in order to ensure a dimensional correspondence of the product , well as a high degree of comfort during the wearing process. This paper presents design solutions for the customized prototypes (the design process is solved with CAD functions) of pants for the 2 aforementioned situations, by taking into account the comfort requirements, and it also analyses the differences between them. In this way, the designer from the company will know what changes are necessary and how they must be done in order to obtain a good appearance and fitting degree of the product.*

Keywords: *prototypes, customized garments, stout persons, fitting degree*

INTRODUCTION

Nowadays, in a modern society, IT applications are very well diversified, developed and adapted to a specific purpose, such as entertainment, science, research, economy, medicine, culture, production, etc. These are used either as a communication tool (mobiles or internet networks) or as a production one, in different shapes, dimensions or degree of complexity. The activity of any small, medium or big company is deeply connected with IT applications or specialized systems because they represent an important instrument used for carrying out different manufacturing phases, production stages or department activities. With them as a tool, a company will have more time to elaborate new strategies for going on new markets and winning new customers or to become more efficient and competitive.
In the textile and clothing industry, the creativity, diversity and efficiency in producing consumer goods are obtained by using modern and updated equipment in each stage of production, with well-trained personnel and qualified workers, with a logically and efficiently organized structure. In this area, there is a huge and intensive competitiveness, because the consumer needs are more and more sophisticated and are also changing at a fast rate. In all branches of industry, as well as in T&C, the design and manufacturing process must be efficient and well-structured, because the product must arrive on the market in a short time, at affordable prices, diversified and in trend lines. Fashion has a major influence on T&C goods, because it influences the consumer's behaviour and needs.
In the modern society, the consumers are looking for specially designed products (customized) which must complete their profile in a harmonious and balanced way. As a consequence, two such products might have to differ one from another.
It is a known fact that two persons have different postures, conformations, and proportions. The shape of the human body is determined by nutrition, hereditary factors, and preoccupations (professional and social), by the person's lifestyle, health condition, and preferences. The modern society is currently facing an important problem: health. The population's health is evaluated by several specific medical tests and by the shape and size of the body. The WHO (World Health Organization) is an organization whose activity is focused on different research subjects [4] concerning the health and well- being state of the population worldwide (with different ages) at a community level or at a governmental one, because the results of their research indicate that there are major problems concerning the quality of life: infectious diseases, strokes, cancer, heart diseases, ***overweight/ obesity***, etc. The WHO defines the overweight and obesity terms as, [5]: an abnormal or excessive fat accumulation that may impair health.
The body mass index (BMI) is a simple index of weight-for-height that is commonly used to classify overweight and obesity in adults. It is defined as a person's weight in kilograms divided by the square of his/ her height in meters (kg/m2).For adults, WHO defines overweight and obesity as follows:

- being overweight is a BMI greater than or equal to 25, and
- obesity means a BMI greater than or equal to 30.

BMI provides the most useful population-level measure of overweight and obesity as it is the same for both sexes and for all ages. However, it should be considered a rough guide because it may not correspond to the same degree of fatness in different individuals or in different geographical areas. In different regions or countries, the obesity degree is very different, and this state of the population is determined by economic factors. The results of the research carried out by WHO on the health population show that in poor countries (such as Venezuela, Marshall Islands, Kuwait, Samoa, Palau, etc.[6]), there is an important percentage of obese persons, because the main concern for people in these countries is to fill up the empty calories with junk or fried food. The United States is the most obese country in North America with 35% of its population having a body mass index of over 30.0. Nearly 78 million adults and 13 million children in the United States deal with the health and emotional effects of obesity every day [6].
The Romanian clothing companies make products for a diverse network of customers for countries from Europe and America, China, Russia, etc. and in these conditions, the demands which they have to fulfil are dynamic and complex. The transition between manufacturing one product and another must be made with minimal perturbations, reduced costs, from the conception and designing phase until the delivery one.
This paper presents a solution of how to change a customized designing scenario of garments (male pants) for persons who do not have particular problems of posture and conformation into one meant for particular clients (persons with a medium obesity degree).

WORK METHODOLOGY

The fatness excesses, located at different levels on the human body, with different thickness determine a big diversity of human bodies with particular postures and conformations. This type of customers must face a serious problem: finding proper goods (clothes, shoes, furniture, cars, etc.) that fulfil their needs . The overweight body has a balanced position if it has a pronounced curved shape of the spine (in the shape of the letter 'S'), with forward positions of the head and neck and a very pronounced belly prominence (figure 1).

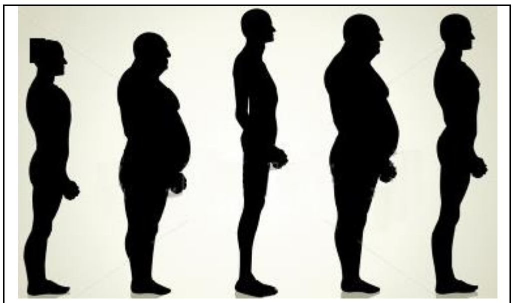

Figure 1. Different shapes of male bodies

Pants is a category of products that is widely used, with support on the waistline, which must be very well balanced and comfortable. The overweight male persons wear pants in two different ways: above or beneath the belly prominence point, according to their comfort needs and habits. [3, 7]
When designing customized pants it is important to know the level of the waistband and if the person wears braces or belts.
Customized garments are possible to design by well-qualified personnel and with proper functions of CAD systems. The Gemini Tailoring Assistant from Gemini CAD systems offers the possibility of making such types of products, by taking into consideration all the needed information about the shape of the human body and the characteristics of the product. The main windows and functions of this module are presented in figure 2. [2]
The classic male pant is designed in the following next steps:
-establishing the needed data type (the human body measurements, dimensions of the product and/or values of allowance) and introducing the particular values for each category, for one or several sizes. These values are either standard ones or individual, if a personalized and customized product is to be manufactured (figure 3);
-starting the design scenario. To do that, it is necessary to choose the position of a free point. This point is usually related to an important point of the pattern outline. The user will choose the design solution according to the shape and size of the customer's body and then she/ he writes different mathematical relations using the geometric functions from the MTM module for positioning the main points of the geometric layer.
The outline shape of the pattern is obtained by drawing and modelling lines anchored to the points from the geometric layer.
If some values of the initial data are changed, the shape of the pattern (piece) is changed in automatically. All derived pieces which are obtained from the main one are also changed .

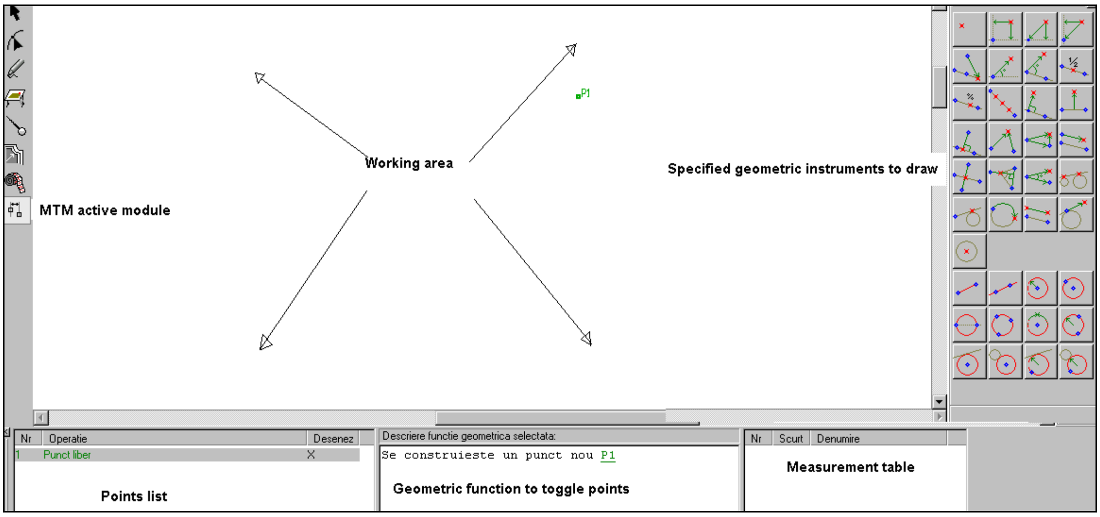

Figure 2. Window of Made to Measure Module

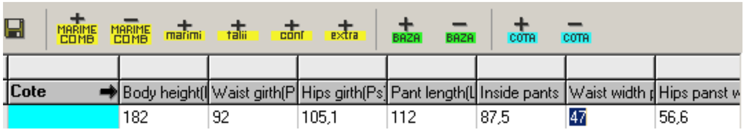

Figure 3. Initial data for designing the pant patterns

Comparing the design scenarios of the patterns of pants for persons with a normal posture and conformation with the one for persons who are overweight, some changes are necessary to do, as follows
-the way in which the level of the crotch line is established. Persons who are overweight have a pronounced shape of abdomen (figure 1). The level of the crotch line is established by taking into consideration this peculiarity;
-the way in which the width of the front and the back on the hips line is dimensioned.
In the case of overweight persons, there is a different way of dimensioning the main parts of the pants (front and back).

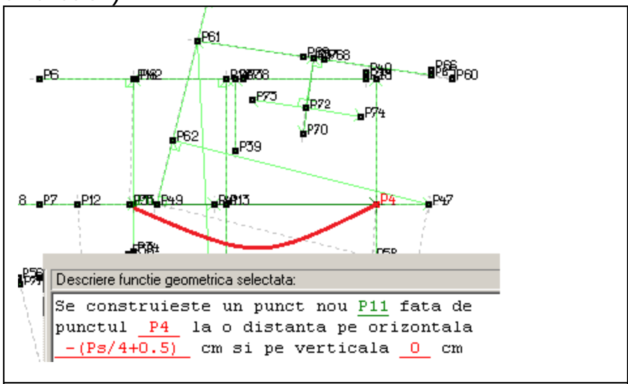

Figure 4. The front width (pants for persons with normal weight, conformation and postures)

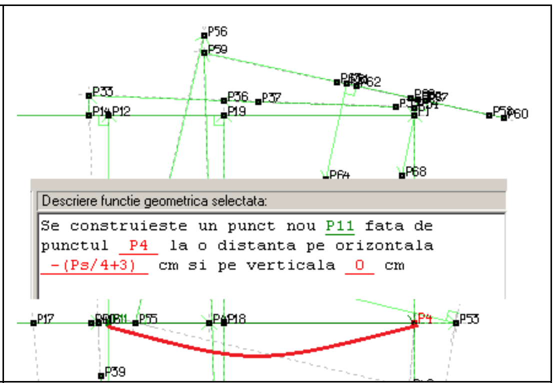

Figure 5. The front width (pants for overweight persons)

-the way in which the width of the main pieces on the fork line is dimensioned. The position of the waistband line.
If the customer wants to wear the pants over the belly point (he wears belt or braces), the middle point of the waistline is up (figure 7) and if he has a very well pronounced belly point, this point is below (sometimes very low).
In the case of overweight persons , there isn't any important difference between the girth of the hips and the one of the waist . As a consequence, it is not necessary to design darts on the waistline for them. The fit of the pants is made only by lateral seams (figure 8).

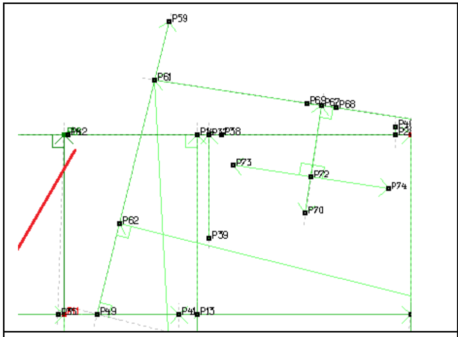

Figure 6. Waist point from the front middle line

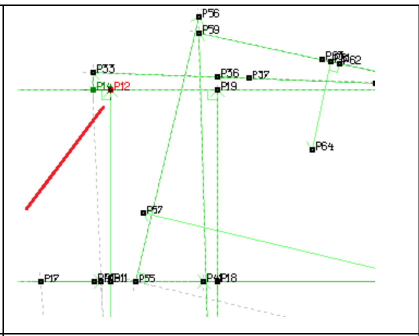

Figure 7. Waist point from the front middle line

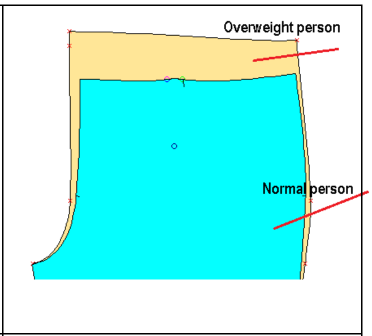

Figure 8. Front pieces superposed

CONCLUSIONS

By choosing this manner for designing particular patterns (for example pants for overweight persons), there are several major benefits that arise:
-at any time, the information from the sizing table can be changed very quickly. If in the sizing table there are added values that describe the dimensions of the body for a particular customer, all the patterns are re-drawn, by considering these new values (the design scenario is the same);
-at any time it is easy to change the design scenario and all the outlines of the patterns that are anchored to this geometric layer are automatically changed (the model pieces from the garment structure are changed);
-each pattern from the sizing table is automatically redesigned according to the initial data.
After modelling the patterns of the main pieces, the designer makes all the templates for cutting the model pieces that are necessary in the manufacturing process. If the designer changes the structure of the mathematical relations, all the pieces (templates) which are connected with the geometric layer will be automatically changed; in this way the designer's work is reduced.
This working method allows the import of all the needed information from a body scanner. The system has the possibility of integrating a 3D Body scanner in order to take the measurements of the human body, after scanning process, and generate all the cutting templates of the model pieces. This is a solution which enables the garment prototypes to be designed with accuracy, in a short time and according to the shape of the person's body .

ACKNOWLEDGMENT. Special thanks to Gemini CAD System for software support.

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THE DESIGN OF APPAREL PRODUCTS FOR PREMATURE BABIES

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Abstract: *This paper presents the design process of custom clothing product for premature babies. The study is based on the results obtained from theoretical and applied research regarding. These babies must stay in incubators for a long period of time and for this reason, they must wear functionally tailored garments suitable for these conditions. The clothes they wear are made from natural materials, perfectly adapted to the technological, physiological and anthropo- morphological requirements as well as to the medical equipment used in neonatal medicine. These clothes must be easy to put on or take off with few manipulations. The functional clothes, which are presented in this paper, were tested under clinical conditions, being very well appreciated by the medical personnel and by the parents.*

Keywords: *preterm babies, functional apparel products.*

INTRODUCTION

The design of adaptive clothing with high optional features represents a direction of the modern scientific research. The single-use adaptive clothing or multiple use adaptive clothing is designed with specific requirements of the groups that will wear them, but with the help of the artistic, constructive and technological solutions, it is perfectly suited to the anthropo- morphological characteristics of the babies and the wearer's usage conditions by facilitating the process of putting them on or off, and the required maintenance and medical procedures.
The aim of the research is the design of some adaptive clothing with high functional features for the premature children or for those who were born with low body mass, which can be used to the incubator intensive applications' conditions. The actuality of the presented research results from the today's analysis in this domain in the Republic of Moldova and worldwide, in the context of intensifying the efforts of the medical institutions and the parents' efforts regarding the increase in the survival and rehabilitation chances of the premature children. By taking into account the statistical data, showing the increase in the number of the premature births and the activities done by the medical institutions to increase the degree of the successful survival of the children born prematurely, the research results come to contribute to the improvement of the state of the premature child from the incubator with the help of the functional clothing products adapted to the requirements and conditions imposed. [1]

EXPERIMENTAL

According to the World Health Organization the baby born prematurely is the baby born alive and earlier than 37 weeks of gestation, usually his (her) weight is less than 2,500 grams, is viable, and has the length between 35 and 47 cm. From morphfunctional, biological, neurological and metabolic points of view, he (she) is immature, not fully developed and which most often adapts with difficulties to extra uterine life, requiring special care at birth and postpartum. The preterm infants require special medical care efforts incomparably greater than that involved in newborn care, and the studies in the field have shown the need to establish a special therapy at birth and postpartum in case of preterm newborns by respecting the actual prenatal care standards in order to reduce the neonatal morbidity and mortality. The premature newborn care includes: stabilization of premature newborn, ensuring and maintaining heating, maintaining respiration, preventing infection and appropriate nutrition. [2]
The experimental studies have established some basic requirements imposed on the clothing products for premature babies. The morphological and physiological characteristics of the premature babies have been analyzed according to the degree of prematurity, the medical care conditions have been considered and the requirements imposed by medical personnel and by the parents have been analyzed.
The premature babies weighing more than 2000 grams, without serious problems, can be placed in special beds, being dressed in clothing products intended for infants covered with extra blankets for additional thermal insulation. [3,4]

The premature babies weighing less than 2000 grams are placed typically in incubators in intensive care departments that provide optimal conditions for the development of the premature babies. They are dressed in clothes intended for infants, but of a smaller size, due to the morphological and physiological characteristics of the premature babies, they require special medical care and medical network in the incubator, the usual clothing products being inadequate as from the anthropometric as well as from the functional point of view, often being cut in areas used for medical devices, or at the end of the products.
The basic requirements imposed on the apparel products for premature babies in incubators are the ergonomic, functional requirements, the products must possess high functional properties, as the medical staff could dress or undress the baby in less than a minute in particularly in emergency medical situations. The clothing products should ensure stable thermal insulation conditions, and through the constructive and technological solutions, they must reduce the heat losses providing access to certain zones of the body without having to undress the baby completely. The elements of the attached medical devices don't have to be affected by the manipulation of medical staff or by the child's movements. The clothing products must be adapted to changes in position of premature child specific to the child's age and movements, the dimensions of the products must be suitable for the anthropo- morphological, but the closure systems and the assembling types should be simple and should not damage the sensitive and immature skin of the premature baby.
The fabrics used to make the clothing products must possess high hygienic proprieties, must be soft, must provide thermal insulation, must be able to be sterilized and disinfected. The natural fabrics of cotton or flax can be proposed according to the analysis of specific characteristics.
The braiding system for maintaining the shape of the product was selected for the design of products because this system allows the possibility to obtain products based on planar elements and it excludes the seams that can be traumatic for the premature baby. This system also allows the increase of the degree of thermal insulation of the product by covering some parts of the body with several layers of fabrics. The products will be encased by folding the parts of the flat elements, forming soft holes for head, arms and legs, giving the possibility to move the arms and the legs without twisting or pressing the attached medical devices.
To close the product, it was selected the superimposed system with buttons placed on the edges of the flat elements, which will not have contact with the child's body and it is ergonomic. Also, it can be suggested the system of closing with Velcro tape, which must be soft, flexible, on a textile tape.
The products can be designed in one size, thanks to the adopted constructive solutions. The dimension of the length of 40 cm bodies was used, the proposed solutions being according to the premature babies, which have the weight less than 2000 grams.
In the context of experimental researches there have been designed several types of products that can be used for the babies placed in the incubator. A product designed for premature babies has been defined, which is being folded to form holes for head, arms and legs. It is a product type sack, which involves attaching some elements to form holes for head and arms covering the legs like coveralls. The dimensions of the products have been designed to ensure hygienic product usage.
The elements of the products have been processed through fringing, but the endings have been processed through coating seams.
An important aspect that can be recommended is the use of products in various pastel colors, which could show the child's age, being a supporting factor for the medical staff.

RESULTS AND DISCUSSION

The research has developed a system of functional clothing products adapted for premature babies, consisting of prema, sack and coverall products. [1] The basic models are shown in Figure 1.
The prema type product (fig. 1, a) is a plan element of a complex shape with fringing contours and covering seams, made of cotton knitted. The product is put on by folding the lower parts covering the baby's groin and abdomen region and by twisted folding of the upper parts we cover the baby's shoulders and trunk, by fixing through the overlay with the buttons on the side edges of the product. Thus, the shape of products is obtained by braiding, the sealing system is on the edges of the sides and with a button and it has no contact with the child's body, and the product has five holes: for head, arms and legs.
The sack type product (figura1, b) shows a lower rectangular element with a curve cut for the neck and two upper elements that may be attached with the help of the buttons on the upper lines of the shoulders and on the side edges. The product is put on by folding the lower parts, covering the baby's legs and abdomen by attaching the upper parts. Thus, the shape of the product is obtained by the braiding system and the closing is on side edges on the frontlines with one button and it has no contact with the baby's body, and it has three main holes: for head and for arms. The product gives access to the lower limbs through the formed holes by folding the lower parts.

The petticoat type product (fig. 1, c) is a plan element of a complex form with fringing contours and covering seams, made of cotton knitted. The product is put on by the cross folding of the side parts, covering the baby's torso, the shoulders, the arms and the legs and fixing through the overlay with the buttons on the higher shoulder edges and the inner edges in the legs' zone. Thus, the shape of the product is obtained through braiding, the sealing system is on the upper and inner edges with buttons and has no contact with the baby's body, and the product has five holes: for head, arms and legs.

a. b c

Figure 1: Clothes for premature baby: a – prema, b – sack, c - petticoat

The functional clothes for premature babies are intended for babies placed in the incubator. The products mentioned are made from natural fabrics and represent constructive and technological solutions adapted to the anthropo - morphological and physiological characteristics of the premature baby, being according to the medical care requirements in the Department of Neonatology Pediatrics and are compatible with the medical equipment from the neonatal medicine. The products can be put on and taken off easily and quickly as by the medical staff, as well as by the parents without manipulations that would traumatize the baby. The products show no assembling seams that might traumatize the skin of the child, their form is obtained through braiding or via attachment or detachment of some elements, the sealing system and the edges are not in direct contact with the body, all of these features provide functionality and a high ergonomic correspondence of the products.
The adaptive clothing products for premature children might also provide psychological and moral support for the parents through the child's neat appearance, the use of several products adapted as dimensionally as morphologically.

The functional clothing products for premature babies are:

1) adapted to the conditions of wearing and treatment in the incubator by palpation, size and shape.
2) they represent components necessary for the premature child care by making the holes in places where specific medical devices are attached in the process wearing.
3) they contribute to the increase of the survival chances of the premature babies through correct positioning of the medical devices and facilitating rapid elimination of the product in medical emergencies.

The original constructive and technological solutions:

1) provide thermal and hygienic comfort necessary for premature children through the overlay of multiple layers of fabrics in the trunk, arms and legs regions, the use of some natural fabrics, and soft covering seams for the product's edges;
2) offer an anthropometric correspondence as for the baby's static positions of the child, as well as for his (her) dynamics by size, shape and the system of obtaining the form through braiding;
3) the braiding system and the closing system with buttons allow attaching the necessary medical devices and reduce the dressing and undressing time in medical emergency situations.

CONCLUSIONS

The design of adaptive clothing products for premature children implies the use of the systemic approach principles to meet the complex system of requirements imposed on these types of products.

The adaptive clothing products developed for children born prematurely are aimed at children placed in the incubator and correspond to the constructive and technological solutions that are original for all functions and requirements imposed to ensure the facilitation of medical care and monitoring the vital condition of the baby, as well as the psychological and emotional support for parents.

The clothes they wear are made from natural materials, perfectly adapted to the technological, physiological and anthropo- morphological requirements as well as to the medical equipment used in neonatal medicine. These clothes must be easy to put on or take off with few manipulations, because it is important to avoid any traumatisation of the child.

The functional clothes, which are presented in this paper, were tested under clinical conditions, being very well appreciated by the medical personnel and by the parents.

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THE STUDY OF THE PARTICULARITIES OF DESIGNING FUNCTIONAL APPAREL PRODUCTS FOR PREMATURE BABIES

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This work presents the results of a survey focused on identifying the constructive particularities of the apparel products designed for a special target group of wearers – premature babies or newborns with low body mass. The industrial production systems are exclusively oriented towards the development of products for newborns with a body length of 50 cm. It has been recently noticed that a big number of newborn children have the body length less than 50 cm (they are called premature children) and for this reason, it is important to analyse the physiological, morphological and functional characteristics of these products, as well as their influence on the designing and manufacturing process of such products. The condition of the premature children, shown by the physical stage and the development level of the thermoregulation system, is influenced by the hygienic properties of the clothes they are wearing. Sometimes, this category of children needs special care (for example resuscitation) and for this reason, those clothes must be functional, in order to allow special treatments. For this category of children, a wide range of products from national and abroad markets has been analysed, and it has been identified what types of apparel products are suitable for them. It has also been established which category of initial data is necessary to be used in the design process of comfortable and functional clothes for prematurely born children with reduced body-mass. This paper proposes constructive solutions (wrap solutions) for designing clothes for premature children, which allow comfort during the wearing time as well as permitting medical actions. The outcomes of this study consist in designing new products with special wrapping systems suitable for premature children who must stay in incubators. The functional clothes presented in this paper have been tested under clinical conditions, being very well ppreciated by the medical personnel and by the parents.

Keywords: *preterm babies, functional apparel products.*

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THE HUMAN BODY PROPORTIONS IN RELATION TO THE FASHION TENDENCY OF DESIGNING CHILDREN CLOTHES

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Introduction. There must exist a balance between the shape of the clothes and the proportions of the human body (calculated as ratios between different body dimensions) for a good correspondence from a dimensional and aesthetical point of view. Clothes for children have special aesthetical, comfort and hygienic characteristics, according to their age, needs, fashion tendencies and trend lines. This paper presents a comparative analysis between the scheme of designing children clothes, elaborated by the Russian designers, and another solution proposed by the authors of the paper, by taking account the compositional, stylistic and chromatic characteristics.

Materials and methods. For the purpose of this paper, the authors analysed stylistic, structural and proportional characteristics of different famous brands which produce children clothes, such as: Roberto Cavalli, Lourdes, Elisa Menuts, Dolce & Gabbana, Veronica Kanashevich, Riccoletass, Jacote, Silvian Heah kids, Sanmar 1968, Blue Seven, Boboli, Mayoral Making Friends, Sanetta, Pan-Con Chocolate, etc.

Results and interpretations. The children want to have clothes as their idols and parents, but these clothes must be manufactured according to their age and gender. The children considered the aesthetical characteristics of the garment more important compared the functional and economical ones. Nowadays, the designers use a middle line between the harmony and the comfort characteristics of the product in their collections.

Conclusions. The proportional and structural schemes proposed by the authors in this paper, by taking into account the ergonomical and comfort requirements, can be used as a reference point in proposing new collections of children clothes

Keywords: *proportions, clothing, children, clothing style, symmetry*.

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THE DESIGN AND THE DEVELOPMENT OF HEADWEAR PRODUCTS ACCORDING TO THE FASHION TREND LINE OF MODERN COSTUMES

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INTRODUCTION. The accessories have always played an essential role in costume appearance because they define the final profile of the wearer. Beginning with the Middle Ages, the Church established that all women should cover their heads with different types of headwear products. The latter protect the head from the influence of the weather (North and South areas), but they also represent an important decorative piece in different national costumes.
MATERIALS AND METHODS. This paper is based on a comparative analysis between the shape and mass of different headwear products, proposed by contemporary designers in different collections, and the position and size of the head.
RESULTS AND INTERPRETATIONS. After a considerable time gap, the headwear products (hats and caps) compete with clothes in fashion, trend lines and materials. These products complete and underline the female silhouette and costume with materials, shape, and size of specific constructive elements.
CONCLUSIONS. Different types of proportions, sometimes opposite, but in a good harmony are in the same collections realized by designers or in worldwide fashion shows. Nowadays, the diversity, complexity, and originality of different traditional folk costumes gain an important role in the customer's preferences, because each type has some special and unique features.

Keywords: *compositional structures, headwear, ratio proportions, collections.*

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KNITTED FABRICS FOR ROMANIAN FOLK COSTUMES

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The Romanian traditional costume is a synthetic fusion of many civilizations. Romanians mostly live in Romania, Moldova, Ukraine and Serbia, so their traditional costumes have many varieties.The beauty of the Romanian folk costumes is given by the existance of many regions and traditions, by the different source of inspiration and the wide range of colors used. Costume has existed for over 100 years, most often handed down from generation to generation. Romanian traditional clothing can be classified according to seven traditional regions, which can be further subdivided by ethnographic zones, which may range between 40 and 120, depending on the criteria used.
The most used materials for these costumes are weaved, because of the high fabric fineness, possible to be obtained on the weaving looms. Another category of materials, which can be succesfully used for such applications, are the knitted ones, due to their high comfort and stretch properties, combined with an attractive design. The applications of these fabrics are also extended to the areas where aestetic aspect takes prime importance, associated with the comfort and easy care, Jacquard fabrics being included in this group. Jacquard patterns are characterised by a combination of different colored yarns and structural elements, respectively floats or miss stitches.
The paper presents a collection of jaquard twill fabrics, with geometrical and floral patterns, designed with various motifs, covering the most representative regions of the country. The machines electronic needles selection and the CAD systems patterning facilities, provide the opportunity of creating a variety of jacquard structures, with different appearances and properties. The fabrics were knitted on the CMS 530 E 6.2 knitting machine and the programmes were designed on the M1 plus® pattern station from Stoll, Germany, in the knitting laboratory of the Faculty of Textiles, Leather and Industrial Management from Iași, Romania. A fashionable vest has been manufactured from jacquard fabrics, with floral designs, from Transilvania region, as a component piece of one popular costume.
An important limitation of weft knitting technology in case of these fabrics, is the machine gauge, which leads to a limited range of yarns that can be used for each gauge, thus influencing the properties and dimensions of the knitted fabrics produced.

Keywords: *knitted structures, jacquard design, folk costumes, CAD-CAM systems.*

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THE USE OF CALLIGRAPHIC ELEMENTS IN CUSTOMIZING PROCESS OF TEXTILES, CLOTHES AND CLOTHING ACCESSORIES

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Abstract: *The paper presents a study of the possibilities of using calligraphic elements in the customization process of textiles, clothes and clothing accessories. These elements were analyzed considering the relation between the graphic characters, the color scheme, the ideographic ensemble, and the position of the element in correlation with the destination, size and type of the product.*
The monograms, ideograms, slogans, and phrases presented in 2D or 3D shape are the calligraphic elements used to design different textile products (clothes, technical products, and clothing accessories). These calligraphic elements can be reproduced either by weaving, knitting or by a handmade process combined with special graphic technologies: pad and screen printing, thermal printing, as well as varnishing, sublimation, and digital typing. These graphemes are put on different materials by using a special ink compatible with its properties, because it must be resistant while used, washed, rubbed or when exposed to light. The type of ink used in these processes is a thermochromic one because it behaves spectacularly under the influence of the environment conditions (its color changes according to the temperature, it creates special effects and gives off pleasant scents).

Keywords: *calligraphic elements, compositional elements, graphic technologies, special inks.*

INTRODUCTION

Customization of the products as a big trend today determines current product designers to use new methods and means that would ensure the possibility of diversifying the ensembles of clothing One of these posibilities concerns on the use of calligraphic elements. If once, old calligraphic elements were used more frequent and in modest monograms, today these represent key-words, mottos, oversized visual and communicative expressions, with a sober geometrical or plastic character expressing itself as a compositional centre or creating illusions of texture found in any genre of textiles, clothing, footwear, fashion accessories, furniture products, body art, interior design pieces, cars, etc. The calligraphic manifestation of designers seems to not know demarcations as a field of application and as a character of a surface that it finds itself reproduced, whether they are 2D or 3D surfaces, textile suports, knits, leather, paper, cardboard, non-woven, polymeric supports, metal, etc.

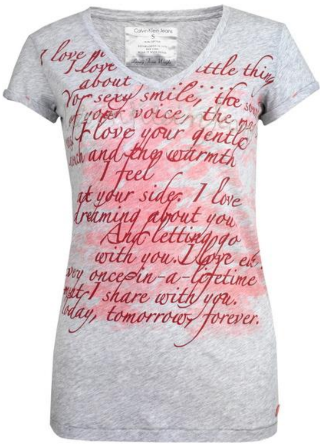
THE GOAL OF THE STUDY

Designation of the textiles, clothing, footwear products and fashion-accessories customized by calligraphic assemblies and the study of their aesthetic solutions and technologies.

MATERIALS AND METHODS

The study was extended on a sample consisting of textiles, clothing, footwear products and fashion-accessories ornamented with calligraphic ensembles presented in the figure 1.The methods used in research were: participant observation, interpretative method, inductive and deductive, qualitative, comparative, functional structural, analysis and synthesis.

Calligraphic elements in clothing products [1, 21]



Calvin Klein brand shirts [4]

Calligraphy in creation of Cristina Ivanov„Mark Ivanov Jeans"brand [8]

Footwear products decorated with calligraphic elements [22]

Calligraphic elements in body art [22]

Calligraphic elements in technical products:umbrella [22]


Calligraphic elements in decoration of a guitar and a airplane [22]


Calligraphic elements in decoration of a car [22]


Calligraphy in cookware and furniture [20]


Calligraphic elements in interior pieces

Figure 1: The use of calligraphic elements [22]

THE ANALYSIS OF CALLIGRAPHIC ELEMENTS USED IN CLOTHING, FOOTWEAR PRODUCTS, FASHION-ACCESSORIES, HEAD COVERS

The analysis of calligraphic elements used in aesthetic diveresification of clothing,footwear products and accessories witnessed the use of monograms by 60's of the XX century. Nowadays the calligraphic processes are represented by key-words, mottos, slogans, aphorisms, logos.The arangement of calligraphic elements that whe notice on different directions: vertical, horizontal, oblique, circular, focused on the most non-tradiotional areas of products: superior, inferior and central zone catch our attention.
The graphic character of elements can derive from the character of style of the product,developing its geometrical and plastic shape.
The compositional organisation of the calligraphic elements and their incorporation in the clothing ,footwear,technical products,fashion-accessories is made similar to execution of calligraphic elements on the paper supports by types of characters from libraries and softwares.Thus, the graphic diversity of analysed calligraphic elements has been structured by the following criteria:

- after aspect there are :
  - straight graphems;
  - italic graphems;
  - bold graphems;
  - bold-italic graphems.
- after thickness there are used:
  - white lines;
  - normal lines;
  - half-black lines;
  - black lines;
  - thick lines.
- after width there are:
  - wide characters;
  - normal characters;
  - narrow characters.
- after the technology of reproducing the graphic elements there are graphems reproduced by:
  - by weaving;
  - knitting;
  - embroidery;
  - hand made
  - screen printing;
  - sublimation;
  - thermal transfer;
  - electrophographic;
  - templating.
- after predestination in relation to the diversity of users was found the diversity of ensembles of graphic elements predestinated for (figure 2):
  - babies;
  - preschool small aged children;
  - high preschool age children;
  - small aged school children;
  - high aged school children;
  - teenagers;
  - young people;
  - adults.
- after the predestination in relation with the calligraphic objective:
  - everyday products;
  - customized products;
  - products for specific occasions;
  - uniform.

Figure 2: Clothing products decorated with calligraphic elements [2-3, 5-20]

The analysis of the possibilities of reproducing 2D or 3D calligraphic elements are made from thread, wool or ink with different properties.

Raised interest have the inks that allow the conversion of 2D to 3D graphics, thermochromic inks sensitive to changes in ambient temperature which lists ensuring tonal variation of gradational chromatics of the reproduced graphics.

Trends latest integration is the aromatic capsule in inks for printing with an application in various fields and purposes such as the: providing opportunities for identifying thematic materials that are used in clothing products for users with visual impairments, promoting calligraphic elements that invoke different flavors.

CONCLUSIONS

- graphical analysis of calligraphic ensembles on the products included in the study has revealed that they are very stylistic identity elements commonly used today as the diversification of clothing and footwear products , clothing accessories , headgear , technical products , etc.;
- textual elements reproduced by weaving or knitting are often grotesque graphemes without serifs , the horizontal ,vertical, oblique simple arrangement. Reproduced by print are characterized by their plastic, the display of serifs, layouts on complex trajectories , their integration with printed illustratitve graphics;
- the use of textual elements are not only decorative but also cognitive functions, informative, of spiritual identity of the user, customization;
- functional diversification of textual elements is made possible with the help of special printing inks: thermochromic, flavored , etc.

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NEW POSSIBILITIES FOR DESIGNING TEXTILES PRODUCTS IN ORDER TO IMPROVE THE SENSE OF PERCEPTION FOR PERSONS WITH SIGHT DEFICIENCIES

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Introduction. The World Health Organization reveals the existence of about 285 million people with impaired sight and about 39 millions of persons who do not see anything [1]. On these terms, it is important to find and use different solutions which can improve the quality of life and also increase their hope of leading a normal one.

The objective of the study. This paper proposes a different aesthetic solution for designing textiles, garments, and other products for this category of wearers (persons with impaired sight or who do not see anything).

Materials and research methods. For this research, there were analyzed different types of textiles made from flax and cotton, with smooth surfaces or not (thematic capsules were incorporated or the surfaces have a different shape of prominences printed with 3D printers), decorated with aromatic ink that gives off scents of fruits, wood, mint, flowers or lakes.

Results and interpretations. The outcome of this research is the use of some special inks with aromatic capsules for different thematic topics reproduced on textile surfaces, correlated with the design process of different embossed elements.

Conclusions. The incorporation of some aromatic substances in the inks used for printing different elements on the surfaces of the textiles helps the persons with impaired sight or who do not see anything make a quick and exact identification of different compositional elements, while also ensuring intensive emotions, providing them with pleasant experiences, and improving the quality of their lives.

Keywords: *aromatic capsules, compositional structuring, users with deficiencies sight, special inks.*

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ANALYSIS OF PRINCIPLES OF CONSTRUCTIVE DESIGN OF TRICOT PRODUCTS WITH SHOULDER SUPPORT FOR WOMEN

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Abstract: *The work examines the problem of elaborating the contours of basic templates of shoulder-supported tricot products for women. The scope of this work resides in determining the factors affecting the quality of positioning of tricot products on the wearers' bodies using the graphic constructive elements elaborated by graphic-analytical design methods. The study is based on the comparative analysis of 10 methods of designing shoulder-supported tricot products. The following criteria were used for analyzing the selected methods: structure of initial data, system of add-ons, modality of dimensioning the basic network, the type of calculation relationships for determining the constructive parameters, the methods of determining the location of constructive points and contour tracing. The theoretical study of design methods taken by the study has been completed with experimental aspects of elaboration and verification of quality of placing the products on the mannequins. The study allowed to identify the zones of vulnerability for the product positioning and implicitly, the construction elements generating defects and divergence in the „man-clothing" system in statics. The results of the study establish the premises for optimizing the algorithms for elaborating the basic templates by identifying the optimum connections between the calculation relationships and the shape of surface on the support.*

Keywords: *basic template, constructive additions, design principles, tricots.*

INTRODUCTION

One of the most sophisticated and sensible stages in the manufacturing of garments is the process of obtaining the templates of unfolded elements of garments. The essence of this process consists in obtaining an unfolded surface of any geometrical shape (model). In this case the unfolded surface implies the totality of all plane elements that allow to obtain a geometric object (product) from diverse materials (fabric, tricot, leather, etc.) adequate for the initial object.
The elements of products obtained in the result of construction, when assembled into a product, must provide for the similitude of model's visual characteristics with the final object. The parametric and geometric characteristics of reference elements must provide the following:

- ✓ Anthropometric adequacy of product in static and dynamic conditions;
- ✓ Reliability and functionality of construction in the process of exploitation of product;
- ✓ Dimensional correspondence of reference elements in the connection places at length and contour without additional adjustment, cutting and correction.

The spatial formation methods of the elements must guarantee their logical interdependence with the properties of respective materials. The configuration of reference elements must guarantee the possibility of technological execution of construction in the production process and during wearing.

STRUCTURAL ANALYSIS OF GRAPHIC CALCULATION DESIGN METHODS

Given the diversity and complexity of tasks to be resolved during the design process, the industry involves diverse methods and recommendations for constructing the templates of reference elements of garments. Some of the most accessible and frequently used ones are the *graphic calculation design methods* providing the possibility to construct templates both for the typical and individual bodies with a minimum number of analytical calculations using the graphic construction procedures. The essence of graphic calculation design technology resumes to the determination of positions of the basic reference points on the template surface in relationship with coordinate axes (unfolding lines) with the help of computed relationships or graphic constructions, with their subsequent attachment in the established order. All graphic calculation design methods are easily formalized allowing to automate the template construction process. Although there is a multitude of graphic calculation methods, these differ on the stages of template construction, structure of

initial information, position of coordinate axes, technology of calculating the coordinates of constructive points and dimensions of construction segments, as well as the employed graphic elements.
The process of constructing basic templates includes two to six stages depending on the applied method.
The first stage of preparation of initial data for constructing a template includes the analysis of constructive-compositional characteristics of the materials, data on the shapes and dimensions of human body.
The second stage implies the preliminary calculations of construction elements for establishing the main dimensional characteristics of corsage, its components and sleeve parameters, as well as the evaluation of coordination degree of the major construction elements.
The third stage – calculation and construction of the template's basic network, in accordance with the preliminary calculations.
The fourth stage – calculation and construction of template's basic scheme conditioned by the product cut, by constructing the symmetry lines on the back and on the front, the neck cut line, the sleeve cut line and superior cuts for the bust and shoulders.
The fifth stage – calculation and construction of principal lines for creating the product shape in the waist area.
The sixth stage – quality checking of basic template.
The initial data for the graphic calculation design methods include the body dimensions and shape, the specific values of legerity add-ons and data specific for the project being designed.
In order to characterize the human body the graphic calculation design methods require 2 to 40 measurement parameters. The number of measurement parameters depends on the type of product, its destination, the position of coordinate axes, the technology of determining the coordinates of constructive points and the degree of product personalization.
In practical constructive design of garments the positions of coordinate axes may vary. So, the vertical У axis may pass through the back symmetry line, or the front line of product. In the first case the construction is made from back to front, while in the second case – in the opposite direction.
The X-axis (horizontal) may pass via the cervical point, the lateral point of neck basis, via the bust or waist line. The position of coordinate axes defines the structure of calculation relationships and the graphic procedures of template construction.
In order to determine the ***coordinates of constructive points*** on the template various calculation relationships are used, depending on the degree of precision they are divided into four categories.
The relationships of type I are the most precise, as they imply a direct correlation between the sought coordinates of points and dimensions of human body. The precision of determining the dimensions of product reference points with the help of relationships of this type depends on how correctly have the add-ons been determined for the various product components.
In case of a smaller number of body measurement parameters, most widely spread being the calculation relationships of type II, in a constructive segment they are calculated with the help of an anthropometric parameter that does not directly characterize the respective dimension of reference element. The precision of determining the values of construction segments with the help of type II relationships depends on the exact expression of correlation between the main and secondary anthropometric dimension and the size of constructive add-on, as well as the correctness of its distribution on the constructive segment. Most often these calculation relationships are used in the methods of designing templates for typical bodies where they are interdependent and have a constant character.
The calculation relationships of type III are used for determining the coordinates of reference points on the template based on a previously established template. They are very rare in the modern methods, as they do not assure the necessary precision that depends, on one hand, on the correctness of establishing the correlation between the two template dimensions, and on the other hand, on the precision of obtaining the previous reference dimension.
The calculation relationships of type IV are used extremely rarely in the graphic calculation design methods where the sought value is defined as a constant numeric value.
The contours of basic templates are defined by the well-determined geometric procedures that involve the tracing of straight lines or curves. The exactness of generation of the curved contour determines the exactness of construction and the degree of dependence on the executor's qualification. The technology of tracing the curved contours in the construction and the compatibility of the method with the specialized design software, and implicitly, its actuality for the industrial design.

COMPARATIVE ANALYSIS OF METHODS OF DESIGNING TRICOT PRODUCTS

The process of elaborating the basic templates of tricot products to a significant extent depends on the tricot properties, especially its extensibility and production procedure.

This study has been focused on the jacket-type products for women, the tricot of extensibility degree I has been used (0-40%) owing to its compliance with the requirements of reliability of material and shape of finite product imposed on the jacket-type products. The external tricot products are characterized by laconic shapes, simplified cut, a reduced number of reference points.
Given the need to provide a good positioning of products on the body, that to a substantial extent depends on the quality of basic templates, it was decided to analyze a series of graphic calculation methods that are actually being used for elaborating the constructions of garments at the industrial scale. The study considered 10 design methods elaborated in 5 countries: Romania, Russia, Great Britain, Italy and Germany.

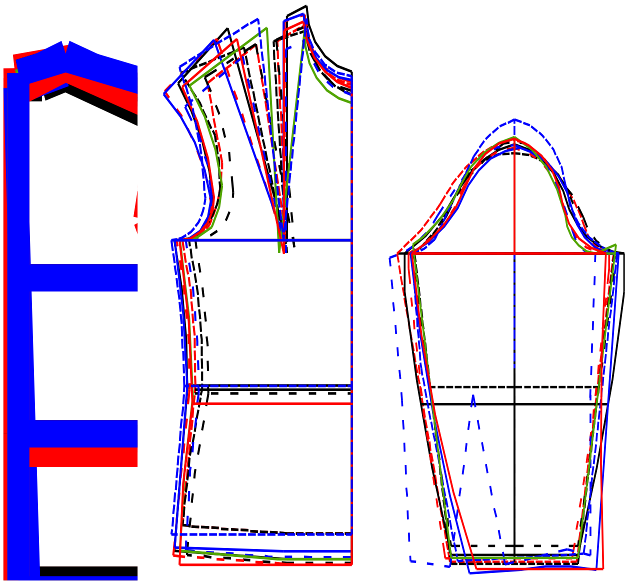

Figure 1: Comparative analysis by the superposition of basic template of a tricot jacket product, elaborated using the examined design methods [1-5]

Legend:

black fine dotted	Italian method	blue solid	Soviet method VDMTI[1]
red fine dotted	Englis method	red dashed	Russian method elaborated by the „Sretenka" Fashion House
black dashed	Romanian method	red solid	Method of Kuznetova L. A.
blue dashed	German method Müller & Sohn	green solid	Method of Konopaliteva N. M.
black solid	Soviet method LTILP[2]	blue fine dotted	Method of Kolomeico G. L.

The considered methods are distinguished by the structure of used initial data, the number of anthropometric indicators varies between 17 and 26, thus determining the incidence of using the relationships of type I. Two of the analyzed methods use the dimensional parameters that take into consideration the morphological particularities of human body. The legerity add-ons are calculated depending on the properties of textile material, practically in all the considered design methods (except for the Italian and German methods), as this ensures the adequacy of the tricot construction.
The methods fit the templates into the network lines, so that the main horizontal lines are resumed to the cervical, axillary, waist and termination lines, while two of the methods impose the tracing of shoulder lines. The vertical lines delimit the width of neck cut, of back cut, sleeve cut at the product front, at the same time determining the position of bust center. As initial design axes were used the superior horizontal line and the front symmetry line – in 8 out of 10 examined methods.
The coordinates of constructive reference points on the template are determined using the relationships of types I and II, assuring the precision of construction, the curvilinear contours being represented by flowery lines, being determined by the position of a series of auxiliary points.
The differences of constructive order between the contours obtained by applying the basic template design algorithms have been established by their superposition, using as superposition axes the symmetry lines of back and front sides, and the bust line of the product, and for the sleeve reference element – the basic line of the sleeve head and its central axis (figure 1).

[1] VDMTI – method of designing garments elaborated by the Union's Tricot Fashion House in Kiev, USSR.
[2] LTILP – method of designing garments elaborated by the Theoretical Institute of Light Industry of Leningrad (presently Sankt-Petersburg), USSR (presently Russian Federation).

The theoretical study of the selected design methods does not allow to determine the best one and to justify it for the design of jacket-type products. Therefore, it was decided to perform their qualitative analysis by manufacturing the models of products and checking the quality of their positioning on the mannequin. The standard body's initial anthropometric data was used: 164-92-100.

When testing the model, the equilibrium factor is determined, as a rule, by the positioning characteristics of certain segments of the product surface below the support elements and not by the positioning of equilibrium points of the support surfaces. The model testing has been performed in several stages.

The first stage included the evaluation of special-volumetric shape of products at the level of support surfaces assured by the respective depth of wedges or by respective heat and humidity treatment. At the next stage of model checking the position of product on the body in other zones has been performed, with evaluation of equilibrium on shoulders and at sides. The third stage of model testing included the balancing of product at the shoulder and lateral levels that depends on the value of back-and-front equilibrium. So, we have determined the zones of the product that have deficiencies of positioning on the body and have identified the principles of designing the templates providing for a high quality of product positioning on the body. These results have been used as a basis for the elaboration of an optimized algorithm of body unfolds adapted to the properties of the basic material and the requirements to a particular type of product.

CONCLUSIONS

The emergence of new materials for the manufacturing of garments requires improvements to the methods of designing the basic constructions. As the tricot industry is rapidly developing new types of materials with different properties, they are often used for manufacturing products of various types and destinations, including classical products that traditionally are characterized by rigid, laconic and smooth shapes. In this context the adequate choice of procedures for elaborating the basic templates determines the quality of product positioning on the human body. The graphic calculation methods are the most widely spread ones in the context of industrial design of garments, as they allow to obtain plane contours of unfold body shapes with sufficiently exact approximation, as well as to use the contemporary computer-aided design technologies. The problem of choosing the optimum algorithm for the elaboration of basic templates can be easily resolved based on the analysis of defining components for the particular group of design methods.

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OPTIMIZATION OF PROCEDURES OF ELABORATION OF BASIC CONTOURS OF TRICOTAGE SHOULDER SUPPORT PRODUCTS FOR WOMEN

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Abstract: *The work examines the assurance of maximum correspondence between the product support surface shape and the shape of human body by selecting the optimum initial data and use of adequate techniques for designing the basic templates. The experimental studies are based on the comparative analysis of 10 design methods for shoulder-supported tricot products for women. These results allowed to optimize the algorithms of elaborating the basic templates owing to the identification of optimum connections between the calculation relationships and the shape of support surface. The attempt has been made to elaborate a relatively simple algorithm of designing tricot products that would allow to reduce considerably the time spent for elaborating the basic templates in industrial conditions without affecting the positioning of products on the body. The subsequent verification of sample positioning on the mannequin has demonstrated the viability of applied algorithm. The optimized algorithm has been proposed and implemented in the experimental section of the company «Saltoianca» LLC in Chisinau municipality.*

Keywords: *design procedures, shoulder-supported tricot products.*

INTRODUCTION

The notion of design technology comprises a complex of methods and procedures used for designing templates allowing to resolve a specific design task. The most important design tasks are [1]:

- ✓ Determination of main physical dimensions of parts and construction elements, providing parametric connections between them;
- ✓ Parametric and geometric correspondence between the elements of support surface and the body shape and dimensions;
- ✓ Solution of problems of assuring the parametric and geometric correspondence between the lateral surface of product construction and the dimensions and shapes of human body.

These tasks become more complicated when designing tricot products due to the need to adapt these technologies to the physical-mechanical properties of textile materials.

THEORETICAL ASPECTS OF CALCULATION AND CONSTRUCTION OF BASIC TEMPLATES

The graphic calculation methods widely used for the elaboration of unfolded surfaces of shapes in order to obtain the basic contours of garments in the industrial production systems use different approaches to the task of determining the major dimensions of components and construction elements, as well as to the formation of parametric connections between them. Although, the best results are obtained using the methods involving the preliminary calculations of constructions. These calculations allow to determine both the physical dimensions of constructions and the connections between the constructive segments and the connected contours. So, in the absence of a preliminary calculation of parametric connections between the cut and the sleeve head there occurs the situation where the sleeve parameters depend exclusively on the sleeve cut parameters and are not correlated with the dimensions of upper extremities.
The problem of assuring parametric and geometric correspondence between the support surface elements of the construction and the dimensions and shapes of human body is directly related to the positioning of product on the body and implies [2]:

- ✓ Determination of values of anterior-posterior and lateral equilibrium;
- ✓ Determination of values of elements assuring the right shape of product on the frontal reference element (the bust cut) and at the back (shoulder cut).

The product is well-balanced on the body if the major level of equilibrium passing to the horizontal perimeter level of bust is in horizontal position. The position of this line depends on the relationship between the length of product front and back. The value of anterior-posterior equilibrium depends on the reciprocal position of upper extremities and neck cut of the front and back template creating the superior component of anterior-posterior equilibrium. The value of this component depends on the curvilinear profile of the body at the back and at the front. In case of greater convexity at front the equilibrium is positive, in case of equality of curves of back and front it is zero and in case of convex back (curved) – negative. The inferior component of anterior-posterior equilibrium depends on the difference between the length of anterior and posterior components measured between the bust and waist lines [3].

The lateral equilibrium depends on the correspondence between the angles of shoulders. The slope of shoulder lines in the construction depend on the position of upper extremities of neck cuts and the position of shoulder points that as a rule, are determined by the intersections of circle arcs, the dimensional indicators involved in these processes determine the quality of positioning the shoulder points in the construction [4].

In order to determine the depth of basic cuts (bust and shoulders) the design methods imply numerous processes. The less justified are the procedures of defining the depth of basic wedges via constant values. Most often, the design methods determine the depth of a bust wedge using the difference between the perimeters of bust II and I. One must mention that the correction coefficient appearing in these calculated relationships indicates a smaller degree of their precision.

The basic construction elements providing for the product shape in the lateral area and in the sagittal plane are the lateral lines, the „relief" lines, the symmetry lines of back and front reference elements. The definitive character of the symmetry lines depends on the presence of seam at that level, on the degree of product adjustment and on the shape of human body. The position of lateral lines depends on the product type, on the wearer's body shape and sleeve cut [5]. So, in free-cut products the lateral lines are located at the middle of sleeve cut, in light clothing for women they are slightly displaced towards the back, while in the constructions for coat or jacket-type products – with a substantial displacement towards the back of the construction.

ASPECTS OF OPTIMIZING ALGORITHMS OF DESIGNING THE BASIC TEMPLATES

In order to determine the optimization criteria for the algorithms of designing the basic templates of tricot products we used the parametric and geometric analysis of 10 graphic calculation methods of designing the unfolds of body surfaces adapted to tricot as basic material. The study involved the formal aspects of these methods: structure of initial data, calculation relationships, determination of connections between the construction elements, as well as the practical research – elaboration of product models and analysis of their positioning on the human body. The study was focused on the jacket-type product for women.

22 dimensional indicators of transversal and longitudinal orientation have been used as initial data, they included the perimeter, length, width, distance, height and diameters. The list of dimensional indicators has been established based on the existing anthropometric standards in order to provide for the possibility of industrial design. It is proposed to extend this list by adding two more dimensional indicators in order to improve the precision of tricot constructions – the distance from waist to the basic line of axillaries and the distance between the waist line and the shoulder line. For experimental purposes the values of these dimensions have been determined by measuring 10 subjects fitting in the selected body type. The system of add-ons has been conceived based on the analysis of alternative design methods, being then adapted after checking-up the product models. As for the product data, the semi-adjusted silhouette has been used, the tricot 0,1… 0,2 cm thick has been used as basic material, of first extensibility group.

In order to determine the main physical dimensions of parts and construction elements, as well as to establish the parametric connections between then a preliminary calculation has been done starting from the sleeve volume, calculated depending on the axillary perimeter of arm, with a legerity add-on, the cut parameters and the sleeve head have been determined, in order to provide for a connection between them. The transversal physical dimensions have been determined using the calculation relationships of type I, providing for the proper precision of construction.

The basic network has been designed bearing in mind the posterior symmetry line and the cervical line. The vertical lines of the basic network include the posterior symmetry line, the basic neck cut line, the line delimiting the width of back from the product, the line delimiting the width of product front, the bust central line and the symmetry line of the product front. The position of these lines has been determined by the I. In order to complete the network, the following horizontal lines have been drawn: cervical line, axillary-bust line, the waist line and the shoulder line coinciding with the product termination line. One must mention that for the tricot products, when determining the position of horizontal lines in the basic network it is recommended to use only thickness add-ons, the legerity add-ons being reduced to 0. This approach is explained by the deformation properties of material in the longitudinal direction under its own weight.

The assurance of correspondence between the product shape and the body at the level of support surface is done at the stage of designing the superior contours of product back and front. The neck cut at back has been fitted into a rectangle, its width depends on the transversal diameter of neck, while its height depends on the difference between the vertical arc of back and the length of back to the waist. The position of shoulder point at back has been determined at the intersection of arcs, depending on the value of oblique height of shoulder and shoulder length. Due to the properties of textile material, the scapular wedge has been substituted with a positional add-on o the shoulder line.

In order to provide for a good correspondence between the body shape and the product, the neck cut width has been increased, compared to the back cut width, by 0,5 cm. The position of upper extremity of neck cut at front, determining the anterior-posterior equilibrium of construction has been determined with the help of frontal waist line. One must mention that the experiment has been focused on a typical body of average size allowing the waist line to be designed horizontally. For bigger bodies the anterior-posterior equilibrium must be divided into superior and inferior components. The position of bust wedge top has been determined by relationships of type I, considering the height of bust and the distance between the mamelon points. The problem of adequacy of product shape in the bust zone is resolved by the parameters of bust wedge depth. It has been decided to use the traditional variant of determining these values by the difference of bust perimeters II and I. Despite of the fact that this variant of determining the wedge depth value is approximate, the ability of tricot to cover complex surfaces has compensated the insufficient precision and excluded the need to use the additional dimensional indicators. The slope of the shoulder line on the front template is equalized with the respective value of the posterior template in order to provide for the optimum value of lateral equilibrium.

The contour of sleeve cut has been traced by segments – two superior and two inferior segments by curved lines. The slope of inferior sector curves has been determined using the position of additional points. Cuts have been made at the limit of inferior sectors.

The position of lateral line has been determined by the basic line of sleeve cut with deviation towards the back reference element – this situation is characteristic for the straight-shaped jacket-type products. The configuration of lateral lines depends on the product shape at the level of waist line and is variable – from the straight line to a complex shape line repeating the body contour. The degree of product adjustment at the waist line level is determined by the specific legerity add-on, while the distribution of excess volume depends on the wanted product shape in the frontal and sagittal plane.

Before designing the reference element of the sleeve one must verify the length of its cut, the contour shall be re-designed, should any deviations be found to exceed 0,5 cm.

The length of sleeve head is determined by the cut length with positioning add-on necessary for providing the proper shape of that element, specific for the assortment. Traditionally, classic sleeves with one seam are designed for tricot products. However, for the jacket-type product the sleeve has to be designed of a stricter shape and therefore, two seams are necessary. The sleeve head contour is connected to the cut contour, the contour itself being a smooth curve.

In order to verify the optimized design algorithm, a product model has been manufactured with subsequent evaluation of its positioning on the body (figure 1).

CONCLUSIONS

The optimized algorithm of designing tricot products is based on a series of graphic calculation methods adapted to the properties of the mentioned textile material. The qualitative and quantitative analysis of these methods allowed to identify the sectors of the construction having a decisive impact over the shape of product and implicitly, over the quality of its positioning on the body. The structure of initial data has been examined in the process of optimization and solutions have been searched for designing the sectors of construction with the most numerous deficiencies. It has been established that despite of the high spatial shaping properties of tricots, when designing exact shapes a sufficiently large number of dimensional indicators is necessary, while the contours of basic templates must be designed with high precision. The results obtained in the process of optimization of the design algorithm have been demonstrated in the process of testing the product model.

Figure 1: Model of jacket-type product elaborated base don the optimized basic template design algorithm for tricot products

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SYMBOLS OF SLOVENIAN/YUGOSLAVIAN FASHION COMPARED TO WORLD FASHION CENTERS

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Abstract: *The rapid development of contemporary fashion design began in the middle of 19th century by the invention of sewing machine. From industrialization period to the World War II, fashion started transforming from tailoring to fashion designing. After the war, fashion and style were different from country to country. The revolutionary fashion began in late 50's and early 60's. In Slovenia and Yugoslavia, the late 1950's fashion was ruled by the trend of copying ready-made designs. The development of the textile industry evoked a need for new jobs in textile and fashion design. During that period, Slovenia as a part of Yugoslavia was similar to the other Eastern countries. Yet, Slovenian/Yugoslavian fashion production of the 60's started to follow current Western fashion codes. So, it started to differ from other Eastern countries. A survey was performed which showed some stereotypes regarding differences and similarities in Eastern and Western fashion.*

Keywords: *fashion, design, Slovenian fashion, Yugoslavian fashion, fashion symbol, fashion code.*

INTRODUCTION

Fashion is mobile; it is a process in motion, forever changing, reflecting society and time. Fashion illustrates the multi-layered and heterogeneous nature of time, cultural behavioural patterns and communication channels, as well as certain aspects of the identity of groups and individuals. Fashion is influenced by society, culture, industry, the economy, technology, the living environment, the media, religion and numerous other factors. Those reveal the importance of clothes as an aspect of fashion and outward appearance as a means of expressing status, privilege, trends, inspirations, symbolic messages, progressiveness, backwardness, needs within a particular historical period, the social and economic situation, as well as other phenomena and motivations that rapidly change the culture of dress and fashion [1]. Fashion is the result of acceptance of certain cultural values, all of which are open to relatively rapid influences or change [2]. Fashion has to do with innovation, the illusion of novelty. It is characterized by change, change in the past but also an expectation of change in the future. Fashion is part of our social world [3].
Fashion, its evolution and consumption, is an aspect of life that emphasises temporal, spatial and socio-historical differences; it allows us to confront how things were, to reflect on the relationship between tradition and the contemporary [1]. Fashion is a system of institutions, organizations, groups, producers, events and practices, all of which contribute to the making of fashion, which is different from dress or clothing [2].

WESTERN, EASTERN OR GLOBAL FASHION

French dominance in the high fashion originates from the 18th century, when the influence of art, architecture, music and fashion of the French court spread throughout Europe. The founder of high fashion was the Frenchman Charles Worth who established the first fashion brand in the French fashion industry. He combined the custom tailored clothing and standardization which is typical for ready-made fashion. His concept was followed by other fashion designers: Callot sisters, Patou, Poiret, Vionnet, Fortuny, Lanvin, Chanel, Maibocher, Schiapparelli, Balenciaga and Dior [4]. So, the development of fashion seems to have occurred in societies which were changing, where that change is valued by some group within the society, and social mobility is possible. Fashion is not possible in totally egalitarian society nor in a rigid hierarchy [3, 5].
In non-Western societies there seems to have been a tendency for dress styles and forms of adornment to remain fairly stable, to change very slowly [3]. Nevertheless, in everyday life, women in socialist countries found alternative ways to acquire pretty and fashionable dresses; whether they made their own clothes, purchased them on the black market or at private fashion salons, acquired them through their networks of connections, or had them made by seamstresses. Starting in 1960s, these unofficial channels gained in importance, with the discrete approval of the regimes. In contrast to socialist fashion, everyday fashion

undermined the system by introducing change, encouraging individual expression, and breaking through socialist isolationism [6].
Over the past few decades, Eastern and Western cultures alike have contributed to democratization of fashion. Multiculturism has enriched and infused Western dress with more divergent symbolic references, codes and conventions. By the early 1980s, the “aesthetics of poverty” dominated the work of a number of key Japenese pret-a-porter designers and their work today continues to underline the postmodernist emphasis on meaning and memory of fashion. Street style fashion in the 1990s became a conglomerate of styles underlined by DIY (do it yourself) philosophy. Ready-to-wear dominated the market on a local, national and international basis. The emergence of industrial globalization refers to the melting down of cultural boundaries – fashion has become borderless, no longer restricted to ideas that shaped nations. Global fashion meant global manufacturing, global marketing and global distribution [7].

SLOVENIAN AND YUGOSLAVIAN FASHION

The rapid development of contemporary fashion design began in the middle of 19th century by the invention of sewing machine. From industrialization period to the World War II, fashion started transforming from tailoring to fashion designing. After the war, style of dressing did not have the same global character, shape, or style. For the first time fashion and style were different from country to country. From that point on, fashion design has started developing all over the world in several different directions.
The concept of today's modern design began in the late 1940s. In 1947 in France, Dior created a collection named "New Look". The New Look was welcomed in Western Europe as a refreshing antidote to the austerity of wartime and de-feminizing uniforms. This form of fashion was embraced by stylish women such as Princess Margaret in the UK. Unlike Paris at that time, UK fashion was influenced by social changes. They developed a pragmatic and productive direction of design, based on the principle of equality, in which the new French fashion hit – Dior lost value by being considered an old-fashioned symbol of luxury and privilege. The establishment of "Made in Italy" coincides with the design by Emilio Pucci. Italian fashion had become popular and recognisable because of the colourful textile design and the precise leather design. In the first period after the war, Claire McCardell, Cristobal Balenciaga, and the comeback of Coco Chanel represented visionaries and pioneers in fashion design of that time [8]. On the other hand, the beginnings of the young, revolutionary force of contemporary fashion can be found in the creative work of Yves Saint Laurent. For the first time in fashion design, inspiration for collection was intellectually based on a new political radical philosophy – existentialism [9].
In the late 1940s, Yugoslav modernity transmitted through fashionable dress, was mainly representational, since industry was unable to deliver fashionable dresses due to post-war poverty and backwardness. Because Yugoslavia had been liberated by its own resistance movement rather than by the Red Army, the country was guaranteed a certain independence from Soviet influence after 1945. Yugoslavia’s different path toward socialism was mirrored in its different symbolic and material production of dress in comparison to that of other East European countries. Although factories had been nationalised, attack on Western fashion were never intense, and the Yugoslav regime did not establish a central dress institution to direct the design, production and distribution of clothes. Urbanized and elegant Western dressed played an ideological role in the domestic fashion press, where they were presented in opposition to the deprivations of the Soviet type of socialism, from which Yugoslavia distanced itself after its break with Stalin in 1949 [6].
Then, a new era of industrialisation began in Yugoslavia. Until the late 1950s, Yugoslavian fashion was ruled by the trend of copying other designs ready-made in the clothing production. The development of the textile industry evoked a need for new jobs, specifically in hiring textile and fashion designers. During that period, Yugoslavia was similar to the other socialist countries such as Russia or Czechoslovakian Republic with regards to fashion. Since 1952 in Yugoslavia started investing in fashion system. Fashion system soon after became major feature of modern-urban life in an improved socialist environment. Western fashion and fashion trends were subject of review and evaluation by a socialist system, in manner to fit the totalitarian pretensions of the regime. Standardization of fashion and control changes were made by specific aesthetics code - "socialist good taste". However, the ideal socialist clothing was an ideological construct that had little to do with real life. In order to prevent conflicts and possible disappointments in state power, the regime embarked on a project to create a whole range of institutions, that improved the fashion production and make commercial revolution [10].
On the other hand, privately owned fashion salons were officially recognized in Yugoslavia but were legally restricted, as private companies were allowed to employ only up to five people. Even the most prestigious among them, such as that of the Croatian designer Zuzi Jelinek, could not develop into proper fashion houses. The Croatian associate of private tailors, established in the late 1940, was active in organizing seasonal fashion shows, which took place with the full approval of the regime in the headquarters of the Crafts Association in the centre of Zagreb. The shows would last for ten days each September, and were

attended both by members of the pre-war elite and the new privileged social strata. The private fashion salons' seasonal fashion shows were important social gatherings throughout 1950s. They rivalled the prominent theatre premieres. At these gatherings, fashion brought together members of the disempowered urban elite with representatives of the new, powerful, but unsophisticated elites of rural origin. New civilizing rituals and rules of propriety were polished at such events through the medium of smart dress. In contrast, the seasonal fashion shows of the state clothing companies failed to attract such a dedicated following. Their dresses were not considered exciting, partly because they were industrially produced and presented in the unattractive premises of the Zagreb fair pavilion, and partly because they lacked the direct connection to fashion's past that the private fashion salons provided. The media also paid much more attention to the private salons' fashion shows than to those organized by the state clothing companies [6].
In the 1960s, there was a change in the Yugoslav fashion system. The regional identity of the fashion industry was linked to the special character of Yugoslavia's political and social situation as a socialist and non-aligned country. The regional identity of Yugoslav fashion can be seen in the designs of the local fashion productions of that time. Some of the most recognized fashion designers in Slovenia/former Yugloslavia were: the socialist version of the haute couture created by Aleksandar Joksimovic, the handmade knitted products "Sirogojno", and the fashion collections of Eva Paulin, Metka Vrhunc, Vesna Gaberscik Ilgo, Mirjana Maric, and many others.
The use of ethnic motifs in socialist fashion was an ideologically informed quotation. Such decoration perfectly suited socialism's isolationism, fear of competitiveness, and idea of its own uniqueness. At its highest representative level, an ethnic-embellished garment was seen as an art piece. The Serbian fashion designer Aleksandar Joksimovic presented richly embroidered dresses in his 1967 collection "Simonida" inspired by the opulent Byzantine style of the eponymous Serbian medieval queen. Cleverly combining simple cuts with lavish decoration, Joksimovic created a collection that the domestic media immediately declared to be the first Yugoslav haute couture. The collection's opulent aesthetic, infused with national heritage, supported the representational needs of the regime [6]. His other collections were also innovative and up-to-date.

Figure 1: Collection "Landscape" (1968) designed by Aleksandar Joksimovic

Figure 2: Collection "Peru" (1980) designed by Vesna Gabrscik Ilgo for Almira knitwear industry

Figure 3: Collection designed by Metka Vrhunc presented at BIO 11 - Bienalle of Industrial Design, Ljubljana 1986

EXPERIMENTAL

A survey as a preliminary study of the Slovenian and Yugoslavian fashion reputation was performed among the participants of the Autex 2016 textiles congress, held in June 2016 in Ljubljana, Slovenia. 7 males and 7 females participated aged from 24 to 57 years. They were all employed in textile technology and design field as university teachers/assistants, researchers and developers in the industry, designers and librarians. They came from Slovenia, Bulgaria, Tunisia, Turkey, Pakistan, Australia and China.

They were asked the following questions:

1. Are you familiar with the way the global fashion system functions?

2. Are you familiar with the development of the global fashion design during the 20th century?
3. Are you familiar with the development of the (ex) Yugoslavian fashion and textile industry in the 20th century?
4. How well do you know (ex) Yugoslavian fashion design and fashion system from the 20th century?
5. Did you ever see or buy a (ex) Yugoslavian fashion or textile product?
6. In your opinion, what are the main qualities of the fashion products that have been made in (ex) Yugoslavia?
7. Do you know an (ex) Yugoslavian fashion or textile designer from the 20th century?
8. Are you familiar with any of the clothing production enterprises from (ex) Yugoslavia?
9. Please circle the name of the (ex) Yugoslavian textile/clothing enterprise, business or fashion brand that you've heard of or known. 1. Almira; 2. Kluz; 3. Sirogojno; 4. Jugoexport; 5. Centrotekstil; 6. Arena; 7. Mura; 8. Labod; 9. Pelister; 10. Bitolateks; 11. IUV; 12. Konus; 13. Titeks; 14. Prvi Maj; 15. Beko; 16. Varteks; 17. Lisca 18. Kroj; 19. Angora; 20. Rašica.
10. If you know any of the following designers, please circle the number in front of the name. 1. Aleksandar Joksimovic; 2. Mirjana Maric; 3. Vesna Gaberscik Ilgo; 4. Metka Vrhunc; 5. Zinka Kovac; 6. Mojca Besenicar; 7. Rikard Gumzej.
11. How would you define the aesthetic of the (ex) Yugoslavian fashion?
12. In your opinion, is the (ex) Yugoslavian fashion system comparable to the global fashion system?
13. To which countries/styles/aesthetic could the (ex) Yugoslavian fashion system be compared? 1. France; 2. Italy; 3. USA; 4. Eastern Bloc; 5. Russia; 6. Turkey; 7. UK.
14. Please circle the number in front of the image that you think is representing a fashion product made in (ex) Yugoslavia.
15. Please circle the number in front of a word, which describes the presented pictures/designs the best. 1. modern; 2. good design; 3. bad design; 4. well done garment
16. In your opinion, what was the main problem of the development of (ex) Yugoslav fashion system?

For the Questions No 14 and 15, the participants were shown pictures of fashionable garments from various decades of the 20th century. Among them, fashion designs of eminent (ex) Yugoslavian designers were presented.

RESULTS AND CONCLUSIONS

The results of the survey showed that the participants older than 35 have heard about or have seen products of the Yugoslavian textile and clothing industry (regardless of profession and gender).

9 of the 14 respondents (5 males and 4 females) thought that the Yugoslavian fashion was comparable to the global fashion. 1 woman had no opinion while 4 respondents answered that it could not compete with the global fashion. Yet, the same respondents revealed that they were not familiar with the fashion system nor with the 20th century fashion.

The majority of the respondents did not know any (ex) Yugoslavian fashion designer. At the same time, only 5 respondents were not able to name a Yugoslav textile factory; all the others know at least one. Only Slovenians or residents of the neighbouring countries could name at least one Yugoslavian fashion designer.

The aesthetics of the Yugoslavian fashion was evaluated as good (2 men and 4 women) and average (5 men and 1 woman), while 2 women did not have an opinion about it.

Most of the respondents pointed photos of models with ethnic patterns as Yugoslavian fashion. It is interesting that 5 respondents recognized Pierre Cardin's collection as Yugoslavian fashion. 4 respondents recognized YSL collection as the Yugoslav fashion while the collection created by Aleksandar Joksimovic was recognized as Yugoslavian fashion by 8 respondents. It is interesting that the ethnic patterns were automatically associated with Yugoslavian fashion.

The Yugoslavian designers were evaluated as follows. 5 respondents thought that Alaksandar Joksimovic's collection was good design, 2 men and 1 woman believed that it was well made, and 2 men and 2 women assessed it as a modern garment.
The collection created by Vesna Gabrscik Ilgo was evaluated as modern by 4 men and 2 women. 2 men and 2 women thought that is had a bad style, while 1 man expressed the opinion that it was well-designed. 4 women found it a well-made garment.

For the collection designed by Metka Vrhunc, 3 men believed that it was good design, 3 believed quite opposite that it was bad design and 1 man believed it was well-made. 1 woman wrote that the presented garment was modern, 3 stated that it was well made, while 2 women believed that it was badly designed. 1 woman didn't know how to assess the garment.

The respondents defined the following main problems in the development of the fashion system in Yugoslavia:

- inappropriate media approach at home and abroad,
- industry not adopted or transformed according to the new circumstances,
- large system disabling smaller producers,
- lack of vision and planning the future.

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TRADITIONAL FOLK COSTUME – INEXHAUSTIBLE SOURCE OF INSPIRATION FOR DECORATING GARMENTS

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Abstract: *The ethnographic and folkloric reality of contemporary Romania continues to be an archive that keeps alive significant values for the Romanian culture. Our duty is to know these values, to acquire, treasure and capitalize them in different forms, from expositions and printings to modern contemporary clothing.*
The new social-economical realities existing in our country following World War II profoundly influenced the people mentality towards the inborn cultural tradition and implicitly both ordinary and festive clothing. Gradually even the peasants started to partially or completely abandon the traditional costume, adopting different types of industrial-made products.
Considering this, it is mandatory the study and exploitation of the traditional costume on a deeper level than purely ethnographically.
The purpose of this paper is to transfer the popular Romanian motifs in knitted structures, respecting both chromatics as well as the folkloric motif. This can be utilised in different clothing products and accessories production.
In this paper certain decorative elements of the Romanian folk costumes were transferred in knitted structures, respecting the original chromatic themes and patterns, in order to diversify, enrich and embellish the knitted products, indifferent of their nature (clothing products, accessories etc.).

Keywords: *folklore, creation, knitting, process, product.*

INTRODUCTION

The economical and social realities of our country profoundly influenced the people's mentality towards the inherited culture and implicitly the quotidian and festive clothing.
Although serial manufactured clothing come first because of diversity, versatility, functionality and improved comfort, as well as modern execution techniques, maintenance and use, a growing interest is observed in returning to a series of folklore products, that provide affiliation, continuity and pride in our ancestral roots.
For quotidian clothing many villagers have accepted serial manufactured garments that replaced the functionally similar pieces, previously home-made. Despite this, the festive and ceremonial outfits of peasants from Bucovina and Iasi continue to be ruled by the traditional costumes deeming that only this way the villagers can completely express their regional affiliation and cultural identity.
Because of the variations that the Romanian folkloric costumes knows, it is required understanding this genre as an inspirational source for the modern man. As such, study and capitalization of the Romanian traditional costume is necessary to be made on another level than the purely ethnographical one, considering the fact that it is absolutely necessary that the youth knows, understands and is educated in the spirit of love for our ancestral attires. Thus diverse possibilities of enriching and embellishing the modern fashion products are created, by adapting the Romanian traditional ornaments and chromatic.

1.1 CHARACTERISTICS OF THE FOLKLORIC ROMANIAN COSTUME

The costume pieces that compose a folkloric woman's attire (figure 1) can include: hair or neck ornaments, shirt, traditional skirt, traditional vest, pouch and traditional leather shoes.
The most simple **head and neck embellishments** were made of beads (that in the past had a magical symbolism) in one colour or in combinations of two-three colours. Especially artistic are **"the collars"** used in all the Moldavian villages, decorated with the same motifs as the girdle: geometrical motifs called "looped flowers" in white, green, black, brown, blue and pink. The interlocking of these colours creates the ornaments.
They give artistic individuality and shine to a folkloric costume and show the socio-economical differences in an area or ethnographical zone.

The decorations on the folkloric costume pieces are concentrated on the sleeves, chest, girdle and vest. For the ornaments coloured wool was initially used. Ulterior, conjoined with the economical growth and life standard rising, different types of coloured cotton, silk yarns, golden or silver metallic yarns, small porcelain or glass beads and tinsels were adopted.

Figure 1: Women's traditional folklore costume

With a special artistic refinement, the decorative compositions are distributed in well-defined ornamental fields. On the sleeves the decor is divided in three distinct segments (figure 2). **The shoulder segment** concentrates a register of successive motifs (geometrical, vegetal, zoomorphic and cosmological), clustered in cases or ordered in chromatically differentiated groups of lines. **The "rippled"** is a 7-10 cm wide band that is always sown in a geometrical composition based on diamond shaped motifs that serves the purpose of separating the shoulder segment from the rest of the sleeve. **"Rivers" or "rows"** are represented by parallel or oblique lines. Their number varies from a single column placed in the middle of the sleeve to three, five or more when they are arranged obliquely. The flounce or the sleeve cuff is also decorated with wrap-round ornamental motifs. On the chest section of the shirt, on each side of the opening, a column of embroidery is realized. On the back of the shirt two more rows of motifs are situated towards the sleeves.

Figure 2: Diverse ornamental motifs of women's folkloric blouse

The embroidery techniques imply multiple types of points, whose variety is dictated on one side by the time in which the pieces were realized and on the other side by the specific of each ornamental field. The beads

and tinsels served in the Bucovinean costume only as accentuating points for embroidery motifs, with the role of highlighting or limiting different motif categories in the sleeve decorations.
The chromatic of the Bucovinean costume is dictated by the wearer's age, characterized by a refined and discrete polychromatic in which tones of red can create the dominant palette for festive pieces of young women or new wives, and burgundy, brown and blue in combination with tones of yellow and olive form the chromatic panels for older women and wives.

1.2 FOLKLORIC ROMANIAN MOTIFS

As far back as Thracian times, in the culture and popular art, people transposed in the national sowing décor their observations and knowledge synthesized and generalized in forms that render both geometrical and non-geometrical figures. The ornamental elements and motifs like "flower, leaf", etc. have been permanently reproduced by the village artists, and the craft of the women practicing the sowing art made possible the simplification, stylization and processing the motifs to the most perfect classic morphology.
The Romanian motif adorning an object varies depending on the use given to the sown piece: as clothing, ornament or household object.
For ornamental pieces (shawl, handkerchief, towel etc.) are used motifs that contain stylized flowers, birds and insects.
For clothing pieces in general and especially festive clothing (traditional women and male shirt, breastplate, sheepskin coat), are used motifs that contain flowers, geometrical elements, household and agricultural tools, animals, cosmic elements all rendered in a stylized form.
These ornamental motifs are classified in 3 different groups: abstract, realistic and symbolist.
In the embroiled décor that contains these elements, they never appear separated from each other, on the contrary they are sown closely interwoven or merged in the same motif.
Ornamental abstract motifs (figure 3) result from material structures, a technique game with dots, lines, overlapped lines, triangles, squares and rhombus etc.

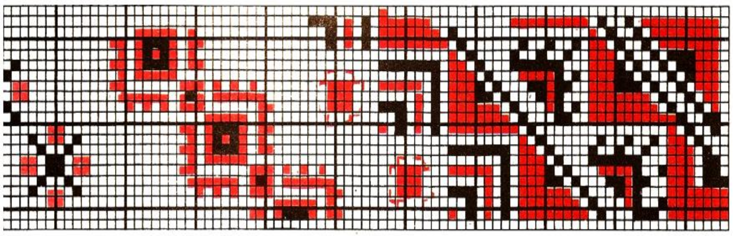

Figure 3: Abstract ornamental motifs

Realistic ornamental motifs are divided in 3 big categories: physiomorphic, skeuomorphic and social. From these, the greatest distribution was known by the physiomorphic motifs that are in turn divided in 4 subgroups: "cosmic", "phytomorphic","zoomorphic" and "anthropomorphic".

1.3 ADAPTING THE ORNAMENTS AND THE ROMANIAN FOLK CHROMATIC IN KNITTED CLOTHING PRODUCTS

In all the Moldavian ethnographical areas, a predilection for polychromatic stitches is seen. Colours are especially used in order to border an embellished field and to spotlight an element, motif or composition, opposed to the monochromic stretch of the piece's background (the white space of the used material, unembellished monochromic space). This way the decorative character of the piece and the artistic value of some ornaments are accentuated. This esthetical conception is strongly underlined in the context of Moldavian embroiled ornament chromatic.
In this paper certain ornaments of Romanian folkloric costumes have been transferred to knitted structures, respecting both the chromatic and the traditional motifs, in order to diversify, enrich and embellish the knitted products, indifferent to their nature (clothing products, accessories, etc.).

1.3.1 Floral motifs (phytomorphic)

In the group of „phytomorphic" motifs are included representations of the vegetal world: plants, leafs, flowers, fruits. The flowers frequently reproduced in sewing are: daisies, roses, mountain peonies, sweet marjoram, sunflowers, etc. rendered stylized, up to a global geometric form. There are areas that are characterized by a non-geometric rendering, in a free hand-drawn manner, reproducing the forms closer to their natural look.

The most encountered fruit motifs are: grapes, apples, pears and plums. In the sewing also appear smaller or larger fir trees or fir branches. In figure 4 some examples of phytomorphic motifs are presented.

Figure 4: Ornamental phytomorphic motifs

In figures 5, 6, 7 are presented four floral motifs transposed in jacquard knitted structures (full jacquard, partial or layered).
In all cases the floral motif and the area specific chromatic was respected. Usually on a monochromatic background – white, the floral motif was realized in colours of red, black, yellow and green, in order to easily stand-out.

Figure 5: Folkloric floral model transposed in knitted structure as a full jacquard design in 3 colours

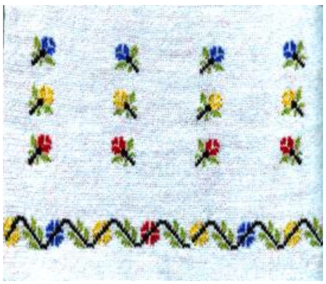

Figure 6: Folkloric floral model transposed in knitted structure as a layered jacquard design

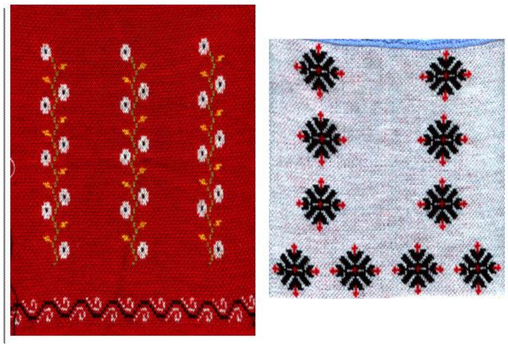

Figure 7: Folkloric floral models transposed in knitted structures as a partial jacquard design in three colours

In figure 8 some examples of knitted products are presented, (clothing articles as well and accessories) with folkloric phytomorphic motifs.

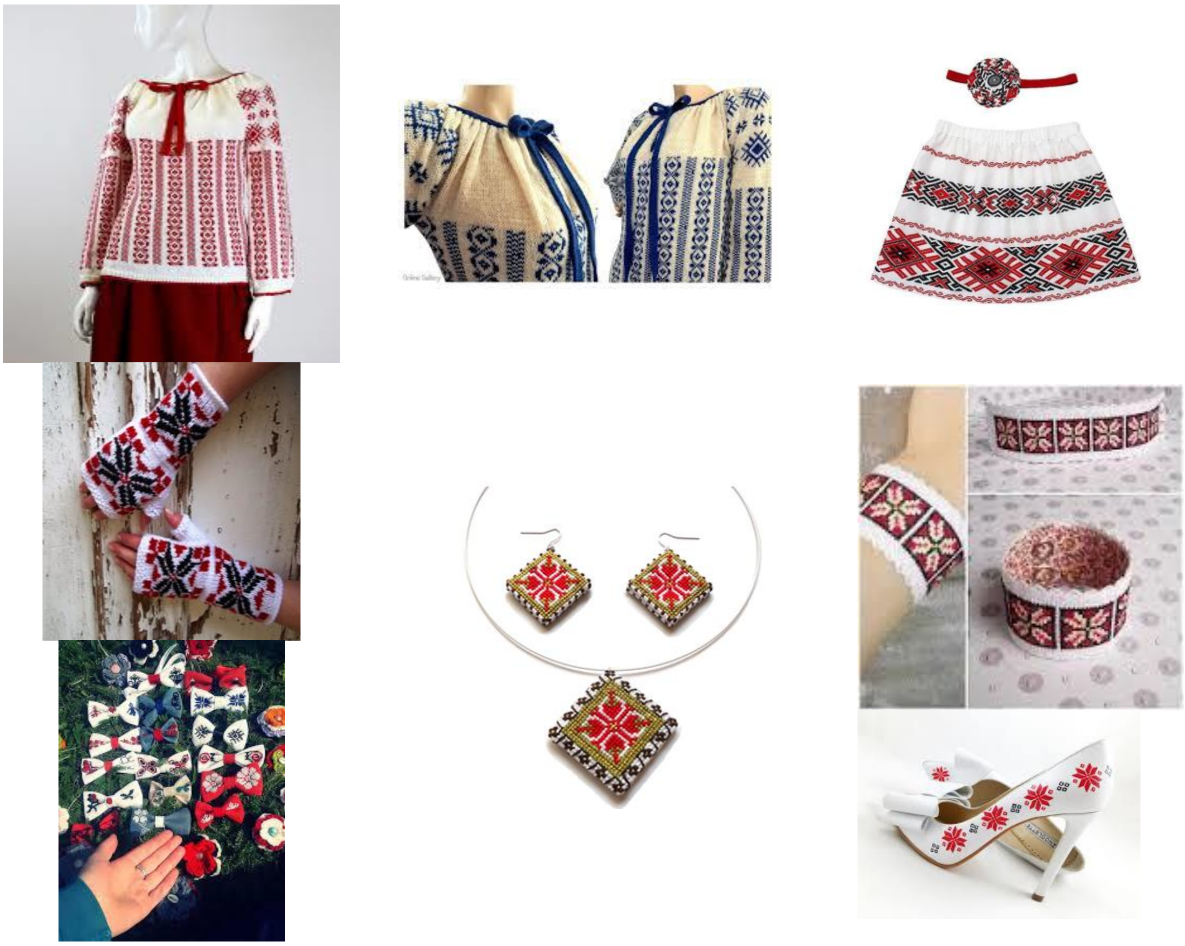

Figure 8: Knitted products and accessories with folkloric phytomorphic motifs

1.3.2 Zoomorphic and aviary motifs

Zoomorphic motifs – „ram horns", „ox head" (figure 9) are very old and wide-spread on both versants of the Carpathians. The zoomorphic motif – ram horns has been realized in a layered jacquard knitted structure in two colours: red and black (figure 10).

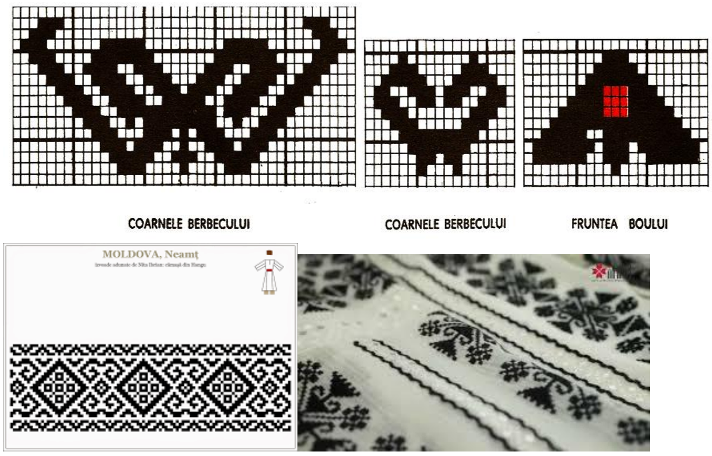

Figure 9: Zoomorphic ornamental motifs



Figure 10: Accessories of knitted structures (layered jacquard in two colours) with zoomorphic folkloric motif

Most common **aviary motifs** are: the sparrow, the rooster, the pigeon and the pair of birds separated by a flower of a small fir tree (figure 11).
The motif – pair of birds separated by a small fir tree that represents the tree of life has been transposed in a partial jacquard knitted structure in three colours: white, red and black (figure 12).

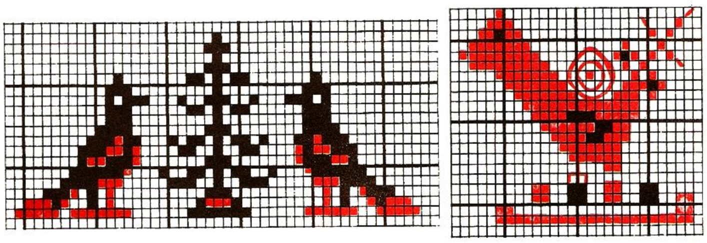


Figure 11: Ornamental aviary motifs

Figure 12: Knitted structure (partial jacquard in three colours) with folkloric aviary motifs

In figure 13 are presented two accessories made of partial jacquard with aviary folkloric ornaments.


Figure 13: Accessories made of jacquard knitted with folkloric aviary motif

1.3.3 Skeuomorphic, cosmic and geometric motifs

The skeuomorphic motifs present a morphologic evolution in a continuous thematic variety. The motif range in this category is very diverse: **hack, hayfork, rake, stilt, plough** etc. (figure 14). In figure 15 the skeuomorphic motif of the plough stilt is presented in partial jacquard in 2 colours.

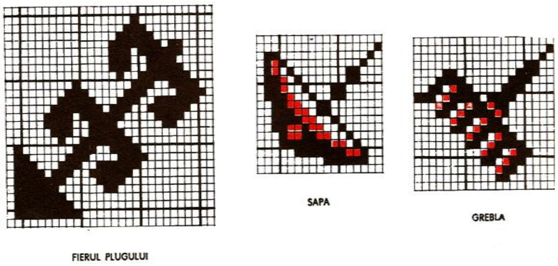

Figure 14: Skeuomorphic ornamental motifs

Figure 15: Partial jacquard structure in two colours with skeuomorphic folkloric motif – plough stilt

Cosmic motifs (figure 16) include decorative elements that render celestial orbs (the star, the Sun), cosmic phenomena (lightning, Milky Way, etc.). In figure 17 a full jacquard knitted structure in three colours with the cosmic motif of the Sun is presented and in figure 18 knitted accessories with cosmic motifs.
In figure 19 a geometric motifs is illustrated in a knitted structure, type full jacquard on one frame.

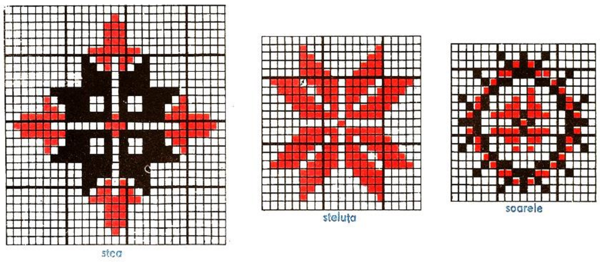

Figure 16: Cosmic ornamental motifs

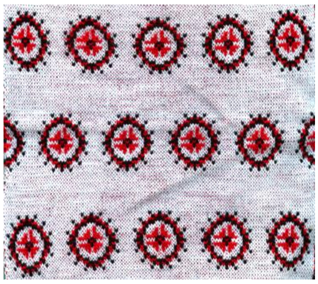

Figure 17: Full jacquard in three colours structure with the cosmic folkloric motif – Sun

Figure 19: Geometric folkloric motif transposed in a knitted structure with a full jacquard design on one frame

Figure 18: Knitted products and accessories with cosmic ornamental motifs

CONCLUSIONS

The folkloric ornaments of the Romanian creation in its ensemble represent the main source of inspiration and knowledge that can be successfully capitalized in textile creations.
The folkloric motifs sown in cross-point can be successfully transposed in knitted structures, our popular art being an art in which the geometric and the stylization are preponderant. The vegetal or animal, realistic or geometric motifs, as well as their chromatic variety, offer originality to the creative idea that doesn't imitate or copy but is inspired by them. The decorative spirit of the folkloric creator, its artistic conceptions in understanding and interpreting the beauty of the surrounding nature put their mark on the traditional ethnic specific that can be deciphered in each creative category of ornamental motifs, compositions, chromatic palette and realization techniques. In the traditional ornamentation, the decorative point and line are basic elements of the compositional fields that through the variety of shapes and simplicity of the elements transposed in the knitted structure represent an inexhaustible source of inspiration in the knitted design.
The classification of decorative points regarding shape, array (linear or circular), grouping, gradation, dispersal and chromatic has been structured from a design perspective and can become a working instrument in the diversification of decorative knitted structures.
Because of the variants that the Romanian traditional costume knows, it is necessary understanding this genre as an inspirational source for the modern people.
This way, diverse possibilities of enriching and embellishing the modern fashion products are created, by adapting the Romanian traditional ornaments and chromatic.

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Section 9: Innovations in textile finishing

GRAPHENE (0.1%)-TIO_2 NANOCOMPOSITE EFFECT ON TEXTILE MATERIALS

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Abstract: *The main purpose of this work was to investigate the photocatalytic properties of cotton knit coated with grapheme (0.1%wt.)-TiO_2. A 3-stages technological process was used to immobilize graphene(0.1%)-TiO_2 on cotton knit: a.pre-treatment to eliminate the impurities and to increase the adherence of the particles to substrate; b.impregnation in graphene/TiO_2 dispersion; c.post-treatment with polymers (Nuva TTC, Hydroperm RPU) to improves the treatment durability. By scanning electron microscopy coupled with an energy-dispersive X-ray analysis (SEM-EDX) we demonstrate the deposition of nanocomposite on the knit surface. The photocatalytic activity is higher under visible light than under UV light, the best efficiency being shown by the sample treated with hydrophilic polyurethane polymer, Hydroperm RPU, which facilitate the generation of reactive species.The materials show good antifungal effects against Trycophyton interdigitale and Epidermophyton floccosum.*

Keywords: *Graphene –TiO_2, cotton, photocatalytic, antifungal effects.*

INTRODUCTION

Different methods and dopants [1] have been used to extend TiO_2 absorption into visible range.
Among them, graphene- TiO_2 composites are considered good potential photocatalysts, due to theirs properties such as chemical stability, high surface area, high electronic and thermal conductivities, high carrier mobility [2], C doping at the TiO_2 surface [3]. Some studies have shown that RGO-TiO_2 composites are able to degrading methylene blue under visible light faster than pure TiO_2 [4, 5]. Recent experiments [6] have demonstrated the multi-functional effects of fabrics coated with graphene-TiO_2, such as self-cleaning performance, electrical resistance, antimicrobial properties, and UV blocking activity. Our work was focused on the photocatalytic properties of cotton knit coated with grapheme (0.1%)-TiO_2 nanocomposite.

EXPERIMENTAL

2.1 Materials

Graphene (0.1%)-TiO_2 – prepared by graphite ball milling, provided by NanoXplore, Montreal, Canada
Itobinder AG (polyacrilic binder, AJ Specialities); Imerol JSF (nonionic surfactant, AJ Specialities)
Nuva TTC (perfluoroacrylate/polyurethane polymer, Clariant); Hydroperm RPU (polyurethane softener, Clariant); Carboxymethylcellulose (CMC) (Aldrich); 100% cotton knit.

2.2 Preparation of 0.5g/L graphene (0.1%)/TiO_2 dispersion

0.4g graphene (0.1% wt.)-TiO_2 (noted S5) was introduced in 800mL distillated water, and stirred at 40^0C for 60 minutes on ultrasonic bath.

2.3 Textile materials treatment

A 3-stages technological process was used to deposit graphene (0.1%)-TiO_2 on textiles materials:
a. pre-treatment: the cotton knit was immersed into 1L solution containing 1mL Imerol JSF and 40mL Itobinder AG and maintained at 50^0C for 60 minutes on ultrasonic bath to allow the deposition of a polyacrylic layer on the material surface ;

b. treatment: the pre-treated knit was re-imersed in 800mL 0.5g/L dispersion of graphene (0.1%)-TiO_2 (S5) and maintained at 40^0C for 30 minutes. Then, the knit was removed from the bath and dried at 100^0C for 60 minutes. The resulted material was noted 1S5;
c. post-treatment*:* the material coated with graphene(1% wt.)-TiO_2 was immersed in 400mL polymers solution maintained at 70^0C for 30 minutes, then dried at 100^0C and thermofixed at 150^0C for 12minutes.
The notations of post-treated knits are: **2S5**- knit post-treated with 40mL/L Nuva TTC; 3S5**:** 1g/L Hydroperm RPU and **4S5:** 1g/L carboxymethylcellulose (CMC)**.**

2.4 Characterization methods

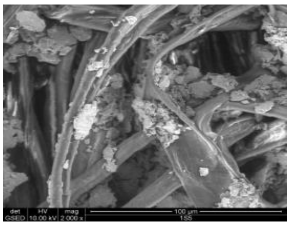
The surface morphology of the graphene –TiO_2 coated knit was investigated by scanning electron Microscope (SEM Quanta 200, FEI, Holland) equipped with an energy-dispersive X-ray analysis (EDX) system. Surface and volume electrical resistivity of the coated textiles were measured according to the SR EN 1149-1: 2006 using a PROSTAT PRS-801 ohmmeter (***Prostat*** ® Corporation). The thermal behaviour of control and treated cotton samples were analyzed using DSC Pyris Diamond (Perkin Elmer, USA). Contact angles were measured on VCA Optima (AST Products, Inc., USA) instrument at room temperature. The physical properties were investigated according to specific ISO standards. The photocatalytic activity of coated cotton knit was evaluated by measuring the CIElab parameters (Ultrascan Pro, Hunterlab, USA) of the materials stained with 0.0064g/L methylene blue and exposed to UV and visible light. The antifungal effects have been evaluated according to standard ISO 20743:2007 against *Tricophyton interdigitale* and *Epidermophyton floccosum*.

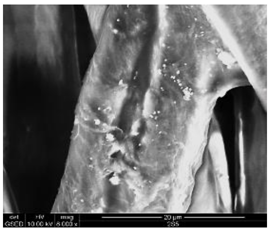
RESULTS AND DISCUTIONS

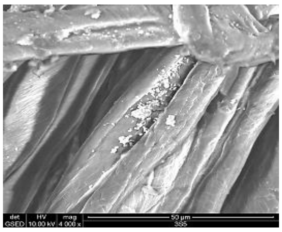
3.1. SEM/EDX analysis of the knit coated with graphene (0.1%)-TiO_2

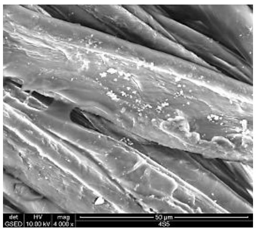
The images of the knits coated with graphene (0.1% wt.)-TiO_2 are shown in the Table 1.

Table 1: Morphological aspect of the knits coated with graphene (0.1% wt.)-TiO_2


1S5

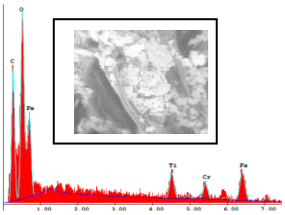

2S5

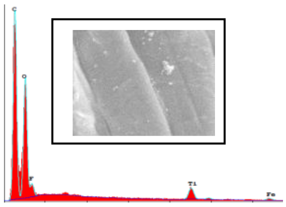

3S5

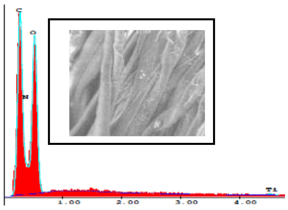

4 S5

The cotton fabric treated with graphene (0.1%) - TiO_2 (sample 1S5) is covered with agglomerated particles, the smallest ones ranging from 118.2nm to 181.5nm. Itobinder AG is a self cross linking aqueous acrylic emulsion. It was used to increase the adherence of graphene-TiO_2 particles on the cotton surface and to protect cotton against the photodegradative activity of TiO_2. It is possible that some of the carboxyl groups of the binder interact with TiO_2 and other functional groups existing on graphene edges. Also, during drying, the binder forms a network which immobilizes the nanoparticles. By post-treatment with Nuva TTC (sample 2S5), the fibers are covered with a polymer film on whose surface, few particles, less agglomerated than in case of sample 1S5 are noticed. Post-treatment with Hydroperm RPU (sample 3S5) determines the coverage of the cotton fibers with thick polyurethane layers on whose surface graphene (0.1%) - TiO_2 particles are agglomerated and non-uniformly dispersed. In the case where the post-treatment was made with CMC (sample 4S5), the fibers surface are covered with apparent thick polymer layers and, from place to place, many particles non-uniformly dispersed can be observed.

Table 2: EDX spectra of the knits coated with graphene (0.1%wt)- TiO_2


1S5


2S5


3S5

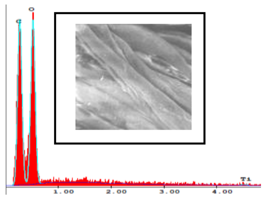

4S5

Table 3: EDX quantification of the TiK% wt on the coated knits

	1S5	2S5	3S5	4S5
TiK, % wt	1.56	2.41	1.86	2.41
	3.90	1.70	1.77	3.88
	2.59	1.70	2.41	3.65
	4.37	1.38		2.47
	4.56			2.53
Average*	**3.39**	**1.79**	**2.01**	**2.98**

*: the extreme TiK, % wt values eliminated: 1S5: 12.51%; 9.62%, 9.54%, 7.94%; 2S5**:** 13.23%

The elements quantification was performed by measurements in 3-9 different points of the material surface. The resilts are shown in Table 2 and Table 3. The extreme values corresponding to particles and high agglomerations were eliminated. What should be noted is the great variation of the particles composition both on the same sample and on different knit samples. Thus on the knit 1S5, % wt Ti K range from 1.56% to 12.51%, variation caused by strong intermolecular forces between TiO_2 particles, which form clusters due to their large surface area. This phenomenon is demonstrated by the concentration of TiO_2 particles on different samples, varying widely from 4.56% (1S5) to 13.23% (2S5). Besides the main elements (C, O, Ti), chromium (Cr K: 9.15-10.81%) and iron (Fe K: 45.02 - 51.52%) are found on sample 1S5 coming from the preparation process of the graphene / TiO_2 by graphite ball milling. Also, distinct peaks for titanium, oxygen, fluorine and iron appear on the fabric 2S5. The high concentration of fluorine (3.48%) indicate the presence of fluorinated polymer (Nuva TTC) in relatively large amount on the fabric surface. On the 3S5 sample, the characteristic peak of nitrogen coming from the polyurethane polymer used in fabric post-treatment is noticed. The high concentration of N K (11-14%) indicates the formation of a thick polymer layer which covers the greater part of TiO_2 particles.
The results demonstrate that the greatest amount of graphene-TiO_2 is found on the fabric pre-treated initially with polyacrylic binder and subsequently with graphene / TiO_2 (sample 1S5). It is assumed that TiO_2 interact by electrostatic forces with the carboxylic groups of the binder, which allows the immobilization of a high amount of TiO_2.

3.2 The surface and volume resistivity

The surface and volume resistivity values of the coated knits are shown in Table 4.

Table 4: TiO_2 Electrical resistivity of the coated knits

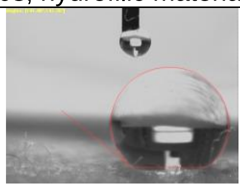
Sample	Surface resistivity, [Ωsq] X10^{13}	Volum resistivity, [Ωxcm] X 10^{14}	Thickness, [mm]
Control	1.5	16.1	1.14
1 S5	2.48	5.74	1.06
2 S5	6.80	1.68	1.08
3 S5	1.80	1.94	1.08
4 S5	2.74	2.03	1.06

It is well known that cotton is a good insulating material having a high surface resistivity [7]. On contrary, graphene exhibits excellent electroconductive properties even mixed with different polymers [8]. Surface resistivity values (Table 4) demonstrate that treatments with graphene / TiO_2 and post-treatment do not cause increased electrical conductivity, but rather increase the insulating ability of the knits, especially when treating with Nuva TTC. This behavior is determinate by the insulating properties of TiO_2 and by the low degree of doping, respectively 2% graphene.

3.3 The wetting capacity of the coated knits

The water contact angles measured in five different points on the coated surfaces are presented in the Table 5.

Table 5: Contact angles of the cotton knit treated with graphene (0.1% gr.)-TiO_2

Sample	Values	Left angle	Right angle	Wetting time, seconds
1S5; 3S5; 4S5		0	0	0s; hydrofilic material
2S5		143.10	144.10	
		142.50	143.50	
		136.20	135.50	
		139.90	139.10	
		141.40	141.30	
	Average	140.62	140.7	Hydrofobic Material

The values of contact angles demonstrate that treatment with graphene (0.1 wt.%) - TiO_2 does not affect cotton fabric hydrophilicity. Post-treatment with perfluoroacrylic / polyurethane (Nuva TTC) polymer confers fabric (sample 2S5) hydrophobic properties (contact angle of 140 degrees) and therefore easy cleaning properties. Self-cleaning properties are improved by the particles of graphene / TiO_2 deposited on cotton surface as micro / nanostructures, which lowers the adhesion forces between water droplets and the surface material. Consequently, when the surface and organic particles are exposed to water, water droplets that roll train the organic pollutants, which are effectively removed from the fabric. Post-treatment with hydrophilic polyurethane polymer, Hydroperm RPU, leads to a soft handle and increase the capacity of the material to retain water, thereby improving the efficiency of photocatalysts. Instead, the post-treatment with carboxymethylcellulose, although maintains the cotton hydrophily, due to high concentration, leads to a slightly rough handle.

3.4 Physical properties of coated knits

The results (Table 6) demonstrate that treatment with graphene-TiO_2 and post-treatment with polymer does not significantly affect the physical properties of the materials. Treatment with graphene and Nuva TTC lowers the permeability to water vapor unlike treatment with Hydroperm RPU and CMC, which causes a slight increase of water permeability due to the presence of the hydrophilic groups.

Table 6: Physical properties of coated knits

Analyses	Sample					Standard
	Blank	1S5	2S5	3S5	4S5	
Weight, g/m^2	222	222	253	226	226	SR EN ISO 12127:2003
Density, course/wales, o/v/10cm	148/149.5	148/155	149/149	144/156	148/155	SR EN ISO 5903:1993
Thickness, mm	1.14	1.072	1.13	1.109	1.088	SR EN ISO 5084:2001
Water vapor permeability, %	34.4	31	32.3	34.7	35.8	STAS 9005:1979
Air permeability, l/m^2/s	390.4	398.75	351	395.5	374.5	SR EN ISO 0237:1999
Resistance to abrasion, nr. cycles		34157	29737	24005	33736	SR EN ISO 12947-2:2006

3.5 The thermal behaviour of coated knits

DSC analysis was performed to determine thermal behavior of the prepared samples. The percentage change in latent heat of fusion was calculated using following equation 1:

$$\% \text{ change in Latent heat of fusion} = 100x\,[\Delta H_T - \Delta H_C]/\,\Delta H_C \qquad (1)$$

where, ΔH_C and ΔH_T are the latent heat of fusion of control and treated samples, respectively.
The results processed by Pyris Analysis software are presented in the Table 7.

Sample	Weight, mg	Onset, ^{0}C	Peak, ^{0}C	ΔH, J/g	ΔH, %
Control	6.1	338.92	369.02	-2014.86	-
1S5	4.9	340.59	369.23	-1746.16	-13.33
2S5	6.2	330.61	354.88	-2240.09	11.17
3S5	4.7	339.65	355.47	-2173.88	7.89
4S5	5.2	340.60	369.98	-2117.85	5.11

Table 7: DSC thermograms characteristics for control and treatead cotton knits

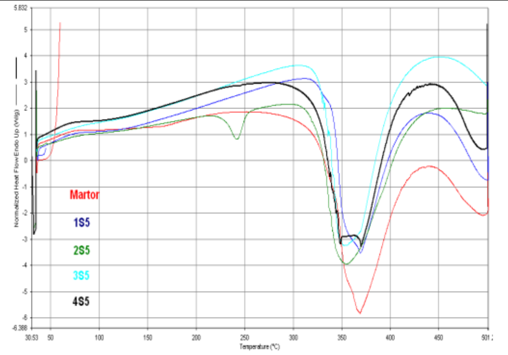


Figure 1: DSC thermogram of control and treated cotton

DSC thermograms (Figure 1) show that all cotton knits present a large exotermic peak related to physically absorbed water evaporation. The sample 2S5 showed a supplementary peak situated at 241.85 ^{0}C representing the decomposition temperature of perfluoroacrylate/polyurethane polymer [9]. The control and samples 1S5 and 4S5 present almost the same the decomposition onset temperature (340^{0}C) and a peak situated at 369^{0}C, representing the pyrolysis of cellulose. This peak is shifted to 355 ^{0}C for samples 2S5 and 3S5, indicating a lower thermal stability of these materials compared with untreated cotton. The decrease of the degradation temperature could be influenced by TiO_2 photoactivity making the polymer to degrade more easily. Except the sample 1S5, the enthalpy change of coated materials slightly increases as compared to control sample, due to the polymers melting.

3.6 Evaluation of the photocatalytic effects

The appearance of exposed samples to light and chromaticity coordinates values are presented in Tables 8 - 12.

Table 8: The appearance of the knits exposed to UV light

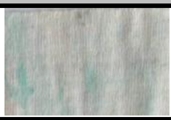
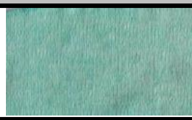
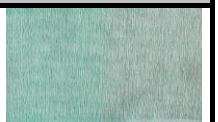
t_0= 0 min				
				
t_1= 42 h				
				
Blank	**1S5**	**2S5**	**3S5**	**4S5**

Table 9: Color coordinates of the knits exposed 42 hours at UV light

Sample	L*	a*	b*	dL*	da*	db*	dE*	Note
Blank	84.31	-10.43	-6.44	0.48	5.08	3.29	6.07	2.5
1S5	79.08	-9.55	-5.67	-1.27	4.12	2.75	5.12	2.5
2S5	84.87	-2.67	1.24	0.44	-0.87	-1.03	1.42	4
3S5	82.23	-4.3	-4.01	**2.79**	10.02	5.3	**11.67**	1.5
4S5	78.5	-9.14	-4.98	-2.23	3.81	2.36	5.01	2.5

The only sample showing better photodiscoloration of methylene blue is 3S5 post-treated with polyurethane softener (Hydroperm RPU), which attracts more humidity from the atmosphere and facilitates the generation of more reactive species contributing to the MB photodiscoloration.

Table 10: The appearance of the knits exposed 12 hours at visible light

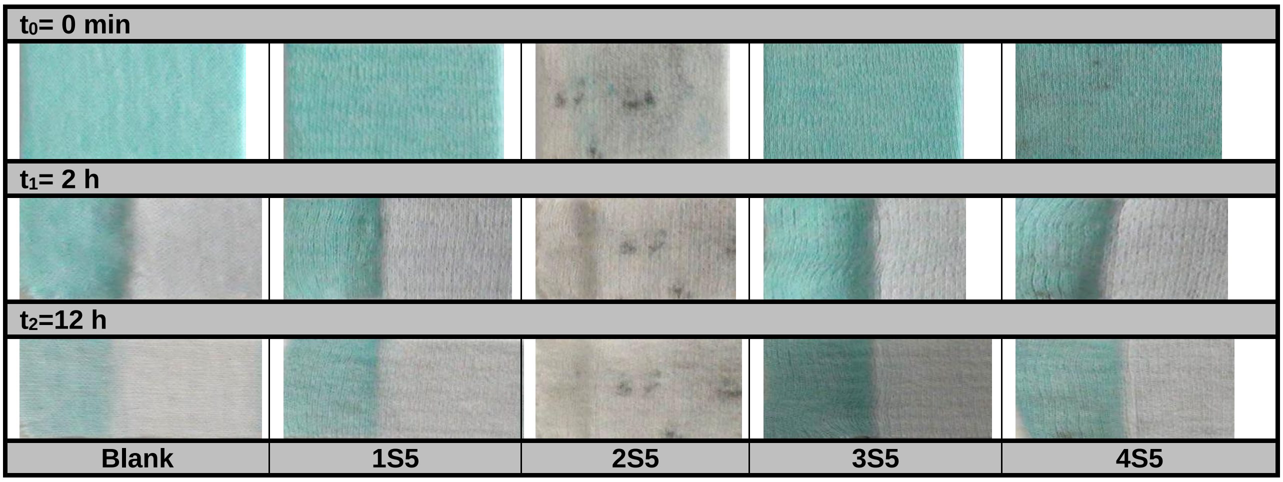


Table 11: Color coordinates of the knits exposed 12 hours at visible light

Sample	L*	a*	b*	dL*	da*	db*	dE*	Note
Blank	88.92	-0.36	-0.78	6.44	9.09	8.12	13.78	1
1 S5	83.77	-0.89	-0.92	5.62	9.3	6.91	12.88	1
2 S5	83.32	-0.22	3.81	-0.99	-0.08	-0.43	1.09	4.5
3 S5	85.37	-1.52	-0.15	**6.44**	8.88	7.43	**13.24**	1
4 S5	82.52	-1.02	-0.45	4.61	8.09	5.05	10.59	1.5

After 12 hours of exposure to visible light, 3S5 sample shows the differences in brightness and color almost similar to the untreated sample followed closely by 1S5. The low values of the chromaticity coordinates may be due to the black color of graphene layer, which remaining on the material influences the measurement. More than that, 2S5 is hydrophobic, the absorption of MB is reduced and the dyeing is uneven.

Table 12: Comparisons: color modifications of the knits exposed to visible and UV light

Sample	Post-treatment	TiK , % Wt	Visible light, 12 hours			UV light, 42 hours		
			dL*	dE*	note	dL*	dE*	note
Blank	-	0	6.44	13.78	1	0.48	6.07	2.5
1S5	Itobinder AG	4.39	5.62	12.88	1	-1.27	5.12	2.5
4S5	CMC	2.98	4.61	10.59	1.5	-2.23	5.01	2.5
3S5	Hydroperm RPU	2.01	6.44	13.24	1	2.79	11.67	1.5
2S5	Nuva TTC	1.79	-0.99	1.09	4.5	0.44	1.42	4

Photodiscoloration of methylene blue is more intense and occurs in a shorter time under visible light than under UV light. The most intensive photodiscoloration is shown by sample 3S5 both under the visible and UV light. This effect can be attributed to high water absorption capacity of the polymer used in post-treatment, Hydroperm RPU, which facilitates the generation of reactive species involved in photodiscoloration. It is worth to mention that Nuva TTC has rather a protective effect against MB photodegradation although both polyurethanes and MB have low resistance to light. This behavior could be attribute to the thick layers of polymers formed on the material surface which prevents the photocatalytic activity of TiO_2 .
Basically, the sample 1S5, containing the highest amount of graphene-TiO_2, deposited on polyacrylic adhesive binder layer should provide the highest photocatalytic effect.
The improved photocatalytic effect of TiO_2-graphene composites is attributed by some authors[10] to three factors: the efficient electron- holes pair separation, extended absorption under visible light, high absorbability of reactants that can generate multiple reactions[11]. Heterojunction graphene -TiO_2 promotes separation of electron-holes pairs acting as an electron trap slowing the recombination, while the holes

remaining in TiO_2 induce oxidation processes[12]. Formation of Ti-O-C determines the extension of the absorption of light by TiO_2.
In the case of cotton treatment, TiO_2 particles agglomerations on graphene surface do not allow a direct contact of the chemical components dramatically reducing the photocatalytic effect.
When TiO_2 is not evenly dispersed on the graphene surface, the generated holes cannot oxidize contaminants present on the large area graphene, beneficial for photolysis. Consequently, a uniform dispersion of TiO_2 on the graphene surface is critical for efficient photocatalytic process. As EDX analysis demonstrated, TiO_2 nanoparticles are not evenly distributed on the surface of graphene.
We supposed that TiO_2 forms chemical bonds with the eventually functional groups present at the edges of graphene foils, and are agglomerated on the folds or other defects of graphene in the form of lumps. Increasing the TiO_2 concentration from 2.01% to 4.39% does not lead to an improvement in photocatalytic effect probably due to particles agglomeration and uneven dispersion on the material surface.

3.7 Evaluation of the antifungal effects

Stock strains were grown on synthetic nutrient medium Sabouraud-agar with dextrose as carbon source, and were incubated at 28°C. The number of viable cells, the rates and logarithmic reduction of colony forming unit (CFU) on the treated material, expressed relative to the untreated material (control) were calculated at the end of the test. The results are shown in Table 13.

Table 13: Antimicrobial efficiency of the treated textiles

Trycophyton interdigitale				
				
Control C_i= 3.32x10^3 UFC/mL	**1S5:** C_{24h}= 6.4x10^2 UFC/mL R%=80.73; Log_{10} red.=0.72	**2S5:** C_{24h}=1.63x10^3 UFC/mL; R%=50.91 Log_{10} red.=0.31	**3S5:** C_{24h}=1.01x10^3 UFC/mL R%=69.58 Log_{10} red.=0.52	**4S5:** C_{24h}=5.9x10^2 UFC/mL R%=82.23 Log_{10} red.=0.75
Epidermophyton floccosum				
				
Control C_i= 4.98x10^3 UFC/mL	**1S5:** C_{24h}=0 UFC/mL R%=100 Log_{10} red.=3.69	**2S5:** C_{24h}=0 UFC/mL R%=100 Log_{10} red.=3.69	**3S5:** C_{24h}=0 UFC/mL R%=100 Log_{10} red.=3.69	**4S5:** C_{24h}=0 UFC/mL R%=100 Log_{10} red.=3.69

Treated materials tested against Epidermophyton floccosum strain showed microbial reduction rates significantly better (between 98.8% and 100%) compared to the tested strain of Trycophyton interdigital (between 28.32% discount rate and 87.35%).

CONCLUSIONS

A 3-stages technological process was used to immobilize graphene(0.1%)-TiO_2 prepared by graphite ball milling on cotton knit. Polyacrilic binder was used to improve the particles adherence and different polymers (Nuva TTC, Hydroperm RPU and CMC) to enhance the treatment durability.

The SEM investigations demonstrate the presence of both TiO_2 particles and polymers layers on fabric surface. EDX analyses demonstrate that the polyacrylic polymer immobilize a high amount of TiO_2 due to the electrostatic interaction between the carboxylic groups of the binder and TiO_2.
Surface resistivity of the materials coated with graphene/TiO_2 and post-treatment increases the insulating properties of the knits, due to the insulating properties of TiO_2, the low amount (2%) of graphene and, uneven dispersion of particles on the knit surface.
Graphene (0.1 wt.%) - TiO_2 does not significantly affect the physical properties of the materials. Post-treatment with polymer perfluoroacrylic / polyurethane (Nuva TTC) confers fabric.
The photocatalytic activity is higher under visible light than under UV light, the best efficiency being shown by the sample treated with hydrophilic polyurethane polymer, Hydroperm RPU, which facilitate the generation of reactive species.

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ADSORPTION OF METHYLENE BLUE DYE FROM AQUEOUS SOLUTIONS USING METALOSILICATE BEADS AS ADSORBENTS

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Abstract: *The synthesis of the aluminosilicate and ironsilicate beads and their ability to remove the Methylene Blue basic dye from aqueous solutions were reported in this study. The adsorbents were characterized by nitrogen sorption technique, SEM and EDAX analyses. The specific surface areas were calculated using the BET multilayer adsorption equation and the free pore volumes were determined from the nitrogen adsorbtion data. The Langmuir, Freundlich and Dubinin–Radushkevic isotherm models were used to describe the equilibrium data. The experimental studies indicated that the aluminosilicate and ironsilicate beads had the potential to act as alternative adsorbents to remove the basic dye from aqueous solutions.*

Keywords: *Methylene Blue basic dye, adsorbent, isotherm, aluminosilicate, ironsilicate.*

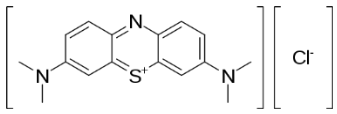
INTRODUCTION

Methylene blue is a common dye mostly used by industries involve in textile, paper, rubber, plastics, leather, cosmetics, pharmaceutical and food industries. Effluents discharged from such industries contain residues of dyes. Consequently, the presence of very low concentrations in effluent is highly visible. Therefore, their removal from the wastewater is required. Various methods have been used for the removal of dyes from the wastewaters such as coagulation, flotation, filtration, adsorption and oxidation [1-4]. The adsorption is a promising technique for the removal of dyes from wastewater streams The commercial activated carbon, clays, fly ashes, industrial by-products, zeolites, bentonite and montmorillonite are the most commonly used adsorbents for environmental applications [5-8].
The objectives of this work are: to obtain porous metallosilicate beads and to investigate the adsorption capacity of basic dye Methylene Blue on metallosilicate beads.

EXPERIMENTAL

2.1 Materials

Commercial basic dye Methylene blue was obtained from Sigma-Aldrich Company. The structure of the dye is:



The adsorbent beads were prepared as follows:
aluminosilicate: 0.551 g $AlCl_3 \cdot 6H_2O$ were dissolved in 13.8 mL solution containing 13 mL distilled water and 0.8 mL HCl 37%, then 3 mL TEOS were added and the mixture was vigorously stirred for 6 hours at room temperature (I). In parallel, 2.7 g yeast cells dispersed in 4 mL distilled water were heated at 85°C for 2 hours. 0.75 g of gelatin was then added in the flask containing the yeast cells and after 15 minutes the heating was stopped. After cooling the mixture, 0.6 mL HCl 37% were dropped in the flask to ensure the complete dissolution of gelatin. Finally, 9 g of chitosan solution 4% (w/v) were added and the mixture was stirred until homogenization (II). Solution I was poured over the gel II and the mixture was kept under stirring for 2 h.
ironsilicate beads: 0.922 g Fe(NO3)3·9H2O, 9 mL distilled water, 1.4 mL HCl 37% and 3 mL TEOS were kept under stirring for 6 h at room temperature (I). A suspension of 2.7 g yeast cells dispersed in 4 mL distilled water was heated at 80^0C under stirring for 2 h. 0.75 g of gelatin was then added in the flask containing the yeast cells and after 15 minutes the heating was stopped After cooling, 9 g chitosan solution

(4%) were introduced and the resulting gel was mixed for 2 h (II). Solution I was poured over the gel II and the mixture was kept under stirring for 2 h.
The gels corresponding aluminosilicate and iron silicate were added dropwise with a syringe pump into a precipitation bath containing an ammonia solution (25% v/v). The beads prepared in this way were kept into ammonia coagulating solution (to harden) for 40 min, separated by filtration in a Buchner funnel and then dried at 50°C for 12 h. The dried samples were calcinated in air at 650°C for 24 h in order to remove the template.

2.2 Characterization of adsorbent beads

The nitrogen adsorption isotherms were measured at liquid nitrogen temperature (77K) using a Nova 2200e system (Quantachrome). The samples were outgassed at 25 mm Hg and room temperature for 12 h before the measurements.
SEM/EDX analysis
The scanning electron micrograph image and chemical composition of the synthetized sample were recorded on A VegaTescan LMHII (VegaTescan) scanning electron microscope coupled with an energy dispersive X-ray analyzer (Bruker XFlash 6/10 SDD with Esprit Software).
Equilibrium studies
In order to determine the wavelength that corresponds to the maximum absorbance (λ_{max}), the standard solutions of dye was scanned in the wavelength range of 200–800 nm using a UV–Visible spectrophotometer. The maximum absorbance value was noticed at a wavelength of 660 nm. The calibration curves in the concentration range that falls in the region of applicability of Beer-Lambert's law employed in this study were: $y = 0.248 \cdot x$, $R^2 = 0.998$ The calibration curve was used for the determination of the unknown dye concentrations from the residual solutions.
The amount of dye adsorbed per unit mass of adsorbent q_t (mg/g) at any time t, was calculated using the mass balance relationship equation as follows:

$$q_t = \frac{(C_0 \cdot V_0 - C_t \cdot V_t)}{w} \qquad (1)$$

where: C_0 (mg/L) is the initial concentration of dye in solution, C_t (mg/L) is the liquid phase concentration of the dye at any time t, V_0 – is the initial volume of solution, mL,$V_t = V_0 - n \cdot \Delta V$ is the volume of solution at time t, n – is the number of withdraws carried out, ΔV = 0.5 mL is the volume of sample withdrawn at any time t, and w is the mass of the adsorbent (g). At equilibrium, $q_t = q_e$ and $C_t = C_e$; therefore the amount of dye adsorbed per unit mass of adsorbent at equilibrium, q_e (mg/g), was calculated by the following expression:

$$q_e = \frac{(C_0 \cdot V_0 - C_e \cdot V_e)}{w} \qquad (2)$$

where C_0 and Ce are the initial and respectively the equilibrium dye concentrations in solutions (mg/L), V is the volume of the solution (L) and w is the mass of the adsorbent (g).

RESULTS AND DISCUSSIONS

3.1 Textural properties of the adsorbents

The specific surface areas calculated using the BET multilayer adsorption equation and the free pore volumes determined from the nitrogen adsorbtion data are presented in table 1.

Table 1: Textural properties of the adsorbents

Sample	aluminosilicate	ironsilicate
S_{BET} (m^2/g)	295.45	143.1
V_p (cm^3/g)[a]	0.515	0.444

The results show that aluminosilicate beads have also the specific surface area as well as the free pore volume higher compared to the ironsilicate beads.

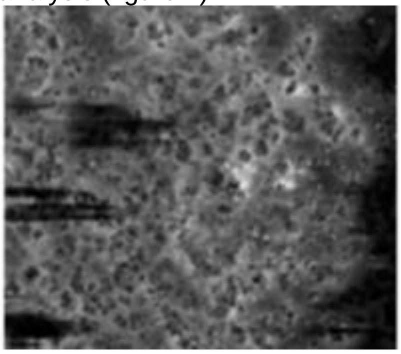
3.2 Energy dispersive X-ray analysis (EDX)

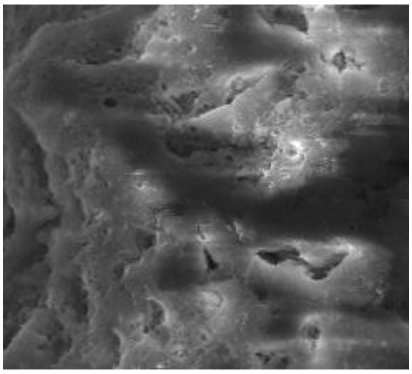
The elemental composition of the synthetised beads determined by EDX analysis is shown in table 2.

Table 2: Elemental analysis of the calcined aluminosilicate and ironsilicate beads

aluminosilicate beads		iron silicate beads	
Element	wt (%)	Element	wt (%)
O	51.06	O	53.5
Si	38.59	Si	32.2
Al	4.34	Fe	5.8
N	4.23	N	2.9
C	1.78	C	2.6

The results obtained from the EDAX analysis confirm the presence of Al and Fe in the synthesized samples.
Scanning electron microscopy
The surface morphology and pores size of aluminosilicate and iron silicate beads were investigated by SEM analysis (figure 1).





a. aluminosilicate b. iron silicate
Figure 1: SEM image of the adsorbents beads

Figure 1 indicates that the samples contain wide pores resulted through removal of chitosan, yeast cells and gelatine.

3.3 Adsorption studies

Effect of adsorbent concentration on dye removal
The results of the experiments carried out with various adsorbent concentrations versus time are presented in table 3.

Table 3: Effect of the adsorbent amount on the adsorption dye

Adsorbent concentration (g/L)	adsorbed dye (mg.g^{-1})	
	aluminosilicate	iron silicate
2	11.12	6.91
3	17.46	11.44
4	23.56	15.71
5	30.28	17.82
6	32.3	20.06
8	33.68	20.88

**T = 298 K, initial dye concentration = 120 mg/L, pH=6.5*

With the increase in the adsorbent concentration, from 2 g/L to 8 g/L, the percentage of uptaken dye increased for both adsorbents studied. This was attributed to the increase of the number of available adsorption sites.

Effect of pH on adsorption dye

The pH of the dye solutions plays an important role on the adsorption capacity of metallosilicate beads. (table 4).

Table 4: Effect of pH on the adsorption of dye

pH	adsorbed dye ($mg.g^{-1}$)	
	aluminosilicate beads	iron silicate
2	18.01	12.73
6.5	30.28	16.82
10	42.11	23.2

T = 298 K, initial concentration of dye = 120 mg/L, adsorbent concentration=5g/L

The results indicate that the dye adsorption increase with the increase of the pH solution. Generally, by increasing of pH increases the negative charge on the adsorbent surface and consequently increases the electrostatic attraction between the cationic groups of dye and the anionic groups from the surface of adsorbent.

3.4 Adsorption Isotherms

Adsorption isotherms describe the relationship between the amount of solute adsorbed onto the solid and the equilibrium concentration of the solute in solution at a given temperature. In order to quantify the affinity of the metallosilicate beads for the basic dye, three widely used isotherm models (Langmuir, Freundlich and Dubinin-Radushkevish) were used to analyze the data obtained from the adsorption process.

Langmuir isotherm

The Langmuir equation which is applicable to homogeneous adsorption systems is based on the assumption that only a monolayer of dye can cover the surface of the adsorbent (each site can hold at most one molecule, all the adsorption sites are equivalent and there are no interactions between the adsorbate molecules on adjacent sites).

The linear form of the Langmuir equation may be written as:

$$\frac{C_e}{q_e} = \frac{1}{q_m} \cdot C_e + \frac{1}{K_a \cdot q_m} \qquad (3)$$

where q_e (mg/g) is the amount of dye adsorbed per unit weight of adsorbent, Ce (mg/L) is the equilibrium concentration of the dye in the bulk solution, q_m (mg/g) is the maximum amount of adsorbate per unit weight of adsorbent required to form a complete monolayer on the surface and K_a (L/mg) is the Langmuir isotherm constant related to the affinity of dye for the adsorption sites.

Freundlich isotherm

The Freundlich expression is an empirical model employed to describe the heterogeneous systems (assumes a heterogeneous energetic distribution of the active sites on the adsorbate surface and takes into account the interactions between the adsorbed molecules). This model is not restricted to the formation of the monolayer. The linear form of the Freundlich isotherm is represented by the equation:

$$\log q_e = \log K_F + \frac{1}{n} \log Ce \qquad (4)$$

where q_e(mg/g)is the amount of dye adsorbed per unit weight of the sorbent, C_e (mg/L)is the equilibrium concentration of the dye in the bulk solution, K_F (mg/g) is a measure of the adsorption capacity and 1/n corresponds to the adsorption intensity (the higher the 1/n value, the more favorable is the adsorption).

Dubinin-Radushkevish isotherm (D-R)

The Dubinin – Radushkevish isotherm (D-R) model is more general than the Langmuir isotherm since it does not assume a homogenous surface or constant sorption potential. This model is often used to determine the type of sorption (physical or chemical). The D-R equation is:

$$\ln q_e = \ln q_m - B_D \cdot \varepsilon^2 \qquad (5)$$

where: qe is the amount of dye adsorbed per unit weight of adsorbent (mg/g), q_m is the D-R constant representing the theoretical monolayer saturation capacity (mg/g) and B_D (mol^2/J^2) is a constant related to the mean free energy of adsorption per mol of the adsorbate and Ɛ is the Polanyi potential which is given by:

$$\varepsilon = R \cdot T \cdot \ln(1 + 1/C_e) \qquad (6)$$

Where: T is the temperature of solution (K); R is the gas constant and is equal to 8.314 J/mol·K; C_e is the equilibrium concentration mg/L.
The constants adsorption isotherms were calculated from the intercept and respectively the slope of the straight line. The values of the parameters for the studied isotherms and the regression parameter R^2 are given in table 5.

Table 5: Parameters corresponding to the adsorption models

Model	aluminosilicate beads	ironsilicate beads
Langmuir		
K_L ($L.mg^{-1}$)	0.128	0.113
q_m ($mg.g^{-1}$)	30.28	17.82
R^2	0.993	0.992
Freundlich		
n	6.09	3.99
K_F ($mg.g^{-1}$)	12.24	7.08
R^2	0.981	0.956
Dubinin-Radushkevish		
Q_m ($mg. g^{-1}$)	25.12	16.11
B_D (mol^2/J^2))	10^{-7}	10^{-7}
R^2	0.861	0,832

Comparing the quality of fitting for the four models of isotherms in terms of correlation coefficient values, R^2, it can be seen that the Langmuir isotherm shows the best agreement with the experimental data followed by the Freundlich and Dubinin-Radushkevishi isotherms.
The results obtained show that the aluminosilicate beads exhibited a higher adsorption capacity of the dye from solutions compared to the ironsilicate beads.

CONCLUSIONS

This work studied the synthesis, characterization and testing of metallosilicate beads as adsorbents. SEM and nitrogen adsorption prove the high porosity of the aluminosilicate beads comparativ cu ironsilicate. The adsorption process was dependent on pH value of solution, adsorbent dosage and initial dye concentration. The results showed that the adsorption capacity of the dye increased with the increase of the pH values of the dye solutions and with the adsorbent concentration. The best adsorption capacity is exhibited by aluminosilicate beads The Langmuir and Freundlich isotherms gave the best matching with the experimental data. Due to their advantages (better accessibility, long lifetime) these materials can be used as adsorbents.

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SYNTHESIS OF NANO PARAFFIN AND ITS APPLICATION TO POLYESTER FOR NEAR SUPERHYDROPHOBICITY

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During some past few years with the emergence of globalisation, change in requirements of modern life, competitive atmosphere and quality consciousness has changed the definition of textiles. In contrast to common clothing and home textiles, so called technical textiles have found an important place for high performance products. Engineering of superhydrophobic textile surfaces has gained significant and industrial interest for its potential applications in outdoor wear and protective clothings. Recently there has been active research in biomimetic technology for developing highly functional materials that mimic nature.[Park,2015] The lotus leaf is one of the best known natural superhydrophobic surfaces because of nano level hydrophobic wax crystals on top of micro-level projections [Liu,2013].
In this study, paraffin nano particles were synthesized by sol gel technique and these particles were characterized by their size using particle size analyser and observed under scanning electron microscope. The nano wax particles were applied to polyester fabrics. The treated fabric samples were characterized by FTIR and DSC. The performance of the treatment on the fabric were evaluated for its efficiency to repel water and its effect on other physical properties viz. hand, air permeability, drapability etc. The synthesized nano paraffin applications were compared with commercially available water repellents. The application of nano paraffin could create a contact angle very close to superhydropbobicity. Kawabata evaluation system proved that application of nano paraffin to polyester results in substantial improvement in total hand value. The outcome of this study suggests that it is possible to achieve high hydrophobicity to polyester by application of nano paraffin. The treatment does not have drawbacks like reduction in air permeability or imparting stiffness. On the other hand it improved the feel as determined by KES measurement.

Keywords: *Polyester, Nano-paraffin, Nano-particles, Superhydrophobicity*

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LOW PRESSURE PLASMA TREATMENTS FOR HYDROPHOBIC FABRICS

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Abstract: *In order to be able to conduct a comparative LCA study on a common functional unit, experimental tests were performed within this research work on cotton (240 g/m^2) and polyester (90 g/m^2) fabrics for hydrophobic functionalization, both with classical and plasma treatments. The experimental plan had the following structure: the classical treatment method was performed with two concentrations (30 g/l and 50 g/l) of Nuva TTC, while for the SF_6 plasma treatments two main parameters were chosen as factors: the power of the RF generator (10-50W) and the process time (1-5 min). A complex investigation plan for determining the modifications of the treated fabrics was performed: specific mass, fabric thickness, air permeability, SEM/EDX, spray test, contact angle. The obtained hydrophobic properties are equivalent for the two treatments and hence the common functional unit needed for the comparative LCA study is met. The hydrophobic fabrics are destined for emergency shelters*

Keywords: *plasma, fabrics, water contact angle, hydrophobic effect.*

INTRODUCTION

The main aim of this research study is to prove the environmental-friendly character of plasma treated fabrics. The final destination of the fabrics is shelters for emergency situations, such as floods, fire or earthquakes. In order to ensure a proper protection, the main needed functionality is the hydrophobic character of the fabrics. The research work aims to comparatively assess classical and plasma hydrophobic finishing methods [1-3], both regarding functionality parameters and environmental-friendly character.

The environmental friendly character of the fabrics will be subject of a comparative cradle-to-gate Life Cycle Assessment study (LCA) [4-5]. However at the current stage of the research work the physical-mechanical and physical-chemical properties of two types of fabrics (100% cotton and 100% polyester) were subjected for analysis regarding their hydrophobic character, after plasma and classical finishing.
The final aim of the current research was to prove equivalent functional properties of the plasma and classical hydrophobic treatment in order to be able to conduct the comparative LCA study on a common functional unit [7].
.

EXPERIMENTAL

Materials and methods

Two types of fabrics, 100% cotton fabric with 3/1 twill weave and specific mass of 240 g/m^2 and 100% polyester fabric plain weave with specific mass of 90 g/m^2 were used as substrates in this study for comparative analysis.

Plasma treatment for obtaining hydrophobic fabrics
Prior the plasma treatment experiments, the fabrics sample were cut in circular form with diameter of 20 cm for spray test investigations and 10 cm squared for specific mass, fabric thickness, air permeability, contact angle and SEM/EDX investigations. SF_6 plasma treatment on the cotton and polyester supports was conducted in a spherical stainless steel vacuum chamber evacuated down to a base pressure of 1x10^{-2} Pa by a system of turbomolecular /rotary pumps [6]. The chamber is equipped with a homemade capacitively-coupled plasma source mounted at 45° and 9 cm distance in respect to the substrate holder, which serves also as grounded electrode. The substrate holder is rotating during the plasma treatment in order to insure uniform plasma exposure over large area. The RF active electrode of the plasma source is constructed as a shower through which a controlled SF_6 gas flow rate (20 sccm) is injected in the discharge. The working

pressure during the plasma process was established at 1.5 x 10^{-1} Pa. The SF_6 plasma treatment experiments were conducted on two directions, in which the applied RF power (10÷50 W) and process time (1 - 5 minutes) were investigated as key parameters for the textile hydrophobisation.

Classical treatments for hydrophobic effect on fabrics
The classical treatments for the hydrophobic behavior of cotton and PES fabrics was preceded by a preparation phase, which included boiling with soda and bleaching for cotton fabrics and dry heat for PES fabric. The classical hydrophobic treatment on fabrics consisted in padding with the substance NUVA TTC by impregnation with 30 g/l and 50 g/l Nuva TTC in solution with pH = 4-5 with 0,5 ml/l acetic acid 60%, drying at 120º C and condensation for 4 minutes at 150º C.

Material characterization

In order to prove the hydrophobic character of the plasma and classical treated fabrics, the following physical-chemical tests were performed:

- Spray test (Standard SR EN ISO 4920/2013)
- Resistance to artificial rain (Standard STAS 6429/2008)
- Resistance to hydrocarbs (Standard SR EN ISO 14419/2010)

The following physical-mechanical tests were performed for evidencing the modifications between the plasma and classical treated fabrics:

- Specific mass (Standard EN 12127:1999)
- Fabric thickness (Standard SR EN ISO 5084/2001)
- Fabric density on warp and weft direction (Standard SR EN 1049:2:2000)
- Air permeability (Standard SR EN ISO 9237/1999).

The scientific approach aimed to assess comparatively the plasma and classical hydrophobic treatments, in case of two different textile substrates (cotton and PES).
Scanning Electron Microscopy (SEM) technique was used to investigate the morphological properties of the untreated and chemical and plasma treated cotton and polyester fabric samples. SEM measurements were performed on a FEI Quanta 200 high resolution microscope which operating at an accelerating voltage of 10 kV. Energy-dispersive X-ray spectroscopy (EDX) technique was employed in the same instrument in order to investigate the chemical composition of the materials.
Contact angle technique was used to investigate the wettability properties of the untreated and chemical and SF6 plasma treated cotton and polyester fabric samples. Water contact angles measurements were carried out at room temperature by a contact angle goniometer Optima VCA (AST products) equipped with a CCD camera. Distilled water droplets of 2 μL volume each were released automatically on the membrane surface for contact angle measurements; each reported value was obtained upon averaging 3 measurements.
The plasma treatments on the fabrics was performed at INFLPR, while the classical treatments and the investigation of the fabrics was performed at INCDTP. The discussion of results was performed jointly.

RESULTS

In table 1 and 2 we present the results of the physical-mechanical and physical-chemical tests for the cotton and polyester fabrics.

Table 1 – Results for the cotton fabric

Textile materials properties		**Blank sample**	**Classic treated material1**	**Classic treated material2**	**Plasma treated material**	**Standard**
Fibrous composition		100% cotton				ISO 1833:1995
Specific mass, g/m²		240	254	257	245	EN 12127:1999
Fabric weave		Twill				SR 6431: 2012
Fabric thickness , mm		0.581	0.596	0.598	0.579	SR EN ISO 5084/2001
Fabric density No. yarns /10 cm	Warp	414	420	420		SR EN 1049:2:2000
	Weft	212	210	205		
Air permeability, l/m²/s; 100Pa		70.14	71.0	74.24	68.87	SR EN ISO 9237/1999
Spray test	ISO grades	0	2	2.5	0	SE EN ISO 4920/2013
	AATCC photographic grades	0	70	75	0	
Resistance to artificial rain		0	18.7%	18.5%		STAS 6429/2008
Rezistence to hydrocarbs.			Grade 6	Grade 6		SR EN ISO 14419/2010

Table 2 – Results for the polyester fabric

Textile materials properties		Blank sample	Classic treated material	Classic treated material	Plasma treated material	Standard
Fibrous composition		100% PES				ISO 1833:1995
Specific mass, g/m2		90	102	102	93	EN 12127:1999
Fabric weave		Plain				SR 6431: 2012
Fabric thickness , mm		0.18	0.183	0.186	0.18	SR EN ISO 5084/2001
Fabric density No. yarns /10 cm	Warp	686	690	688		SR EN 1049:2:2000
	Weft	338	340	336		
Air permeability, l/m2/s; 100Pa		470.2	468.9	482.6	649.09	SR EN ISO 9237/1999
Spray test	ISO grades	0	5	5	1	SE EN ISO 4920/2013
	AATCCphotographic grades	0	100	100	50	
Resistance to artificial rain			0.65%	0.45%		STAS 6429/2008
Rezistence to hydrocarbs.		-	Grade 7	Grade 7		SR EN ISO 14419/2010

Figures 1 and 2 present a SEM/EDX image evidencing that the material presents a fluorine content upon plasma treatment and respectively the water droplet on the fabric and the obtained water contact angle which shows the hydrophobic behavior of the surface upon treatment (SEM/EDX and contact angle performed in INCDTP).

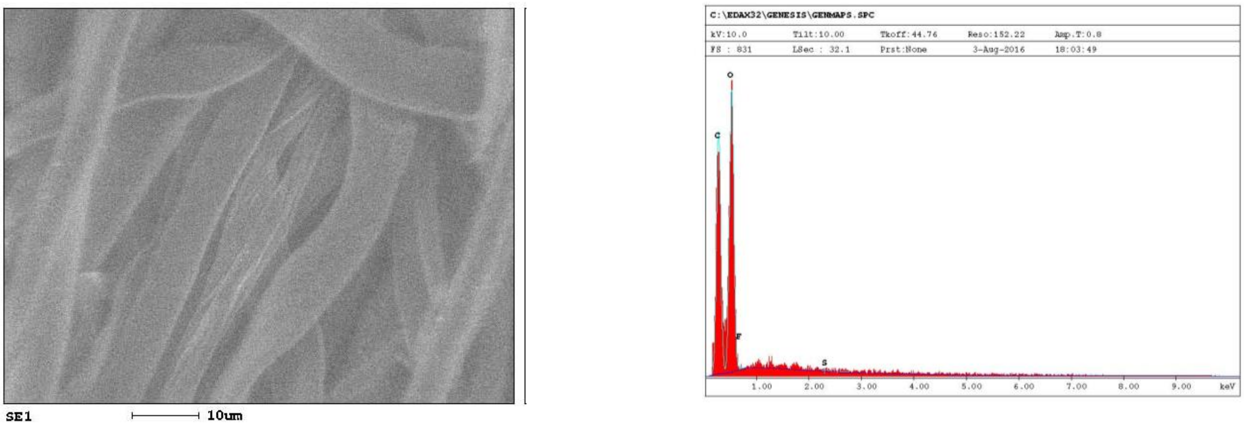

Figure 1– SEM image of plasma treated fabric (left)
and EDX spectrum evidencing the presence of fluorine in the fabrics (right)

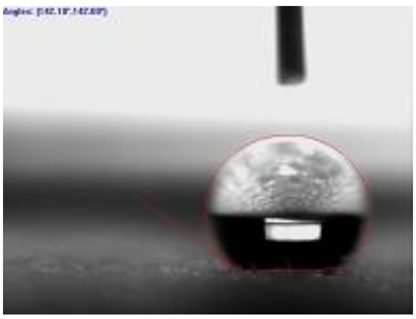

Figure 2– Contact angle measurement on cotton fabrics

DISCUSSION

The physical-mechanical properties of the hydrophobic treated fabrics were analyzed (specific mass, fabric thickness, air permeability) and the results presented in figure 3. The following graphs show the normal values of the evolution of the properties for the cotton and PES fabrics in four treatment phases: untreated (= normal value), classical treatment with 30 g/l Nuva TTC, classical treatment with 50 g/l Nuva TTC and a mean value for all the samples treated in plasma.

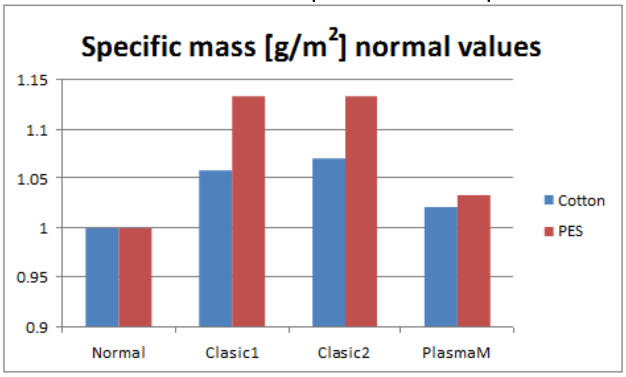

Figure 3 – Normal values for the specific mass of the classic and plasma treatments

From this graphs we can conclude that the classical treatment has an effect of increasing the specific mass, explained by the deposition of the hydrophobic substance Nuva TTC. On the other hand, the surface polymerization in case of plasma treatment has the same effect, but less compared to classic treatment. This fact opens a research theme for studying of new hydrophobic applications with reduced specific mass.

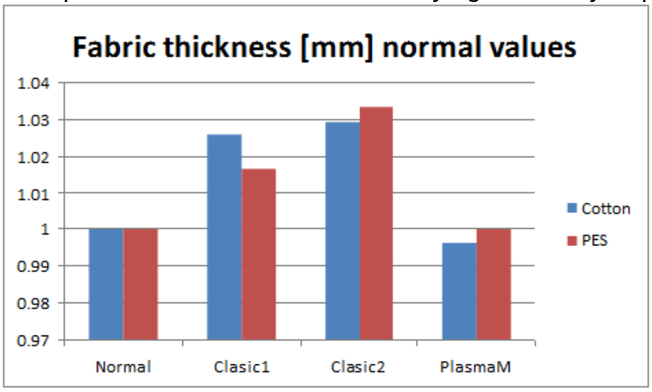

Figure 4 - Normal values for the fabric thickness of the classic and plasma treatments

Regarding the fabric’s thickness (figure 4), it registers a relatively high increase in case of the classical treatment, while a slight decrease can be observed in case of plasma treatment. This fact can be interpreted by a etching of the fabric’s surface by means of SF_6 plasma treatment. Upon correlating the fabric thickness with the specific mass, it results that in case of the classic treatment, the deposition of substances occurs in bulk, while in case of plasma treatment the material become more compact and deposition takes place on the surface of fibers.

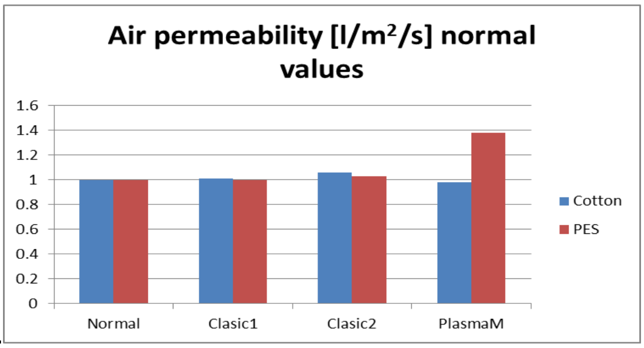

Figure 5 – Normal values for the air permeability of the classic and plasma treatments

Air permeability has a different behavior in case of cotton and PES. In case of plasma treatment, the functionalization gas SF_6, has a different effect on the two materials, causing the increase on PES and the decrease on cotton as presented in figure 5.

The following physical-chemical tests evidencing the hydrophobic character of the treated fabrics were performed in INCDTP laboratory:
A Spray test (SR EN ISO 4920/2013)
The results obtained for spray test have the following values for the classical treated fabrics:
- Grade 2 (Nuva TTC 30 g/l) and grade 2.5 (Nuva TTC 50 g/l) for ISO scale
- Grade 70 (Nuva TTC 30 g/l) and grade 75 (Nuva TTC 50 g/l) for photographic AATCC scale

For the plasma treatment only one sample could be tested, due to the required dimensions of the sample and the possibilities of the plasma equipment. Hence, this test could not be considered relevant.

B. Resistance to artificial rain (STAS 6429/2008) tests were performed only on classical treated materials with the following results: 18.7% and 18,5% for Nuva TTC with 30 g/l respectively 50 g/l at cotton and 0,65% respectively 0,45% at PES.

C. Resistance to hydrocarbs (SR EN ISO 14419/2010) was of Grade 6 for cotton and grade 7 for PES, which represent good results for the classic treated fabrics. This tests indicates oleophobicity and reflects only indirectly the hydrophobic effect.

D. SEM images and EDX graphs reflect a substantial content of fluor for the plasma treated materials, with a percent of cca. 0.95-1.35%, compared to 0% on the untreated sample.

Wettability investigations of the PES and cotton fabrics treated by SF_6 low pressure plasma are illustrated in the figure 6. The figure 6 present the surface contact angle variation of the plasma treated PES and cotton fabrics against the applied RF power and SF_6 plasma treatment time. In addition, several photographs of water droplets (2 µl) sitting on the top of cotton and PES fabrics are added in the graphs in order to allow visualization of the PES and cotton fabrics surface hydrophobisation after plasma fluorination.

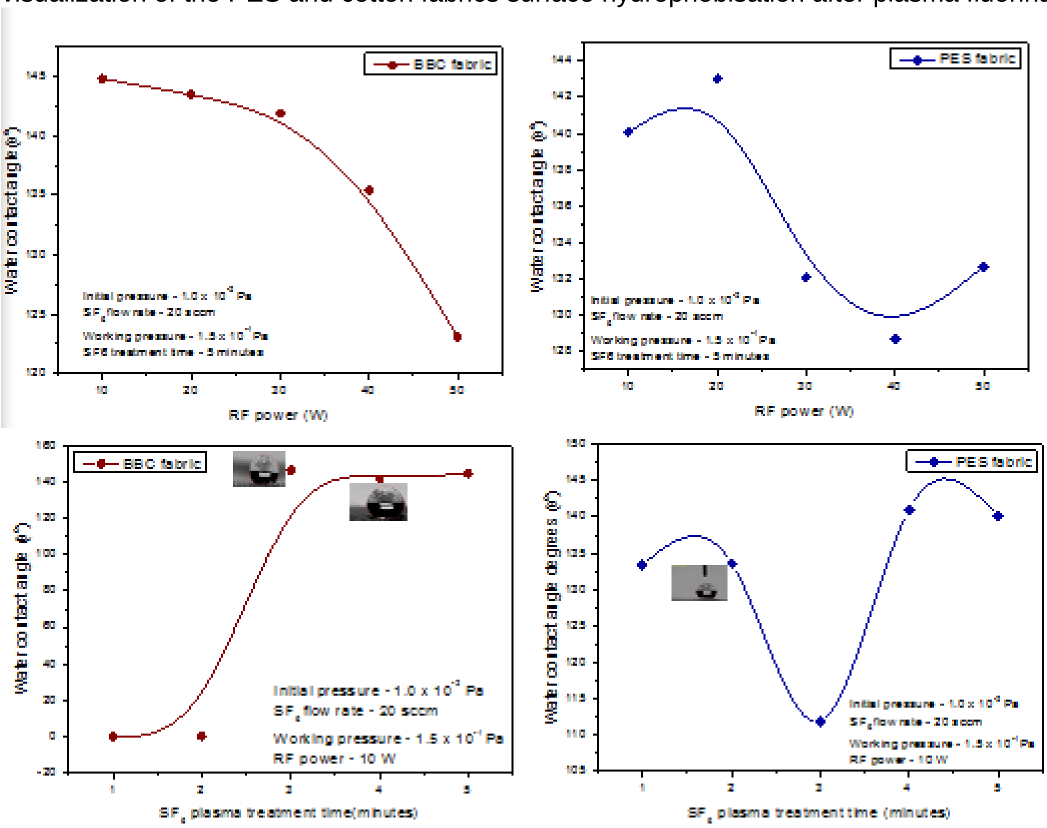

Figure 6 – Water contact angle variation of the plasma treated PES and cotton fabrics against the applied RF power and SF_6 plasma treatment time

These investigations reveal that applied RF power induce slightly decreasing of the water contact angle for the cotton fabric samples, while for the PES fabric samples there is no clear trend. However, for both investigated materials, the water contact angle values increase drastically upon exposure to fluorinated plasmas as compared to untreated materials, which have an absorption time of the water droplet less than 1 s. The most pronounced hydrophobic character both for the cotton and PES fabric samples is obtained in the range of 10 ÷ 20 W applied RF power, suggesting that upon using higher power levels, a surface etching process accompanied by redeposition is present, which modifies the surface properties. This is in accordance with the values of the specific mass and fabric thickness, presented in figure 3 and 4. Anyway the cotton and PES fabric surfaces present hydrophobic character with WCA values higher than 120 degrees. Regarding the variation of water contact angle against the SF_6 plasma treatment time, we can observe a drastic increase of water contact angle values at treatment times longer than 3 minutes for cotton fabrics as compared to shorter deposition time where the surface treated materials were hydrophilic. In the case of PES fabrics, we can observe the same non-monotonous wettability trend as in the previous case.

When comparing the WCA values for cotton treated with the plasma and classical finishing we obtained values in the range of [140º-145º] for classical treatment and values in the range of [135º-146º] for the plasma treatment, depending on the treatment parameters. In case of the values of WCA for PES, the classical finishing yields values in the range [138º-146º], while the plasma treatments values in the range [112º-144º]. The main conclusion is related to comparable hydrophobic results in case of plasma fluorination and classical treatments, both for cotton and PES fabrics

CONCLUSIONS

The conducted research study aimed to prove the equivalent hydrophobic properties of plasma and classical treated fabrics destined for emergency shelters. The final goal of the study will be to perform a comparative LCA study, meant for evidencing the eco-friendly character of plasma treatments.
The tests proving the hydrophobic character were performed on two fabrics: 100% cotton and 100% PES. They showed good and similar results for hydrophobicity for both the plasma and classical treatment on the two fabrics. A new approach is represented by using SF_6 gas for the plasma treatment. The premises for conducting the future Life cycle assessment study are fulfilled.

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COMPLEX COMPUNDS WITH O, O' HYDROXY AZO DYE AND SILVER (I)

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Abstract: *In this paper the synthesis and the study of the complexes with Ag (I) and o,o' hydroxy azo dye, Acid violet 78, was presented. The study of the new compounds was performed in aqueous solution and also in solid state. The method involved in the investigation of the coordinative compounds in solution were: UV-VIS spectroscopy and conductometry. From experimental data result that the combination ratio of central metallic atoms with the ligand Acid violet 78 was: 1:1 and respectively 1:2. In the experiments were used salts of $AgNO_3$. In order to determine the structures of the new synthetised complexes, the following analyses were performed, too: elemental analysis, IR spectroscopy, XRD spectroscopy, and the thermal stability. From the experimental data one observes that the both new compounds had a thermal stability to about 110 - 120ºC.*
There have been proposed the structural formulas of these new complex compounds by the experimental results. The proposed structures indicates that Acid violet 78 dye is a tridentate ligand.In the future scientific studies we want to determine if the new synthetized compounds will present similar properties as the silver characteristics.

Keywords: *complex compounds, azo dye, tridentat ligand, silver (I)*

INTRODUCTION

In the present work we have continued the research studies in the field of complex compounds with tridentat ligands [1]. For this reason we have decided to choose Acid Violet 78 to be complexed with silver (I).
Acid Violet 78 dye (C.I.12205) belongs to a class of monoazo metal-complex dyes containing hydroxyl groups in positions 2,2 ', compared to the azo groups. Their application to wool is similar to that for acid dyes, but the pH value is restricted to the range of 4.5 to 6.0 .
We decided to choose silver (I) as the metal for complexing this azo dye because it is well-known that silver and silver nanoparticles are used as antimicrobial in a variety of industrial, healthcare and domestic applications[2,3]. In the futures studies we want to determine if the new synthetized compounds will present the same or improuved properties as the silver characteristics.
There were synthesised two complexes at the 1:1 and 1:2 molar ratio, Ag(I): Acid Violet 78. In order to determine the structure of the new compounds, the following analyses were performed: elemental analysis, FTIR, UV-VIS and XRD spectroscopy. In the final of this work, the thermal stability of the new complex compounds were analyzed, too.

EXPERIMENTAL

As reagents were used $AgNO_3$ (>99%) purchased from Sigma-Aldrich and Acid Violet 78 dye (>98,9%) purchased from Fluka company for chemicals.
The structure of the organic dye, noted as H_2L, is presented in figure 1.

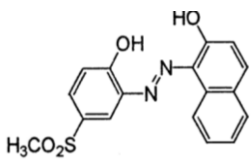

Figure 1. Structure of Acid violet 78

There were used $0.15 \cdot 10^{-3}$mol/L concentrations by isomolare solutions of the reactants for electric conductibility determination.The solution conductivity was measured using the OK 109 Radelkis –Budapest conductometer. Before measuring the conductivity, the devices calibrated the conductometer with KCl standard solution.
The spectrophotometric measurements were carried out using a UV-VIS CAMSPEC M50 single beam spectrophotometer, in the 190-1100 nm range, in quartz cell, l=1 cm at λmax = 580 nm, where the complexes 1:1 and respectively 1:2 have maximum absorbance. The combination ratio central atom: ligand was determined using "the molar ratios method" [4, 5]. The stability constants for the studied compounds were determined from spectrophotometric values applying Harvey-Manning method [5].
The Ag : H_2L molar ratios and the stability constants of complexes in aqueous solution were determined, in low light conditions, not to increase natural reduction of Ag (I)[6], by spectrophotometric and conductometric methods at room temperature [6].
Solid products were obtained by re-crystallization the complex compounds formed in concentrated solutions from the interaction between $AgNO_3$ and the Acid violet 78 dye. The solutions mixture was taken in molar ratios 1:1; 1:2. After stirring two hours continue at room temperature in low light, when the reaction was completed, the obtained compounds were separated and washed by distilled water for three times. The complex compounds were dried in an excicator at room temperature till the constant weight. The obtained products were brown dark friable solids.
Chemical analysis was made for solid compounds in order to determine the content of carbon, hydrogen, nitrogen and silver(I).
The infrared absorption spectra were recorded on solid samples in the 200-4000 cm^{-1} range employing the KBr pelleting method using an FTIR 660 Plus photometer. To confirm the new coordination compounds formation, the infrared absorption spectra was recorded the changes in frequencies of chemical bonds involved in complexation.
In order to study the thermal stability of the new complexes, it was used a Diamond derivatograph produced by Perkin Elmer – USA. The temperature of descomposition was up to 500°C.
The crystallinity degree was investigated with X-ray diffraction. The diffractograms of the new compounds were recorded at Bruker D8 Advan CE diffractometer with a nickel filter, copper anode in the 2θ = 2-60° range, at room temperature.

RESULTS

From the graphic of fig. 2 – 3 of absorbance and respectively the conductivity versus molar ratio it was observed a decreasing curve that changes the slope in the points to the values 1 and 2, which means in solution it is formed the complexes in 1:1 and 1:2 molar ratio.

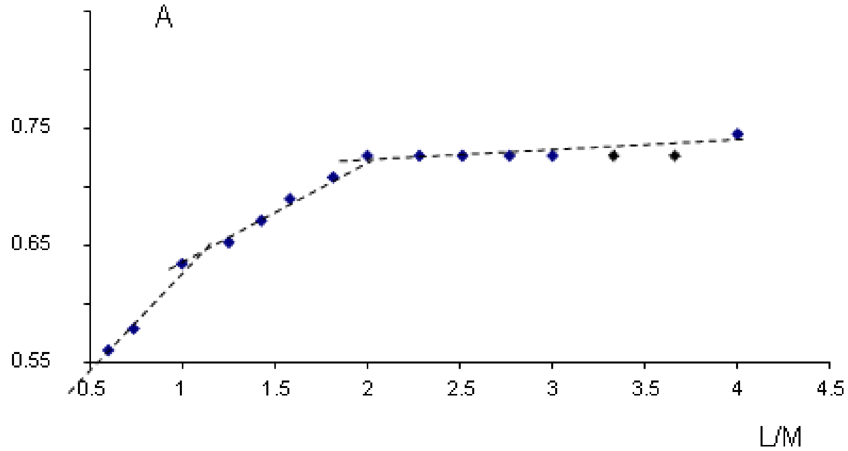

Figure 2. The curve representing absorbency values of the aqua solutions of $AgNO_3$- H_2L versus the molar ratio L/Ag (λ=580nm)

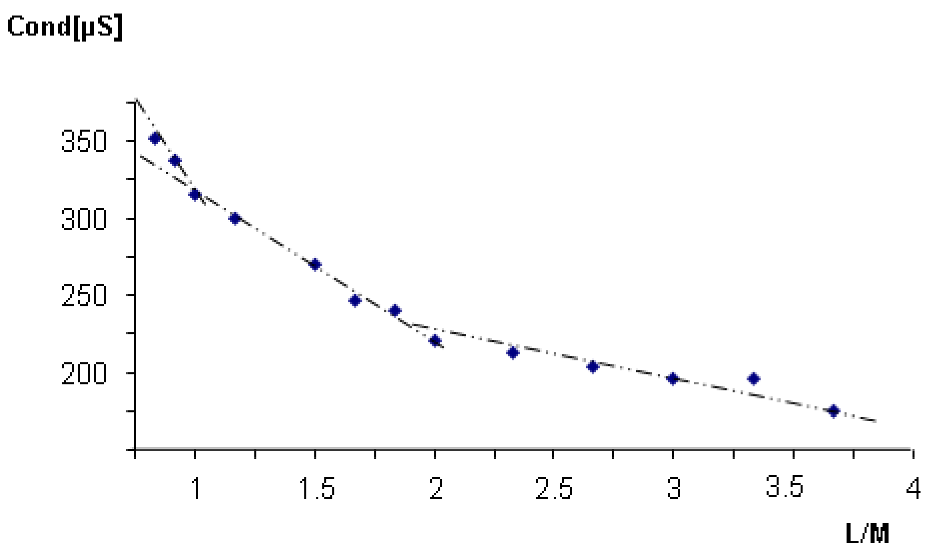

Figure 3. The curve representing conductivity values of the aqua solutions of $AgNO_3$- H_2L versus the molar ratio L/Ag

The values of the stability constants for the new obtained compounds are $K_1=0.11\cdot10^7$ for complex at molar ratio 1:1 and $K_2 = 0.16\cdot10^9$ for complex at molar ratio 1:2.

Elemental analysis

The determined elemental composition corresponds, within the error limit of ±0.20%, to the following chemical formulas: $H[Ag(L)(H_2O)_3]$ and $H_3[\ Ag[(L)_2]\cdot\ H_2O$. These were corroborated with the thermal analysis and IR spectra.
The results are listed in table 1.

Table 1. Elemental analysis data and molecular formula for $H[Ag(L)(H_2O)_3]$ and $H_3[\ Ag[(L)_2]\cdot\ H_2O$

Concentration of element, %										*Formula*
Ag_{calc}	Ag_{exp}	C_{calc}	C_{exp}	H_{calc}	H_{exp}	N_{calc}	N_{exp}	O_{calc}	O_{exp}	
20.91	20,59	39.54	39,18	3.48	3.29	5.42	5.15	21,71	21,26	**$H[Ag(L)(H_2O)_3]$**
13.42	13,09	50,75	50,12	2,98	2.29	6.96	6.21	15,92	15,13	**$H_3[\ Ag[(L)_2]\cdot\ H_2O$**

FTIR spectra

The analysed specific frequencies are listed in Table 2. Structural data of the ligand and the comparison of the complexes FTIR spectra allowed assigning the characteristic vibrations[7]. High-frequency region contains bands determined by the stretching vibrations of: water molecule ν(O-H), group –OH (from free ligand) and -N=N- group ν(N=N).
The wavenumbers of these bands correspond to the position expected from the structural data. In concerned range, the complexes spectra are complicated by the water bands. The characteristic bands with peaks at 3080, 3395, 3425 cm^{-1} are assigned to the ν(O-H) vibration from –OH group of free ligand and H_2O after coordination[9,10]. The hight intensity of ν(O-H) band for $H[Ag(L)(H_2O)_3]$ and $H_3[\ Ag[(L)_2]\cdot\ H_2O$ complexes can be related by the presented of the molecule of water after coordination.

Table 2. The shift of characteristic vibrations in the FTIR spectra of the ligand and the synthesized compounds.

Compound	ν_{C-N} cm^{-1}	ν_{N-N} cm^{-1}	ν_{-OH} cm^{-1}	ν_{Ag-N} cm^{-1}	ν_{Ag-O} cm^{-1}
ligand	917	1600	3080	-	-
$H[Ag(L)(H_2O)_3]$	1095	1500	3395*(from H_2O)*	525	642
$H_3[\ Ag[(L)_2]\cdot\ H_2O$	1086	1490	3425 *(from*	530	642

Compound	ν_{C-N} **cm⁻¹**	ν_{N-N} **cm⁻¹**	ν_{-OH} **cm⁻¹**	ν_{Ag-N} **cm⁻¹**	ν_{Ag-O} **cm⁻¹**
			H_2O)		

The values of stretching frequencies of -N=N- bond decrease and it is showed in Table 2. This process is accompanied by the decreasing of the bands intensity. Accordingly, the oxigen atom of hidroxil group after deprotonation is bonded to the silver cation. The appearance of the frequency at 642 cm $^{-1}$ indicates the involvement of the O in the Ag-O bond.
The influence of silver(I) on the C-OH group releves that the C-N bond becomes stronger. The fact is due to the displacement of the electrons pair from this bond nitrogen toward the metal determining the shortening of the bond with the reorientation of the π electrons.
From the elemental analysis, UV-VIS and infrared absorption spectral data it was accepted the following equilibrium reactions:

$$AgNO_3 + H_2L + 3H_2O \rightarrow H[Ag(L)(H_2O)_3] + HNO_3$$

$$AgNO_3 + 2\,H_2L + H_2O \rightarrow H_3[Ag[(L)_2] \cdot H_2O + HNO_3$$

XRD analysis

From the data obtained by the indexing of the synthesised complexes diffractograms results that they are bouth amorfous.

The proposed structures

Based on the above data we propose the folling structures for the synthesized compounds.
Acid violet 78 azo dye is a tridentate ligand for central atom silver(I) which have a hexahedral surrounding (Figure 4).

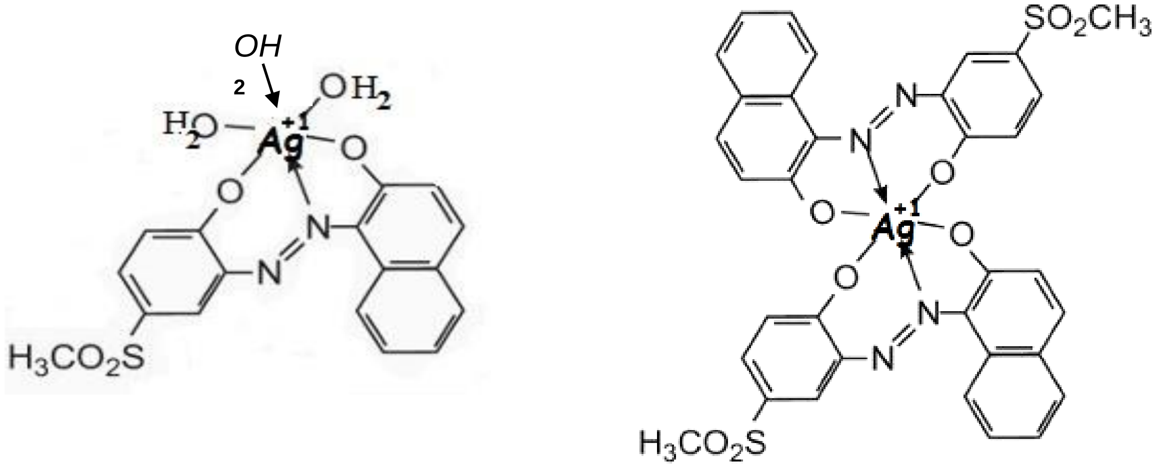

Figure 4. The ions complexes structure of the $H[Ag(L)(H_2O)_3]$ and $H_3[Ag[(L)_2] \cdot H_2O$

Thermal analysis

The loss of water molecules from the coordination sphere, of the first complex (molar ratio 1:1) occurs until the temperature of 110-120 degrees. It was observed that the silver oxide, which are formed from the central cation of the complex, after these temperature remains stable till the 260 degrees, which corresponds to literature data[11]. The loss mass and the rate of loss mass are presented in table 3.
In this domain of temperatures take place the following chemical decomposition:

$$H[Ag(L)(H_2O)_3]_{(s)} \xrightarrow{110-120^0\ C} 2H[AgL]_{(s)} + 2H_2O\uparrow$$

Other loss mass take place between 120°C and 260°C, corresponding formation of silver oxid and volatile substances:

$$2H[AgL]_{(s)} \xrightarrow{120-260^0 C} Ag_2O_{(s)} + \text{volatile}$$

Up to 260ºC the silver oxide decomposes to Ag.
In the first stage for the second complex (molar ratio 1:2), the crystal water was lost under the 100 degrees temperature. Then, silver cation from anion complex emerges from turning into silver oxide. The silver is formed after 260 ºC from the silver oxide.
In table 3 it is presented both theoretical and practical loss mass in weight percentages.

Table 3. Domains of decomposition temperatures, theoretical and practical loss mass, relative errors for the new complexes

Compounds	Stage	Domain of temperature, ºC	% Loss mass		$\lvert\varepsilon\%\rvert=100(\%W_p-\%W_t)/\%W_t$
			Theoretical,% W_t	Practical, $\%W_p$	
$H[Ag(L)(H_2O)_3]$	I	110-120	12,96	12,89	2.07 %
	II	120-260	54.09	53,98	0,048 %
	III	260-500	57,11	56,91	0,14 %
$H_3[Ag[(L)_2]\cdot H_2O$	I	98-110	0.602	0,599	0,58 %
	II	110-265	68,95	66,30	0,291 %
	III	265-500	67,87	68,07	0.175%

We may conclude the general decomposition process, under the 500 ^{0} C, for the both complexes compounds:

$$H[Ag(L)(H_2O)_3]_{(s)} \xrightarrow{t^0C} Ag_{(s)} + \text{volatile gases}$$
$$H_3[Ag[(L)_2]\cdot H_2O_{(s)} \xrightarrow{t^0C} Ag_{(s)} + \text{volatile gases}$$

CONCLUSION

We have synthesized a two new complexes of silver (I) with Acid violet78 dye in 1:1 and 1:2 molar ratio. They were characterized by physico-chemical methods in order to determine their structures and properties: UV-VIS, spectrophotometry, conductometry.The compound are non-crystalline solid brown dark colored.
The second complex are more stable ($K_2 = 0.16\cdot10^9$ for complex at molar ratio 1:2) than the first at molar ratio 1:1 (K_1=$0.11\cdot10^7$). This is because the second complex presents a symmetry in spatial arrangement of the strcture.
Thermal decomposition begin at the 110 degree for the second complex and at above 120 degree for the first complex at 1:1 molar ratio.
The experimental data was in agreement with the literature data [11, 12, 13] and we proposed the structures of the new complex compounds with silver(I). So, the sp^3d^2 hibridization at the central atom, Ag(I), coresponding to the octahedral structures of the each new compound synthesized in this work.
In the futures studies we want to determine if the new synthetized compounds will present the same or improved properties as the silver characteristics.

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MEDICAL TEXTILES WITH A CONTROLLED RELEASE OF DRUG IN CUTANEOUS THERAPIES

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Abstract: *The aim of research is to present the experimental data obtained to release the specific drugs to solve some dermatitis diseases. One has in view presenting drug delivery systems using cyclodextrin derivatives, hydrogels and multi-layer. As methodology, one determines the specific recipes used to prepare and obtain the temporarily reservoir of drug on a cellulose textile structure able to form a knitted fabric which subsequently will deliver the active principle to dermis. For drug delivery has been used a perspiration kit specific for dermis behavior. For hydrogels is used chitosan and sodium sulfate which form a specific structure able to deliver a drug. In the case of multi layer system has been presented some short researches to to characterise the whole system.To model the delivering process is used the Korsmeyer-Peppas delivery coefficient. Are presented some developments to improve certain restrictions regarding the release of certain active principles.*

Keywords: *drug, knitted fabric, cutaneous therapies, release kinetics, delivering coefficient.*

INTRODUCTION

Medical textiles represent a general brand for industrial goods but the textiles which could obtain a temporarily reservoir of drug on surface have a good potential for medical practice. In the current wearing they are able to release the drug from the textile surface to the skin under de action of a stimulus (dermatic enzyme, perspiration, friction with the skin). On this way, one can develop a medical textile using the following working algorithm: i) establish the therapeutic dose; ii) form the temporary drug deposit; iii) modeling the condition of drug release to the dermis.
In the literature, there are some ways which could adjust at the appropriate conditions for a medical textile. One can use the following systems: - the Ringsdorf model, -cyclodextrin derivatives, - hydrogels, - liposomes and – multilayer; each one with its own advantages and limits.The most used system seems to be the cyclodextrin, the hydrogels (are at the very beginning) and the multilayer (has been already used for other purposes but not for medical textiles wit a controlled drug delivery).
Usually, one uses a cyclodextrin derivative with a good reactivity to a textile support; this is setted on textile fabric by padding (or spraying); drying and curing. These processes favour the chemical grafting on cellulose or other type of fibrous polymers in textiles. Then, one apllies the drug on textile surface.
Another possibility could be the complexing a cyclodextrin with the drug and then setting the complex on textile surface. This working version implies severe and difficult experimental conditions. According with the reactive sensitivity of each chemical individuality to the action of the binder used could initiate decomplexing effect from cyclodextrin cavity. On the other hand, it is possible to be necessary the usage of a solvent for which the clinicians have serious hesitations. A strong reason to follow this second experimental version is to avoid „the burst effect" which gives some therapeutic failures. It is possible the existence of some active principles or pharmacodynamic products which could determine experimental satisfaction. The version needs experimental tests for each situation.
First steps in the use of hydrogels have been made in the case of hydrocortisone acetate delivering from pores of a hydrogel made by chitosan and sodium sulphate. Unfortunately, as well in this delivering system appears a higher burst effect by comparison with cyclodextrin case. In the both systems, cyclodextrins and hydrogels, the molecular dimensions of drug have got some restrictions made by specific dimensions of cyclodextrin cavity and hydrogel pores.
In the case of a multilayer delivering system, one uses two natural polymers soluble in water which, are deposited on a textile structure. Between layers are deposited portions of a drug. Under the action of physiological factors from human body, each layer is biodegraded and then the drug becomes free in the

system. On this way, there are not anymore dimensional limits for a drug and the burst effect could be totally avoided. The drawback of the multilayer system is the harsh handle of biomaterial obtained. There are some solutions to overcome the disadvantage mentioned.
The textile comfort [1] is an important issue for a textile garment directed to a sensitive skin of patients with dermatological pathologies. From a technical point of view, the comfort implies a thermo-physiological side objectively assessed using measuring equipment, a sensorial side, and finally a physiological side, the last two being subjective in their nature. The thermo-physiological component imposes that the garment assembly is able to transfer the heat and humidity produced by the body to the environmental medium; or else, it establishes a coefficient of thermal conductivity as a threshold starting from which the heat transfer is considered as adequate, and a coefficient of permeability to air, water vapors and carbon dioxide. It is not easy to scientifically argument the determination of the threshold values, even if the textile products are fibrous polymers assembled in a structure for which there is a transfer of heat, moisture and air between human body and the environment. There is a significant variability from the point of view of human subject, depending on geographical position, hydration level, the season for which the estimate is made (cold or warm), patient age, and skin *p*H. The skin *p*H is correlated with age (the children have the *p*H closest to the neutral one, but when they grow up, the *p*H becomes acid); in the specialty environment, the mean *p*H value is considered *p*H = 5.5 [2].
In the conditions of the present study, the esthetical function of the medical textile is less important, and it passes on the second plane, unlike the comfort, which is an important criterion. Yet, one cannot completely ignore the esthetic aspect, especially at clothing articles destined to women.
In order to provide the comfort of medical textiles, one must establish at first the components of the system:

- human body - textile product - surrounding medium. Microclimate plays an important part in the irritations at
- coetaneous level [3]. The values of microclimate parameters for which the patient feels comfortable are:
- temperature: 32±1 ^oC, relative humidity 50±10%, air displacement velocity 0.25 ± 0.15 m/s [1].

1.1 Drugs used for cutaneous diseases

According with the therapeutic class, drugs present structures with a lipophilic or a hydrophilic character. Lipophilic molecules or structural segments are absorbed inside the cyclodextrin hydrophobic cavity, the process being favored by low temperatures and relatively long during time periods. Up to now the controlled drug release systems that use CD-grafted textiles have been studied for various therapeutic applications: chronic venous insufficiency [4], allergic dermatitis [5], psoriasis [6-8] and microbial infections, hydrocortisone acetate is the main physiological glucocorticoide utilized as such or as esters. From a pharmacology-dynamic standpoint, hydrocortisone acetate has an anti-inflammatory action of reference for glucocorticoids. At present, hydrocortisone acetate is used in therapeutics for its anti-inflammatory, anti-allergic and anti-itching effects, having applications in psoriasis treatment too. The classical formulations are: injectable solution (25 mg/mL), ointments, creams, emulsions, suppositories, lotions with concentrations ranging within the interval 0.25%-2.5%. For topical applications, the quantity varies from 1.7 g ointment/cm^2 skin when taken from a jar, to 0.7 g unguent/ cm^2 skin, when taken from a tube [9, 10].
The paper makes an exploratory work trying to sett the main points which could establish practical criteria in the use of clothing in direct contact with human dermis.

EXPERIMENTAL

2.1 Materials

The textile material is a 100% cotton interlock knitted fabric used for manufacturing pajamas, body blouse, under garments and vests. The knitted is made by cotton yarns with yarn count, Nm= 60/l. Monochloro trazinyl-beta-CD, type Cawatex is purchased from Wacker Chemie; Lavotan DSU, is a tensid provided by Clariant, is a wetting, emulsifying and cleaning agent for all kind of fibers; Sirrix 2UD is an organic acid mixture, provided by Clariant, which has a de-mineralizing action of cellulose fibers; $Na_2S_2O_3$ is used as reducing agent to prevent cellulose degradation during boiling under the action of oxygen from alkaline solutions; Contavan ARL is a stabilizer of hydrogen peroxide consisting of a surfactant mixture supplied by Bezema; chitosan with a de-acetylating degree of 75-85%, with molecular weight = 600 kDa, delivered by Fluka; HCr purchased from usual market, as a white powder, was used without modifications; Ferric chloride, potassium hexacyanoferrate, sulphuric acid and all reagents (NaOH, Na_2CO_3, H_2O_2, $Na_2S_2O_3$) have been used without modifications as purchased from Sigma Aldrich supplier.

2.2 Procedures

The knitting fabric is subjected to the following procedures:
Procedure 1:
1) Alkaline boiling at a liquor ratio of 1:1, with 10% NaOH (reported to the weight of textile material), 5% Na_2CO_3, 1 g/L Lavotan DSU, 1 g/L Sirrix 2UD and 2 g/L $Na_2S_2O_3$; 2) Alternative washing for 10 min. at 90ºC and 10 min. at 20ºC; 3) Bleaching with hydrogen peroxide (through pad-batch, at a liquor ratio of 1:20, using: 20 ml/L H_2O_2 (32%), 20 g/L NaOH, 5 g/L Lavotan DSU and 4 g/L Contavan ARL, and then a period of 18 hours for relaxing at room temperature; 4) Warm and cold washing; 5) Drying 24 at 20ºC. MCT-β-CD grafting on knitted fabric was carried out by a pad-dry-cure procedure, using the procedure 2.
Procedure 2:
1) Padding with 100 g/L mono chloro triazinyl-β-cyclodextrin and 20 g/L Na_2CO_3 at 135% squeezing degree (100 kg textile material includes 135 liters solution); 2) Drying at 80ºC, 10 min.; 3) Curing at 160°C, 7 min.; 4) Repeated warm and cold washing until a pH=7 is obtained; 5) Final drying at 80°C, 10 min.

2.3 Dosing the hydrocortisone acetate

Drug dosing uses an analytical solution [11,12] based on HCr oxidation to the acid form and the reduction of ferric to ferrous salt, with the formation of an yellow solution; the color is intensified with potassium hexacyanoferrate to a bluish-greenish shadow [11].
A HCr-based solution of 60 mg/100 ml ethyl alcohol was prepared. The solutions for HCr calibration curve contain 2 ml sulphuric acid (4N), 2 ml ferric chloride solution (0.5% v/v), 0.5 ml potassium hexacyanoferrate (0.5% v/v), 3 ml perspiration kit, and increasing concentrations of HCr from the basic solution (0.5; 1.0; 1.5 and 2.0 ml); a witness solution which contains 2 ml H_2SO_4 (4N), 0.5 ml potassium hexacyanoferrate (0.5% v/v), 3 ml perspiration kit and 2 ml ferric chloride (0.5% v/v) is added to these. The prepared solutions are thermostated 15 min at 70°C, then cooled down and brought at constant volume of 25 mL with distilled water. The absorbance is determined versus witness sample at 780 nm, finally plotting the calibration curve.

2.4 Drug quantity released from textile grafted

The hydrocortisone acetate releases *in vitro* was determined by the use of a perspiration kit accrording with ISO 105-E04-2008 standard [13]. The samples have been immersed at different during times which is applied at the pH=5.5 the same value as human skin pH. The amount of drug was spectrophotometrically dosed at the wavelenght of 780 nm, in the visible spectrum.

2.5 Procedure 3 for the deposition of chitosan-based hydrogel on knitting fabric

0.5 g chitosan is solved in 50 ml distilled water, warm, stirring in acid medium of glacial acetic acid (96%). After 12 h, the samples are removed from solution and fastened on a device hanging over the beaker from which pours the solution to be impregnated in the knitted fabric. Chitosan saturated knitted fabric is immersed in a solution of hydrocortisone acetate and cross-linking agent (Na_2SO_4) for 24 h, under stirring at the environmental temperature. The drug solution was prepared by dissolving 0.06 g HCr in 100 ml 25% ethyl alcohol. In the solution was added 0.156 g Na_2SO_4. From the solution was taken 20 ml to include the fabric which already had chitosan. The amount of Na_2SO_4 was calculated as related to CS acetylation degree, in order to provide a slight excess as compared to the number of moles of ammonia group with which it forms ionic bonds. The final ethyl alcohol/water ratio is 25/75%.

RESULTS

The results obtained in research are illustrated in three separate sections according with each type of biomaterials.

3.1. Textile knitting grafted with cyclodextrin derivative and loaded with drug

EDAX elemental analysis revealed the nitrogen presence on cotton knitted which indicates the presence of triazinyl group. The results of drug release are illustrated in figure 1, whch represents the kinetics of drug release from cotton grafted with a cyclodextrin derivative and respectively with hydrogel.

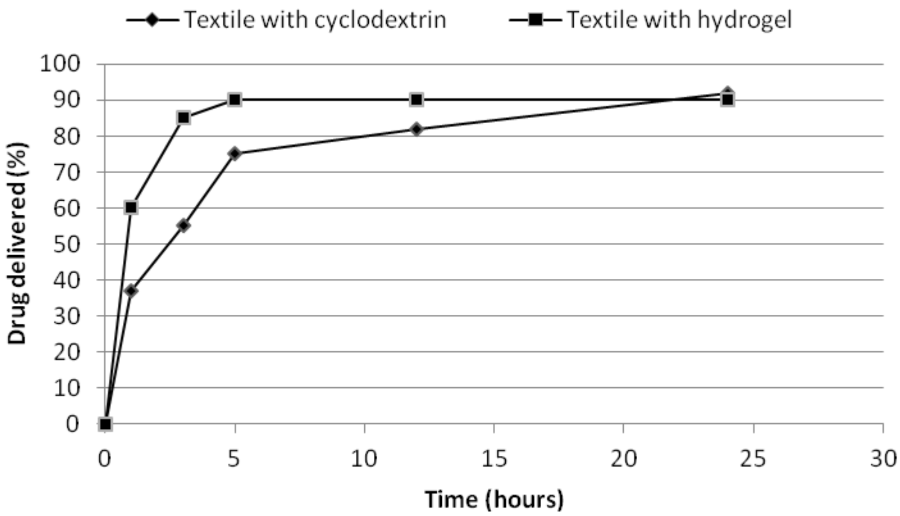

Figure 1: Kinetic of hydrocortisone acetate release from the textile fabric

The perspiration kit [13] was used at pH=5.5 and temperature of 37ºC (body temperature) to modelling the physiological cutaneous conditions of drug release. Loading degree was determined with equation 1.

Loading degree (%) = 100 (Wf-Wi)/Wi (1)*

Where, Wf - is the weight of the fabric with drug on it and Wi - is the initial weight of knitting fabric before loading with cyclodextrin and drug.
In order to have a quantitive image on the release characteristics of a drug from a certain system, several mathematical models have been proposed, among which Korsmeyer-Peppas [14-16] is more used. Equation 2 represents the Korsmeyer-Peppas formula:

$$Mt/M_\infty = K.t^n \quad (2)$$

Where: Mt is the quantity of drug released at the moment t, M∞ is total quantity of included drug, k is the release constant and n is the release coefficient. For determination, one needs to analyze the segment of curve of the hydrocortisone acetate release from textile surface for which the release is smaller than 60%. The coefficient n is determined by processing the experimental data Mt, M_∞ and t. The experimental values of the exponent taken from literature [14] can provide information on the drug transport and release mechanisms. The experimental value obtained for the release coefficient (Equation 2) is n= 0.79.

3.2 Textile knitting loaded with hydrogel and drug

The hydrogel-knitted fabric system is characterized from structural and morphological standpoints, as well as in terms of its swelling capacity in physiological liquid, an important characteristic for the drug release systems controlled by diffusion.
EDAX tests confirmed the chitosan presence in the hydrogel deposed on textile material, by the presence of nitrogen originating in the amino group of chitosan, and of the ionic cross-linking agent (Na_2SO_4), through the presence of sulphur, demonstrated by the elemental analysis. Since the hydrogel swelling characteristics in aqueous mediums are determining factors for the amount of included/released drug, as well as for drug transport/release mechanisms, we proceeded to the assessment of the swelling kinetics of the new materials in such mediums. Given the fact that hydrocortisone acetate inclusion was realized in an aqueous solution of ethyl alcohol (25%), the swelling process was studied in this medium. Under these circumstances the swelling degree of knitted fabric in an (25%) ethyl alcohol solution had reached the value of 124%. As well, the swelling degree of knitted fabric with hydrogel in an ethyl alcohol (25%) solution was of 189%.

3.3 Multilayer system

Details on performing of multilayer system, the way of loading and delivering was communicated elsewhere [14]. In the figure 2 is illustrated delivering kinetics of a drug from a multilayer system.

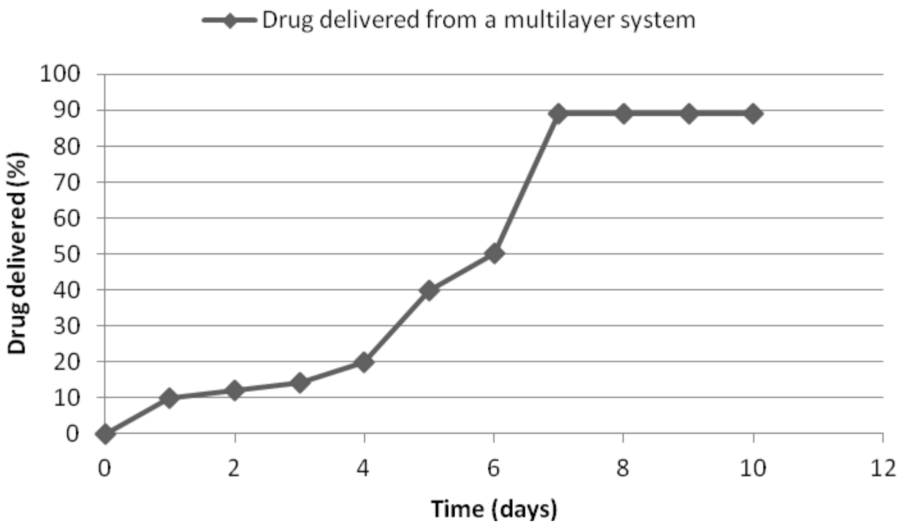

Figure 2: Kinetic of a delivery- voluminous drug from a multilayer system

DISCUSSION

One presented three different systems of drug delivery. One is the use of cyclodextrin, the second is the use of a hydrogel perfomed by chitosan and sodium sulphate and deposited on a knitting fabric in which was inserted the drug. The last one is a multilayer system used specially for drug molecules which cannot be processed by the use of a cyclodextrin or hydrogel. The use of cyclodextrin is restricted only for lipophylic drugs and with dimensions less than 7 angstroms. The hydrogel is not related exactly with a certain dimension of a drug but it is acute neccesary to have an available volume of pores for the diffusion of drug to the skin. In the third case, of a multilayer system does not appear the restrictions mentioned before.
Concerning diffusional behavior, the value of the release coefficient (Equation 2) is n= 0.79 for drug complexed into inner volume of a cyclodextrin cavity and, n = 1,03, respectively for the hydrogel system. The first value is situated in the non-Fick diffusion range. In the second case, it is clear that drug transport and release through the hydrogel are not leaded only by diffusion, the process mechanism being probably affected by the hydrogel erosion under the action of the compounds from the perspiration kit, which can destroy in time the ionic cross-linking.
The difference between the two values of swelling degrees (fabric with hydrogel and fabric without hydrogel) is 189-124=65%; the value represents the swelling value due to the hydrogel presence on the knitted fabric. One can, also, notice that the swelling rate during the first minutes of the process is higher in the case of the knitted fabric with hydrogel deposited on the textile material. Water molecules diffuse among macromolecular chains of chitosan and break the inter-chains hydrogen bonds, replacing them with hydrogen bonds established between chitosan and water. The high swelling capacity shows the conclusion of a high potential of drug sorption in hydrogel.
Kinetic of drug release (presented in figure 1 both for textile with cyclodextrin and textile with hydrogel) show a »burst effect« which means high rate of drug diffusion in the first stages of releasing. The aspect is considered a severe drawback.
In the case of last system presented, i.e. multilayer, according with the structure of layers deposited on surface of a woven textile fabric (layer thickness, temperature of settings, packing way, charge of each layer) and the amount of drug inserted between layers the diffusion of drug could have different profiles. On the other point of view, the releasing kinetics (see figure 2) does not present an ”burst effect” by comparison with the use of cyclodextrin or hydrogel as a system to deliver a drug from a textile surface to skin.This last characteristic is the most outstanding aspect concerning practical application.

CONCLUSION

The use of the cyclodextrin derivatives is a valuable solution to deliver lipophylic drugs with specific dimensions less than 10 Angstroms. The practical applications needs a serious and additional research concerning the aspect of drug controlled release.
The drug delivery system based on a hydrogel is at the beginning (there are only some communications in the field) and there are some drawbacks which need to pay more research attention.
The multilayer systems have high potential for a drug release, mainly because has not present restrictions as in case of cyclodextrin or hydrogel; according with the future evolution the system seems to become a strong engineering tool in the area of medical textiles.

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OPTIMIZATION OF PRINTING PROCESS WITH PIGMENT YELLOW 17

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Abstract: *In this research was studied the influence of zinc chloride and titanium dioxide added to the print paste containing pigment Yellow 17, on the properties of printed cotton fabrics. Samples of cleaned and bleached 100% cotton fabric were printed with a paste containing the pigment, thickener and various concentrations of zinc chloride and titanium dioxide. After printing the samples were dried and condensed. Experiments were carried out according to a central, rotatable second order compound program, with two independent variables. This method aims the description of functional dependency between one or more response parameters (dependent variables) and two independent variables.*

Keywords: *UV radiations, color differences, pigment Yellow 17, titanium dioxide, zinc chloride.*

INTRODUCTION

Printing with pigments is quite usage for fabrics and knits made from natural or regenerated cellulose fibers. The resistances of pigment printed textiles depend on a number of parameters: the chemical structure of the pigment, crystallization form of the pigments, composition of print paste etc [1,2].
Data from the literature show that titanium dioxide or zinc chloride can influence behavior of textile materials dyed or printed with pigments towards UV radiations [3]. By introducing in the printing paste titanium dioxide or zinc chloride, appear some changes reflected by improving the properties of printed textile material to UV radiation. The results obtained from mathematical modeling of the printing process of cotton samples with pigment Yellow 17 using a central, rotatable second order compound program, led to the establishment of functional dependence of the response parameters Yi (resistance to UV radiation, brightness of printed samples (ΔL), color differences (ΔE)) and two independent variables Xi (concentrations of $ZnCl_2$ and TiO_2).

EXPERIMENTAL

For this study were selected two independent variables:
- X_1 - $ZnCl_2$ concentration (%);
- X_2 - TiO_2 concentration (%).
As dependent variables (Yi) which highlight properties of printed samples were chosen 6 variables:
Y_1^1 – resistance to UV radiation after an exposure time of 2 hours, measured by the color difference (ΔE) between the non-irradiated and irradiated sample;
Y_1^2 – resistance to UV radiation after an exposure time of 4 hours measured by the color difference (ΔE) between the non-irradiated and irradiated sample;
Y_1^3 - resistance to UV radiation after an exposure time of 6 hours measured by the color difference (ΔE) between the non-irradiated and irradiated sample;
Y_1^4 - resistance to UV radiation after an exposure time of 8 hours measured by the color difference (ΔE) between the non-irradiated and irradiated sample;
Y_2 - color change of printed samples (ΔE) compared to blank (for which printing was performed with unmodified pigment);
Y_3 - brightness of printed samples (ΔL).
The working relationship between independent and dependent variables is of the form of regression equation:

$$Y = b_0 + b_1x_1 + b_2x_2 + b_{12}x_1x_2 + b_{11}x_1^2 + b_{22}x_2^2 \quad (1)$$

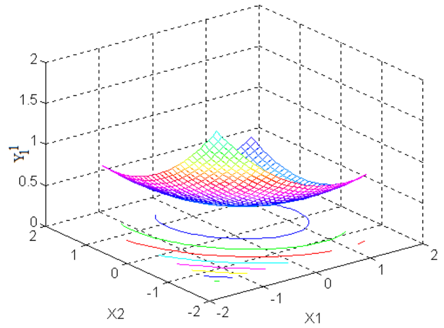
After conducting experiments was tested the extent to which the chosen independent variables have a significant influence on the selected dependent variables.

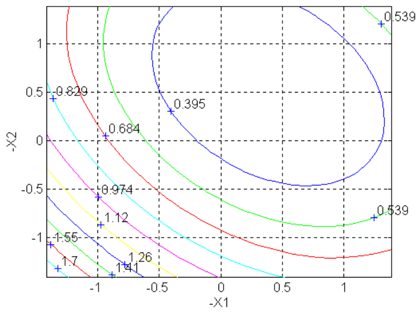
RESULTS AND DISCUSSION

The mathematical model proposed was plotted using Matlab software. Highlighting the effects of relevant factor interactions on the proposed target function (Yi) was performed by plotting the response surfaces and curves representing the values of the dependent variables.

3.1 Resistance to UV radiations (Y_1^{1-4})

The vast majority of materials which are dyed or printed are subjected to the action of UV radiations. During these exposures occur degrading of pigments with consequences on color. From this reason it is important to find various methods for improving resistance to UV radiations.
By introducing in the printing paste composition the substances containing Zn and Ti, occur changes in the pigment structure reflected by improving the quality of printing materials. This is reflected by improving the resistance to UV radiations with increasing concentrations of both substances added to the printing paste (Figure 1).
The color difference is smaller, the resistance of printed material to UV radiations is higher. In Figure 1 is noted that for the same duration of irradiation, both substances added to the printing paste improve the resistance to UV radiations by increasing their concentrations.





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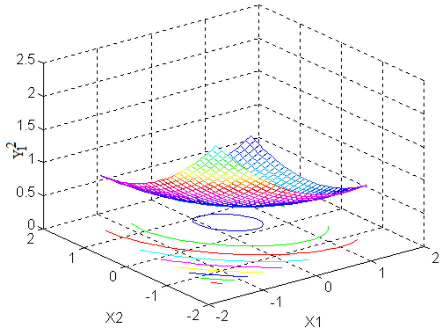

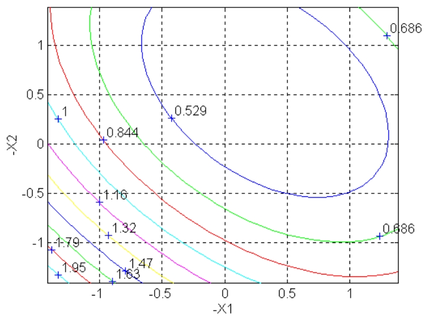

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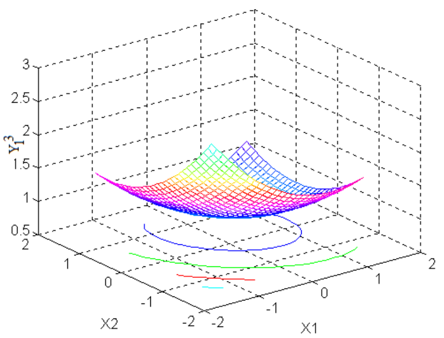
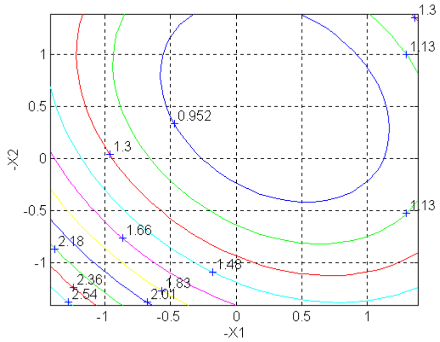




The irradiation time - 6h

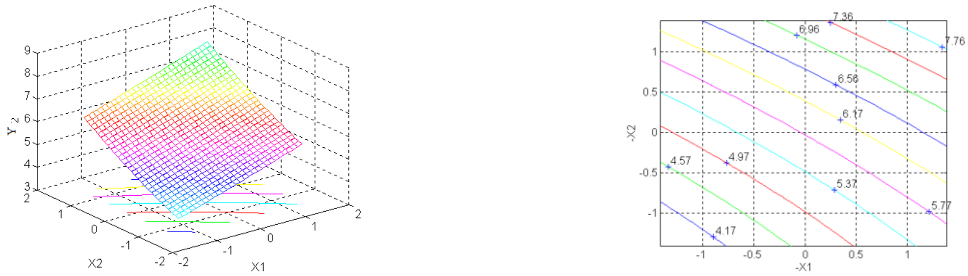
The irradiation time - 8h

a. b.

Figure 1: Variation of color difference compared to the duration of UV irradiation (Y_1^{1-4})
a. Response Surfaces; b. Curves of constant level

3.2 Color changes of printing samples (Y_2)

By adding in the printing paste those two substances appear color changes compared to the control sample (Figure 2).



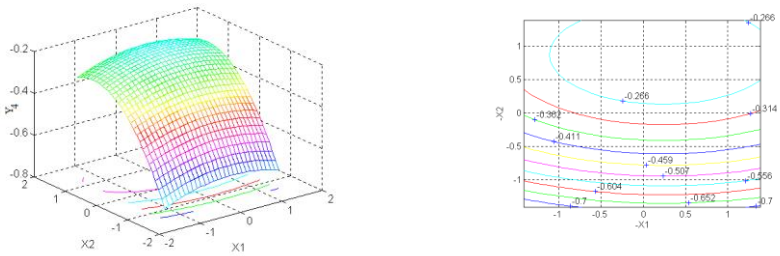
a. b.

Figure 2: Variation of color difference compared to the composition of printing paste (Y^2)
a. Response Surfaces; b. Curves of constant level

Both substances contribute to the color change, but the biggest influence, as shown in Figure 2.b, has increased concentration of $ZnCl_2$ (parameter values (ΔE) ranges from 4.17 to 7.76) compared to the titanium oxide (parameter values (ΔE) ranges from 4.17 to 6.17) in the chosen experimental domain.

3.3. Brightness of printing samples ΔL (Y_3)

Brightness, as property of bodies color which does not emit its own light, represent the visual sensation according to which a colored surface appears to emit more or less light. Brightness axis extending from the ideal black (L * = 0) to ideal white (L * = 100). The difference in brightness between two samples $\Delta L^* = L^*_{sample} - L^*_{standard}$ indicates:
- ΔL *> 0 sample is brighter than standard.
- ΔL * <0 sample is darker than standard.



a. b.

Figure 3: Variation of brightness compared to the composition of printing paste (Y^3)
a. Response surfaces; b. Curves of constant level

From the representation of the regresion equation shown in Figure 3 is observed that printed samples have a lower brightness than standard sample. Regarding the influence of the concentration of $ZnCl_2$ and TiO_2, it can seen that:
- Zinc chloride does not affect the brightness;
- Titanium dioxide has a greater influence on brightness; as its concentration increases, the brightness of printed samples increases.

CONCLUSIONS

The results obtained from mathematical modeling of printing process of cotton samples with pigment Yellow 17, using a central rotatable factorial program, led to the following conclusions:
- Were conducted 13 experiments: 7 factorial experiments in the vertices of a experimentally polyhedron, at a distance of ± α from the center, so calculated as to obtain a twisting and five experiments performed in the center of the experimental field for errors estimation (reproducibility of experimental data);
The independent variables of the printing process chosen for the study were:
x1 - the concentration of zinc chloride (%) and x_2 - concentration of titanium oxide (%);
Were established the mathematical expressions for the five proposed functions:
- Resistance to UV radiations (Y_1^{1-4});
- Color changes of the samples printed with printing pastes ($ZnCl_2$ and TiO_2, pigment Yellow 17, agglutinat) compare to those containing only pigment Yellow 17 and agglutinant paste (Y_2);
- Brightness of printing samples ΔL (Y_3).
The obtained results led to the establishment of functional dependence between the dependent parameters Yi (resistance to UV radiation, brightness of printed samples (ΔL), color change (ΔE)) and two independent parameters Xi (concentration of $ZnCl_2$ and TiO_2).
- By introduction in the composition of printing paste the compounds containing Zn and Ti, appare some changes reflected by improving the properties of printed material towards UV radiations.
- Both substances placed in the printing paste leads to a color change, but the biggest influence has $ZnCl_2$ concentration;
- Regarding the influence of two parameters on brightness can appreciate that zinc chloride affects less brightness while titanium oxide has a greater influence on brightness.

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Section 10: Advances in leather processing

ECO-FRIENDLY LEATHER OBTAINED BY USING AN OLIGOMERIC RESIN AS PRE-TANNING AGENT

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Abstract: *It is the aim of this paper to assess the eco-friendliness of a cow leather obtained by an improved process, which consists in pre-tanning with an oligomer resin, followed by low-offer chromium tannage. Namely, the leather tendency to release the tanning chemical auxiliaries was tested. The following analyses were performed to quantify the auxiliaries from aqueous leather extracts: total dissolved solids, organic and inorganic soluble matter, UV-VIS spectroscopy, HPLC chromatography. Experimental data indicated high release rates of oligomer and resorcin from the pre-tanned leather.The release rates of the same compounds after chromium tanning and retanning was about 4 times lower. This is due to the suplimentary complexation effect of the oligomer resin and resorcine upon the trivalent chromium. Resin and resorcin used in the pre-tanning step proved to be versatile complexation agents, which determined the decrease of chromium salt consumption by 50 ÷ 60 %, and advanced exhaustion of spent floats. Low-offer chrome tanning preceded by pre-tanning can contribute to the obtaining of eco-friendly leather.*

Keywords: *leather, pre-tanning, oligomeric resin, resorcin, eco-label.*

INTRODUCTION

At present, about 80-85 % of the worldwide leather production is tanned with chromium (III) salts and, except some leather types with special applications, chromium basic sulfate cannot be replaced by salts of other metals if high quality products must be obtained. In order to reduce chromium consumption in the tanning operation and chromum-tanned leather waste, mechanical operations such splitting and shaving must be performed as early as possible in the manufacturing process. During splitting and shaving, the in-process leather is subjected to mechanical stress and its temperature increases up to 65º ÷ 70°C, which produces collagen fibers denaturing; to prevent this, stabilization and reinforcement of the collagen matrix together with the reduction of leather cross-section pH are required. Both effects can be achieved during the pre-tanning operation, which can be performed with different chemical auxiliaries such as: Al, Zr, Ti or Mg basic salts, synthetic organic tanning agents, silicates or combinations of them; modern leather manufacturing technologies demands that splitting and shaving are not performd on wet-blue leather, but on pre-tanned leather, which can be classed as wet-white leather [1, 2]; thus, finding new pre-tanning agents is of interest for clean technologies, with low chromium salts consumption.

Basically, the insertion of pre-tanning operation is beneficial to the manufacturing process, because it results in important saving of chromium tanning salts in the tanning operation and in chromium-free leather wastes resulted from the shaving operation, which mitigates the environmental impact of the tanning industry [3-7].

Generally speaking, there are two classes of requirements a leather type must comply with, in order to be labeled as “eco-friendly”:

1 *Conditions related to the manufacturing process:*
- use of raw hides and skins coming from animals that are not subjected to any breeding or slaughtering restrictions;
- use of environmentally-friendly preservation methods, such as freezing or brine-curing;
- use of enzyme-aided or oxidative unhairing process, instead of sulfide-based process;
- replacement of inorganic acids with organic acids or acidic salts in the wet-processing operations;
- replacement of chromium basic salts with vegetable tannins in the tanning operation or use of advanced-exhaustion chromium-tanning technologies;
- obtaining of wet-white leather as intermediate product;
- reducing the filling/retanning offer and increasing the fatliquoring agents offder during the wet-finishing stage;

- use of low-molecular acid dyes in the dyeing process;
- use of finishing coats free of aldehyde or other low molecular weight cross-linking agents.

2 *Requirements related to the acquired physico-chemical characteristics of the leather material and leather goods:*
- lack of hexavalent chromium in leather section;
- lack of fatty or powdery spew;
- no release of volatile compounds and low-molecular weight chemical auxiliaries from leather cross-section or surface.

These requirements can not be concomitently met by any leather type or leather manufacturing company.

It is the aim of this paper to assess the eco-friendliness of a cow leather obtained by an improved process, which consists in pre-tanning with an oligomeric benzenesulfonate melamine-formaldehyde resin (BSMF) (Pruneanu, 2011; Pruneanu, 2012), followed by low-offer chromium tannage and conventional wet-end operations (Pruneanu, 2010). Namely, the leather tendency to release the chemical auxiliaries during pre-tanning, tanning and retanning was tested. The following analyses were performed to quantify the auxiliaries from aqueous leather extracts: total dissolved solids, organic and inorganic soluble matter, UV-VIS spectroscopy, HPLC chromatography. Experimental data indicated high release rates of oligomer and resorcin from the pre-tanned leather, which means that the pre-tanning process alone is reversible.

EXPERIMENTAL

Dry-salted cattle hides not exceeding 12 kg, previously processed to reach the delimed pelt state, were used as raw material for the pretanning-tanning-wet finishing-crusting processing flow, as described in Table 1. The pretanning operation complicates the overall manufacturing process, but this disadvantage is counterbalanced by technological and environmental benefits.

Table 1: Alternative leather manufacturing process that includes pretanning with the tanning oligomer

Operation	Process description
Pretanning step with oligomer resin	
Input: delimed pelt from dry-salted cattle hides not exceeding 12 kg	
Pretanning with oligomer resin and resorcin	100 % float, 40 °C; stirring for 10 minutes 5 % Densotan A (1:2); stirring for 10 minutes 10 -15 % Oligomer resin; stirring for 120 minutes 1,0 % Resorcinol; stirring for 60 minutes 5 % salt; stirring for 15 minutes 5 % Eskatan GLS; stirring for 30 minutes 1-1,2 % formic acid (1:10); stirring for 20 minutes Control float pH = 3,5; float exhaustion
Washing	100 % float, 40 ºC; 1 % Boron SE; stirring for 10 minutes;float exhaustion
Horse up after pretanning	Leathers are piled on the fleshing beam and covered with polyethylene foil, for 36 hours;
Setting out and sammying	On the setting-out and sammying machine
Splitting	On the splitting machine
Shaving	On the shaving machine
In-process product: Pretanned wet-white leather. Determination Shrinkage temperature	
Tanning with low-offer basic chromium(III) sulfate	
Acid treatment	200 % float, at 25 ºC; 8 % salt; 10 % HCl solution stirring for 10 minutes, trough slow dosage HCl solution
Tanning with basic chromium salt	In the same float at 25 ˚C; 1 % Cr_2O_3, stirring for 4 hours; Basification with $NaHCO_3$ solution; 5 % ESKATAN GLS, emulsion; Stirring for 60 minutes; Control float pH = 4,2;float exhaustion;
Horse up after chrome tanning	Leathers are piled on the fleshing beam and covered with

	polyethylene foil, for 36 hours;
Setting out and sammying	On the setting-out and sammying machine
In-process product: Wet-blue obtained by a combination tanning: oligomer pretanning and low-offer chromium tanning	
Wet finishing sub-process	
Washing	100 % float at 40 ºC; 0.5 % BORRON SE; stirring for 10 minutes; float exhaustion
Neutralization	200 % float at, 40 ˚C; 1.5 % $NaHCO_3$ (1:20); stirring stirring for 3 hours; control neutralization; 200 % float at 40 ˚C; stirring for 15 minutes; float exhaustion.
Rinsing I	200 % float at 40 ˚C; stirring for 15 minutes; float exhaustion
Retanning	75 % float at 40 ˚C; 4 % DENSOTAN A (1 : 2); stirring for 20 minutes; 5 % mimoza extract;stirring for 60 minutes; 3 % ESKATAN GLH; stirring for 30 minutes;
Dying and fatliquoring	In the same float 4 % LUGANIL Braun NR (1 : 2); 4 % LIPODERM liquor PSE; 2 % LIPODERM liquor SLW; stirring for 60 minutes 1 % formic acid solution 10 % ;stirring for 20 minutes; float exhaustion;
Rinsing II	200 % float at 40 ˚C; stirring for 15 minutes; float exhaustion.
Tanning with low-offer basic chromium(III) sulfate	
Setting out and sammying	On the setting out and sammying machine
Uscare în stare liberă Air Drying	In the tunnel dryer
Staking I	On the hydraulic staking machine
Toogle Drying	In the toggle dryer;
Conditioning /Rewetting	On the water spray machine
Milling tumbling	In the milling drum;
Staking II	On the staking machine;
Horse up	Piled on the beam for 5-6 h ;
Buffing on the flesh side	On the buffing machine;
Dedusting	On the dedusting machine;
Chemical grain corection	Leather is sprayed on the grain side with an aqueous solution of 1 g /L ammonia, 0.5 g / L BORRON SE and 6 g /L ethanol
Natural air drying	On the overhead air dry chain conveyor
Mechanical grain correction	On the hot plate machine
Intermediate product: crust leather ready for any dry finishing process. Samples of the crust leather were withdrawn and subjected to physico-chemical characterization. Determination Shrinkage temperature.	

Shrinkage temperature of the leather samples BSMF 10, BSMF 15 and BSMF 15T indicates tanning performance, according to SR EN ISO 5397:1996, using the device for shrinkage temperature determination (Digital Shrinkage Temperature Testers), IG/TG-Giulini Company, Italy. Shrinkage temperature value is the average of five values.

The release of low-molecular weight from leather cross-section and of particulates from leather surface was investigated by spectrophotometric and chromatografic methods, on the aqueous extracts of leather samples, processed in accordance with recipes given in Table 2. The UV-VIS spectra of the aqueous extracts were recorded on a Jasco 550 with the following characteristics: 1 mL quartz cuvette, wavelenght range 190÷600 nm, scan speed 200 nm/min,resolution 1 nm. A Zorbax SB-C18 (4,6 x150 mm) column, provided with a programmable Varian 9010 ternary pump, Waters 717plus autosampler and a Waters 486 UV-VIS detector, was used to record the extracts chromatograms; the HPLC system working conditions were: MeOH solvent/water = 50/50 (v/v), solvent flow 0,5 mL/min, maximum absorbancy wavelenght 254 nm. The UV-VIS spectra were processed with a dedicated SpectraManager software and the chromatograms were processed with the OriginLab 7.5 software.

RESULTS AND DISSCUSION

Leather obtained according with the process described in Table 1 was subjected to physico-chemical characterization The following analyses were performed to quantify the auxiliaries from aqueous leather extracts: total dissolved solids, organic and inorganic soluble matter, UV-VIS spectroscopy, HPLC chromatography. The results of gravimetric determinations are given in Table 2.

Tabel 2: Shrinkage temperature, the soluble solids content of aqueous extracts of pretanned leather and of conventionally tanned leather

Leather sample (aqueous extract)	Sample label	Total soluble matter %	Maximum acceptable concentration MAC*	Inorganic soluble matter %	Organic soluble matter %	Shrinkage temperature °C
Pretanned with 10 % BSMF 1 % rezorcin	BSMF10	1,44		0,35	1,09	77
Pretanned with 15 % BSMF 1 % rezorcin	BSMF15	2,38	max. 1,5 %	0,8	1,58	84
Pretanned with 15 % BSMF, 1 % rezorcin, tanned with 1 % Cr_2O_3, retanned with 5 % mimosa extract	BSMF15T	0,77		0,5	0,27	100

**certifies the absence of adverse effects on users, assigned by TÜV Rheinland, Fresenius Institut, Prüf- und Forschungsinstitut Pirmasens e.V. (PFI),*

In the presence of resorcin, BSMF has the ability to increase the shrinkage temperature of the treated leather, but the intensity of this effect depends on the amount of oligomer resin used in the process (see Table 2).When the BSMF offer is 15% on a dry dermal substance basis, the shrinkage temperature raises up to 84°C, in the presence of resorcin as crosslinking agent. Further tanning with low-offer basic chromium(III) sulfate increases the shrinkage temperature to 100°C, which is identical to the performance of a conventional chrome tannage.

Leather samples tanned with BSMF in the presence of resorcin have a pronounced tendency to release organic chemicals, which increases with the tanning oligomer initial offer. Instead, leather sample tanned according to the novel technology (BSMF15T) exhibit significantly lower release of solubles from its structure, which confirms the strong binding of the chemical auxiliaries to the collagen matrix.

The organic compounds released by the leather samples processed in accordance with the recipes given in Table 2 were identified on the UV-VIS spectra and HPLC chromatograms of the corresponding aqueous extracts.

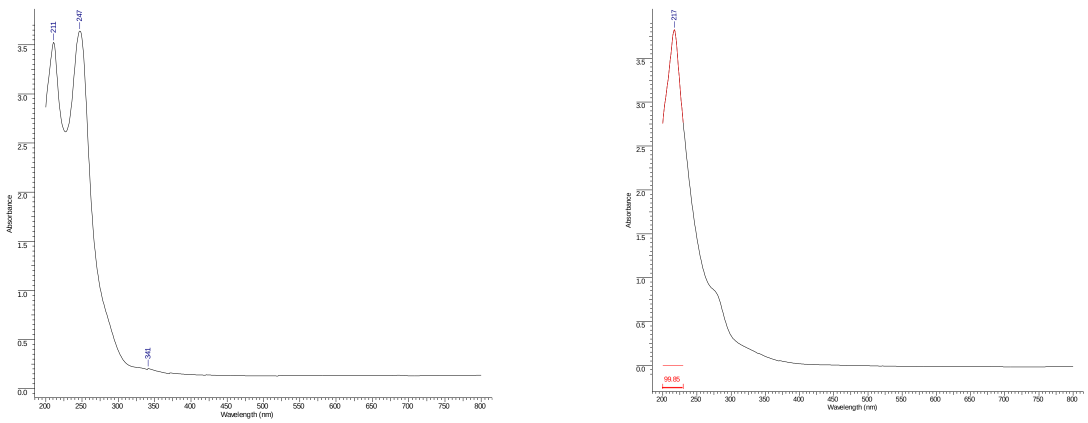

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Figure 1: UV-VIS spectra of leather aqueous extracts: **a-** BSMF 15; **b-** BSMF 15T

The UV-VIS spectrum of the aqueous extract of the BSMF15 pretanned leather (Figure 1a) points out the release of two organic compounds, with maximum absorbancies at λ = 211 nm and λ = 247 nm, respectively. The first peak, at 211 nm is characteristic to the –C = O chromophore group of the carboxilic function of the formic acid. The second peak, at 247 nm, can be assigned to the chemical compound resulted from the reaction between the BSMF resin and resorcin (Figure 2), more precisely to the m-disubstituted benzen cycle and the 1,3,5 triazine cycle **)** [8-10]. The UV-VIS spectrum of the aqueous extract of the BSMF15T leather, processed in accordance with the novel technology (Figure 1a) indicates the presence of only one peak at λ = 217**,** and the absence of the peak at 247 nm, which may indicate the absence of the reaction product between BMSF and resorcin in the tanned leather.

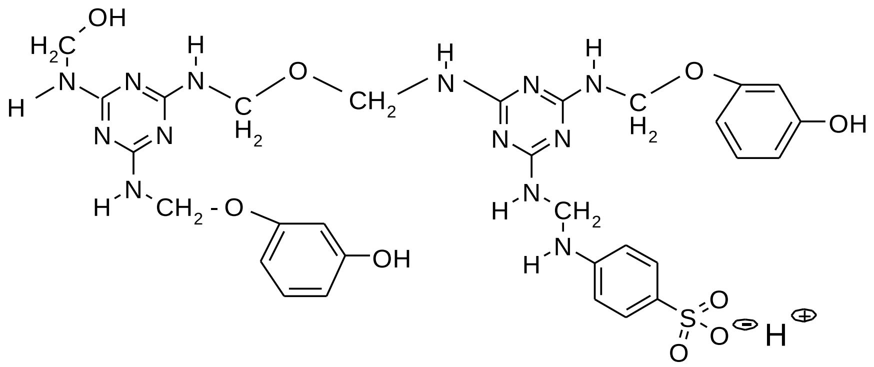
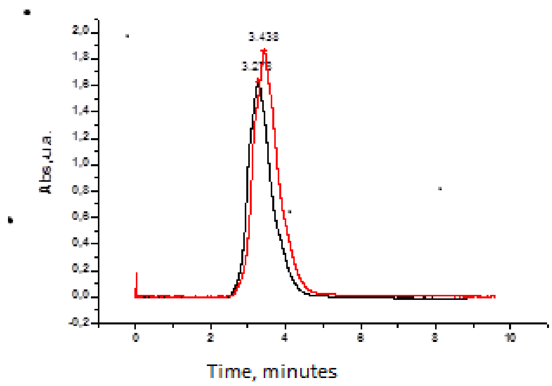


Figure 2: The reaction product between BMSF and resorcin

Two peaks are recorded on each of the HPLC chromatogram of aqueous extracts, corresponing to the two injections (Figure 3).The peak maximum corresponds to a certain retention time, which is the qualitative characteristic of the organic compounds found in the analyzed solutions. The peak hight (h) and area (A) account for the amount of the analyzed compound in the sample**)** [8-10].



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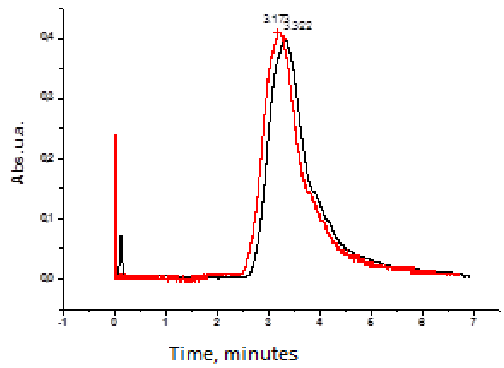

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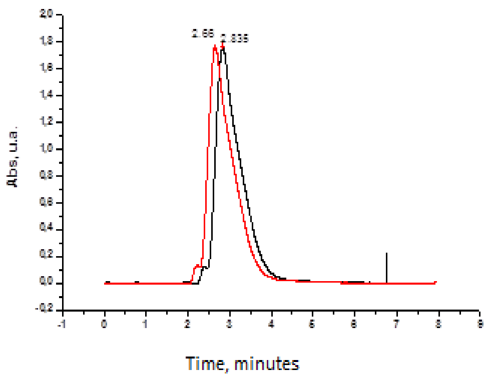

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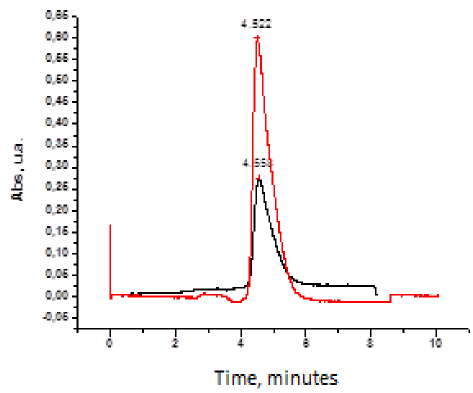

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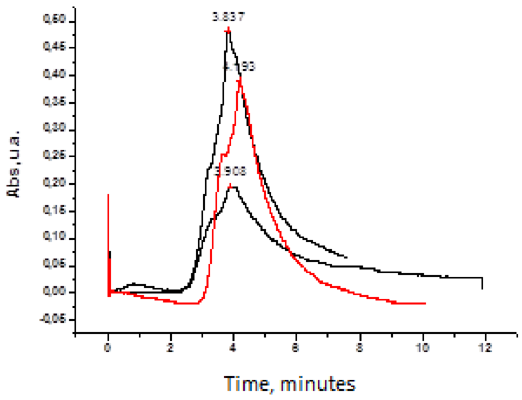

e

Figure 3: HPLC chromatograms of leather aqueous extracts: **(a)** BSMF15 **(b)** BSMF 15T **(c)** 0.1 % BMSF aqueous solution**;** **(d)** 0.1% resorcin aqueous solution; **(e)** 0.1 % mimosa colloidal solution

The HPLC chromatograms are consistent with the UV-VIS spectra and with the theoretically predictable composition of the aqueous extracts. Comparative chromatograms of the BSMF resin, resorcin and aqueous extracts of BSMF15 and BSMF15T samples are given in Figure 4. The experimental retention times are as follows: resorcin, 4.53 min; BSMF resin, 2.81 min; aqueous extract of the BSMF15 sample, 3.26 min and aqueous extract of the BSMF15T sample, 3.31 min.

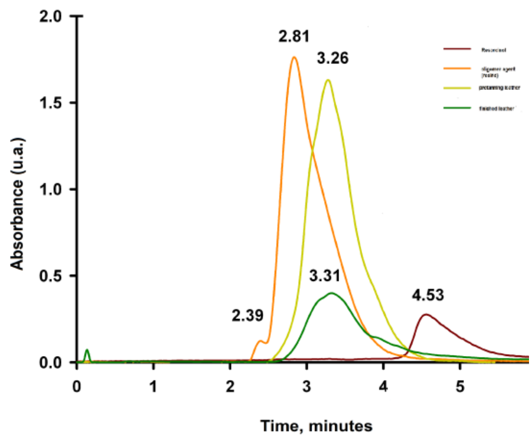

Figure 4: Comparative HPLC chromatograms of resorcin, BSMF, and aquueous extracts of tanned leather

The values of retention time and maximum absorbancy indicate that leather pretanned with the BSMF oligomer in the presence of resorcin as cross-linking agent have the tendency to release the chemical auxiliaries entered into the collagen matrix cross-section, which suggests that pre-tanning alone is a reversible process. If pretanning is followed by coventional tanning and retanning, the amount of released organics is four-fold lower. The stronger binding of tanning agents to the collagen matrix is due to supplementary complexation effect that BSMF and resorcin exert on the chrome complex salt. The oligomer resin and resorcin are known as extremely versatile complexing agents, and their use in the tanning process result in the reduction of chrome salts offer by 50-60% and an advanced chrome exhaustion in the tanning spent floats

CONCLUSIONS

Pretanning with the oligomeric benzenesulfonate melamine-formaldehyde resin has a dual effect on the collagen substrate and can be applied through different processes, depending on the desired leather type and degree of "eco-labeling" requested to the final product.

Pretanning with the BSMF product result in the increase of shrinking temperature up to 78º ÷ 82 °C and consequently in the improvement of leather firmness, which favors the effectiveness of splitting and shaving and generation of chrome-free solid wastes amenable to superior valorization. The final shrinking temperature is close to 100°C, despite the fact that the chromium offer in the tanning float is decreased by 50%.

In the case of upper leather, which must exhibit high hydrothermal stability,chrome- tanning can not be replaced by any other alternative; even so, pretanning allows a low-offer chrome tanning not exceeding 1% Cr_2O_3, which tresults in high exhaustion of spent floats and low chrome content of finished leather. At the same time, the occurence of hexavalent chromium in leather cross-section, which is one of the most restrictive indicators for leather eco-labeling, is considerably reduced.

In the case of leather types destined to garments, leather goods and upholstery, pretanning with the oligomeric resin in the presence of resorcin as cross-linking agent provides the hydrothermal stability imposed by the final utilisation and can be completed with vegetable tannage, if eco-labeled leather must be obtained.

When conventional chrome-tannage is performed after organic pretanning and mechanical operations, the resin can be removed from the wet-white cross-section due to the reversibility of the oligomer –collagen interaction, but in this case, the finished leather cannot be considered as “eco-labeled”.

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Section 11: Footwear design and technology

OPEN INNOVATION IN THE FASHION INDUSTRY: PORTUGUESE FOOTWEAR INDUSTRY

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Department of Textile Engineering

Abstract: *The Portuguese footwear industry had in the last five years a remarkable performance in the exportation values, trade balance, quality and product design, and international image. The forecasts for 2016 are very positive, with a higher exportation growth than other Portuguese industries during this period [1]. After a long period of difficulties and with a strong reduction of companies and employees since 1994, nowadays the Portuguese footwear industry is a success case in the Portuguese industry. There are several innovative companies in this traditional and mature sector in Portugal, some of them leaders and important players in the international/global context. This paper analyses the innovation category followed by the companies, according Oslo Manual classification, developed by seven innovative companies (two are leaders in the Portuguese footwear industry) and shows the linkage that the partners have in the innovation processes, where open innovation is clearly identified as critical for these excellent performance achieved.*

Keywords: *Open innovation, fashion industry, footwear, Oslo Manual.*

1 INTRODUCTION

The textile, apparel and footwear industry belong to the called “fashion industries”. Indeed, there are many similarities between the footwear industry and the textile/apparel industries (ITV) in Portugal. They are traditional industries, mature and consolidated, “low-tech” and labor intensive, with a long story in the Portuguese economy and represent thousands of jobs and thousands millions of exports. They export more than other Portuguese labor-intensive industries, mainly to Europe, and contribute to a very positive trade balance in the national economy. The Portuguese textile and apparel industries have suffered an important impact with the economic crisis of 2009-2012, but in the last three years they started the recovering process (Table 1). Also the Portuguese footwear industry shows an excellent performance in several indicators in the last five years. The economic and social indicators of the footwear sector for the year 2014 published by APICCAPS (Associação Portuguesa dos Industriais de Calçado, Componentes, Artigos de Pele e seus Sucedâneos) [1] show that 1.430 companies are employing 37.781 workers and had a gross production value of 1.884 million euros (Table 2). The coverage rate (value) is around 411%, one of the highest in the Portuguese economy. Year by year, this industry became stronger, creates new jobs with new skills, and increases his competitive position between the global stakeholders, players and competitors, even in demanding and sophisticated European markets, such the Italian or French.

Table 1: General data of Portuguese textile and clothing industry - ITV (2010-2015)

YEAR	2010	2011	2012	2013	2014	2015
Production (millions €)	**5.640**	**5.770**	**5.647**	**6.028**	**6.407**	**6.479**
Turnover (millions €)	**5.815**	**5.983**	**5.838**	**6.296**	**6.654**	**6.755**
Exports (millions €)	**3.844**	**4.167**	**4.127**	**4.288**	**4.620**	**4.836**
Imports (millions €)	**3.419**	**3.467**	**3.116**	**3.343**	**3.608**	**3.795**
Employment	**137.264**	**132.133**	**124.329**	**124.147**	**127.901**	**129.452**

In two decades, the footwear companies in Portugal made a strategic change in the business model and they started do develop own products and own brands, supported by a large and successful international marketing campaign to new foreign markets. The presence in international fairs (e.g. MICAM), exhibitions and congresses are common and with more and more Portuguese participants. The last MICAM in September 2016 had around one hundred Portuguese footwear companies as exhibitors. This performance wasn't achieved yet in the same way by the textile and clothing industry in Portugal, but the results in 2015 and in the first semester of 2016 already reached by the ITV industry are very promising.

Table 2: General data of Portuguese footwear industry (2010-2014)

YEAR	2010	2011	2012	2013	2014
Production (millions €)	**1.283**	**1.511**	**1.824**	**1.797**	**1.884**
Number of companies	**1.245**	**1.324**	**1.322**	**1.399**	**1.430**
Exports (millions €)	**1.297**	**1.541**	**1.600**	**1.735**	**1.846**
Imports (millions €)	**425**	**467**	**403**	**422**	**449**
Employment	**32.132**	**34.509**	**34.624**	**36.889**	**37.781**

Portugal is placed in the twelfth position as world exporter in the footwear industry (table 3) and has the second highest average export price (pair of shoe) among top 15 exporters [1], just behind Italy. The Portuguese footwear industry represents around 3,6% of the Portuguese exports, one of the highest percentage in all European exportation values. Leather shoes are the type of footwear more traded in 2014, with 77% of the total exported by Portugal.

Table 3: World top 15 exporters in value (2014)

Rank	Country	Value (millions USD $)	World Share (%)	Average Price ($) – (Rank)	Export Markets (Top 3)
1	CHINA	53 837	40,5	4,44 (15º)	USA/Japan/Russia
2	VIETNAM	12 200	9,2	16,09 (12º)	USA/France/Gwermany
3	ITÁLY	11 138	8,4	50,92 (1º)	France/Germany/USA
4	BÉLGIUM	5 566	4,2	24,50 (4º)	France/Netherlands/UK
5	GERMANY	5 166	3,9	22,62 (6º)	France/Netherlands/Poland
6	INDONÉSIA	4 761	3,6	20,88 (8º)	USA/Belgium/Germany
7	HONG KONG	4 014	3,0	16,65 (11º)	USA/China/Japan
8	SPAIN	3 540	2,7	22,07 (7º)	France/Italy/Germany
9	NETHERLANDS	3 295	2,5	19,99 (9º)	Germany/France/UK
10	FRANCE	3 095	2,3	31,74 (3º)	Italy/Germany/Spain
11	ÍNDIA	2 610	2,0	13,08 (13º)	UK/USA/Germany
12	PORTUGAL	2 452	1,8	31,88 (2º)	France/Germany/Netherl.
13	U K	2 079	1,6	12,83 (14º)	Germany/Ireland/Netherl.
14	ROMANIA	1 374	1,0	24,01 (5º)	Italy/Áustria/Germany
15	SLOVAKIA	1 226	0,9	17,20 (10º)	Germany/Áustria/Poland

Innovation plays an important role in these economic results. Innovation can be observed and identified clearly in the most innovative and competitive Portuguese footwear companies, and innovation in marketing and innovation in products are the more important categories of innovation (according Oslo Manual classification).
Open innovation model is focused in the companies [2], whatever the industry, including obviously traditional industries as footwear or textile/clothing. Open innovation also prepares the firms for the globalization and the new advances in information and communication technologies (ICT's) and social networks [3]. This model requires several partners, with different skills and resources, prepared to cooperate and share information, data, problems and solutions. As stated Chesbrough, "*Open Innovation means that valuable ideas can came from inside or outside the company and can go to market from inside or outside the company as well*", [2], (pp.43). The sectorial organizations from Portugal (APICCAPS and CTCP) play an important role in the coordination of joint projects partnerships. This is a positive reality in the Portuguese footwear industry and works well. Spillovers and technology transfer occurs in some common projects and open innovation (Figure 1) explains the innovation process verified and the improvements achieved. Cooperation in I&D is necessary to share resources in many industries [4] and to make innovation profitable.
The present paper analyses the innovation category followed by the companies, according Oslo Manual classification [5], developed by these seven innovative companies (some of them are leaders in the Portuguese footwear industry) and shows the linkage that all the partners share in the innovation processes. Open Innovation strategies can be easily identified in the footwear's leaders companies.

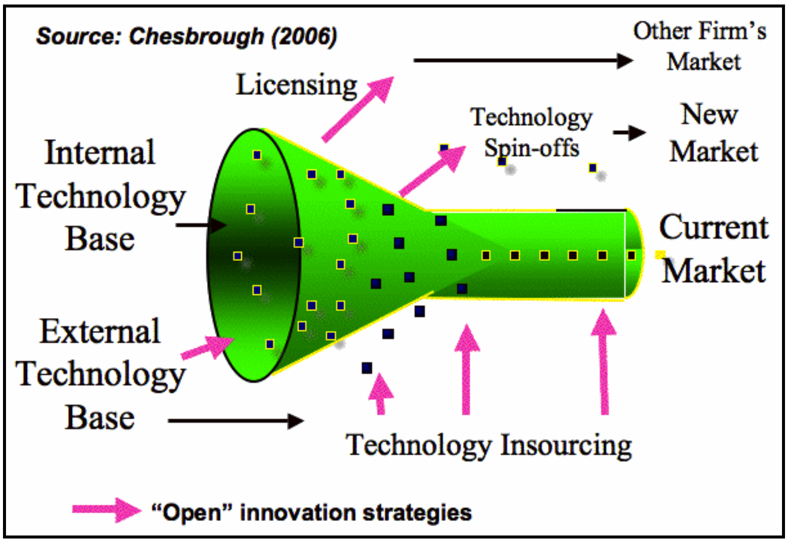

Figure 1: Open Innovation model (Chesbrough, 2006)
Source: http://blog.openinnovation.net/2010_08_01_archive.html

2 METHODOLOGY

This paper analyses seven cases of the Portuguese footwear industry: Felmini, Savana, Centenário, Procalçado, Kyaia/Fly London, Soze/Dkode and Aco Shoes. The research methodology followed was qualitative and the strategy for data collection was the case study (multiple case studies), as suggested by Yin [6]. The qualitative analysis is presented as the most recommended when the researcher wants to study a small sample of entities and the study is focused on a theme (innovation) or sector (footwear sector). It is also recommended when the investigation aims obtaining detailed and in-depth information on organizations, interactions and behaviors observed by the investigator during the field research [7].
Qualitative research usually provides direct, deep and detailed quotes, and careful descriptions of situations, practices, events, people, interactions and behaviors in organizations [8].
Several authors and specialists who have dedicated themselves to the investigation of small companies suggest that the use of a qualitative approach is the most suitable for the study of micro, small and medium enterprises (SMEs), situation that occurs in the Portuguese footwear industry [6],[9].
Hill and McGowan [9] argue that for the study of small businesses and their leaders and administrators, is convenient to use an epistemological approach that minimizes the distance between the researcher and the entrepreneur, allowing a positive interaction between them. In this research, the main sources used were semi-structured interviews, questionnaires and observation of reality in the workplace (real work context).

During more than six months were listened several members from the companies and was filled a small questionnaire about innovation.
The case studies represent one of the most used and popular research strategies in various areas of knowledge and research. It is of great convenience when the researcher wants a deep understanding of the context and the research process, and is adjusted to exploratory and explanatory studies of certain events or situations. This strategy allows to the researchers obtain holistic and relevant features of real events, regardless of the element of analysis is related with an individual, group or organization [6],[10]. The opportunity to get a holistic view of a process is a significant advantage for the case study strategy when it is chosen [11].
Yin [6] considers that a case study *"is an empirical inquiry that investigates a contemporary phenomenon in depth and in the context of real life, explicitly when the boundaries between phenomenon and context are not clearly evident*" (pp.18). The case studies are particularly useful "*where you need to understand some particular problem or situation in great depth, and where they can identify rich information cases*" [8] (pp.19), as it was occurred during the research in these seven companies. Simons [12] states that case study "*is a deep exploration of multiple perspectives of the complexity and uniqueness of a particular project, a policy, an institution, a program or a system in a real life context" (pp.21).*
To select these seven companies, mainly SMEs, were used the purposeful or intentional sampling [9]. The logic and the power of purposeful or intentional sampling is based on the selection of cases that are rich in information for in-depth study of a particular phenomenon, and on which can be drawn from relevant information and central to the purpose of the investigation [10]. There are several strategies to select the footwear companies using the intentional sampling. The maximum variation strategy and the sampling with criteria are the most appropriate to the present investigation [8], focused in innovation. The collaboration with APICCAPS and CTCP (Centro Tecnológico do Calçado de Portugal) was extremely important in order to select the seven innovative footwear companies.

3 RESULTS

As main result, it will be presented a table (Table 4) that shows the type of innovation followed by the companies and the open innovation strategy that the partners identify in the footwear industry. The innovation level was assigned by the researchers after the depth analysis of each case. By other hand, the presence of Open Innovation is related with the cooperation projects and the spillovers resulting of innovation activities reported by the companies, and also by the performance in their markets.

Table 4: Innovation & Open Innovation and economic indicators

Year 2013	Felmini	Savana	Centenário	Procalçado	Kyaia	Soze	Aco
Type of Innovation (Oslo Manual)	Product Marketing	Process Organisational	Product	Product Marketing	Product Organisational Marketing	Product Marketing	Proces
Innovation Level (1-5)	4	2	3	5	5	3	2
Open Innovation	Yes	No	Question Mark	Yes	Yes	No	No
Turnover (million €)	13,443	8,954	9,187	21	56	10	33,49
Ratio Turnover/Wrk. (€/worker)	73.460	63.050	124.150	70.950	90.320	62.500	45.200

The ratio "Turnover/worker" is quite different in the seven cases analysed. Centenário has the highest ratio and it is linked with the kind of materials used in their shoes: alligator and crocodile leather, snake, Brazilian fish skins, etc. The three cases in which can be identified the presence of open innovation model suggested by Chesbrough, present higher ratios "Turnover/worker" than the other three cases. The competitive positioning is different according the innovation observed in each case and the strategy followed.

4 DISCUSSION

Innovation is critical to the competitiveness and sustainable development of the world economies and industries [13]. In traditional and "low-tech" industries, dominated by SMEs, innovation plays an important role in the performance shown by the sector and their companies.
Innovation is present throughout all the analyzed companies, regardless the type of innovation, the strategy implemented in innovation, the results obtained and the degree of this innovation.
Innovation in products and innovation in marketing are the most representatives among the innovative companies studied, according to the categories proposed by the Oslo Manual. Companies that follow these two innovation categories have the best economic results (see Table 4) and have the best sectorial image. Thus, it is increasingly important to consolidate the existing innovation processes (innovations drag innovations) and enhance the conditions for improving the internal innovation processes inside the companies [14].
The process of innovation in industrial companies presents a set of requirements and assumptions that not all can achieve, being mainly the leaders and the best prepared companies able to successfully implement these processes. The resources of organizations are important, whether human, technological or financial resources, but the complexity of the innovation process is assumed by the most innovative companies and leaders as an important barrier to innovation. Open Innovation is important to maximize the use of internal resources and to engage the external resources of all the partners in order to achieve the common goal.
The project "HighSpeedShoeFactory", led by Kyaia, will result in a radical innovation to the footwear sector, and involves different partners of the footwear value chain. "Shoe Factory Model for Agile Response in 24/48 hours" can shortly describe the project [15]. The main goals were: pair-to-pair production and reduction of stocks; online sales, small orders and fast replacements; production of samples and new collections of own products; flexibility and versatility. The level 5 in innovation is obvious to this leader footwear company. Also level 5 in innovation were given to Procalçado because they are continuously developing new products for very competitive and demanding markets (WOCK products for professional footwear and Lemon Jelly, fashion shoes molded, all in injected materials, are excellent examples). They are also Portuguese leaders in components for footwear industry, producing soles and insoles in several materials.

5 CONCLUSIONS

An important conclusion of the research is the relation between the category of innovation and the economic performance of the innovative companies. So, the future sectorial strategies should focus on the preparation, development and implementation of innovation processes in product innovation and marketing innovation. A long road was already walked, but to keep the growth of these footwear companies is necessary maintain the road map active and demanding for new steps and challenges. Furthermore, it can be concluded that open innovation is present in the most innovative companies analysed in the research, and these most innovative companies should spread the knowledge acquired for the entire footwear cluster. The royalties and other intellectual property rights have to be protected, but Open Innovation allows spillovers in other small companies of the cluster. These small companies (mainly working in private label regime and less than 30 workers) can benefit directly because they work in production contracts to the more innovative companies (mostly of them with own products, own collections and own brands) but can incorporate some of the results to internal improvements.
Investment in qualification of human resources, as innovation and internationalization, should allow the Portuguese footwear sector the maintenance of its performance and positioning among the world´s leading exporters of fashion footwear, mainly leather shoes. The role of the universities and sectorial organisations is very important to consolidate these achievements and to continue to feed the innovation process in the Portuguese footwear industry and to remain highly competitive, as it is already.

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COMPETE PROGRAMA OPERACIONAL FACTORES DE COMPETITIVIDADE
QREN QUADRO DE REFERÊNCIA ESTRATÉGICO NACIONAL PORTUGAL 2007.2013
UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional
FCT Fundação para a Ciência e a Tecnologia MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

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FITTING DIGITAL DESIGN ON VARIOUS DIGITAL LASTS CREATED WITH 3D DELCAM CRISPIN DYNAMICS CAD SUITE

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Faculty of Textiles, Leather and Industrial Management

Abstract: *This paper presents the basic functions for creating the shoe and product footwear design analysis last using* ***Delcam CRISPIN Dynamics 3D system –Last Maker*** *and* ***Shoe Design*** *modules. There is a brief presentation of* ***Delcam CRISPIN Dynamics 3D*** *which is a CAD/CAM system for footwear which offers new and enhanced solutions for shoemakers.* ***Delcam CRISPIN Dynamics3D*** *have developed a range of quality software products to give the shoemaker a major advantage in front of its competition. With the specific instruments of* ***Delcam CRISPIN Dynamics CAD Suite software, Model Tracer and Shoe Design*** *modules for product footwear design analysis. We presents in this paper a visual method for fitting various digital designs on digital lasts, created with* ***Delcam Crispin Shoe Design****.*

Keywords: *shoe last, footwear, women, fitting design, solution for shoemaker.*

INTRODUCTION

3D DELCAM CRISPIN Dynamics CAD Suite have developed a range of quality software products to give the shoemaker a major advantage in front of its competition. With the specific instruments of this software: **Model Tracer** and **Shoe Design** modules we presents in this paper a visual method for fitting various digital designs on digital lasts, created with **Delcam Crispin Shoe Design**. The paper are severals parts.
The first part of the paper presents general informations for shoe lasts and the system **CAD Suite Delcam Crispin Dynamics**.
In seconde parts are informations for modeling shoe last. Using the functions of the **Model Tracer**, **Shoe Last** on creating severals shoe women lasts and creating a database. This database can be used in viewing, article by article, including graphics of the last and their main geometrical parameters and in searching for a last, after one or more parameters, depending on user options. The database that was created is useful for footwear manufacturers that can always find the shoe last accordingly to their product.
In three parts are information for creating a new design for severals lasts shoe and shoe women a visual method for fitting various digital designs on digital lasts created with **Delcam Crispin Shoe Design**.

1.1. General information

The last is the most complex spatial form and is indispensable in the manufacture of footwear.
Even the most experienced manufacturers of footwear products mentioned the last to be the "soul "of the footwear. Without the last there would be no footwear, no footwear industry and no footwear fashion [1]. At the same time, they claim that the design and execution of the last is the most complex and elaborated process of the entire shoe manufacturing business, the launch pad of its manufacture[3], [4].
There are no straight lines on the last. The last made of a continuous flow of contours and configurations. In this respect, it is considered "a masterpiece of engineering and a work of art".
However, while taking into account fashion and the characteristics of each style, the contours must meet precise standards of measurement and sizing [1], [3], [4].
But the process of defining the geometry of the last is complex. Specialists in computerized design of spatial forms, state that computer-aided design of a last includes the most advanced design techniques: from defining the 3D geometry of the last to obtaining its numerical form. This enables manufacturers to make patterns and prototypes using Numerical-Command-Machines (NCM) such as computer-aided design techniques currently used in industries of aerospace and car manufacturing and a number of applications requiring processing of spatial coordinates in three-dimensional shapes [2], [3], [5].

With this purpose in mind, there have been developed a series of specialized CAD/CAM software products to design lasts, with interfaces for pattern production. In the following there are presented some advanced methods available for **CRISPIN Dynamics CAD Suite** for footwear, regarding the last modelling with their specific advantages and a visual method for fitting various digital designs on digital lasts, created with **Delcam Crispin Shoe Design.**

1.2. About for CRISPIN Dynamics CAD Suite

In this part are presented the most advanced methods offered by CRISPIN Dynamics CAD Suite system for footwear concerning the modelling process for the shoe last shape with the specific advantages. There are also facilities to re-centre front and back guide lines, change foot (no need to re-digitize) and set the correct heel height and roll. You can create guidelines to save with the last and extend the last for a boot design. The last type can also be changed to a type that allows the entire last surface to be used for a design [1],[2].

The applications in the suite are:

- **LastMaker** - a program providing the means to design and modify lasts with outputs to various 3D file formats.
- **ShoeDesign** - a program for designing uppers on 3D lasts provided by **ModelTracer** or **LastMaker**. Create realistic looking designs and flatten the styles for development in **Engineer**.
- **2D Engineering –** a program for designing on 2D lasts provided by Shoe Design, and. Digitizing., This product has been developed for shoemakers who wish to ensure that their business remains competitive by increasing the efficiency, speed and accuracy of pattern development and grading.

Complementary Products

- **ModelTracer** - a program to digitise lasts in 3D using a Microscribe™ mechanical digitizer.
- **DataStore** - a WEB based database system for managing pattern/design information.

METHODE FOR CREATING A SHOE LAST

2.1. Recording the shape of the last, 'point cloud data', with the application Model TRacer

The way that **ModelTracer** works is by recording 'point cloud data' and some control lines with individual points on each side of the last. The process moves interactively and in discrete steps, using **Edit Panel** menu. Some of the steps are optional and need to be selected in the Configuration dialogue if they are not to be skipped. Three registration points are first recorded so that the lasts position in space is fixed. As the last is turned to digitize each side and possibly the bottom, picking these points each time will 'tell' the program where the last is [3], [4].

Figure 1: Digitizing the shape of the last

With these three points recorded, two centre lines are digitize a point at a time. The program can now differentiate the two sides of the last (fig. 1). For each side the feather line and a top line have to be recorded (fig. 2).

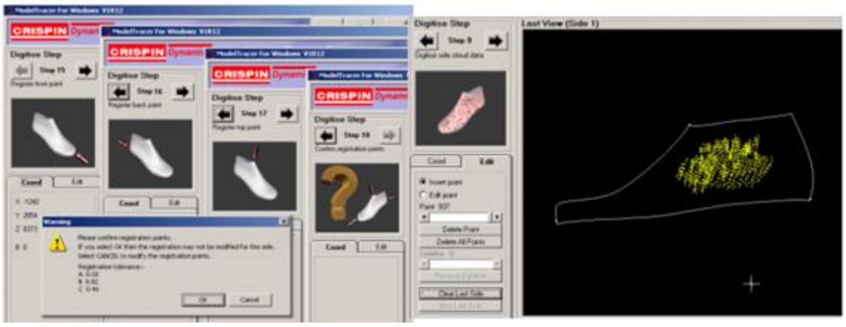


Figure 2: The steps for digitizing the base points and creating point cloud data

2.2. Cloud Data Conversion

The last part of the conversion process is the same for all the imported formats. The options are only available in the Last module. In this cases the conversion results in a **Crispin 3D** last data file with the extension ***.lst** [4], [5]. This part of the conversion process allows you to select and do additional smoothing, if necessary, to any of the vertical lines either by cursor clicking on a line near the feather line or with the help of arrows. Starting from the back centre line the two blue arrows allow you to step through or around the last from one vertical line to the next, in either direction. When you reach a line that needs extra smoothing click on the 'hammer icon'. You can only do this once for each vertical line. Having smoothed any lines that look like they needed it, click the green arrow to continue. A lot of processing is required in this next stage which creates the 3D mesh, so it can take several seconds to complete (fig. 3).

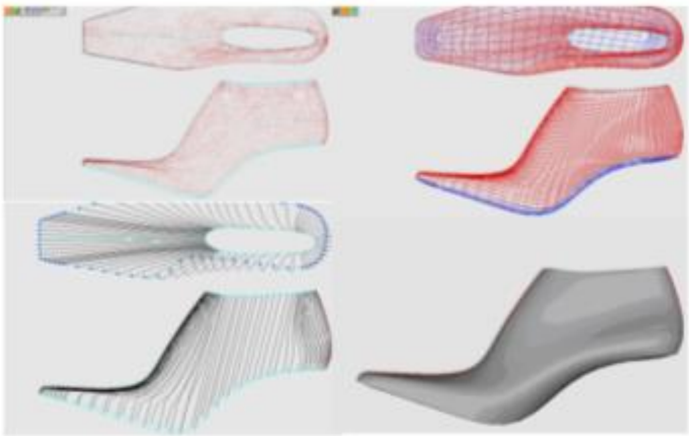


Figure 3: Cloude data conversion

2.3. Last Information

Information about the last can be displayed in a dialog box using the menu:

Information > Last Info

function from the main menu. Once the Last Info option is selected, a dialog is displayed and the system prompts you to specify the Operator name and displays information over the current last fig. 5.

The field of the window are:

File name: file name of the current last with its destination path,

Operator: Name of the operator.

Gender: Current gender (or grading system) assigned to the last for grading purposes.

Size index: The corresponding size index number in the gender being used.

Width index: The corresponding size index number in the gender being used.

Toe Spring: System-calculated distance from the toe point to the ground when the last is in standard orientation.

Heel Height: Operator-entered value for the heel height (or pitch).

If any of the above last information is changed in the program (e.g. the toe spring is changed), the information displayed in the **Last>Adjust** option is automatically changed accordingly (fig. 4).

Using the menu: **Edit>Last>Adjust** on visualized and modified the parameters for shoe last (fig. 4). Each parameters on modified using a specify window.

METHODE LINES FOR CREATING THE DESIGN

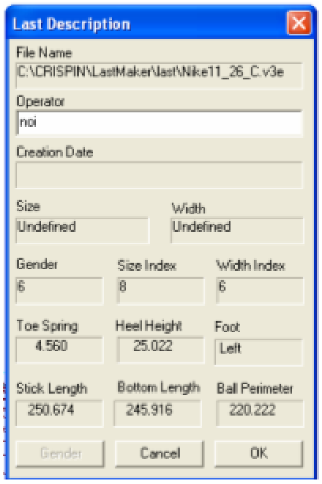
In this phase in the design of a shoe you draw the style on the last surface, create panels and apply detail like textures. There are also facilities for you to create 3D features and accessories like stitch rows, buckles and logos [4], [5]. The base function for creating 3D design is presenting in the follow table, fig.5.
Draw the style on the last surface. The function **Style-lines** are generated on the last surface with this 'user friendly' software product allowing new designs to be achieved in minimum time whilst achieving an accurate representation of the shoe.

3.1. Building a shoe last database

While building the data base there were required the following techniques:
- viewing the database, item by item which includes the graphic shape of the last and their main geometrical parameters.
- using the database for searching a last, by one or more parameters depending on the users options.

To this purpose were created two files: one **Excel** file and one **ASCII** file. The second one could be exploited by a specialized program to search for a last from the database, based on one or more parameters.
To create each article of the data base were followed these steps:
- the last was digitised using Tracer Model application
- the shape was obtained as an outline and a cloud of points and consequently converted into a solid, continues and smooth object
- the spatial form of the shape was analysed using Shoe Design
- the graphical form of the last was collected and its specific parameters, through computer-aided methods

Geometric parameter	Symbol
Toe Spring	
Heel Height	
Stick Length	
Bottom Length	
Width	
Upper Girth	
Bottom Girth	



Icon	Function
	Surface Draw
	Projected draw - (Draw and project back to surface)
	Stream line draw - (Draw and project back to surface)
	Creating the shapes
	Edit Line
	Move or Duplicate Line(s)
	Mirror Line(s)
	Margin Line(s)
	Offset Line

Figure 4: The window Last Description

Figure 5: The base function for 3D design

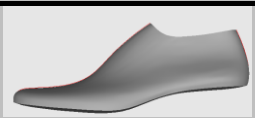
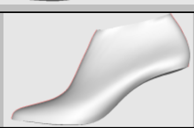
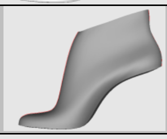
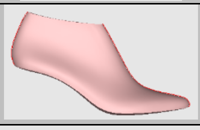
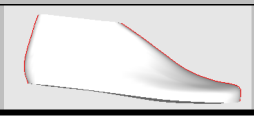
3.1.1 Creating the Excel file

Each column of the file offers the following information:
- 1st column - the graphical shape of the last
- columns 2 to 6 - numerical data of the base geometrical parameters of the last

Observations
1. The file can be seen by any computer user, because it made in Excel
2. The user can select one of the lasts by directly consulting the file. Along with the numerical information, which are difficult to follow, each article contains one cell with the graphical representation of the last
3. The file may be rearranged according to user options and sorted by relevant geometrical parameters
4. A shoe last that presents interest may be analysed using Shoe Design application, Last Process menu
5. The geometrical parameters of the last may be modified in the limits presented in table 1.

Below is presented a list of LAST file, available in Excel.
The creation of database required building the spatial shape of the last in computer-assisted sessions, the analysis of the last from all points of view and determining the main parameters that characterize it (table 1).

Table 1: Database with lasts

Lasts	Heel Height	Stick Length	Bottom Length	Upper Girth	Bottom Girth
	32.5	279	280	141	88
	73.8	230	240	123	71
	88.20	202	221	183	77
	64	232	235	154	70
	26.5	281.5	278	106.1	74.4

Figures, i.e. illustrations and pictures should be set into the body of the text at appropriate point, close to where they are referenced in the text and not grouped together at the end of the paper. Place the pictures between paragraphs and centre them between the margins. Figures layout should be in line with text. Figures should be made in high quality, suitable for reproduction and print. The notations on figures must be clearly readable. They must be numbered using Arabic numbers. Figure captions should be written below each figure and left aligned.

3.2. Creating a design and several view for finding this design

Draw the style on the last surface. **Style-lines** are generated on the last surface with this 'user friendly' software product allowing new designs to be achieved in minimum time whilst achieving an accurate representation of the shoe (fig. 6).

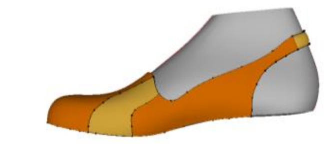
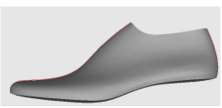
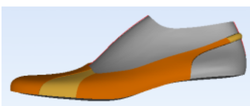
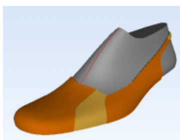
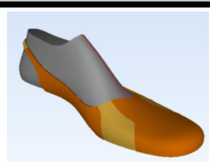
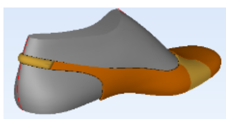
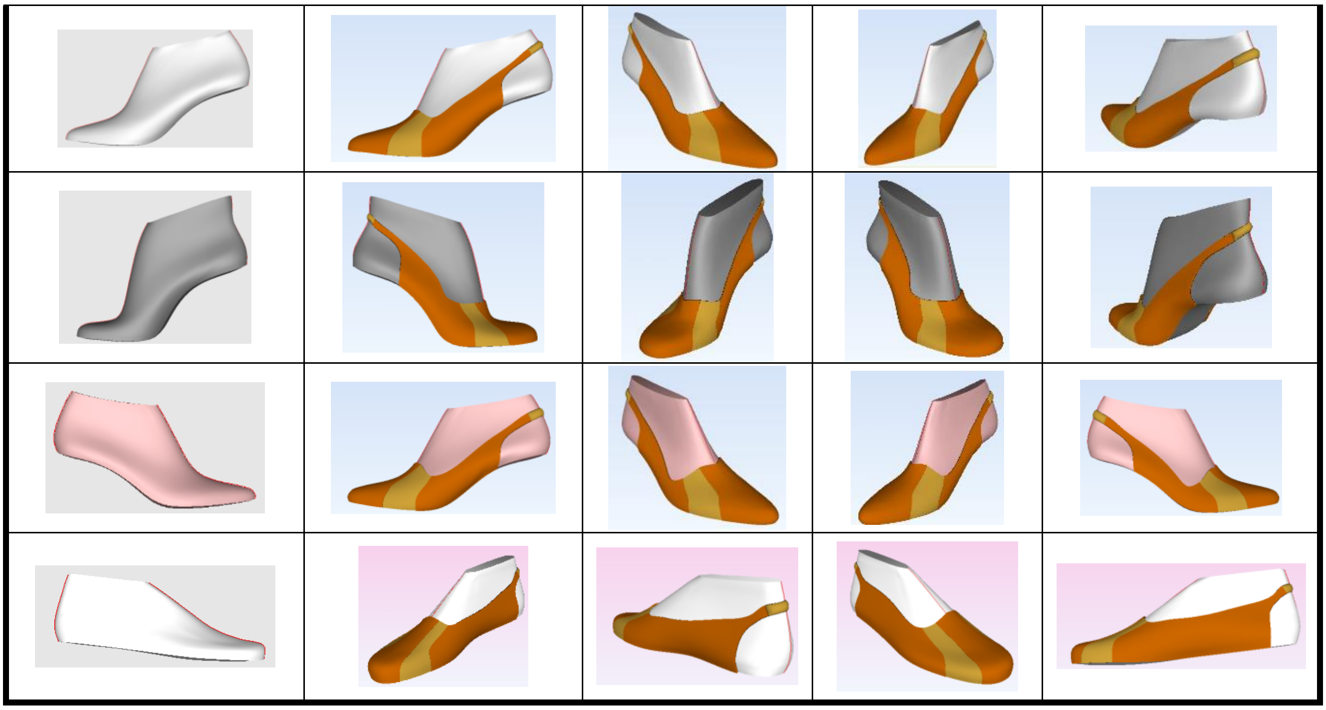


Figure 6: Creating a design of the soe last

The new design is a type file ”line style” and is using for the shoe last of the data base (table 2) with the aplication **Shoe Design**. For this on selectet fiwe shoe lasts for women for, creating a new design we and presents for fitting various digital designs on digital lasts, created with **Delcam Crispin Shoe Design** in table nr 2.

Table 2: Database with models

Shoe women last	Several views for finding a design “shoe low-cut” using digital women shoes			
	View 1	View 2	View 3	View 4
				



CONCLUSIONS

The work content: a methode for creating digital women shoe lasts, a methode for creating a design " shoe low cut" and several view for finding this design.
The creation of database required building the spatial shape of the last in computer-assisted sessions, the analysis of the last from all points of view and determining the main parameters that characterize it.
Building the data base required the following software using modes: viewing database, item by item to include graphics of the last and their main geometrical parameter, using the database for searching for a last by one or more parameters depending on the options of the user. This base is one instrument for elaboration the footwear product.

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THE IMPACT OF REINFORCED LINING ON UPPER BREATHABILITY

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Abstract: *In footwear technology the upper materials are backed with heat bonding textile materials in order to increase the tensile and tear strength and the thermal resistance of the entire structure due to higher thickness. This paper studies the effects of the backing with heat bonding textiles on air permeability, an important comfort characteristic. It also shows the importance of breathable upper in order to maintain a comfortable microclimate for feet inside of shoe. Several studies have shown that feet are a sensitive part of the body when referring to body comfort. The objective of this paper is testing the air permeability of upper materials especially the thermo-adhesive lining and their impact of upper breathability.*

Keywords: *footwear, reinforced lining, air permeability, thermo-adhesive lining.*

INTRODUCTION

The use of heat bonding is extending, due to the development of new materials with different physical, chemical and mechanical properties, as well as a large range of synthetic adhesives. The welding gives the structure an increased resistance to weather conditions and different chemical agents. This thermal joining was first called laminating.

Regardless of the position on the human body, the process requires a ground material and a material with thermal adhesive characteristics that is called reinforced lining. The upper material is bonded with the reinforced lining in order to obtain improved tensile and tear strength and, according to experimental data, also air permeability.

The materials and the fabric structure affect the performance of the lining. The purpose of lining is to provide foot comfort, to cover the inside seams of the shoe and draw out moisture [3].

The thermo-lining leads to stable connections without affecting the hygienic properties.

Nowadays in footwear industry is an increasing demand for thermo- adhesive lining [6]; it is used to reinforcing some parts of the shoe (figure 1) but also for external linings [7].

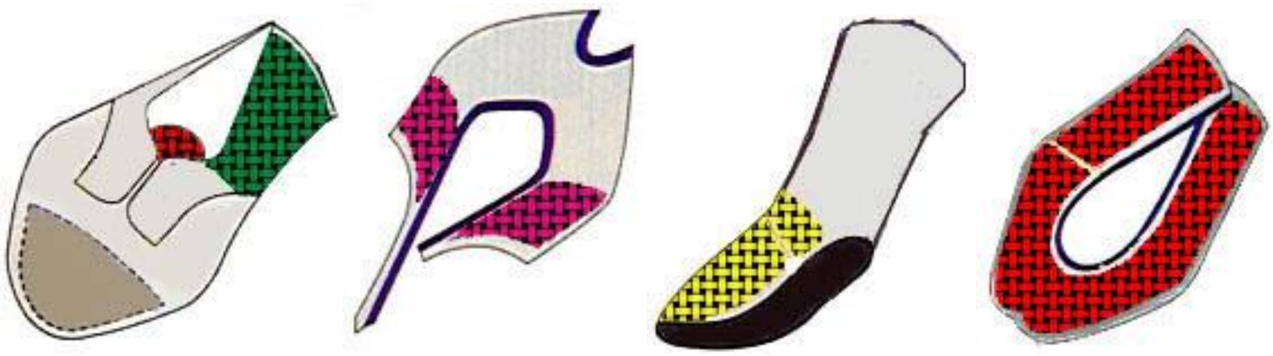

Figure 1: Reinforcing of parts with thermo-adhesive lining

Adhesives used for bonding process must be selected according to the textile structure and surface. Thermo-adhesive used for linings are in the form of powder with different particle size, and the proper behavior have polyamides with 200 – 400 μm grain [1]. In the lamination process, the application of adhesive varies from 25 – 30 g/m^2 (dots) [2] depending on area of use. All stages of rolling are conducted in specialized installations, where technological parameters are depending on the nature of the support, adhesive and machine design [4].

MATERIALS AND METHODS

The air permeability of a material or a system is defined as the amount of air passed over a surface under a certain pressure difference in a unit time. Generally, the pressure difference between layers is 0.2 to 20 mm water column.
The air permeability is calculated with the following relation:

$$P_a = \frac{V}{t \cdot A} \text{ , (m}^3\text{/m}^2\text{.min; l/m}^2\text{.s)} \quad (1)$$

Where:
V – volume of air passing through the sample under a preset difference of pressure (m^3, mm water column; l);
t – duration of air passing, (min, s);
A – sample surface (m^2).
The ratio between the volume of air V (m^3 or liters) and the time when the air flows through the material t (minutes or seconds) defines the air flow q (l/h).
The influence of the heat bonding with lining on the air permeability was studied using 3 types of bovine leather for upper materials and 4 types of knitted and woven fabrics for lining, presented in Table 1.

Table 1: Materials

Style name	Material	Code
Upper materials	Box with Corrected grain	A4
	Printed split	A6
	Suede leather	A7
Linings	Thermo-adhesive knitted fabric	C3
	Thermo-adhesive knitted fabric	C5
	Thermo-adhesive woven fabric	C6
	Thermo-adhesive woven fabric	C9

The materials have been tested in laboratory for their air permeability. Both, the upper and the lining, were cut and then welded using a heat bonding press and then cut to sample size.
The parameters of bonding process are the temperature, between 140 - 160 ºC, 4 atm pressure and the time of pressing around 6 – 8 seconds [5]. Those parameters are set in according with the adhesive characteristics and the finishing of leather surface. The adjustment of bonding parameters must be set in optimum limits, because otherwise can damage the color and even the structure of the leather.
It is important to have a perfect jointing structure between leather and reinforcement lining, flexible and also resistant. The unsoldering resistance should be between 0,3 – 0,5 N/mm^2 [6].
The method to determine the air permeability is relatively simple and known. The air flow passing through the sample fixed on the device with the face upward is measured for certain values for the pressure difference. In this case, the air flow was measured for a pressure difference of 20 mm water column. For each material, the air permeability was measured three times.

RESULTS AND DISCUSSIONS

Table 2 presents the average values for the experimental data.

Table 2: Air permeability

Code	q (l/h)	A (cm^2)	P_{ai}=q/(6*A) (m^3/min.m^2)
A4	3	20	0.025
A4+C3	28	20	0.233333333
A4+C5	11	20	0.091666667
A4+C6	15	20	0.125
A4+C9	8	20	0.066666667
A6	8	20	0.066666667
A6+C3	39	20	0.325

A6+C5	17	20	0.141666667
A6+C6	24	20	0.2
A6+C9	21	20	0.175
A7	17	20	0.141666667
A7+C3	65	20	0.541666667
A7+C5	25	20	0.208333333
A7+C6	30	20	0.25
A7+C9	24	20	0.2

Generally, the materials used for leather products have low air permeability, but the values can be improved through heat bonding. Figures 2 to 7 present the variation of the air flow with the material thickness for the experimental variants.

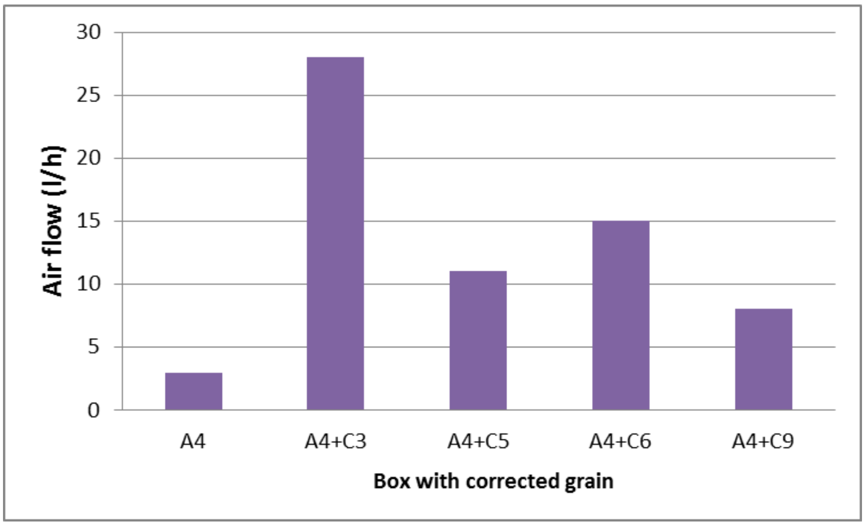

Figure 2: The air flow for box with corrected grain

These structures obtained from box with corrected grain and reinforced lining present an increase of the air flow with over 800% for A4+C3 and around 160% for A4+C9. For this upper structure was obtained the most important increase of the air permeability for all type of used linings.

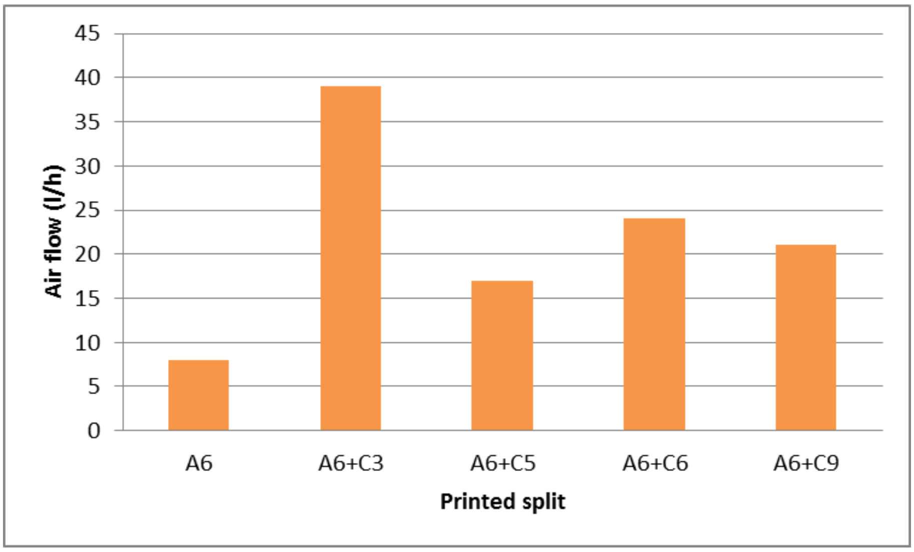

Figure 3: The air flow for printed split

The structures resulting from the printed split and different types of the reinforced lining present a major increased air flow. For structure A6+C3 the air flow was improve 387% and in case of structure A6+C9 up to 162%.

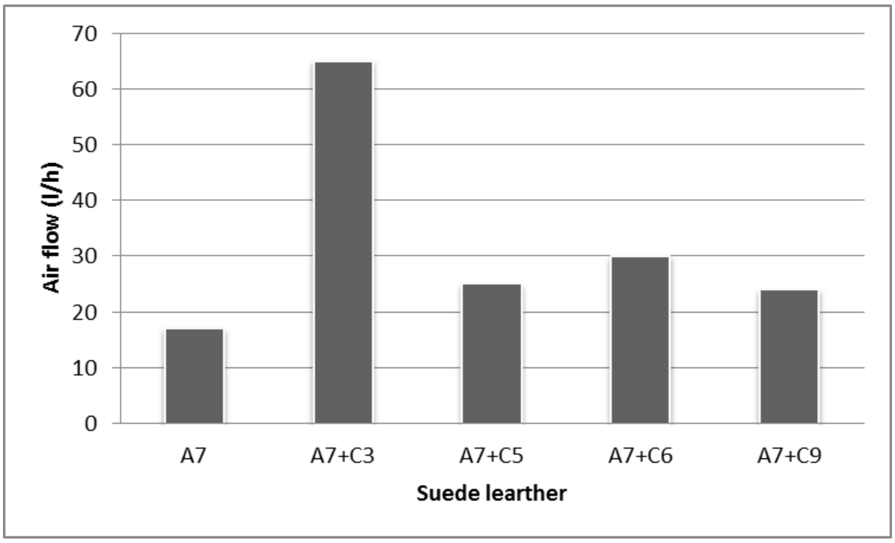

Figure 4: The air flow for suede leather

Like in previous two cases, the air flow was remarkable improved by the heat bonding. In this case, the structure A7+C3 has an air flow with over 2805 more than A7 and with 24% more for A7+C9.
The discussion was making only for the structures with the biggest or the lowest increase of the air flow after heat bonded with reinforced lining: C3 has the best results and C9 has the worst results. This mean, the air permeability depends of type of lining (knitted or woven fabric), thickness and design of fabric.
Thereby the permeability of the leather variants is considerably improved by heat bonding with a jersey knitted fabric, thickness 0.735 mm. The graphics presented in figures 5 to 7 and the regression equations in Table 3 show that the air permeability presents an increasing trend with the backing of the upper material using heat bonding.

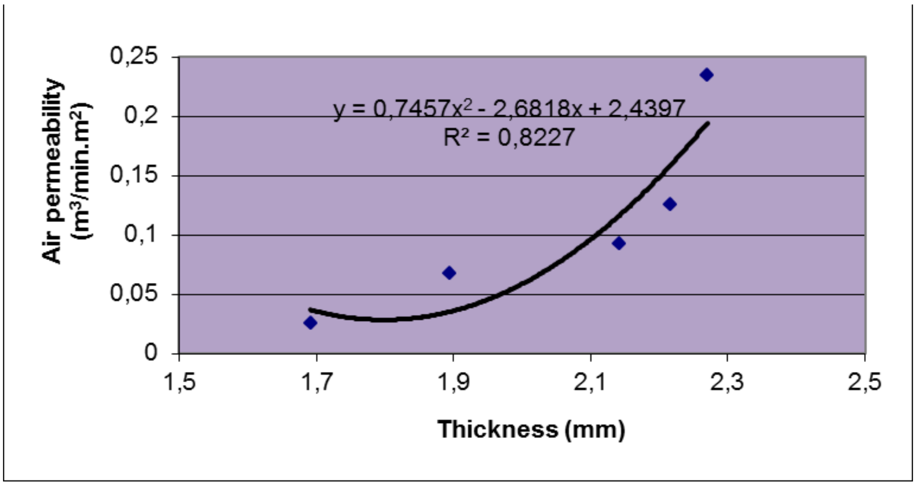

Figure 5: The air permeability for box with corrected grain

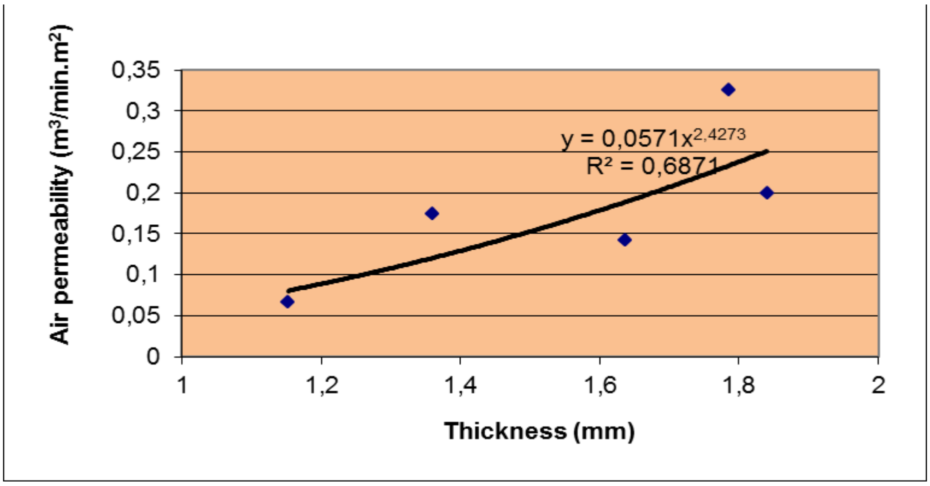

Figure 6: The air permeability for printed split

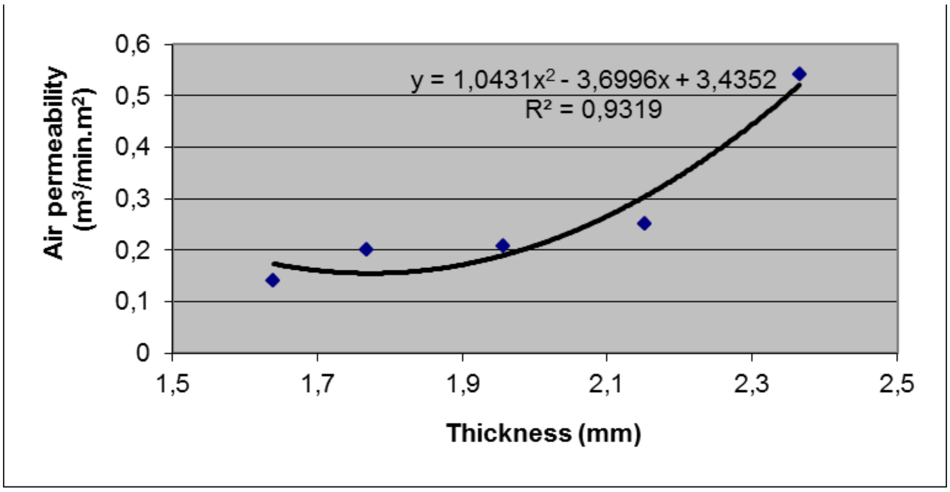

Figure 7: The air permeability for suede leather

The regression equations presented in Table 3 are polynomial functions and the values of the correlation coefficient are close to 1, indicating a strong correlation between the two parameters.

Table 3: Regression equation and correlation coefficient

Regression equation	Correlation
$y = 0.7457x^2 - 2.6818x + 2.4397$	$R^2 = 0.8227$
$y = 0.0571x^{2.4273}$	$R^2 = 0.6871$
$y = 1.0431x^2 - 3.6996x + 3.4352$	$R^2 = 0.9319$

The conclusion is important and surprising: the air permeability increase with thickness and heat bonding linings. It is surprising because it is against of the low of the textile structures and against of the general opinion that the heat bonding affect in a negative way the permeability of the upper.

CONCLUSIONS

This paper investigates the effects of the backing with heat bonding textiles on air permeability and the results can be concluded thereby:
1. When analyzing the effects of the thermal treatment and pressure on the air permeability it can be concluded that the heat bonding of upper leather parts increase it.

2. A strong correlation was determined for all experimental variants between air permeability and the overall thickness.
3. The conclusion drawn from the experiment is somewhat surprising: the air permeability increases with the thickness. This contradicts the general behavior of textile structures, for which the air permeability decreases with thickness. In this case, the thermal process associated with heat bonding causes the contraction of the entire structure and therefore increases porosity.

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SOME CONTRIBUTIONS IN THE DESIGNING OF THE INJECTION SYSTEMS OF THE MOULD CAVITIES IN SHOES INDUSTRY

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Abstract: *The paper presents some contributions in the designing of the injection systems of the mould cavities in shoe industry. It develops some aspects about the optimization of the principal and secondary injection canals placing confrunted by the mould cavities, some aspects about the injection canals placing straight contactly with the mould cavities depending on the shape and the dimension of the cavities and some aspects about the dimensioning of the injection canals.*

Keywords: *footwear, moulds, injection systems.*

INTRODUCTION

The semi products used in the shoe manufacturing are mostly made through polymer blend injecting in moulds.The injection moulds are designed with one or more cavities.
The moulds with one cavity are used in shoe making straight on the vamp and in polymer blend shoe making.
The moulds with two cavities are used for making of the soles which were assembled on the vamps and for making of the inner soles with plastic mass injected joint.
The moulds with more than two cavities (always in an even number) are used in heels and heel covers making and, sometimes, in simultaneous making of two pairs of soles.
When the mould has only one cavity the injection is made straight in cavity through one canal or through one main canal and more auxiliary canals.
The cavities of the mould may be posted symmetrically or asymmetrically referring to the main canal.
The penetration of the polymer blend from the distribution canals to every cavity of the mould is made through one barrier which realizes a flow rate and a temperature increasing compensating the heat losses along the canals.
The unit between the injection nozzle, the canals and the barriers passed by polymer blend to the mould cavity make up the injection system of the mould.
The designing of this unit means to post the cavities and the injection canals in the mould, to dimension the canals and to post the contact points between the injection canals and the mould cavities.
The correct dimensioning of the injection system determines the quality of the injected pieces and the productivity of the manufacturing process.
The injected pieces of the shoe manufacturing use the systems with direct injection through only one unheated canal or through one unheated main canal and more auxiliary distribution canals, or through one heated canal and more auxiliary distribution canals.
The shoes, the shoe soles, the heels etc. have a large variety of shapes, dimensions and sizes. In the same time, the injection parameters have a lot of values depending of the injected plastic mass.
The aspects of the designing of the moulds for shoe manufacturing are complex and represent a problem for the specialists.
The paper presents some contributions in the designing of the injection systems of the mould cavities in shoes industry, about the placing of the main and auxiliary injection canals referring to the mould cavities, about the dimensioning of the canals and the barriers, about the placing of the injection canals straight contacting the mould cavities.

THEORETICAL CONTRIBUTIONS

2.1. The placing of the injection canals referring to the cavities of the mould

When the polymer melting is injected in many cavities of the same mould, it is used one main canal and more auxiliary canals.

The mould cavities may be placed symmetrically to the main canal (in this case, the auxiliary canals have equal diameters and lengths) or asymmetrically in the unsymmetrical placing case there are used auxiliary canals with different diameters and different lengths. The grouping possibilities of the cavities around the main canal [1], [2] are figured in Fig. 1.

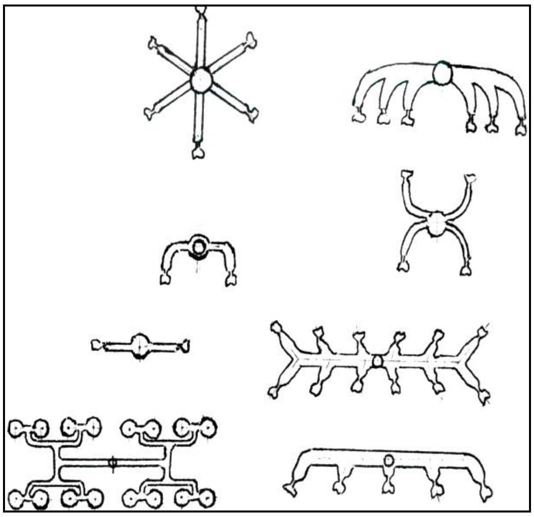

Figure 1: The placing possibilities of the mould cavities referring to the main injection canal

2.2 The dimensioning of the injection canals

When the distribution canals of the polymer melting are dimensioned in the mould cavities there are restricted: the filling of all mould cavities must take place in the same time; the friction head in the canals must be minimal and the filling volumetric speed of the cavities must be constant whatever of their placing referring to the main canal.   The theoretical conclusions [1], [2], [3] show that the circular section of the distribution canals is better for polymer blend flowing. In this case, the flow speed has a second degree curve distribution along the section Fig. 2.

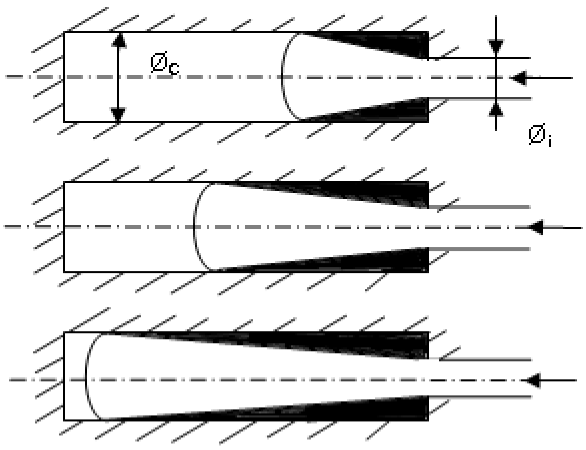

Figure 2: The polymer blend flowing through a circular section injected

When the thermoplastic plastic masses flow (liquefied in injection equipment), the Reynolds coefficient has the following values: Re=0,5-0,05; so, the flowing is a parallel one in this case, the friction and the friction head have big values.

The friction relation (1) is:

$$\lambda = \frac{64}{\mathrm{Re}} \cong 1280 \div 12800 \qquad (1)$$

This friction goes to the friction head, relation (2):

$$\Delta p = \lambda \frac{l}{D}\frac{v^2}{2}\rho = \frac{64}{\mathrm{Re}}\frac{l}{D}\frac{v^2}{2}\rho \qquad (2)$$

Where
l - canal length, [m]; D- canal diameter, [m]; v- speed, [m/s]; ρ-density, [Kg/m^3].
Replacing the Reynolds definitely parameters, it results relation (3):

$$\Delta p = 32\frac{\eta l v}{D^2} \qquad (3)$$

H- dynamic viscosity.
Replacing the speed with the flow rate Q, in relation (3)

($v = \frac{4Q}{\pi D^2}$), it results:

$$\Delta p = 40{,}77\eta \frac{1}{D^4} Q \qquad (4)$$

Relation (4) shows that a small diameter variation for the same flow rate Q goes to the variation of the friction head with a four exponent.
In working condition, the smallest diameter will be choose; so, the technological loses through the solidification of the plastic mass in the feeding canal will be reduced.
The dimensioning of the feeding canals must provide zero value for the speed loose. In general case, when the mould has “n” cavities, when the feeding of the cavities is simultaneously (having a uniform flow rate in each auxiliary canal) the diameter of the canals is in relations (5), (6) and (7).

$$nq = Q \qquad (5)$$

Where:
n-number of the auxiliary canals;
q-flow rate through the auxiliary canal;
Q-flow rate through the main canal.

$$\frac{n\pi d^2}{4} v = \frac{\pi D^2}{4} v \qquad (6)$$

Where:
D-diameter of the main canal [m];
d-diameter of the auxiliary canal [m].

$$nd^2 = D^2 \qquad (7)$$

Where:
d-diameter of the auxiliary canals, [m];
D-diameter of the main canal, [m];

Considering the friction head through the auxiliary feeding canals for a symmetrical placing, their diameter must be modified, so the flowing speed of the polymer blend will be constant. So, relation (7) becomes:

$$nd^2 \rhd D^2 \qquad (8)$$

The unsymmetrical placing of the cavities (referring to the main canal) imposes feeding canals with different diameters. The placing of the cavities in symmetrical positions (referring to the main canal) is the most important condition for a constant flow speed through the feeding canals, in the feeding of different cavities of the same mould.

EXPERIMENTAL PART

After years researches, the authors observed that the nozzles and the feeding canals of the moulds used in shoe manufacturing have small diameters, between 3 and 7 mm. Using bigger diameters (an advantage in the injection process) goes to the decreasing of the injection net efficiency because of the plastic mass solidificated into the feeding canal losses.
Table 1 shows some dimensions of the feeding canals of the moulds used in shoe manufacturing. The dimensioning of the canals depends on the mass of the injected pieces and on the type of the polymer blend. The values in Table 1 were calculated for a minimum level, for the moulds designing. If it will be necessary, when the moulds will be experimentally verified, the diameters of the nozzle and of the injection canals will be increased.
The values in Table 1 were calculated for a minimum level, for the moulds designing. If it will be necessary, when the moulds will be experimentally verified, the diameters of the nozzle and of the injection canals will be increased.
The length of the injection main canal depends on the size of the mould plates, on the number of the auxiliary canals and on the cavities volume. The recommendation is a ratio l/d between 5 and 9 (l-canal length; d-canal diameter).The penetration of the plastic material from the distribution canal to each cavity of the mould is through a barrier, Fig. 3.

Table 1: The diameter of the injection canals depending on the polymer and the mass of the injected piece

Polymer	Mass of the piece , g				
	20-50	50-100	100-150	150-200	200-300
	Canal diameter, mm				
Polymerized vinyl chloride	4	4,5	5	5,5	6
Polystyrene	4	4,5	5	5,5	6
Polypropylene	5	5,5	6	6,5	7
Polyethylene	4,5	5	5,5	6	6,5
Polyamide	4	4,5	5	5,5	6

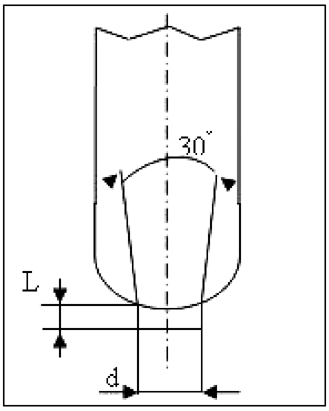

Figure 3: The representation of the injection canal barrier: d-barrier diameter; l-barrier length

The presence of the barrier determines a flow speed and a melting temperature increase compensating the heating losses along the canals. Generally, the designing of the barriers is for minimum dimensions; so, after the mould testing, the dimensions may be increased, in case. The dimensions of the barriers depending on the injected pieces mass are presented in Table 2.

Table 2: Dimensions of the injection canal barrier

No.	Piece mass, g	Barrier diameter, mm	Barrier length, mm
1.	20-50	0,8-1,2	2
2.	50-100	1,2-1,8	2,5
3.	100-150	1,5-2,5	2,5
4.	150-200	1,5-2,5	3
5.	200-300	1,5-2,5	3

When the injection is made in cavities having large variations for the cross and longitudinal dimensions, the polymer melting moves forward in a jet, along a filling direction which is in an opposite direction in comparable with the injection nozzle; so, the mould cavity fills up through pressing while the injected polymer cools, Fig. 4. The cooling takes place layer by layer as long as the polymer blend contacts the walls of the mould cavity [1], [4]. When the whole cavity fills up, the pressure in the mould cavity has a maximum value; in time, increasing the feeding speed goes to the cooling of the polymeric material into the canal and to the sealing of the cavity.
An important aspect in the injection of the polymer melting is the placing of the contact points of the injection canals referring to the mould cavities.

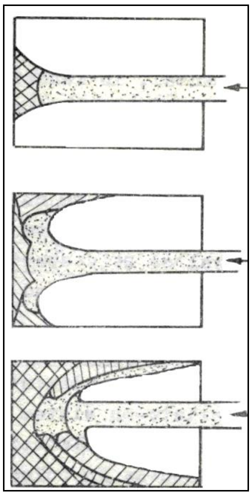

Figure 4: The filling up of the mould cavity through pressing

When the injection of the shoe soles takes place, the phenomenon is more complex (due to the variation of the dimension along the two axes); so it has some solutions, [5] showed in Fig. 5.
When the injection point is chosen it must consider the polymer blend flowing but the soles aspects after the plastic mass solidification, too.
It is known that, after the breaking of the connection between the plastic mass from the feeding canal and the injected object, on that contact area appears a visible sign. The feeding along the length of the cavity goes to the most uniform filling up. But this solution is a rare one in the injection of the shoe soles, because of the contact area between the sole and the feeding canal, the sign being an aesthetic one. The solution will be adopted only if this inconvenient may be invisible. Often, the feeding of the soles cavities will be made along a normal line of that length.
When the soles injection is straight on the vamps (when the injection is made from the exterior of the cavity, respectively the sole area with non-slip relief) the placement of the injection point will be invisible due to the design of the relief.
In the case of soles injection obtained as semi products which will be assembled with sewing or gluing on the vamps, the injection will be made from the exterior of the cavity. In this case, the choosing of the injection point will not be restricted by the aesthetics conditions anymore.

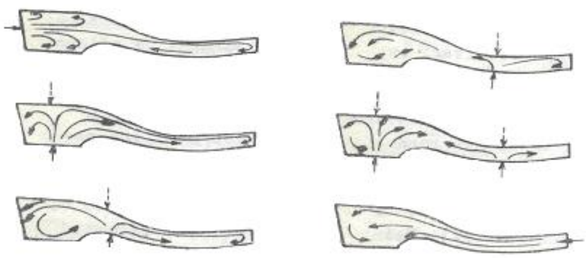

Figure 5: Some variants of the placing of the contact point between the injection canal and the cavity, in the soles injection

When the main canals of the moulds are heated and the polymer blend is in a fluid state, it will make 2-3 auxiliary distribution canals. So, the injection efficiency will be increased without the increasing of the lost plastic mass which solidified into the canals.

CONCLUSIONS

The designing of the injection systems of the moulds used in the shoe manufacturing must respect the following conditions:
1. When the feeding is simultaneous in more cavities, the cavities designing will be in symmetrical position relating to the feeding main canal.
So, the flowing speed of the polymer melting through the canals is constant.
2. When the distribution canal of the polymer melting in the mould cavity will be dimensioned, the filling up of all mould cavities must be in the same time; the flowing way of the polymer melting must be as short as possible; the passing from the main canal to the auxiliary ones must have big curvature radius; the pressure losses into the canals must be minimum; the volumetric filling up speed into the cavity must be constant even the position of the cavity is relative to the main canal.
3. The nozzles and the feeding canals of the mould cavities used in shoe manufacturing have diameters between 3 and 7 mm. The using bigger diameters (which is a favorable situation for the injection process) goes to the decreasing of the injection net efficiency, because of the looses caused by the solidification of the plastic mass into the feeding canals.
4.When the injection of the shoe soles is made, the placing of the injection canals in straight contact with the cavity will be adopt as the connection band on the sole surface to be invisible.

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CONTRIBUTION OF THE FOOTWEAR OUTSOLES MOULDS PROGRAMMING MADE ON INJECTION EQUIPMENTS

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Abstract: *Footwear soles manufacturing takes into account the percentage distribution of the size numbers of the size series. When o portative assembly is used for the manufacturing of the footwear soles using the injection with "n" working posts, it is very important an optimum distribution of the working posts. The disadvantages of these equipments are the situations of the no equilibrium programming of the moulds, so that, in one time, some working posts spread out of the work.*
The paper presents some practical and theoretical solutions for moulds stock programming in portative assembly for footwear soles injection, so that an optimum equilibrium degree of the working posts will obtain.

Keywords: *footwear, moulds, injection systems.*

INTRODUCTION

The moulds stock necessary for a certain product volume realization, in rhythmically conditions depends on some criterions such as: the range of products volume daily realized, the sizes structure of those ranges and, respectively, the sizes tally, the technological time for an used mould depending on the equipment efficiency, the provide necessity of spare moulds, the using and fixing conditions.
The paper presents some results of the authors' researches about the optimum run of the injection and manufacturing of the shoe footwear soles in moulds and the placing of the moulds on the equipments algorithms, so that, an optimum equilibrium degree of the working posts will obtained. The equipments used in footwear soles manufacturing, by cooling and injection thermo chemical processes are, from constructive point of view, divided in two branches, equipments with injection straight on vamps and soles injection equipments, as semi finished articles which will be assembled on the vamps.
From the efficiency point of view, the equipments may have two working posts, left-right, or more working posts (always, an even number), as 6, 12, 24, 40 posts. These differentiations have a direct influence up to the manufacturing cycle time, respectively, up to the time between two identical successive steps of the process. Entirely, this time has two components: the impose time of the thermo chemical process and the time for the technological servicing of the equipment and of the mould.
When the footwear soles are injected using portative equipments with "n" working posts, the placing of the moulds on working posts has a great importance. This placing must provide the lots of the same kind products realization in contractual pre-established sizes tally, and, in the same time, the equipment working posts must be equilibrated used.

THE INJECTION IN FOOTWEAR SOLES MOULDS OPTIMUM RUN ESTABLISHING

These moulds are for the shoe soles manufacturing, based on thermoplastic polymer blends. The injection takes place after the mould cavity is closed. Then the molding and partial cooling processes take place until it is realized a temperature which avoids the deforming of the products and then, the unloading of the products at high temperature (60-80ºC) depending on the polymer.
The injected soles manufacturing takes place in two situations: the injected soles realization straight on the vamps and the soles realization as semi finished articles which will be assembled on the vamps using gluing or sewing processes. When the soles manufacturing takes place straight on the vamps, there are used, for each pair and for each size number, two sets of moulds for each sole of each leg. Usually, these equipments have two shoe-lasts for each leg, one of them is into the mould (for the sole injection) and the other one has injected sole and waits the footwear unloading.
The using of two shoe-lasts for the same mould determines a time for a fitting up of the vamps on the shoe-lasts (for the soles injection), respectively, a time for the unloading of the footwear with sole after the

injection, out of the sole thermo chemical process manufacturing. The necessary technological time (a cycle time), (t_c), for one sole manufacturing is pointed [2,3] in formulas (1), (2), (3):

$$t_c = t_a + t_p + t_e, \quad \text{(minutes)} \tag{1}$$

$$t_d = t_a + t_e, \quad \text{(minutes)} \tag{2}$$

$$t_c = t_p + t_d, \quad \text{(minutes)} \tag{3}$$

Where:
t_c - cycle time for a finished sole manufacturing, minutes;
t_a - fitting up time of the vamps on the metallic shoe-lasts of the mould, minutes;
t_p - time of the thermo chemical injection, moulding and cooling of the polymer blend process, minutes;
t_e - time for unloading of the products, minutes.

The process time has the following components: the time for the mould closing and the time for the injection and cooling of the polymer melting used in sole manufacturing. This time is the main one in the technological time, necessary in one product manufacturing and it depends on the polymer blend formula, on the object dimensions and on the cooling regime.
For a good efficiency providing, on each working post, respectively, on each mould which realizes a pair of soles, the injection aggregates have refrigerating equipments which decrease the cooling time of the polymer melting after the injection into the cavity. The fitting on the vamps on the metallic shoe-last for the sole injection time (t_a), respectively, the unloading of the footwear with sole from the metallic shoe-last time (t_e) are components of the mould attending time (t_d). This time is during the waiting of the mould, just before or after the sole manufacturing process.
In these conditions, the efficiency of this aggregate (in pairs/480 min) for each working post is [4], [5]:

$$P = \frac{T - t_{pi}}{t_c}, \quad \text{(cycles/480 min)} \tag{4}$$

Where:
P- pairs/480 min;
T- time per shift (480 min);
t_{pi} - time for preparing and finishing the work, minutes;
t_c - time for one cycle, minutes.

The preparing and finishing of the working time (t_{pi}) has the following components: the time necessary for the preparing of the equipment and of the moulds at the beginning of the work, the time for the cleaning of the moulds at the end of the work and the time necessary for the changing of the moulds during the shift.
The main problem in this case is the used mould number in a continuous process.
The used degree of the moulds depends on the soles number sizes tally which must be realized per shift. Depending on this tally, considering the different working posts of the aggregate, the used degree of the moulds is between 6-100%. The adjustment of the moulds necessity, depending on the efficiency of the equipments, on the number of the size tally and on the working posts number of the portative equipment (6, 12, 24,…., 40), is a difficult problem, but a solvable one. The algorithms for establishing of the moulds stocks using program will be presented in the next paragraph and they represent a solution of the problem.
Considering that the time of the process (t_p) takes place in the same time with one rotation of the rotative equipment, (excepting the using time (t_d)), the number of the moulds working posts per one worker is:

$$n_m = \frac{t_c}{t_d} \tag{5}$$

Where:
n_m - number of the moulds a worker may use.
The rotation rhythm of the injection aggregate uniselector depends on the number of the working posts, respectivelly, on the number of the moulds (m), depends on the time of one cycle (t_c) and on the using time (t_d), as in formula (6):

$$t_c = m \cdot t_d \text{ (minutes)} \tag{6}$$

When the soles are obtained injecting straight on the vamps, experimental researches [4], [5] show that almost all aggregates (whatever how the number of the working posts is) have a medium efficiency for one mould, at about 100-200 pairs/8h. Industrial conditions show that the preparing and finishing time for one shift (t_{pi}), is about 30 minutes. Replacing the values in formula (4), the time of one cycle per mould (t_c), becomes about 2,25 minutes. This time will be completed with the time necessary for closing and opening the mould which is about 0,4 minutes. So, the time for one cycle per mould is about 2,65 minutes.
In the soles moulds case, the using time contains only the unloading time of the product. Providing of the necessary time of the process (t_p) (considering the using time to be maximum 0,2 minutes), increases the posts numbers of the uniselector till 24, even 40 working posts.

ALGORITHMS FOR THE PROGRAMMING OF THE MOULDS ON WORKING POSTS OF THE UNISELECTOR AND EXPERIMENTAL RESULTS

3.1. The programming of the assembly of the moulds and the working posts balance in the researched case

The quantity of soles which must be processed on each working posts depends on the distribution of the moulds on the posts, for an optimum balance degree of the used equipments obtaining.
The paper presents some theoretical and experimental conclusions of the authors and the results of the researches obtained [6], [7] using an uniselector with 12 working posts.
The lot of products taking into consideration, has the size P = 7500 pairs of footwear of the perforated type, for the teenagers, with injected soles straight on vamps, in the VAMOS model. To make the lot of footwear/shoes which covers sizes from 22 cm to 28.5 cm, it will be used a set of moulds which have a cavity corresponding to the model of the sole. The delivery of the footwear according to sizes and of the moulds in the VAMOS set is presented in the Table no.1 below.
From Table 1, we draw the conclusion [8], [9] that the set contains 20 pairs of moulds which will be set on the 12 working posts of the equipment to get different quantities of footwear according to size numbers; this will lead to the coupling of the moulds of different sizes on the same post, in order to ensure a balanced loading of the working posts.

Table 1: .Outfit of moulds for a certain production

Footwear size, cm	Quantity, pairs	Number of moulds, pairs
22	40	1
22,5	80	1
23	130	1
23,5	420	1
24	780	2
24,5	690	2
25	1270	2
25,5	1010	2
26	1010	2
26,5	680	2
27	650	1
27,5	410	1
28	230	1
28,5	10	1
Total	7500	20

It is considered that the balance of the working posts of the equipment may be appreciated by the degree of balance of the loading, symbolized by E, expressed in % and which may be determined using the equation (7):

$$E = \left[1 - \frac{M(n - n_{min})}{(M - 1)n_{max}} \right].100 \ ,(\%) \qquad (7)$$

Where:
M - number of the working posts of the equipment;
n - number of cycles of the rotating table necessary to make the lot of products P, for a certain assembly programmed and rolling of the moulds;
n_{min} - minimum number of cycles of the rotating table necessary to make the same lot of products P, in the condition of an ideal balance of 100%, for M posts;
n_{max} - possible maximum number of cycles necessary to make the lot of products in the condition of null balance, 0%, respectively, when all moulds of the set would be placed successively only on one working post. In short, the degree of balance, E, can be calculated using the equation (8).

$$E = \frac{M(P - n)}{P(M - 1)}.100 \ , (\ \%) \qquad (8)$$

In the equation (8), the terms have the same meaning as in the equation (7). For the concrete case under discussion:

$$M=12$$

$$n_{min} = \frac{p}{m} = \frac{7500}{12} = 625 \qquad n_{max}=P=7500$$

$$n = \frac{P}{number \cdot pair / cycle} = \frac{7500}{6} = 1250$$

The degree of balance, E, calculated using both equations, has the value of 90,9 % in the case under discussion. To make the lot P=7500 pairs of shoes with the set formed of 20 pairs of moulds, which surpass the number of working posts (12) of the equipment, it appears the problem of establishing the type of coupling of the moulds of different sizes on certain working posts. This time, symbolized T, is expressed in hours and can be determined using the equation (9).

$$T = \frac{PAS(M.L + I - M) + \sum Ts_i}{3600} \ , \text{(hours)} \qquad (9)$$

Where:

PAS - rhythm of the equipment, seconds that is the time between 2 successive injections;
M - number of posts of the equipment;
L - loading of the respective mould expressed through the quantity of products which are made on it, expressed in pairs;
I - number of the order of the respective working post on the rotating table of the equipment;
ΣTs_i - sum of the changing time of the moulds from other posts on which the moulds where replaced, seconds, if the replacement demanded to stop the equipment. At the injection installation of carousel type, the DESMA makes, PAS = 6s and ΣTs_i = 400 s.

3.2. The obtained results and their interpretation

Taking into consideration the concrete values of the above sizes, through the automatic processing of the data there were obtained the results presented in Table 2. The results [5], [9] in Table 2 show that out of the set of 20 moulds, only 19 will be used, when the equipment starts to function and they will be assembled on the 12 posts of the equipment in the following order: 28/1, 25/2, 25/3, 22.5/4, 28.5/5, 22/6, 25.5/7, 27/8, 23/9, 26.5/10, 26.5/11, 24.5/12. After producing the quantity of shoes, the moulds that correspond to the extreme numbers of the series will be replaced with others as follows: 28 ----27.5 (post 1), 22.5 ---26 (post 4), 28.5----26 (post 5), 22----25.5 (post 6), 23---- 23.5 (post 9), 26.5---24 (post 10), 26.5----24 (post 11). Through coupling the moulds of different sizes on the working posts shown, the variable loading is between the limits of

(505 – 730) pairs/posts and after a number of 15.3 h of continuous functioning of the injection installation there can be achieved the entire lot of shoes of 7500 pairs.

Table 2: Moulds placing on working posts

Order number of working post	Size number of the mould set on the post(cm)	Quantity of shoes made on the post and mould(pairs)
1	initial 28 27.5	230 410 640
2	25	635
3	25	635
4	initial 22.5 26	80 550 630
5	initial 28.5 26	10 550 560
6	initial 22 25.5	40 505 545
7	25.5	505 505
8	27	650
9	initial 23 23.5	130 420 550
10	initial 26.5 24	340 390 730
11	initial 26.5 24	340 390 730
12	24.5	690
Total	19 moulds	7500 pairs

For the variant of distribution and use of moulds on the working posts of the presented equipment in Table 2, the concrete degree of balance of the equipment (E), calculated with the equation (8), has the following value of the equation (9):

$$E = \frac{12(7500 - 730)}{7500(12 - 1)}.100 = 98{,}47\% \tag{9}$$

CONCLUSIONS

1.To balance the loading of working posts of the injection installation of Carousel type presented in the paper, can be achieved only when the number of moulds of the set is bigger than the number of the working posts of the equipment.
2. The balance degree (E) is influenced by the type of rotation of the set of moulds on the working posts of the equipment, the total size of the lot of shoes, the series of sizes in the lot, the quantity of shoes, on each size number of the series.
3. The automatic processing programmed of data used in the concrete case presented in the paper has a general character and it is used in all cases which obey the specified restriction in the first formulated.

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PLANTAR FOOTPRINT ANALYSE OF THE ELDERLY'S FEET – ONE CASE STUDY

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Abstract: *The aim of the article is to analyze the feet of an elderly subject regarding the footprints, the foot axis angle, the gait cycle, and also, the balance of the feet. A large number of systems within the human body, like the musculoskeletal, central nervous systems, sensitive, vestibular and visual systems are involved when the human balance and gait are studied. The loss of the ability to walk due to foot problem, not only produces physical limitations, but also has a significant impact on the persons's mental, social, and economic status. Having biomechanical data of the foot simplifies the customization of the product, reduces the number of test and increases the footwear technological process efficiency. Foot dynamics is perceived as being linked to a variety of musculoskeletal symptoms, including personal injury from running and plantar pain, especially on the heel. Plantar footprints have been obtained using RSScan plate and the associated software. By using this powerful equipment and its application, various measurements and observations were made. A complete knowledge of the foot can be obtained; and then, solutions can be found. In this case, the solutions were custom made orthotic devices for each foot. Shoes with custom insoles have been shown to be effective in reducing peak plantar pressure. Reduced plantar coetaneous sensation could thus be considered as a relevant factor for alterations in plantar pressures while walking especially in case of elderly persons.*

Keywords: *arthritis, plantar footprint, foot parameters, impulse, balance.*

INTRODUCTION

A large number of systems within the human body, like the musculoskeletal, central nervous systems, sensitive, vestibular and visual systems are involved when the human balance and gait are studied. The loss of the ability to walk due to foot problem, not only produces physical limitations, but also has a significant impact on the persons's mental, social, and economic status status [1-6]. Having biomechanical data of the foot simplifies the customization of the product, reduces the number of test and increases the footwear technological process efficiency. Foot dynamics is perceived as being linked to a variety of musculoskeletal symptoms, including personal injury from running and plantar pain, especially on the heel [7].
Measurements of plantar pressure provide useful information about structure and function of the feet and are used as tools for evaluating patients with foot complaints [8].
For measuring efficacy of footwear for off-loading properties, a plantar pressures reduction has to be used. Shoes with custom insoles have been shown to be effective in reducing peak plantar pressure. Reduced plantar coetaneous sensation could thus be considered as a relevant factor for alterations in plantar pressures while walking [9, 10].

PARAMETERS AND METHODOLOGY

The aim of the article is to analyze the feet of a single subject regarding the footprints, the foot axis angle, the gait cycle and also, the balance of the feet. To get the plantar pressure, the RSScan plate and the Footscan Gait Scientific software were used. 67 women, aged between 52-84 years old and weighing 45-70 kg were involved in the Mobility research project. A representative subject of this group was chosen to be analyzed in this article. The parameters are a weight of 60 Kg, with 40 French size number for a particular subject.

The methodology is the following one:

- In static, the subject is placed onto the plate and must not move. Then a capture of its plantar pressure is taken.

- In dynamic, the subject moves from the plate and walks, passing by the plate with only one foot. Then, the subject reproduces this movement, but with the second foot. There five measurements taken in order to compare and to have an average of data.

RESULTS

In the orthostatic position as well as in dynamics, the subject has a high arched foot figure 1 a, b.

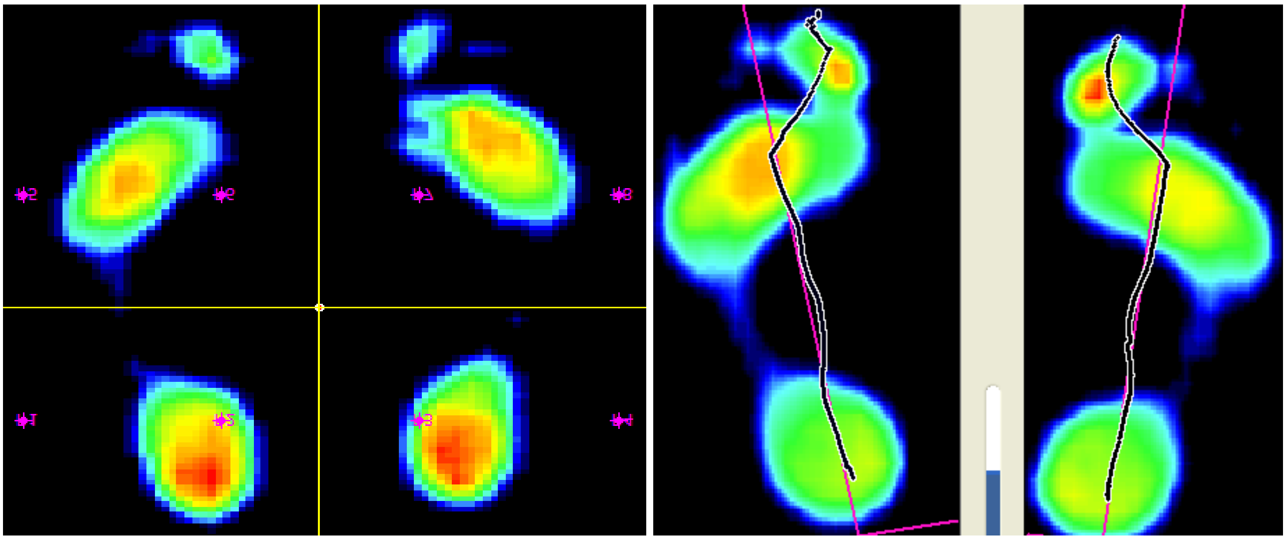

Figure 1: a. Static plantar footprint; **b.** Dynamic plantar footprint

The high arch foot (pes cavus) is characterized by an abnormally high medial longitudinal arch, inverted hindfoot, and adducted forefoot. In high-arch foot, the rigid arch causes the foot to strike down on its lateral side while walking [11].

For obtaining the length and the width of foot, the extreme posterior and anterior points are taking into considerations, respectively the extreme interior and exterior points. However, the results obtained by this way are not enough accurate as those from anthropometry. The foot axis angle, as well as the length and the width are presented in the following table and figures:

Table 2: Feet dimensions

Parameter	Foot	
	Left	**Right**
Length (cm)	22.9	22.7
Width (cm)	8.2	8.6
foot axis angle (°)	13.01	13.32

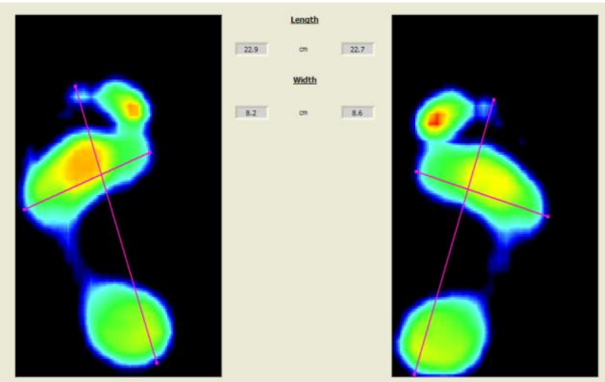

Figure 1: Feet sizes (length and width)

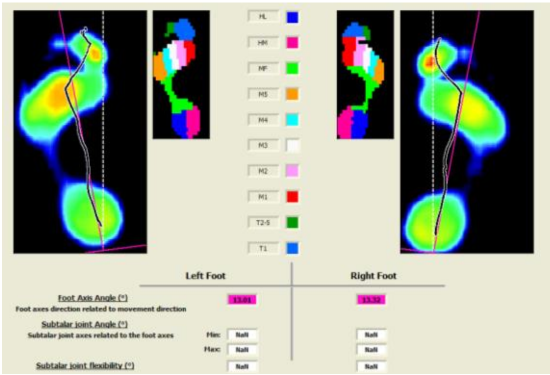

Figure 2: Feet axis angle

Using the software, one can also calculate the foot axis angle, as shown on figure 2.
The gait cycle can be divided into three main stages: the first contact with the surface (impact), the stance stage when the entire foot is in contact with the ground and the propulsion stage when the foot is pushing off the ground. Five phases of the gait cycle are presented for the left foot and five phases for the right foot (figure 2). For the herby study case, the left step time is 1772 ms and the right step time is 1716 ms, both values being over the average step time of 900-990 ms reported in research studies [12, 13], being explained by the age of the subject.

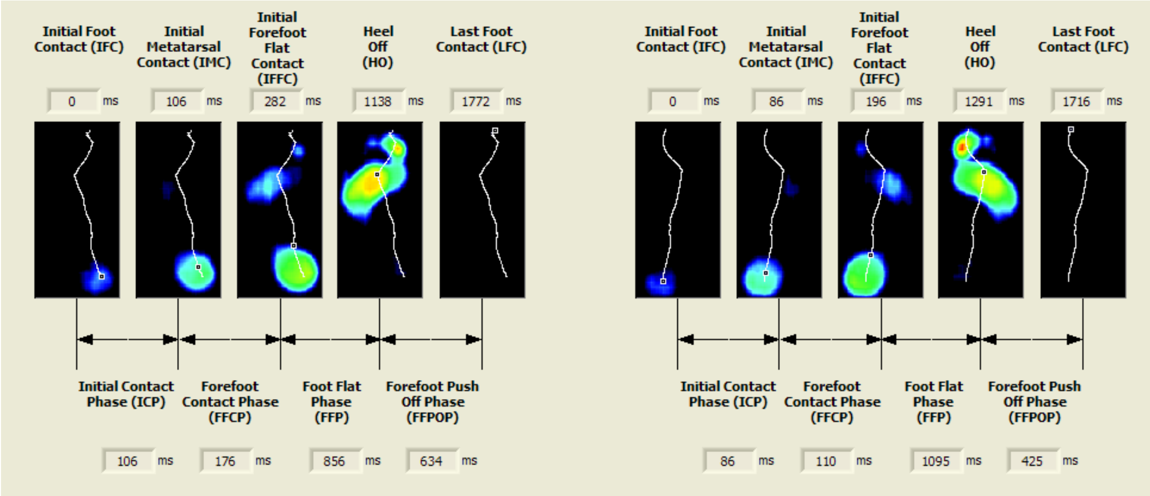

Figure 3: Gait cycle

The Footscan software gives the pressure graphs depending on the foot areas (figure 4). Therefore, the foot is divided into 10 areas (toe 1, toe 2 to 5, metatarsal 1 to 5, medium foot, medial heel and lateral heel), each of them being differently coloured (figure 4). The same legend of colours is kept for pressure graphs, in order to easily recognize how the pressure varies for each area of the foot.

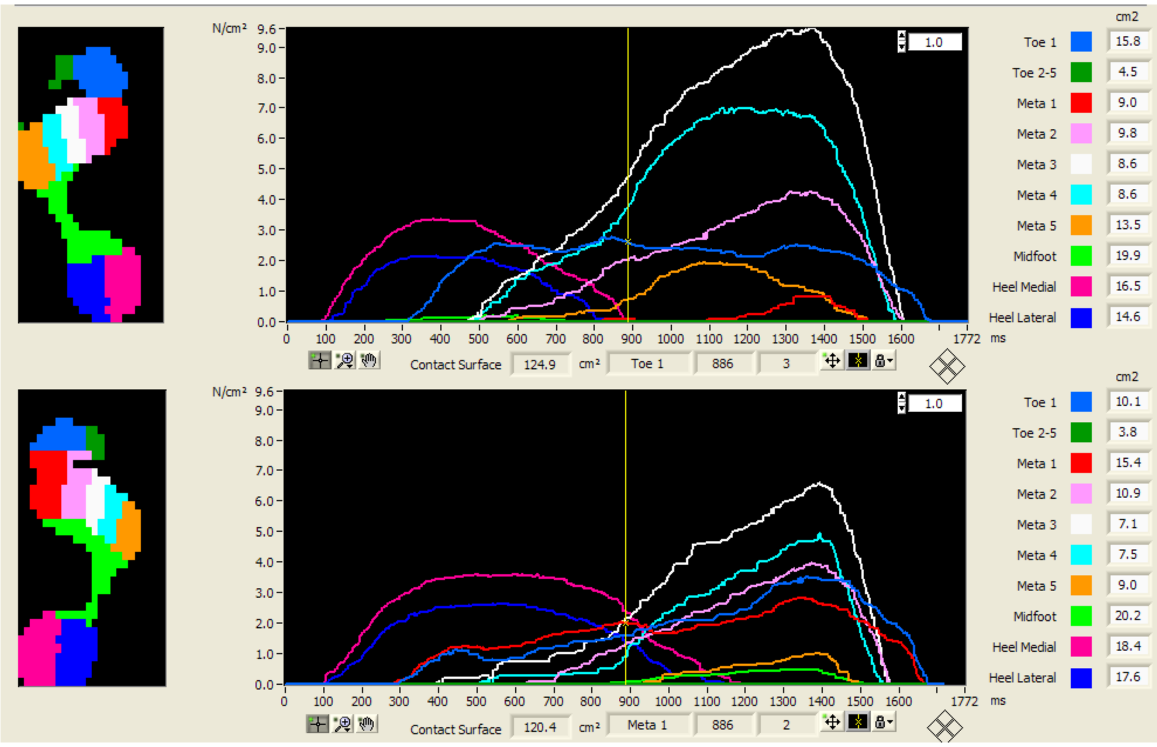

Figure 4: Plantar pressures divided into 10 areas

For a complete biomechanical analysis, the balance graphs are studied. In all those graphs, there is a white area, which represents the normal values, in what concerns heel rotation, hallux stiffness, foot balance, forefoot balance, medial forefoot balance and Meta loading. In every graph, green line represents left foot, and red line the right foot.

Figure 5: Heel rotation

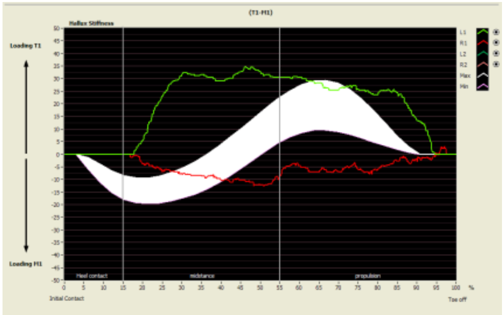

Figure 6: Hallux stiffness

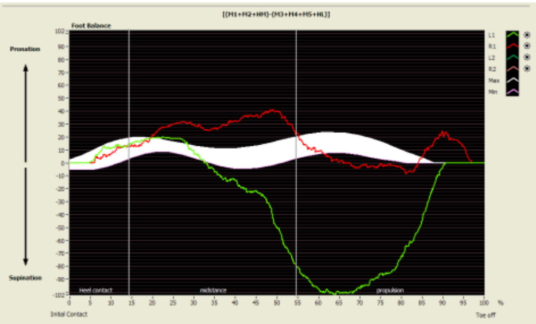

Figure 7: Foot balance

In figure 5, the left foot is near to be in the average values, so left foot will probably not cause pronation or supination; at the opposite, right foot presents an risks of pronation in propulsion stage.
For figure 6, the left and right feet are loading too much at the time of midstance and propulsion.
Figure 7 shows us the foot balance. On heel contact phase, and the beginning of midstance phase, the feet are balanced, but after, the right foot presents a small pronation, and in case of left foot, the curve falls down and a big risk of supination appears, which increases at the end of midstance phase and propulsion.

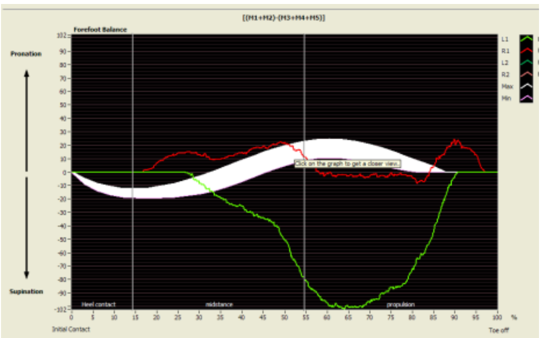

Figure 8: Forefoot balance

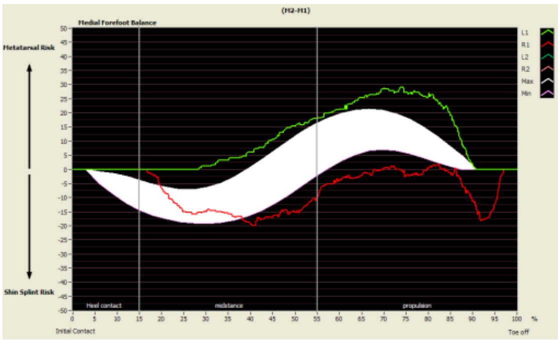

Figure 9: Medial forefoot balance

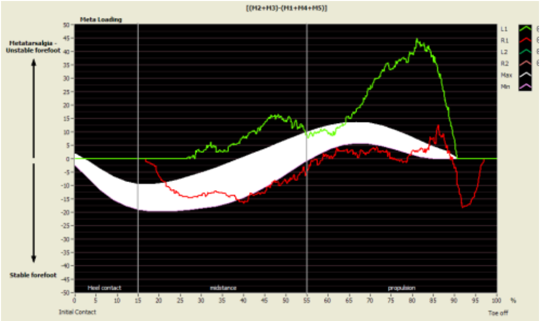

Figure 10: Meta loading

Concerning forefoot balance (Figure 8), the results are the same than with foot balance: left foot it is loosing balance and a very high risk of supination appears.
Medial forefoot balance (Figure 9) is close to normal. Indeed, the left foot is not so for from the white zone.
Figure 10 shows the Meta balance. At the propulsion moment the left foot is loaded too much, highlighting an unstable forefoot, a risk of metatarsalgia.
To conclude these experiments, using Footscan software, the authors are able to present a solution to the problems met, by simulating the necessary insole.
This solution is to create a special orthotic device for each foot. The orthotics suggested are to be introduced in the D area (Figure 11), at the exterior of the foot. For producing those kind of devices, different materials can be used (leather, polyurethane, silicon) and different thickness (2mm, 3mm etc). [8, 9, 10]

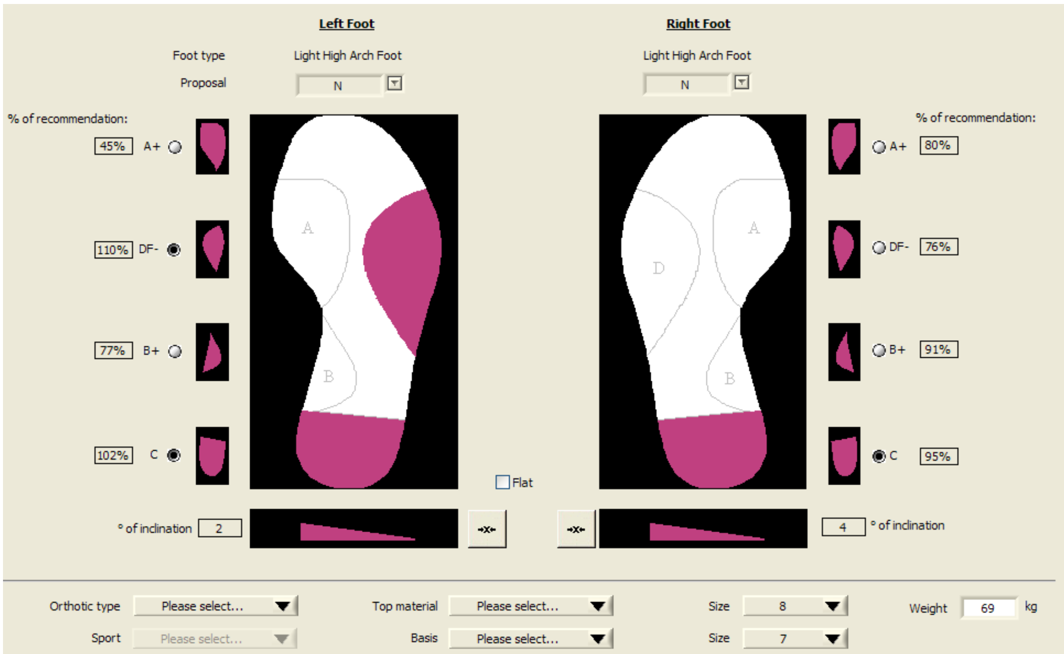

Figure 31: Suggested orthotic devices

CONCLUSIONS

Using RSScan plate and the associated software, plantar footprints have been obtained for an elderly subject. Footscan software is a powerful application, allowing various measurements and observations, only by analyzing plantar pressure, the way of the gait and giving simple geometric tools. The loss of the ability to walk due to foot problem, not only produces physical limitations, but also has a significant impact on the persons's mental, social, and economic status.
The footprints were used to analyse the typology of the feet. There has been demonstrated that the right foot is different from the left foot in what concerns the foot axis angle, the gait cycle and also for the balance of the feet. A complete knowledge of the feet can be obtained; and then, solutions can be purposed and found. In this case the solutions were special insole for each foot. The next stage of the research will be focused on designing and rapid prototyping of personalized insoles for this particular subject.

Acknowledgement
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KNOWLEDGE PLATFORM FOR TRANSFERRING RESEARCH AND INNOVATION IN FOOTWEAR MANUFACTURING

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Abstract: *The Knowledge4Foot (K4F) project aims to contribute at fostering the excellence in tertiary level of training and education for product design and development, engineering and management by linking the three areas of education, research and business oriented innovation in order to demonstrate good practices of cooperation and to bridge the worlds of education and work. In order to achieve this aim, the project has following objectives: 1) to set-up a Knowledge Platform that facilitates the transfer of innovation in footwear manufacturing by simulating the developing stages of the research projects; 2) to develop active collaboration among universities, business community and research centres in order to assess the skills needs on innovation and technological transfer; 3) to design, test and implement a common curriculum for virtual internships and the related e-learning content, which incorporates a creative thinking and problem-solving approach. K4F project will contribute at developing sustainable solutions to attuning curricula for placement/internship in order to develop skills and competencies in area of project-based work focused on research, innovation and technological transfer. Thus, the K4F project will have a significant impact on the development of higher education for Leather & Footwear sector.*

Keywords*: research, innovation, footwear manufacturing, knowledge platform, e-learning.*

INTRODUCTION

Europe has valuable tradition and leading recognition in footwear manufacturing. In a global economy where enterprise sustainability and employability are uncertain, the need for making the knowledge triangle (education, research and business) to work becomes obvious [1]. The European Footwear sector, as most of the manufacturing sectors, has been affected by the economic and financial crisis in Europe. Europe has a very long tradition in the production of footwear, but the sector is very sensitive to international challenge represented by globalization like opening of markets with lower wages and lower production costs because of not respecting the high quality standards in force in Europe.

European footwear is highly appreciated around the world as demonstrate European export statistics to third countries, which illustrate an increase of 46% in quantity and 78% in value from 2009 till 2014 [2]. However, the leading reputation can only be maintained if businesses' competitiveness comes, inter allia, from a very high capacity for innovation, which cannot take place without the appropriate trained workforce.

Consequently, the nowadays challenges of EU companies include to count with highly qualified engineers, product & process developers, top and middle managers among their staff. They should have the right mix of skills, both professional and transversal, to demonstrate their competence for applied research, development and technological transfer [3].

The three sides of the 'knowledge triangle' are joined through K4F project in order to enhance the contribution of higher education to jobs and growth in EU footwear sector, as well as its attractiveness in partner countries by applying good practices and mastering the most advanced methodologies for transferring the results of research into business environment thought real project-based work focused on technological transfer [4, 5].

Making the knowledge triangle work by connecting Higher Education, Research and Business for excellence is one of the goals of the EU policies and national political priorities in all EU countries. The partners of the Erasmus+ Knowledge4Foot project recognize the benefits for the sector's growth of such partnership approach, and will develop innovative tools for transferring knowledge to the European footwear sector by providing the High Education (HE) students and professionals with skills for applied research and innovation.

AIM AND OBJECTIVES OF THE PROJECT

Knowledge 4Foot (K4F) project aims to contribute at fostering the excellence in training for footwear manufacturing by connecting the three areas of education, research and business oriented innovation in order to demonstrate good practices of cooperation and to bridge the worlds of education and work.

A preliminary investigation on the HE needs, that was performed by the K4F consortium in the preparation stage of project proposal has revealed that most of the HE students are not familiar with the latest researchers, trends and possibilities for rising up the business in leather and footwear on next level. Moreover, the internship/placement activities undertaken by students, as part of their study or training curriculum, are very limited and they are manly oriented toward work training for getting skills on traditional processes and technologies. That is, in fact, very necessary but not sufficient. Even if the HE graduates have core and professional skills, they do not have the right skills for performing research, development and technological transfer activities and they are not trained for exploring innovative solutions in companies immediately after they graduate the study program.

Therefore, the project has the following objectives:

1. to set-up a new Knowledge Platform (Figure 1.) for transferring research and innovation for Leather and Footwear where the students will receive project-based training into a virtual environment by simulating all developing stages of the research projects and having as starting point the real identified needs in leather and footwear companies;

2. to develop active collaboration among education, business community and research in order to assess the skills needs on innovation, research, development and technological transfer;

3. to design, test and implement a common curriculum and related e-learning content which incorporate creative thinking, problem solving approach and project-based learning by placements/internships into virtual environment.

Figure 1: The K4F project website - www.knowledge4foot.eu

The project consortium (Figure 2.) involves nine organizations with different expertise and competences such as universities, research centres, and SMEs from Romania, Spain, Portugal, Greece and Croatia and the European Confederation of Footwear Industry (CEC) with headquarters in Brussels.

The project partners are the following:

- TUIASI – "Gheorghe Asachi" Technical University of Iasi – Romania
  www.tuiasi.ro, www.tpmi.tuiasi.ro
- CEC - European Confederation of the Footwear Industry – Belgium
  www.cec-footwearindustry.eu
- Virtual Campus Lda – Portugal
  virtual-campus.eu
- INESCOP - Instituto Tecnologico del Calzado y Conexas – Spain
  www.inescop.es
- CTCP- Centro Tecnologico de Calcado de Portugal – Portugal
  www.ctcp.pt
- UNIVERSITY OF ZAGREB - Faculty of Textile Technology (TTF) – Croatia
  www.ttf.unizg.hr
- The Research Committee of the Technical University of Crete – Greece
  www.tuc.gr
- INCDTP- Institutul National de Cercetare-Dezvoltare pentru Textile si Pielarie – Romania
  www.icpi.ro
- CRE.THI.DEV- Creative Thinking Development – Greece
  www.crethidev.gr

Figure 2: The K4F Consortium

ENVISAGED RESULTS

The Knowledge4Foot project introduces innovative tools to adapt and update the learning and training curricula of higher education providers for managers, designers, and engineers, in order to achieve greater creativity, innovation and high performance in European footwear manufacturing and related sectors.
The envisaged project results/products are the following:

- Mapping the knowledge triangle for transferring research and innovation in footwear manufacturing.
- Training program and e-learning content for transferring research and innovation
- Multimedia handbook for project-based training and virtual placement of HE students and trainees from SMEs.
- Knowledge4Foot Platform for Transferring Research and Innovation in Footwear Manufacturing.
- Book of lectures for Entrepreneurial thinking in footwear manufacturing.

Mapping the knowledge triangle for transferring research and innovation in footwear manufacturing

The aim of this study is to give a deep overview of the labour market needs for highly qualified professionals in footwear manufacturing with right mix of transversal and professional skills in order to boost the transfer of novelties coming from research and innovation in product, processes and services that provide added value.

For the Output 1, several implementation activities have been performed. Implementation activities are organized in logical sequences so the outputs to be realized at the proposed level of achievement (qualitative and quantitative). Regarding field research, target groups and stakeholders from partner countries where involved and their feedback collected via questionnaires.

Questionnaires were applied in order to analyse the installed capacity of companies to perform Research, Development and Innovation in Footwear Manufacturing (Figure 3.). This questionnaire is organized into three sections. The first one has 10 questions where the respondents characterize the company. In the second section which contains 6 questions, they characterize their collaboration with Universities and Research Centres. The last section has 7 questions and it aims to emphasize the role of education and research and to provide a deep understanding of the training needs for innovation and technological transfer.

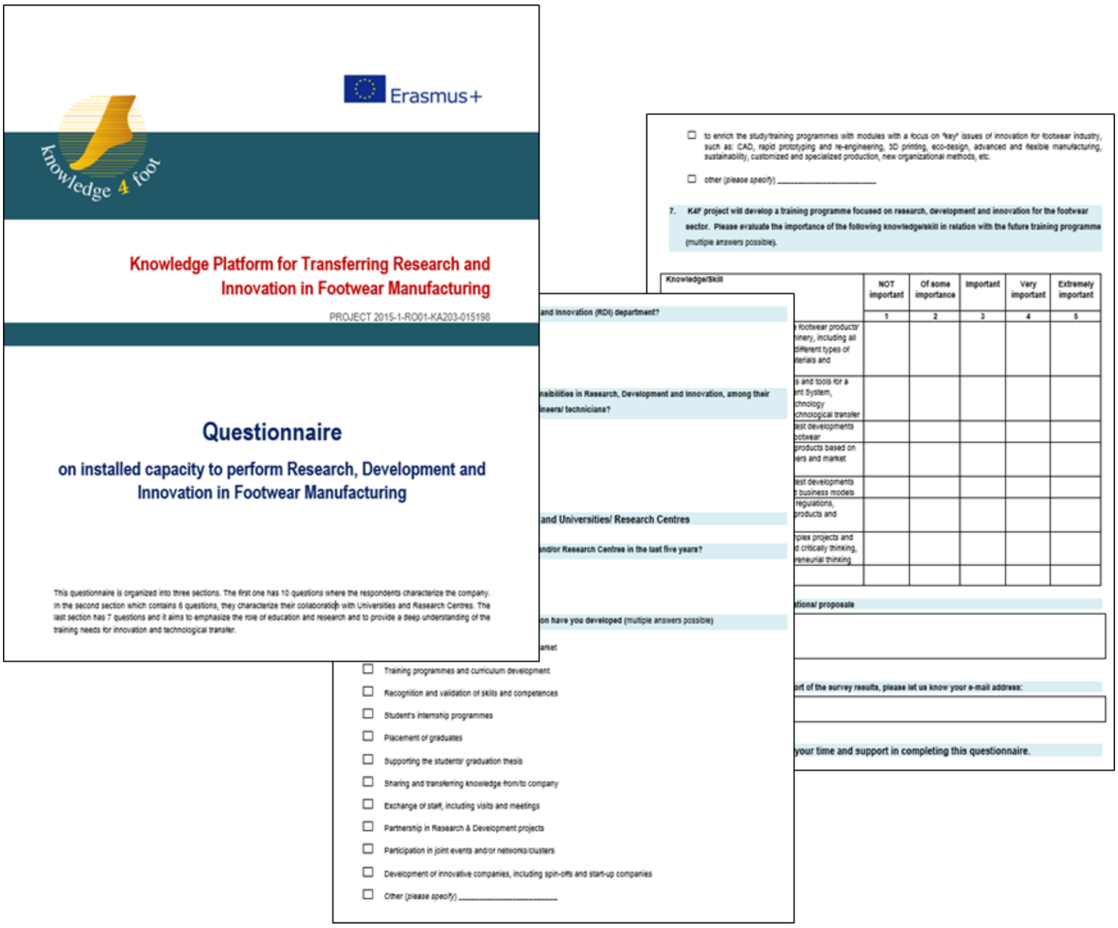

Figure 3: K4F Questionnaire on installed capacity to perform Research, Development and Innovation in Footwear Manufacturing

In Romania, the questionnaires were applied to representatives from 25 footwear companies. Regarding the number of employees, 18 companies are small and medium, representing the majority, and only 7 companies can be considered large ones (over 100 employees). In terms of target group, the majority of companies produce ladies' shoes (21 companies), followed up by men's shoes (16 companies) and only 9 companies produce children's shoes. From these companies, the majority produce fashion and casual shoes and sport shoes. Regarding the collaboration with Universities and Research Centres, 20 companies from 25 have collaborated, indicating hosting of student/interns, supporting students' graduation thesis, sharing and transferring knowledge from/to company and participations in joint events and/or networks/clusters/ meetings. Regarding the benefits of cooperation, the companies indicated competitiveness rise, increased added value of products and access to research results. Only 2 companies answered that they are not interested in becoming part of Knowledge4Foot Project Community.

In the last section of the questionnaire, Section C - Role of education and research in fostering innovation, the companies were asked to evaluate the importance of various knowledge/skills in research, development and innovation (Table 1.) in relation with the future K4F project training programme for the footwear sector. The importance of knowledge/skills for the evaluated companies is illustrated in Figure 4.

Table 1: Knowledge/skills in research, development and innovation for the footwear sector

Code	Knowledge/skills
A	to demonstrate broad knowledge on the footwear products' processes and related technology/machinery, including all phases of footwear manufacturing and different types of construction, design techniques raw materials and components
B	to elaborate and to apply the procedures and tools for a Research and Development Management System, including new product development, technology development, process development, technological transfer
C	to carry out projects in relation to the latest developments on new materials and components for footwear
D	to develop new footwear concepts and products based on specific requirements of various customers and market trends
E	to carry out projects in relation to the latest developments on new manufacturing technologies and business models
F	to comply with the available legislation, regulations, certifications and standards regarding products and manufacturing processes
G	to demonstrate soft skill adapted to complex projects and working situations, such as: creative and critically thinking, solving problems, team working, entrepreneurial thinking

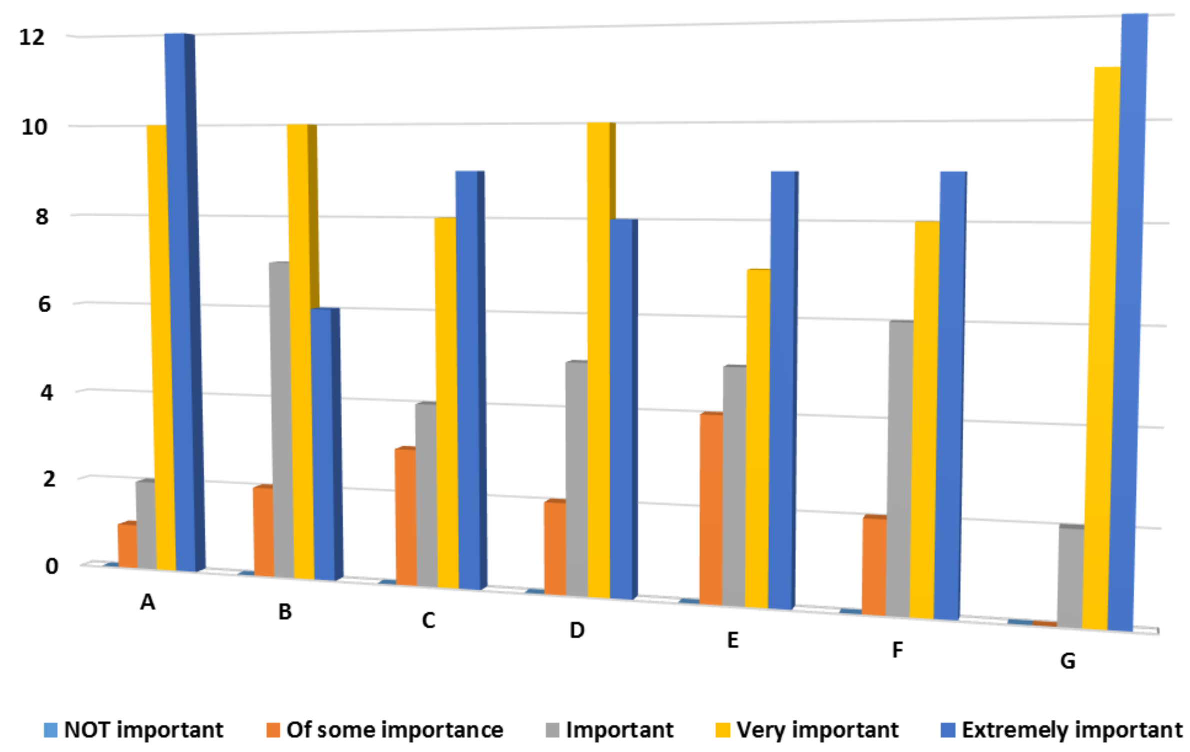

Figure 4: The importance of the knowledge/skills in relation with the training program of K4F project

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RESEARCHES ABOUT THE REALIZATION OF THE MOULDS BY ELECTROCHEMICAL TECHNOLOGIES

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Abstract: *The paper presents researches about the elaboration of some electrochemical technologies for the manufacturing of moulds used in the footwear soles obtaining. There are presented a few methods in the obtaining of the moulds using in electro-deposit process. The paper presents the stages in the obtaining and preparing of the electrodes (including the compatibility properties), in the preparing of the electrolysis equipments and in the obtaining of the metallic dies which will be fitted into the proper mould.*

Keywords: *footwear, sole, mould, electro-deposing technology.*

INTRODUCTION

The field of the electrochemical technologies includes the technologies used in the obtaining of certain working parts of the moulds, under the current action, into the aqueous of metallic salts. These technologies may be electro-deposit once or electro-chemical corrosion once. Both kinds may be applied in the obtaining and varying of the moulds used in the footwear industry.
The paper presents solutions for the obtaining of certain working parts of the moulds for soles, considering the electro-deposit technologies.

EXPOSITION

The electro-deposit technology is used, in the manufacturing of the moulds for soles, in two variants: the electroplating and the electroforming. Using the electroplating, it will settle down thin layers of high-oxidizable metals on the surfaces of usual metals objects, as a protection against their oxidization under the action of the environment or chemical agents. The electroforming technology is used for the thicker deposits, over 1 mm, on the surfaces of certain shapes, for the obtaining of the assemblies with high mechanic strength. The so obtained layers will, usually, appear from the surface and then, they will be used in this state or after a previous consolidation.
In the case of electro-deposit technologies, the surface which receives the metal in an ionic state represents one of the electrodes of the electrolysis equipment, the other one being a metallic bar (which has the same material as the deposit one, or another kind of metal, but an inert one, from the electrolytic leaching point of view). In this process, it is very important the quantity of metal which is deposed on the cathode, both in the electroplating case and in the electroforming one, too. [1], [2], [3]. This quantity is in proportion to the current quantity which passes by the electrolyte and to the electrochemical equivalent of the certain material. This statement, which is the sum of the two electrolysis laws enunciated by Faraday, allows a quantitative estimation of a certain metal deposits, depending on the current quantity which passes by electrolyte. So, a current quantity, equal to 1 coulomb (one ampere per second), will release different quantities of metal from cathode. These quantities are adequate to the electric energy unit passes by and they are called the electrochemical equivalent of the certain metal. Making a ratio between the chemical equivalent of the metal, the molecular mass/valence and the electrochemical equivalent, it will obtain a number which is constant for all metals, the so called Faraday number, whose value is 96500 coulombs, more exact, 96487,3±0,5 coulombs.
In these conditions, the metal quantity which is deposed on the cathode is given by relation (1):

$$m = K \cdot q \text{ , [g]} \quad (1)$$

where: m-mass of the metal deposed on the cathode, in gram; K-factor of proportionality, respective, the electrochemical equivalent of each metal which were electrolyzed; q-electricity quantity which passes by the solution, in ampere seconds, which is given by relation (2):

$$q = i \cdot t \text{ , [A.s]} \quad (2)$$

where: i-amperage, in ampere; t-time, in second.
The electrochemical equivalent, K, may be calculated for each metal, knowing the Faraday number and using the relation (3):

$$K = \frac{M}{v \cdot 96500} \tag{3}$$

where: M-atomic mass of the metal; v-valence of the metal; 96500-Faraday number.

The metal deposits by electrolysis are realized during the some currents (which have small voltage, 2-6 V, and big amperage) passing through the electrolyte solution. The value of the voltage is specific to each metal. The amperage, in ampere, is variable, but it provides a current density which value is about 10 A/dm^2. Knowing the surface on which the electro-deposits will take place, in dm^2, it will choose the source of direct current [4].
The protection covering with thin layers, electroplating and the protection covering with thick layers, electroforming, take place, as a rule, in the same way for each metal but the realizing conditions are different.
The paper presents a method which was used in the obtaining of the certain mould working parts, of the certain cavities which, ulterior, were fixed into the proper moulds used in the soles manufacturing.

EXPERIMENTAL PART

3.1. Preparing of the non-metallic electrodes

The moulds for soles, which are obtained by electro-deposit, are realized using the electrolysis equipments. This kind of equipments has an electrolytic tank made from a material which does not react with electrolyte solutions. Into its interior, there are placed two electrodes, between them being a certain distance. The electrodes are connected with a source of direct current. The cathode is the electrode which receives the metallic deposits resulted by electrolysis. In the case of the electroplating process, the cathode is the metallic object which will be covered with a protective layer. In the case of the electroforming process, the cathode may be a metallic object but a non-metallic one, too, (its surface is made conductive through a metallic layer which has a small thickness). The anode may be a soluble or an inert one. In the interior of the tank, there is the electrolyte which is an aqueous of a salt of the metal which will be deposed.
Before the realizing of the electro-deposit processes, the preparing of the electrodes was necessary. The paper presents the preparing of the non-metallic electrodes, only.
The non-metallic electrodes are, usually, bodies which have complex spatial shapes and were obtained from non-metallic materials by copying processes as processes of mould of certain waxes, resins or thermoplastics plastics on real objects. The obtained moulds are made conductive by superficial metallization; when they become good conductors of electricity, they may be used as cathodes into the ionic baths. In these conditions, using the electroforming processes, it can obtain moulds in entire or parts of moulds. The concrete technologies know two classes of operations, previous to the electro-deposit operation: the operations for the realization of the moulds and the operations for making the moulds to be conductive [4], [5].

3.1.1. Moulds realization

Alter they are made conductive, the casts will be used for the metallic electro-deposing, which will be a mould or a working part of the mould. The metallic layer obtained by electro-deposing must be interlinked to the object which was obtained into the mould. Having this purpose, starting with a real object, the ways to arrive to the object produced into the mould could be the following:
a. primary model (+)→plastics cast (-)→ plastic electrode (+)→conductive proprieties by superficial metallization (+)→electro-deposing for the obtaining of the mould or of the mould element (-)→forming of the plastics finished product (+);
b. primary model (+)→ covering of the model with a wax film (+)→conductive proprieties by superficial metallization (+)→electro-deposing for the obtaining of the mould or of the mould element (-)→forming of the plastics finished product (+).
In both situations, “(+)” means the primary model and the finished product and some intermediate stages which have identical forms with these, too, and “(-)” means the interlinked forms. Interlinked form means the

shape which was obtained by casting or by electro-deposing on a primary model or on an object identical with this.
The first way is longer because it needs intermediate operations. In the same time, it allows the realization of more identical electrodes; this situation provides a continuity of the moulds obtaining activities, without the remaking of the primary model, every time. The second way, the shorter and simpler one, is used in the prototypes case, especially in all activities which prepare the new collections of products.
From now on, the paper will present, in shortly, the two ways in the realization of the moulds used in the obtaining of certain polyurethanes rubber soles [5].
For the casts obtaining it is necessary, in the beginning, the realization of the primary model of the sole, the shape of sole, which it will be obtained into the mould. The primary model will be made by wood, using a mechanical or manual shaping process, for the medium number of size. The entire series of sizes will be obtained by multiplication using a machine for the shoe-lasts copying. The primary model of the sole will not include the sole model, in the beginning. So, its dimensions will be decreased respectively to the size of the non-skid relief. These primary models, made from wood, will be completed, using various procedures, with the model of the non-skid relief, for example, the covering with textures, meshes, natural or artificial leathers, the confectioning by hands of some models, etc. The primary models of the soles are represented in figure 1.
For the cast obtaining, the following steps must take place: The primary model of the sole completed with model of the future sole (+) will be fixed on a wood or burnt plaster base; the assembly will be fixed into a drain box; on the entire surface of the primary model and of the base will be sprayed an anti-adhesive lacquer and then, it will cast the mixture used for the cast forming, (-). All For the casts obtaining, it may use easy forming materials and which may copy all surface details of the covered primary model. So, it can use silicone rubber, unsaturated polyester resins, epoxy resins, burnt plaster.

Figure 1: Primary models of the soles

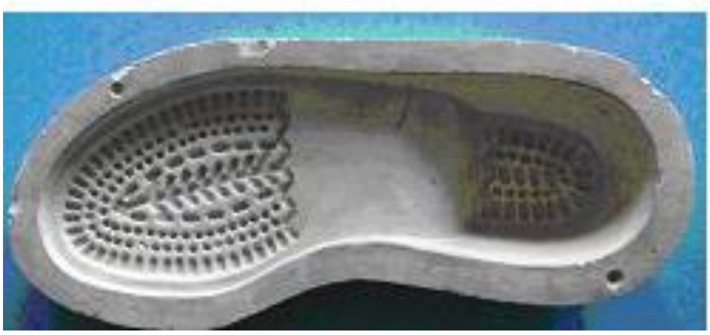

Figure 2: Burnt plaster cast

Figure 2 represent a cast made from burnt plaster. When the mould is obtained using the second way, it will not use the intermediate model. So, the primary model of the sole will not be fixed on a wood base but on a burnt plaster one.
Preparing a mixture of three parts of water and one part of burnt plaster, it will be obtained a fluid pulp which can easy take the shape of the drain box and of the object whose shape is the cast one. For the resistance increase, the burnt plaster casts may be reinforced with glass fibers, asbestos fibers, textile fibers etc. In this way, the burnt plaster casts may be used in repetitive casting of the electrodes. From this point, the obtaining process of the mould takes place as in the first method case.

3.1.2. Realization of the waxes or plastics electrodes

The object which is identical to the covered primary model and will be used as electrode, will be obtain [5] into casts, manufactured as paragraph “a” shows. Following this aspect, into these casts, it may be cast waxes, acrylic resins, polyamide resins, epoxy resins, polystyrene, etc.
The waxes are the easiest material to be used; it binds and coalesces easily and, in a melting state, it takes easily the shape of the object which covers by casting. To reproduce exactly every detail of the cast, before the casting, the waxes will be heated at 50-60^{0}C. The wax is a mixture which may or may not contain graphite for conductibility proprieties.
The acrylic resins are obtained by entire polymerization of the methyl methacrylate. Following this aspect, the monomer will be blended together with 5-15% plasticizer and with 1-3% dibenzoyl peroxide (lucidol), as initiating agent, 30-60 minutes. In this way, it avoids the air checks generation before the casting into the silicone rubber cast. To avoid the adherence of the polymer to the silicone rubber cast, it will spray a solution of paraffin into benzene. Knowing that the polymerization process introduces constrictions, the casting may be made in steps, for the shapes which have bigger thickness. After the casting, for the polymerization, the shapes may be heated in steps, until 125 ^{0}C. The thermal condition is pointed when the

monomer and the initiating agent are delivered. The so obtained product is firm and it may be corrected by ulterior machine works.
The polyester resins are used for the non-metallic electrodes obtaining by using a casting technology which is similar to the technology of the acrylic resins casting.
The epoxy resins are used in a fluid state, completed with active filler, such as different amines and other substances and with some fillmasses. The so obtained products have a high mechanical resistance.
The thermoplastic polyamides are used for the non-metallic electrodes obtaining, too. They are obtained by casting, in a melting state, into a cast which was heated over 80^0C, to realize the copying of all details of the cast.
The polystyrene may be used for the electrodes obtaining, too. In this case, it will use shock-absorbent polystyrene foils which have 0,8-1,5 mm thickness and which are obtained in vacuum, after a previous heating with a infrared source. The using of the vacuum forming process is applied when the primary model does not have very fine surface details.
The technology of the non-metallic electrode obtaining it consists in the following operations: the fixing of the cast, obtained as paragraph “a” showed, into the drain box; the greasing of the cast, using a petrolatum; the casting of the one of the anterior presented mixture. Figure 3 represents an electrode which was obtained using wax as a material.

Figure 3: Wax electrode

3.1.3. Obtaining of the conductive electrodes

Excepting the wax electrodes, which content graphite, the rest of the electrodes are not electric conductive. Wanting their using as conductors, their surface must be covered with a metallic film. This operation may be realized using one of the following two methods.
The first method in the obtaining of the conductive electrodes is based on the realization of a mixture between phenol formic aldehyde, soluble in alcohol, blended together with a copper colloidal powder and its layers, in a thin film, on the surface of the electrode. This film is applied, with good results, on the surfaces of the wax electrodes which do not contain graphite in their mixture. The presence of the alcohol into the solution, allows the superficial solubilization of the wax and the anchorage of copper powder. This method has a version which consists of the spraying a slurry of powder of copper, silver or graphite in polymers diluated solution.
In the other kind of electrodes case, but in the case of those made from wax, too, it may apply a special method of conductive proprieties obtaining, which consists of the reduction of some copper, silver, nickel, cobalt salts at the metal state.
Before the covering, in some cases, it is necessary to excite the surface of the polymer. So, the objects made from polystyrene or some other polymers, which are used as electrodes, are degreased with organic solvents and then, they are kept 3-5 minutes into a solution NaOH 10% at 50-60^0C. After the washing with water, the object will be introduced into a stannous chloride and hydrochloric acid solution (10g $SnCl_2$+40 cm^3HCl per liter) and will be kept 3-4 minutes at 25^0C. The tin will be reduced and so, it fixes on the surface of the object. After the washing with water, the process goes on by treating the part with a silver ammonia solution, 10g/l $AgNO_3$ and 50 ml/l NH_3.
The object coating will be made by its immersion into a solution or by its spraying. In the coating with copper deposition it may be used different solutions versions [4,5], consisting of a copper soluble salt, complexing salts and reduction agents. Following these aspects, the compositions of these solutions are given in table 1.
In all the cases, the solutions have a strong basic pH, (12). The reduction agent, the formic aldehyde, will be added into the solution, with a few minutes before the using. In the spray coating case there are used two kinds of solutions [4], [5] which are sprayed, in the same time, on the surface of the object, using a pistol for each of them.

Table 1: Solutions versions for the coating of the non-metallic electrodes by immersion

Chemical substance	Version		
	1	2	3
Coating by copper deposition			
Copper sulphate ($CuSO_4.5H_2O$)	7 g/l	10 g/l	5 g/l
Rochelle salt	22,5 g/l	-	25 g/l
Soda salt	2 g/l	10 g/l	25 g/l
Sodium hydroxide	4,5 g/l	100 g/l	7 g/l
Nickel chloride ($NiCl_2.6H_2O$)	2 g/l	-	-
Formic aldehyde (sol.40%)	26 ml/l	40 ml/l	10 ml/l
Glycerine	-	100 g/l	-
Coating by nickel deposition			
Nickel sulphate ($(NiSO_4).7H_2O$)	25 g/l	-	-
Sodium hypophosphite (NaH_2PO_2 H_2O)	25 g/l	10 g/l	-
Sodium pyrophosphate($Na_4P_2O_7.10$ H_2O)	50 g/l	-	-
Aqueous ammonia (28%NH_3)	20-25 ml/l	-	-
Nickel chloride ($NiCl_2.6$ H_2O)	-	30 g/l	-
Sodium citrate ($Na_3C_6H_5O_7.2$ H_2O)	-	10 g/l	-
Coating by silver deposition			
Silver nitrate	20-30 g/l	-	-
Potassium hydroxide	10-15 g/l	-	-
Ammonia solution, 25%	60-80ml/l	-	-
Glucose	12-15 g/l	-	-

3.2. Obtaining of the metallic chills

The deposition of the metallic layers on the conductive non-metallic electrodes will realize by electroforming. Using this kind of galvanic deposition, it will obtain metallic chills whose thickness is 5-6 mm, with a certain mechanical resistance and which can be ulterior incorporated into the proper mould.

These chills are the cavities of the future moulds. For the metallic chills obtaining the coated non-metallic electrode is placed into electrolysis installation, in a cathode position.

The metal deposing will be made by anode solubilization or, when anode is non-soluble, by reducing of a certain salt of electrolyte solution which contains the metallic ion. The metal deposing will be made slowly, sometimes over 72 hours. It depends on the concentration of the metallic ions into the solution, on the current density and on the presence of some epilamens. At the beginning the current density has a small value 1-2 A/dm^2, and then, it will be raised to 10 A/dm^2. So, the surface of the electrode will be uniformly, by metallic deposits which will complete the discontinuances of the coating layer. The deposing, which is more irregular in the beginning, becomes more regular and, in the end, it will produce a regular, compact texture which obey the geometrical system of the crystal lattice. This kind of metallic chill is presented in figure 4.

Figure 4: Metallic chill, sole

For the obtaining of the copper metallic chills, it will use the electrolyte solutions 150-300g/l copper sulphate ($CuSO_4.5H_2O$), 7-15 g/l sulphuric acid and 30-50 ml/l ethanol. The value of the current density is 1-3 A/dm^2. In the case of the nickel deposing it will use solutions which have compositions as like as in the case of the nickel protection. [4,5]. This kind of solutions are presented in table 2. The metallic chills obtained by electro-deposit will be incorporated, by different casting technologies, mechanical working, into the proper moulds used for the soles obtaining. A sole obtained into this kind of mould is represented in figure 4.

Table 2: Solutions of the electrolytes used foro nickel chills obtaining

Chemical substance, parameters	Quantity		
Nickel sulphate ($NiSO_4.7H_2O$)	280-300 g/l	400-420 g/l	220 g/l
Natrium sulphate ($Na_2SO_4.10\ H_2O$)	-	140-160 g/l	-
Magnesium sulphate ($MgSo_4$-$7H_2O$)	50-60 g/l	-	-
Sodium chloride	5-10 g/l	-	8-10g/l
Sodium fluoride	-	2-3 g/l	-
Nickel chloride ($NiCl_2.\ 6H_2O$)	-	25-30 g/l	-
Fumarole acid (H_3BO_3)	25-30 g/l	25-30 g/l	25-30 g/l
Temperature	30-40 ^{0}C	55-60 ^{0}C	50-60 ^{0}C
Current density	2-4 A/dm^2	8-12 A/dm^2	1,2-1,5 A/dm^2
pH	3,0-5,0	3,5-4,5	4,2-4,6

CONCLUSIONS

- The moulds for soles or parts of them, which are obtained by electro-deposit are realized using electrolysis equipments.
- The using of these technologies is an advantage, especially in the designing and quick realizing of certain new soles collections stadium. The moulds for soles obtained by electro-deposit technologies will be realized with low costs, in a short time, in the experimental phases (for the marketing tests), before of the proper mould realization for the mass production.
- The casts used for the non-metallic electrodes realization will be made with classic technologies.
- The conductive properties of the electrodes will be obtained by a process of metallic coating on the non-metallic electrode. The coating of the object will be made by its immersion into an electrolyte solution or by spraying. When the immersion process is applied, it will use many kinds of electrolyte solutions, which may be a copper, silver, nickel, cobalt, aluminum soluble salt. When the spraying process is applied, it will use two kinds of solutions, one of them contains the metal which will be deposed, copper, nickel, silver salts, and the other one which is the reduction agent applied, in the same time, on the electrode surface; for each of these substances, it will use another pistol.
- The metallic chills which will generate the cavities of the moulds, the sole proper models, will be obtained by galvanic deposits using characteristic electrolysis installations. After that, these chills will be fitted into the proper moulds which will be parts on the injection equipments.

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Section 12: Ecology in textiles and leather processing

CARBON AND WATER FOOTPRINTS - TOOLS FOR MEASURING SUSTAINABILITY OF LEATHER PROCESSING

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Abstract: *Environmental impact of human activities and sustainability are some of the greatest concerns of our society. Environmental footprints, of which carbon footprint (CF) and water footprint (WF) are the best-known, play an increasing role as tools for measuring the pressure that industry puts on the worldwide natural resources. The CF and WF are used by manufacturing industries as inventory elements of the products life cycle, not only to demonstrate a commitment to reduce the environmental impact, but also to certify the sustainability of their products. The highly polluting tanning industry is faced with the challenge of taking action for sustainability in the leather sector, by reducing its footprints. It is the aim of this paper to present the approaches to defining and quantifying CF and WF of leather, actual values of tanneries footprints, and to point out their relationship with the sustainability of leather manufacturing; actions currently taken to reduce the environmental impact of tanneries are also shown.*

Keywords: *environmental footprints, environmental impact, leather, sustainability, tannery.*

INTRODUCTION

Beyond its conventional definition, the sustainability concept reflects the contemporary society concerns for the environmental impact produced by human activities, through unwise consumption of natural resources and extensive pollution. Efforts are being made to develop coherent concepts and metrics for measuring the environmental sustainability. In this respect, environmental footprints (EF) are gaining popularity and play an increasing role as tools for sustainability research and evaluation. Besides carbon footprint (CF) and water footprint (WF), a variety of other footprints have been developed, to measure the overall impact on the environment [1].

The leather sector, and tannery industry in particular, have a quite negative public perception, due to several reasons: 1) tanneries are resource and labour intensive plants, which use different toxic chemicals for processing and release great amounts of solid waste and heavily polluted wastewater [2]; 2) there is a false idea that animals are killed for their hides or skins. In fact, the raw material for leather sector – hides and skins – is a by-product coming mostly from farms that breed animals to produce meat and other valuable food products. Only less than 2% of animals are farmed specifically for their skins to produce luxury goods. Non-processed hides and skins represent an organic waste that would create an enormous waste disposal problem, with the associated health hazards. There are several options for using the hides and skins but the highest added value is obtained by tanning, to produce different types of leather [3].

As tanning is an important manufacturing sector in many countries, efforts are needed to shift towards the sustainability model, and there is a growing commitment of tanneries to assess the environmental impact and to take action for sustainability in the leather sector. Leather footprinting is a key element of this effort and EFs are used not only to measure and find the most apropriate ways to reduce the environmental impact of leather making, but also to meet the consumers' sustainable buying decisions, according to which they are willing to pay more for products provided by environmentally responsible companies.

This paper aims to examine the approaches to defining and quantifying CF and WF of leather, regarded as the end product of a tanning plant, and to review actual values of carbon and water footprints measured in different tanneries. The relationship with the sustainability of leather manufacturing and actions currently taken to mitigate the environmental impact of tanneries on their way to sustainability are also reviewed. The discussion is limited to the leather making process so the footprinting is restricted to this segment of the total value chain of leather products.

ENVIRONMENTAL FOOTPRINTS OF LEATHER – SIGNIFICANCE AND CALCULATION METHODS

Environmental sustainability is not only a vague concept, it also means practical actions regarding the improvement of resources usage efficiency, usage of clean technologies, waste reduction etc., specifically taken in each manufacturing plant. At a global level, sustainability must be measurable in a comparable way and there are the environmental footprints the well-defined, measurable and manageable parameters that can quantitatively assess the sustainability of human activities (Figure 1). This is the reason for increasing interest in footprints and the diversification of footprints, beyond CF and WF. Footprinting is a key element of sustainability, because it allows the assessment and control of the impact of human activities on the environment.

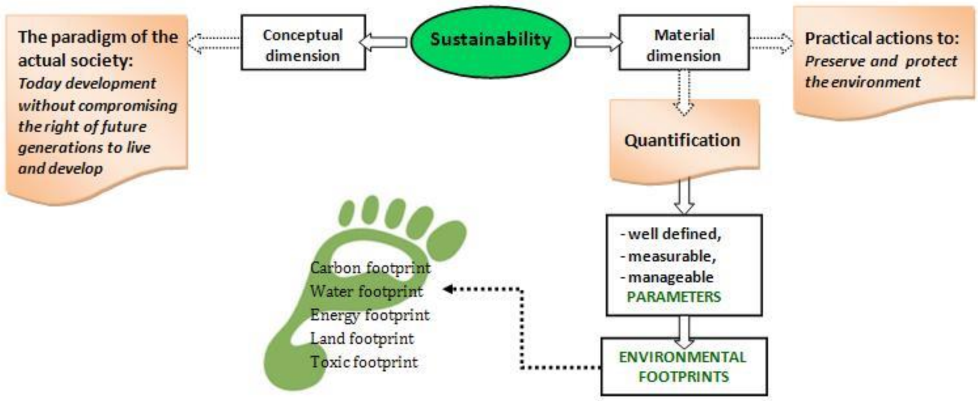

Figure 1: Dimensions of sustainability and environmental footprints as sustainability indicators

There are different systems for which footprints can be determined, but for leather the most convenient and rationale is the product footprint, where "product" means the different finished leather types leather resulted as end products of tanneries.

2.1 The carbon footprint of leather

Global climate change is believed to be predominantly caused by emissions of greenhouse gases (GHG) to the atmosphere. Carbon dioxide (CO_2) is used as the reference and the global warming potential of other gases is expressed relative to CO_2. For this reason, the carbon footprint (CF) is defined as the sum of all GHG emissions of a product or company over its entire life cycle, expressed in terms of kgs of carbon dioxide equivalent (CO_2-eq.). As the GHG emissions are mainly caused by the burning of fossil fuels to produce energy, the CF is related to the energy efficiency. Estimation of the total amount of GHG produced during the various stages in the life cycle of products is referred to as Products Carbon Footprint (PCFs).
The leather sector involves a lengthy and complicated supply chain, which is responsible for the significant amount of carbon footprint creation. Several approaches can be taken in consideration for defining and quantifying the leather CF [4]:
1 individually, per every type of finished leather, which is impractical;
2 cradle to grave, covering all the stages of the leather product life from cattle breeding (the entire LCA);
3 corporate carbon footprint (CCF), related to the production of leather in the tannery.
Currently, a harmonized methodology for measuring the PCF does not exist and no agreement has been reached internationally on leather PCF calculation methods, but there are several reports in which some common requirements or benchmarks are payed attention to [5], as given in Figure 2.
Functional unit is a concept used in LCA and carbon footprinting to provide a reference to which environmental impacts are related. The functional unit must correspond to the basic unit that the tannery uses for trading the finished leather it produces; the recommendation is to use, as functional unit, 1 m^2 of finished leather, including an indication of the thickness of the material [6].
Quantification refers to the unit of measurement and the calculation methodology of PCF. It is generally agreed that the leather PCF should be expressed in CO_2-eq/m^2 of finished leather; the calculation methodology lies on the subdivision of leather production in single processes (see Figure 3) and the summation of CO_2-eq of each process: CO_2-eq content of all materials and products entering the tannery (UPSTREAM PROCESSES), plus CO_2-eq produced in the tannery itself (CORE PROCESSES), plus CO_2-eq emerging from wastewater treatment and waste recycling or disposal (DOWNSTREAM PROCESSES).

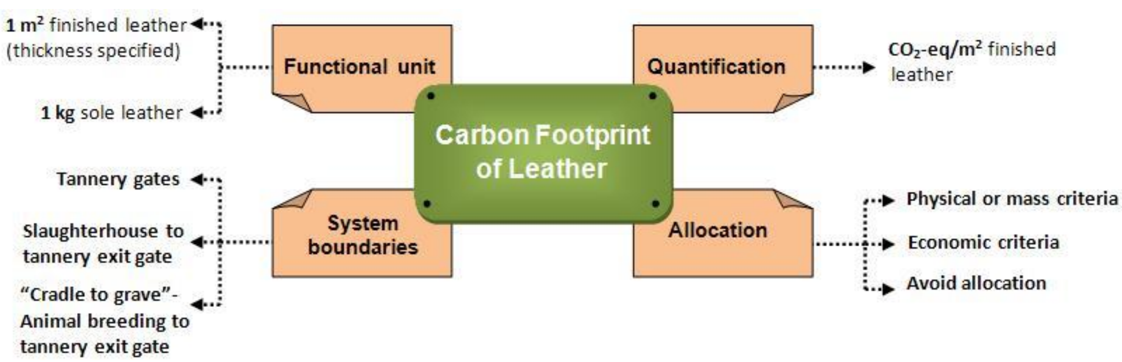

Figure 2: Main requirements for leather PCF quantification (adapted from [5])

Setting the **System boundaries** is the most controversial methodological issue for companies seeking to estimate the PCF of leather. The main problems related to this approach is whether the CF of cattle breeding, namely the equivalent of CH_4 emissions, should be included in the LCA and how to deal with the significant environmental burdens associated with livestock breeding and agricultural production of animal feed. At present, the argument that the raw hide is a by-product of meat industry and it cannot be directly responsible for the animal life footprints is generally accepted [7]. A UNIDO-commissioned report [5] recommends that for raw hides and skins coming from animals which have been raised mainly for human feeding purposes, such as milk and meat production (and therefore, bovines, sheep, goats and some other), the system boundaries are to be considered starting in the slaughterhouse, where activities and treatments are carried out in order to prepare the hides to be used for tanning. If it is considered a by-product of meat industry, than it is reasonable to accept that leather cannot entirely take the footprint burden from the meat industry.

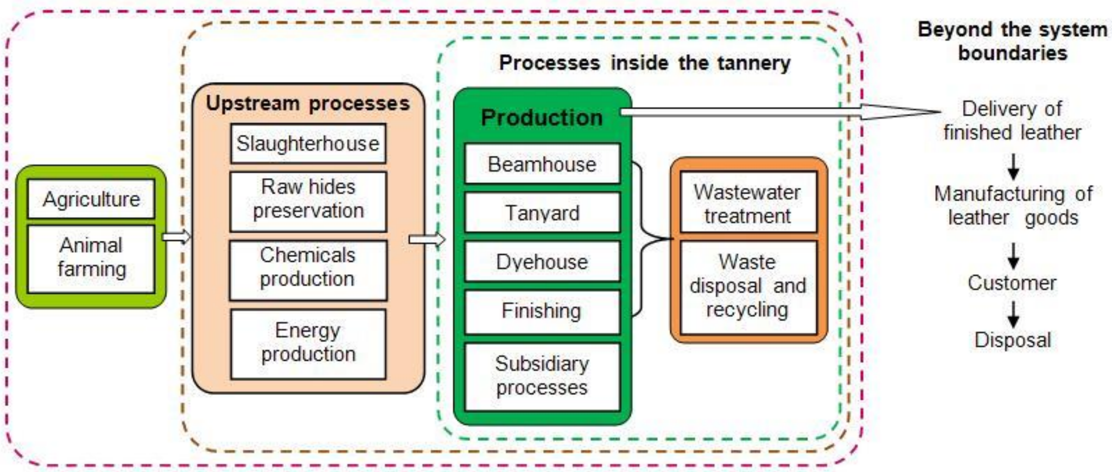

Figure 3: System boundaries of a tannery

Values of leather CF provided by different leather companies must be examined critically and always in relationship with the established system boundaries and the process elements taken in account. For example, the Dany SpA tannery, which included the cattle breeding within the system boundaries, reported a carbon footprint of 45.5 kg CO_2-eq/m^2 leather, in which the share of cattle-breeding and agriculture is 90%, the share of transportation is 1% and the tannery itself is responsible for only 9% of the total. It is not clear if CF of processing chemicals and of other utilities were taken in account. The figure above is the average of the four leather types the tannery manufactures [8]. A study on the CF of aniline leather, undertaken in several tanneries in Taiwan, followed the same "cradle to gate" scenario, and showed that almost three quarters of the GHG emissions of the finished bovine leather came form the cattle raising and preliminary operations of raw hides; thickness of finished bovine leather has significant impact on the CF and increasing values were obtained for increasing thickness values (1.5 mm, 1.7 mm, and 1.9 mm); the reported mean value was 73 kg CO_2-eq/m^2 [6]. K. Joseph et al. [9] reviewed the life cycle material flows of leather which indicated the carbon footprint of finished leather to be about 152 kg CO_2-eq/m^2 leather for shoe uppers. Differences may come from different allocation rules, different leather types and from the degree to which the tannery has undertaken action to reduce pollution and to improve the efficiency of materials consumptions.

Allocation refers to the distribution of the environmental impact between economic actors from the value chain of leather, within the system boundaries: Slaughterhouses, Chemicals Producers, Energy and Water suppliers, Tanneries, Effluent and waste treatment plants. Practical experience showed that in the leather making process, economic allocation is imprecise and consistent calculation of reliable ratios is improbable. Thus, allocation should be avoided whenever possible and, if unavoidable, it should be made according to mass balances within each individual process.

2.2 The water footprint of leather

At present, water is becoming one of the most critical resources of mankind. The concern for the impact of water consumption on the global water resources leaded to the emergence of the "water footprint" concept, introduced by Hoekstra [10] to provide a consumption-based indicator of water use. *The water footprint (WF) of a product is defined as the summation of fresh water volumes consumed and polluted in all processing stages of its production.* Each step has a direct water footprint and an indirect water footprint. The direct water footprint of one process becomes the indirect water footprint of the next process. In this way, the full amount of water consumed or polluted is taken into account and the product WF is calculated by a down-top approach. The functional unit of WF is the ratio between a volume unit (L; m^3) and the specific unit of the final product (kg; ton; piece, pair of footwear etc.).

According to Mekonnen and Hoekstra [11], the water footprint has three components: blue, green and gray (see Figure 4). ***Green water*** footprint refers to consumption of green water resources, i.e. rainwater that does not run off or recharge the groundwater. ***Blue*** water footprint is the volume of fresh surface and groundwater water consumed during production processes. Precisely, it is the amount of water incorporated into a product or that does not return to the catchment from which it was withdrawn. ***Grey water*** footprint refers to pollution and is defined as the volume of freshwater that is required to dilute pollutants to maximum admisible concentration imposed by water quality standards. The green water footprint is not usually considered in leather industry if the process WF is assessed.

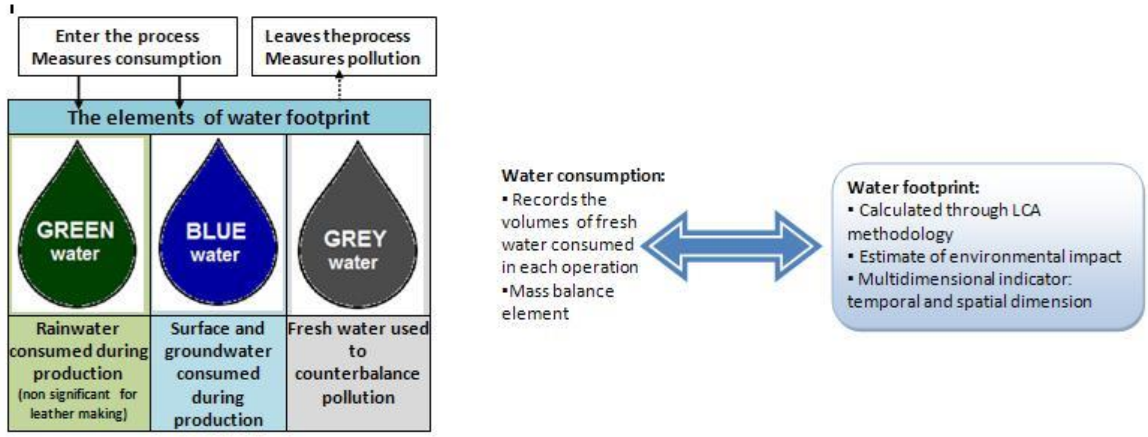

Figure 4: The water footprint breakdown and relationship with water consumption

Water appropriation is a term used in the context of water footprint assessment to refer to both the consumption of freshwater for human activities and the pollution of freshwater by human activities. Green water and blue water are related to water consumption or to water that enters the process. Grey water is related to water pollution or to water that leaves the process.
A product WF is calculated as the sum between water consumption during the manufacturing process (process water) and water volumes needed in all other processes in the production system. The process water is the basic building block of all other water footprints: WF of a business, WF of a group of consumers etc.
Importance of measuring WF: A product WF indicates how much pressure that product has put on freshwater resources. By measuring the volume and source of water consumed in the production of a product and the volume of water needed to assimilate pollutants so that water quality standards are met, one can get a picture of how a specific product contributes to the water scarcity and water pollution. By measuring the water footprint of a product it is possible to assess how efficiently the product has been

produced and to compare different products. **Water scarcity** defines the degree to which the available water resources meet water needs, in a specific geographic location and a given time of the year.
Leather is a water-intensive product and fresh water is an essential element of the material flows in a tannery; considerable amounts of highly polluted wastewater are generated, as well. Environmental and economical constraints has driven the reduction of water demand from 50-60 m^3/ton hide in traditional leather processing, to 25-30 m^3/ton in technically advanced and well-managed tanneries [12]. Water consumption inside a tannery, expressed in L/kg or m^3/ton of salted hides, is the sum between process water (beamhouse, tanyard, dye house, finishing etc.) and technical water needed for energy generation, waste water treatment, sanitary purpose etc). Estimated average consumptions are: 32 m^3 process water, 8 m^3 technical water, which means total 40 m^3/ton hide, with about half of it consumed in the beamhouse operations [13].
As the output of a tannery is the finished leather traded by surface, the WF must be expressed as L/m^2 (in order to be consistent with the CF functional unit) but the assessment of WF is based on water consumptions and water balance, given in terms of m^3/ton (L/kg) of raw hides. The conversion between WF and water consumption can be readily made on the basis of weight/surface equivalent [13] It is estimated that one ton of raw hides (i.e. 39 hides, average area 4 m^2/hide,) with a total surface area of approximately 156 m^2 yields 138 m^2 of grain leather and 60 m^2 split (Figure 22), when leather is processed to obtain shoe upper leather. The yields related to green weight are as follows: grain leather 12.5 dm2/kg and split leather 5.4 dm2/kg: a total yield of 17.9 dm^2/kg green weight.
There is a key difference between water consumption (WC) and WF:

- water consumption simply records the volumes of fresh water consumed for each operation of the process flow and is a strictly quantitative indicator;
- the WF is calculated through LCA methodology and reflects the environmental impact of the processing activity and of the resulting product, because WF can be extended to the life cycle of the product

The WF of a product refers not only to the total volume of water used, it also refers to where and when the water is used; all components of a total water footprint are specified geographically and temporally. For this reason, WF is a multidimensional indicator, which includes a temporal and a spatial dimension. This is important for industries that externalised their water footprint, importing water-intensive goods from elsewhere, which is also the case of tanning industry.
The production processes contributes much compared to other supply chain processes in the life cycle of leather. The tannery is a processor and the system boundaries is the key aspect when the WF is assessed. Inclusion of animal WF or taking in account only the direct water usage in tannery is the main issue. Attention must be given to data given in literature, to avoid misinterpretation, and to harmonize the animal WF and the WF of leather, regarded as an industrial product. The average WF of cattle bred for meat and leather is of about 17,093 m^3/ton (93% green, 4% blue, 3% grey) which seems huge, but it is calculated for the entire animal lifetime and accounts mainly for its feed. Water footprint of operations in slaughterhouse, related to the preparation of hides and skins for the leather industry, is very low. On the other side, WF of leather is calculated based on completely different grounds and the share of green water is negligible. As with the CF, it is reasonable to exclude the WF of the animal lifecycle and to take responsibility for a convenient share of about 5% of the steer/cow's life-cycle water consumption [14]. On the other side, very low values of WF can arise from the exclusion of beamhouse operation [9].
A unified methodology for measuring the WF of leather has not been established yet. Production processes are different, depending on the characteristics of the raw materials and the leather types to be obtained, yields are very different, so the figures have limited validity. Several attempts have been made to estimate the WF of different leather types, but the obtained values are quite inconsistent, mainly because the system boundaries are not clearly specified. The PrimeAsia tannery reported a WF of 3.3 L/sq ft, equivalent to 35.53 L/m^2, when the system boundaries were extended to the cattle's life [15]. The allocations between economical actors are also given (see Fig. 5). Direct contribution of the tannery appears to be very low, only 1%, because the beamhouse operations and chemicals manufacture were externalized. Removing the water usage attributed to the lifecycle of the animal significantly changes the distribution. Water utilization is then: 56% is consumed within the beamhouse processes, 33% during the manufacturing of input chemicals and 11% used directly within PrimeAsia tanneries. The tannery share is very low in both cases, because it performs only a segment of the total processing flow.

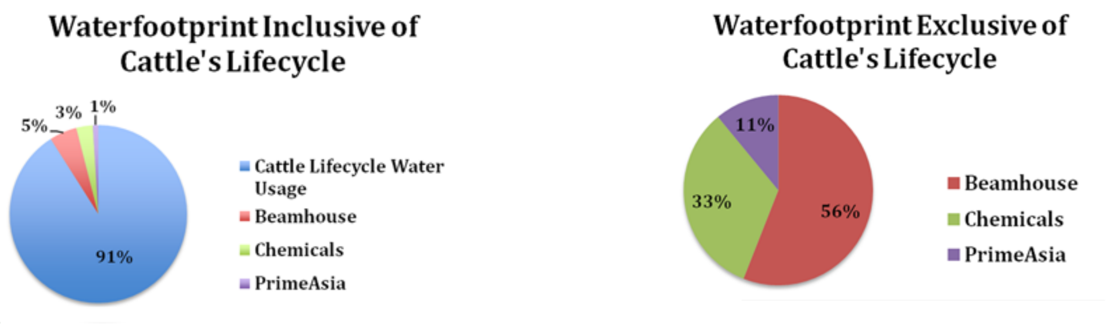

Figure 5: Allocation of leather WF when different system boundaries are considered [15]

Chrome retanned leather in a Bangladesh tannery was chosen as case study to perform a computer-aided LCA [16]. The system boundaries were the slaughterhouse and the exit gate of the tannery. It was found that the main contribution to blue water scarcity came from the beamhouse operations, where the water consumption were the highest. The blue water scarcity of all processes in the life cycle was 32.8% which indicates low value (<100%). and does not exceed blue water availability The grey WF was significant in operations where chemical auxiliaries are used and was generally much greater than the blue water of corresponding processes. The largest contribution comes with the production processes followed by packaging and electricity production where the ontributions are 30.6%,1.4% and 0.54% respectively. A realistic WF should take in consideration the blue/grey ratio and not simply the water consumption.

THE RELATIONSHIP BETWEEN PRODUCT FOOTPRINTING AND SUSTAINABILITY. REDUCING LEATHER FOOTPRINTS

Tanneries are highly polluting industrial plants, but the raw material they process is a reneawble resource. Thus, the sustainability of the leather product depends on the manufacturing process rather than on the hides and skins from which it is made [3]. Accordingly, the responsibility lies with the industry. To produce leather in a sustainable way, specific actions must be taken inside the tanneries.

As with other manufacturing plants, environmental sustainability of a tannery is dealing with:
- Full compliance to environmental regulations concerning water quality and solid waste management;
- Commitment to energy efficiency;
- Definition of Life Cycle Assessment (LCA) and assessment of environmental footprints of leather;
- Commitment to apply the best available techniques (BAT) in the manufacturing process.

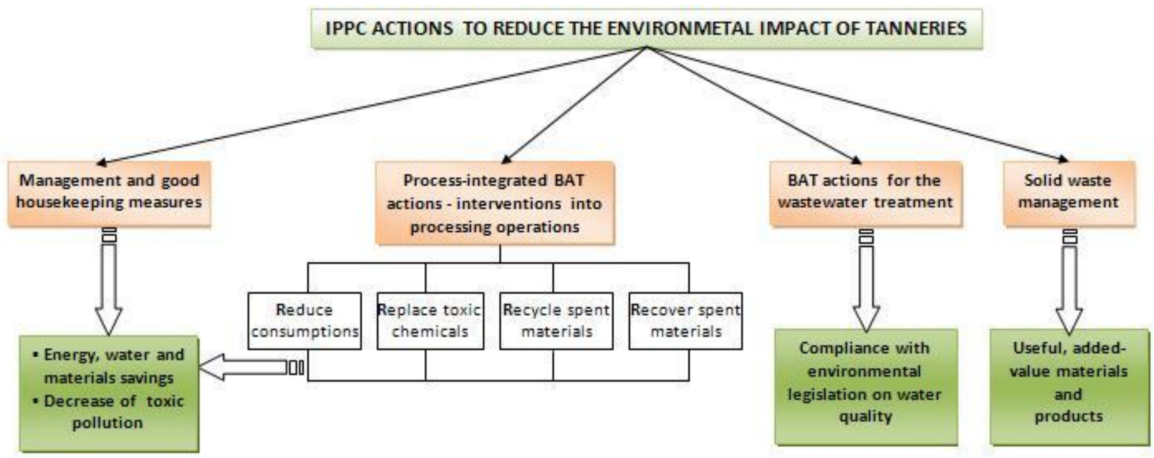

Figure 6: Actions in environmentally responsible tanneries to reduce the environmental impact

Reducing the carbon footprint is related to improving the energy efficiency and reducing energy and chemicals consumption. Reducing the water footprint is mainly related to the reduction of freshwater consumption in processing, the reduction of wastewater volumes and pollution charge and to proper water management inside the tannery.

The Integrated Pollution Prevention and Control (IPPC) is the most advanced concept promoted by the current EU environmental legislation to prevent or reduce the environmental impact of different industries. The IPPC 96/61/EC Directive [17] is an important tool for environmental and economic sustainability of the industrial activities considered as having a high environmental impact, amongst which tanneries. The best available techniques (BAT) to be applied for the minimization of the environmental impact of tanneries are settled out in one reference document for the tanning of hides and skins [2]. The critical measures and actions that can improve the environmental performance of tanneries, in accordance with the IPPC concept, are shortly presented in Figure 6.

3.1. Making steps towards certified sustainability

When talking about manufacturing processes and their products, sustainability refers to minimization of resources, water and energy, in order reduces the environmental impact; the final goal of these efforts is certification as sustainable. Sustainability standards and certifications are voluntary, usually third party-assessed, norms and standards relating to environmental, social, or ethical issues, adopted by companies to demonstrate the performance of their organizations or products in specific areas. These certificates are very important mainly in relationship with the costumers, who are becoming more aware of the current environmental issues and are willing to buy and use products from companies that have demonstrated their sustainability commitment.

As the tanning industry needs natural resources, chemical products and energy, environmental sustainability becomes a fundamental aspect of leather production. The tanneries' commitment to environmental sustainability can be confirmed by some important international product certifications assumed on a voluntary basis. Some of the most relevant are [18]*:*

- the **Carbon Footprint of Product** (CFP), in compliance with **ISO/TS 14067:2013**, identifies the quantity of greenhouse gas emissions released during the whole process of leather production, from the animal farming to the delivery of the final product to a client;
- the **Environmental Product Declaration** (EPD), based on **ISO 14025 standard**, is a voluntary international certification aimed at providing relevant, verified and comparable information about the environmental impact of an activity gathered by examining the whole production chain of a tannery;
- The **ECO$_2$L label** (energy-controlled leather) developed by the Forschungsgemeinschaft Leder e.V. (Leather Research Foundation), is the world's first calculation and auditing model for calculation the CO_2 emissions and energy efficiency and of a tannery, as an active contribution of a responsible leather industry towards climate protection and as a significant aspect to evaluate a sustainable leather production. ECO$_2$L was developed primarily for the production of upholstery leather from cowhide, but can also be used for shoe upper leather with no restrictions [19].

CONCLUSIONS

Leather manufacturing is the best way to add value to hides and skins regarded as by-products originating from the meat industry, and to prevent the huge disposal problem that might arise if these easily decaying materials accumulate in the environment.

As the tanning industry is resource-intensive and highly polluting, environmental sustainability becomes a fundamental aspect of leather production. The environmental footprints, of which carbon and water footprint have the widest applicability, are key tools for assessing leather sustainability and for undertaking the best measures to achieve it.

Harmonization among the methodologies currently in place in the leather world for footprints calculation is a necessity, but this attempt demands Life Cycle Inventory performed within unambiguous system boundaries, consistent data quality and calculation requirements along the value chain, and consistency and transparency in the presentation of results.

Establishing the system boundaries of the life cycle remains the most arguable aspect when product footprints are assessed and compared.

Tanneries are becoming strongly committed to sustainability principles and efforts are being made to quantify and minimize the environmental footprints of tannery activities, but making the leather industry sustainable remains a challenge.

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DEVELOPMENT AND VALIDATION OF ANALYTICAL METHOD FOR DETERMINATION OF CARCINOGENIC AMINES FROM TEXTILE DYES

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Abstract: *Chemicals safety control and eco-properties have become a priority for the textile industry to avoid the negative effects on humans and environment. The European regulations limit the presence of 24 listed carcinogenic aromatic amines by 30 mg/kg of textile material. The main goal of this research work was to develop and validate HPLC/MWD and GC/MSD methods for precise and reliable identification and quantification of carcinogenic aromatic amines derived from banned azo dye specific to the textile industry. The simultaneous determination of 22 regulated aromatic amines has been conducted by two chromatographic methods in order to avoid matrix interferences and compounds misidentification due to the presence of structural isomers. Preliminary analyses to establish the maximum absorption wavelength of each standard solution of aromatic amine were performed simultaneously at four wavelengths, 240, 280, 305 and 380 nm; to enhance the separation efficiency and sensitivity for multicomponent amines solutions, we optimized the pH value, and we experimented isocratic and gradient elution systems; Both liquid and gas chromatography methods were validated demonstrating the consistency, reliability and accuracy of the analyzed data.*

Keywords: *ecology, carcinogenic amines, dyes, HPLC, GC-MS, validation.*

INTRODUCTION

Over 65% of industrial production of organic dyes is represented by azo dyes, widely used as coloring agents in textile and leather industries, due to their excellent tinctorial properties and bright, high intensity colors [1,2]. In specific conditions, azo dyes produce by *in vivo* reductive cleavage of the azo groups (-N=N-), primary aromatic amines (PAAs), that are considered by the international authorities to be toxic, and have mutagenic and carcinogenic effect [1]. The main responsible for their toxicity is represented by the amino group bound to the aromatic system. The chemical reactivity of this amino group depends on the mesomeric interaction with the aromatic system, which is determined by further substituents and steric factors [2].
There are three main routes of exposure to azo dyes: a) ingestion, mainly by babies and children, b) dermal absorption, the largest concern both for people wearing dyed clothing and for the staff from factories producing dyes and c) dye inhalation worrying for workers from factories but also for handling freshly dyed materials with azo dyes [1].
Many strict government regulations worldwide limit the usage of azo dyes in textile and leather products. 22 aromatic amines are classified by the EU Commission as proven or suspected human carcinogens: “Azo dyes which, by reductive cleavage of one or more azo groups, may release one or more of the aromatic amines listed in Appendix 8, in detectable concentrations, i.e. above 30 mg/kg (0,003 % by weight) in the articles or in the dyed parts thereof … shall not be used, in textile and leather articles which may come into direct and prolonged contact with the human skin or oral cavity” [1]. Oeko-Tex Label, that has been designed to protect the consumers and is widely adopted by textile manufacturers, has regulations on textile products for 24 aromatic amines, of which 22 overlap with the European legislation. This certificate limits the maximum amount of carcinogenic aromatic amines to no more then 20 mg/kg[1]. This strict regulations and the increasingly need of materials for textile and leather industry that have minimum or no harmful effects on human health justify the necessity for fast and accurate analytical methods to test aromatic amine in consumer products.

EXPERIMENTAL

2.1 Reagents and standards

Acetonitrile, ultrapure water, methanol form Merck KGaA (Germany).
Analytical standard of 22 aromatic amine from Sigma-Aldrich and Dr. Ehrenstorfer GmbH (Germany).

2.2 Instrumentation

HPLC separation was performed on Agilent 1100 LC System using an Agilent Zorbax Eclipse XDB C18 column with detection on Agilent MWD 1100. GC separation was performed on Agilent 6890 GC System coupled with Agilent 5973N transmission quadrupole mass spectrometer (Table 1).

Table 1: HPLC-MWD and GC-MS Operating Conditions

Agilent 1100 HPLC/MWD Operating Conditions		
Analytical Column	Zorbax Eclipse XDB C18 3.5µm, 150 x 4,6mm	
Column Temp.	32 ºC	
Injection Volume	5.0 µl	
Mobile Phase	Eluent 1: methanol	
	Eluent 2: 0.68 g potassium dihydrogen phosphate in 1000mL water, 150 mL methanol	
Run time	35 min	
Flow rate	0,6 - 2,0 mL/min (gradient)	
Quantification	at 240 nm, 280 nm, 305 nm and 380 nm	
Gradient	Time (minutes)	Gradient (% Eluent 1)
	0.00	10.0
	22.50	55.0
	27.50	100.0
	28.50	100.0
	28.51	100.0
	29.00	100.0
	29.01	10.0
	31.0	10.0
	35.00	10.0

Agilent 6890 GC/5973N MS Operating Conditions	
Capillary Column	DB-35MS(J&W), 35m; 0.25mm, 0.25µm;
Injector System	splitless
Injector Temp.	260 ºC
Carrier gas	helium
Temp. programme	100ºC (2 min), 100ºC - 310ºC (15ºC/min), 310ºC (2 min)
Injection Volume	1.0 µl
Detection	MS
Acquisition Parameters	EI Positive Ion Mode, 70 eV

2.3 Sample preparation

Stock solutions of each amine (according to - ISO/FDIS 14362-1:2016(E), [1]) with the concentration of 300 µg/mL in ACN were prepared. From this stock, we prepared 5 solutions for calibration curve with the concentration: 2, 10, 20, 30, 40, 50 µg/mL.

RESULTS

3.1 Selection of maximum absorption wavelength for each of 22 aromatic amines

Each standard solution of amine in concentration of 50 µg/mL was analyzed using spectrophotometric detection simultaneously at four wavelengths, 240, 280, 305 and 380 nm. Thus, we performed a classification of the 22 amines depending on the wavelength at which absorption is maximal (Table 2)

Table 2: Classification of amines depending on the maximum absorption wavelength

240 nm	280 nm	305 nm	380 nm
Amines 3, 4, 6, 7, 8, 9, 13, 14, 15, 16, 17, 18, 19, 20, 21*	Amines 2, 12, 1, 10	Amines 11	Amines 5, 22

* according to aromatic amines numbering from Table 1 - ISO/FDIS 14362-1:2016(E)[8]

The overlaid chromatograms of amines 3, 18, 21, and 13, solutions with concentration of 50 mg/L are shown in Figures 1-4.

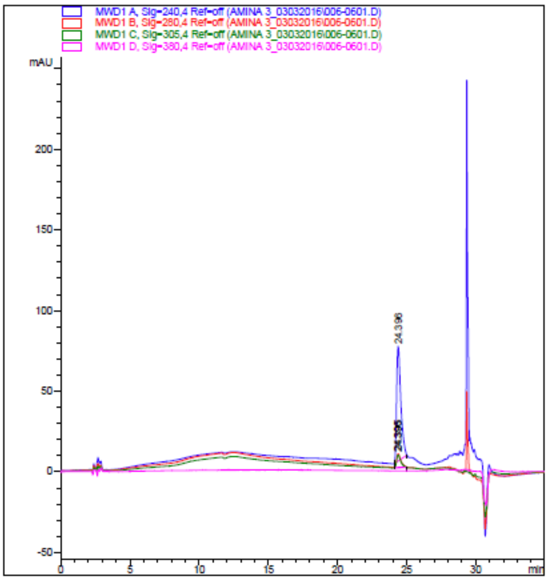


Figure 1: Overlaid chromatograms of 4-chloro-o-toluidine, 50 mg/L, maximum absorption wavelength at 240 nm

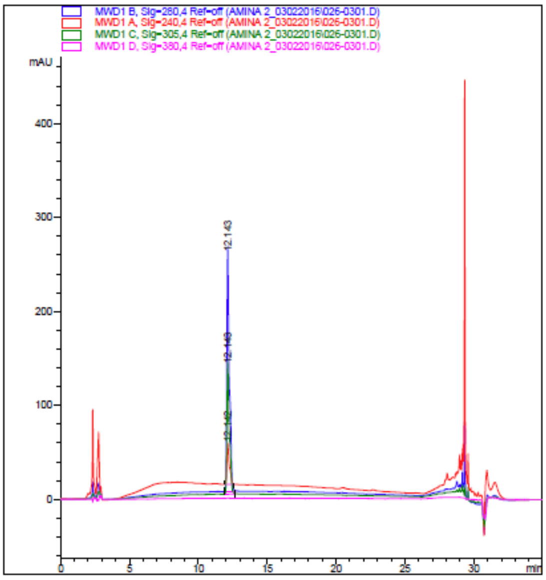


Figure 2: Overlaid chromatograms of benzidine, 50 mg/L, maximum absorption wavelength at 280 nm

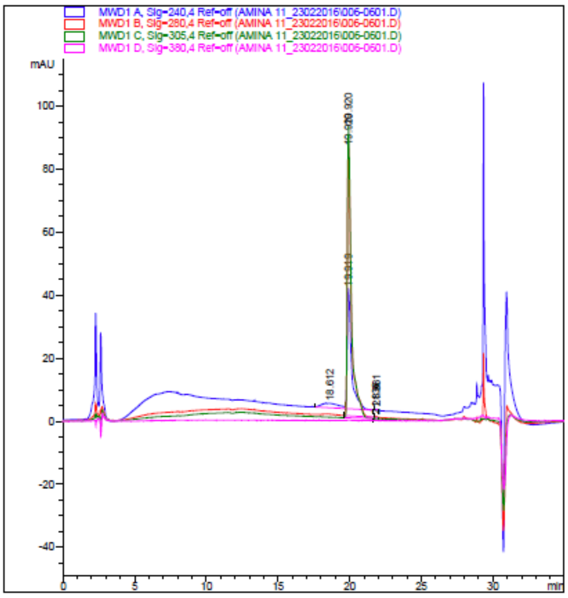


Figure 3: Overlaid chromatograms of o-dianisidine, 50 mg/L, maximum absorption wavelength at 305 nm

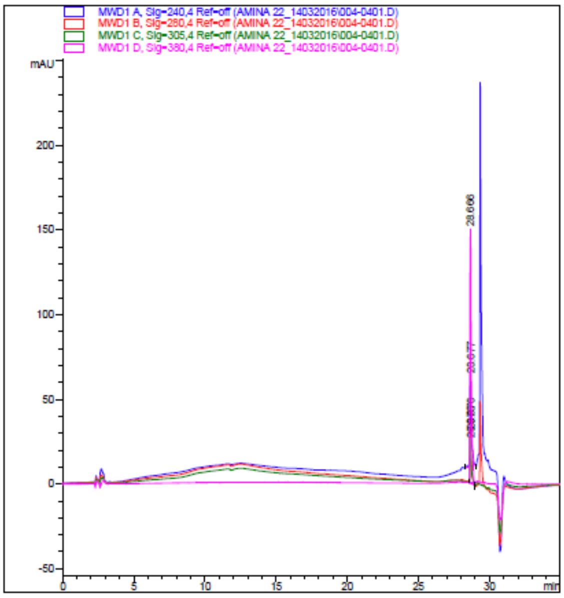
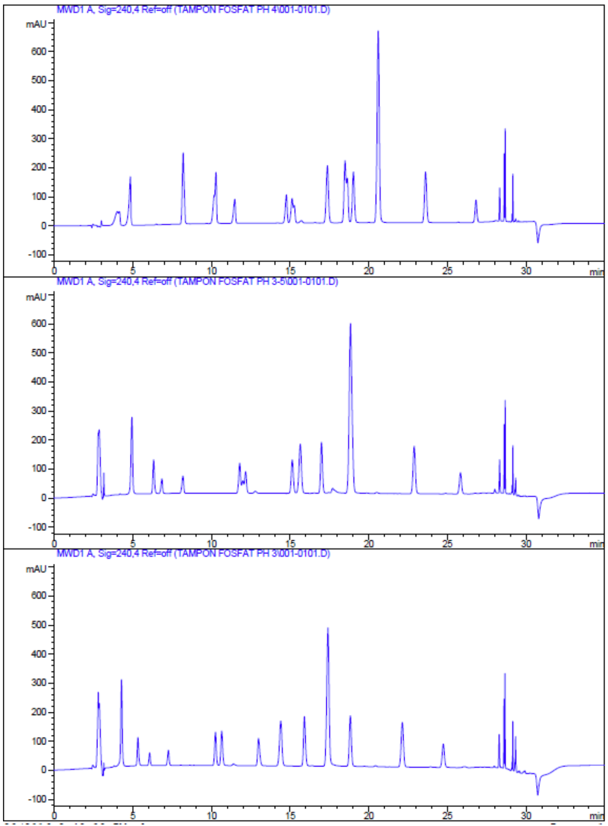


Figure 4: Overlaid chromatograms of 4-aminoazobenzene, 50 mg/L, maximum absorption wavelength at 380 nm

3.2 Optimisation of mobile phase pH value

To enhance the separation efficiency for multicomponent amines solutions, acid mobile phase is required, assuring ionization of amino group. Acid medium promotes a better control over solute absorption and desorption processes and relevant retention times to identify and separate structurally similar compounds.



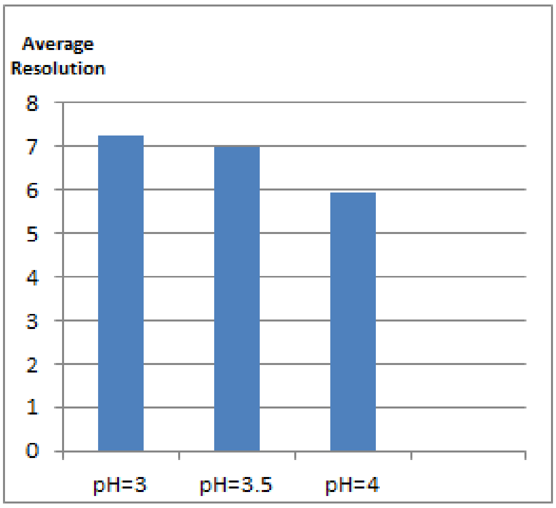


Figure 5: Graphical representation of average chromatographic resolution depending on the pH of mobile phase.

Figure 6: Chromatograms of multicomponent 22 amines solutions, 50 mg/L

As the pH of the mobile phase decreases (from 4, to 3.5 and eventually to 3), promoting the ionisation of amino group, the selectivity of the chromatographic separation increases, generating a greater chromatographic average resolution (Figures 5 and 6).

3.3 Isocratic and gradient elution systems

In order to justify the necessity of gradient elution system, we analysed the multicomponent mixture of 22 amines, 13.64 mg/L of each amine in concentration, choosing isocratic elution. We followed the same HPLC analysis conditions specified in standard ISO/FDIS 14362-1:2016(E), except for the elution system: we used 50% potassium dihydrogen phosphate buffer and 50% methanol, in a 50 minutes chromatographic separation.

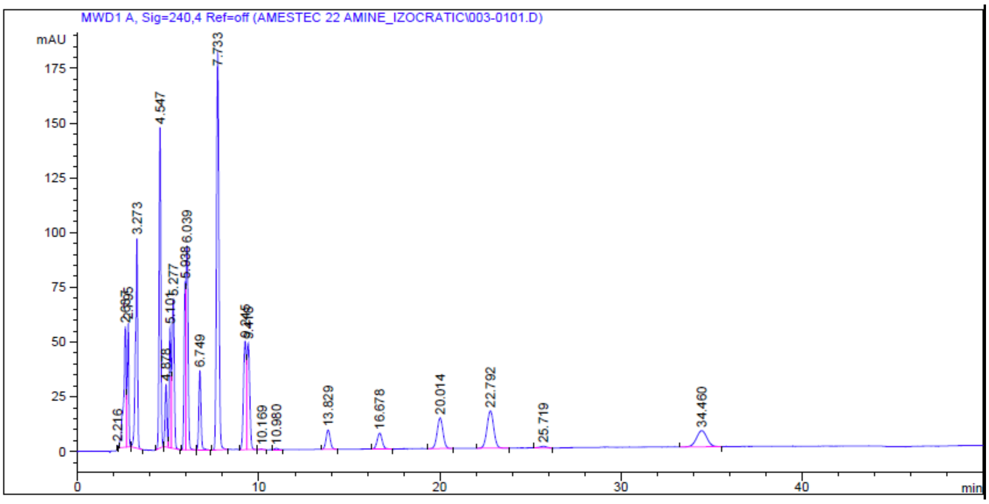


Figure 7: Chromatogram of multicomponent 22 amines solutions, 13.64 mg/L

As it can be observed in Figure 7, isocratic elution system favour rapid elution of most the compounds in the first 10 minutes of separation; this can be explained by the significant percent of methanol in the mobile phase, assuring a reduced interaction of amines with the column stationary phase and a rapid elution. One advantage will be the reduced duration of separation, but the big disadvantages are the poor resolution and the inability to separate compounds with similar chemical structure (e.g., 3,3'-dichlorobenzidine and 3,3'-dimethoxybenzidine).

3.4 Validation of GC and HPLC methods of standard aromatic amines analysis

With the scope of demontrating the consistency, reliability and accuracy of the analyzed data, both liquid and gas chromatography analytical methods were validated. HPLC-MWD and GC-MS methods used follow the standard ISO/FDIS 14362-1:2016(E).

Selectivity

In order to evaluate the methods capacity to measure and differentiate analytes from the multicomponent mixture, we evaluated chromatographic resolution; we analysed multicomponent mixture of 22 amines, 50 mg/L, simultaneously by HPLC-MWD and GC-MS analysis.

Table 3: HPLC-MWD and GC-MS results for multicomponent mixture of aromatic amines

Maximum wavelength of absorption	**Compound number (acc. to ISO/FDIS 14362-1:2016(E))**	**HPLC results**		**GC results**	
		t_R	**R_S**	**t_R**	**R_S**
240 nm	Amine 8	4.083	0.042	9.570	2.374
	Amine 19	5.025	2.344	8.710	2.811
	Amine 16	12.301	25.153	16.24	0.599
	Amine 21	13.615	4.846	6.140	1.104
	Amine 18	14.878	4.876	4.890	3.278
	Amine 9	17.585	10.281	16.41	0.445
	Amine 7	18.522	3.549	6.531	1.585
	Amine 6	18.806	1.101	10.724	4.819
	Amine 14	20.045	4.833	7.093	1.285
	Amine 17	20.507	1.973	20.352	1.364
	Amine 3	24.143	15.751	7.520	3.735
	Amine 13	25.249	4.633	18.691	0.958
280 nm	Amine 2	11.581	5.869	16.563	2.825
	Amine 12	19.648	34.813	19.076	3.057
	Amine 1	27.701	45.032	11.797	12.674
	Amine 10	28.284	5.279	20.825	4.548
305 nm	Amine 11	19.314	8.598	20.934	3.278
380 nm	Amine 5	28.587	6.587	17.692	2.582
	Amine 22	29.152	12.288	15.276	2.751

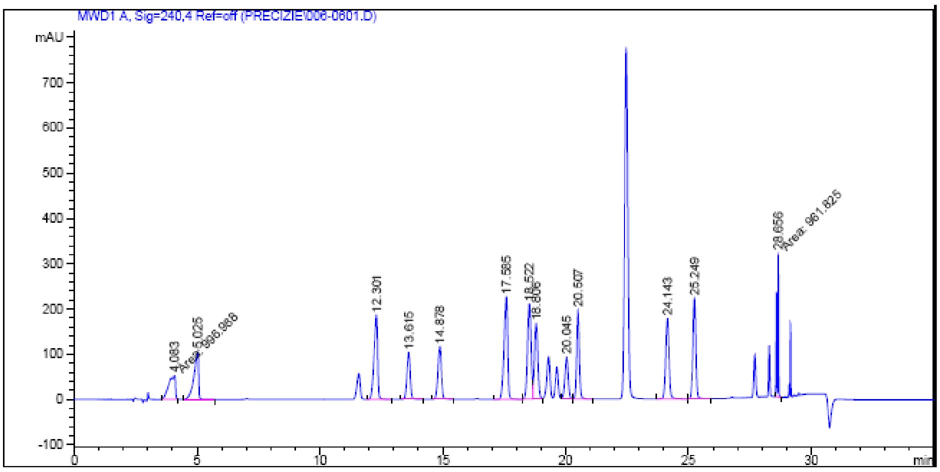


Figure 8: Chromatographic separation of amines 8, 19, 16, 21, 18, 9, 7, 6, 14, 17, 3, 13, 50 mg/L, detection at 240 nm

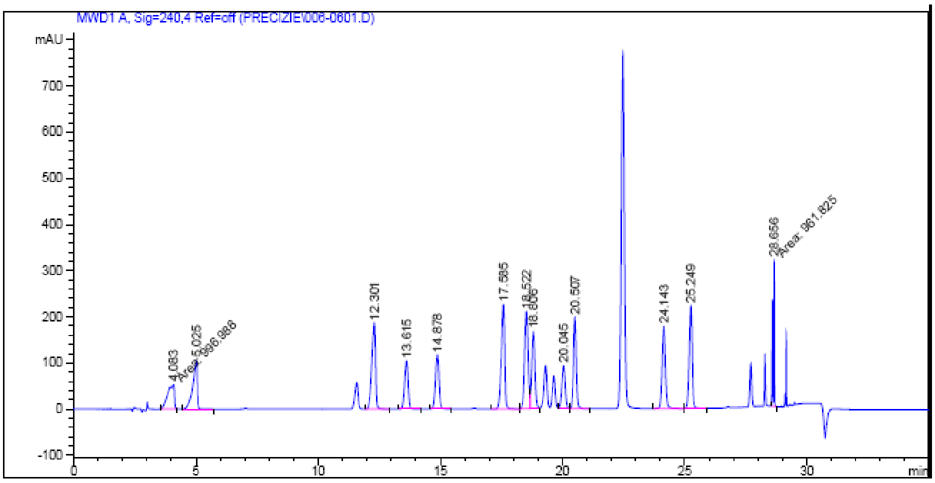


Figure 9: Chromatographic separation of amines 2, 12, 1, 10, 50 mg/L, detection at 280 nm

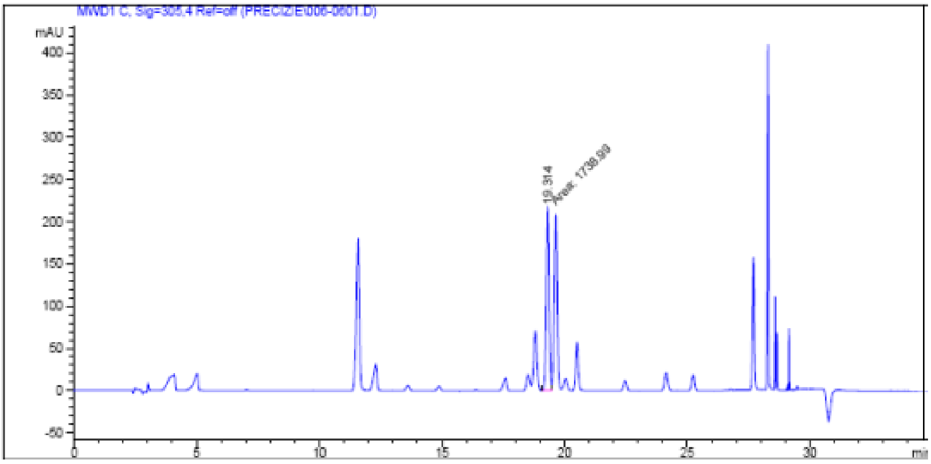


Figure 10: Chromatographic separation of amine 11, 50 mg/L, detection at 305 nm

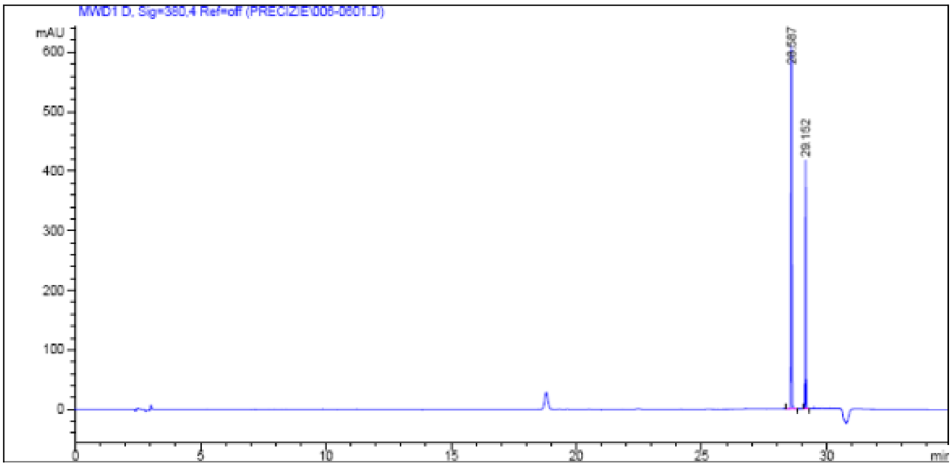


Figure 11: Chromatographic separation of amines 5 and 22, 50 mg/L, detection at 380 nm

As it can be observed In Figures 8-11 and Table 3, each amine was evaluated at the wavelength corresponding to it maximum absorption; for most of the amines, resolution value is greater than 1, proving a selective separation of the mixture.

Repeatability

Methods repeatability was evaluated by repeated measuring (8 analyses) of multicomponent mixture, 20 mg/L, in the same day, same laboratory and analyst, on same HPLC-MWD and GC-MS equipments (Table 4).

Table 4: HPLC-MWD and GC-MS results for repeatability

Compound no.	HPLC-MWD results		GC-MS results	
	Average conc. (mg/L)	RSD%	Average conc. (mg/L)	RSD%
Amina 8	19.6	0.6	22.9	9.3
Amina 19	19.7	0.9	23.1	10.5
Amina 16	19.7	0.9	23.1	10.3
Amina 21	19.8	0.9	23.2	10.6
Amina 18	19.8	0.8	22.9	10.1
Amina 9	19.7	0.9	22.7	11.2
Amina 7	19.7	0.9	22.5	11.6
Amina 6	19.7	0.8	22.8	10.7
Amina 14	19.7	0.9	21.4	9.2
Amina 17	19.7	0.9	22.1	11.1
Amina 3	19.7	0.9	20.6	10.3
Amina 13	19.7	0.9	20.0	8.4
Amina 15	19.9	0.9	20.1	8.7
Amina 2	19.7	0.9	20.4	8.8
Amina 12	19.7	0.8	20.3	9.6
Amina 1	19.9	0.9	20.2	8.1
Amina 10	19.8	0.9	20.7	7.9
Amina 11	19.9	0.8	20.4	8.5
Amina 5	19.9	0.9	20.9	7.1
Amina 22	19.7	0.8	21.2	7.6

As shown in Table 4, RSD% values do not exceed 20% (maximum accepted value), proving that both methods indicate a good repeatability.

Accuracy

Methods accuracy was assessed by comparing results of chromatographic analyses with the reference value by determining the following parameters: trueness%, bias% and accuracy% (Table 5).

Table 5: HPLC-MWD and GC-MS result for accuracy

Compound no.	HPLC-MWD results					GC-MS results			
	Average conc. (mg/L)	Reference value	Trueness %	Bias %	Accuracy %	Average conc. (mg/L)	Trueness %	Bias %	Accuracy %
Amina 8	19.644	20	98.218	1.78	0.526	22.000	110.000	10.00	2.418
Amina 19	19.618	20	98.092	1.91	0.453	22.400	112.000	12.00	3.032
Amina 16	19.615	20	98.073	1.93	0.405	22.200	111.000	11.00	2.991
Amina 21	19.656	20	98.282	1.72	0.360	22.533	112.667	12.67	3.458
Amina 18	19.671	20	98.353	1.65	0.365	22.167	110.833	10.83	2.715
Amina 9	19.614	20	98.070	1.93	0.453	22.033	110.167	10.17	2.893
Amina 7	19.648	20	98.238	1.76	0.385	21.767	108.833	8.83	2.314
Amina 6	19.612	20	98.060	1.94	0.455	20.600	110.833	10.83	2.943
Amina 14	19.654	20	98.272	1.73	0.409	21.167	103.000	3.00	0.924
Amina 17	19.644	20	98.218	1.78	0.415	19.500	105.833	5.83	2.309
Amina 3	19.618	20	98.088	1.91	0.390	19.233	97.500	2.50	1.119
Amina 13	19.568	20	97.842	2.16	0.476	19.200	96.167	3.83	0.252
Amina 15	19.719	20	98.597	1.40	0.490	19.367	96.000	4.00	0.172
Amina 2	19.656	20	98.282	1.72	0.364	19.233	96.833	3.17	0.711
Amina 12	19.635	20	98.175	1.82	0.407	19.400	96.167	3.83	0.669
Amina 1	19.750	20	98.750	1.25	0.330	19.600	97.000	3.00	0.625
Amina 10	19.714	20	98.570	1.43	0.344	19.600	98.000	2.00	1.021
Amina 11	19.809	20	99.045	0.95	0.230	19.000	95.000	5.00	0.807
Amina 5	19.889	20	99.447	0.55	0.207	19.933	99.667	0.33	1.369
Amina 22	19.652	20	98.260	1.74	0.388	21.100	100.500	0.50	1.804

Trueness values for chromatographic methods can vary between 75-125%, values obtain for amines analysis by the 2 methods being included in this interval (Table 5).

Limit of detection and quantification

The lower concentration of analyte that can be determined with reasonable statistical certainty by the 2 methods of analysis is presented in Table 6. As can be observed, values for LD and LQ permit detection and quantification of amines at low level of concentration.

Table 6: HPLC-MWD and GC-MS result for limit of detection and quantification

Compound no.	HPLC-MWD results			GC-MS results		
	Average conc. (mg/L)	LD	LQ	Average conc. (mg/L)	LD	LQ
Amina 8	2.1437	0.5324	1.7746	1.8538	0.7439	2.4795
Amina 19	2.2001	0.3659	1.2196	2.0738	0.8512	2.8372
Amina 16	2.2539	0.5179	1.7262	2.1328	0.9105	3.0351
Amina 21	2.0900	0.3643	1.2143	2.0301	0.8783	2.9277
Amina 18	2.0745	0.3241	1.0802	1.9601	0.8302	2.7673
Amina 9	2.1604	0.5743	1.9143	2.0249	0.9149	3.0495
Amina 7	2.1537	0.4224	1.4079	2.0073	0.7120	2.3731
Amina 6	2.1893	0.4361	1.4538	2.0372	0.8438	2.8128
Amina 14	2.1572	0.4134	1.3780	2.0087	0.5107	1.7023
Amina 17	2.1722	0.4860	1.6201	2.0226	0.6036	2.0119
Amina 3	2.1196	0.4771	1.5902	1.9965	0.5013	1.6709
Amina 13	2.1056	0.6241	2.0803	1.9862	0.4542	1.5139
Amina 15	2.0689	0.8312	2.7708	1.7498	0.3969	1.3228
Amina 2	2.1966	0.4843	1.6142	2.0539	0.4975	1.6583
Amina 12	2.1502	0.5068	1.6894	2.0235	0.4975	1.6583
Amina 1	2.2753	0.5861	1.9537	2.0815	0.4732	1.5773
Amina 10	2.2048	0.5047	1.6823	2.0382	0.4034	1.3446
Amina 11	2.2278	0.3979	1.3264	2.0851	0.1565	0.5215
Amina 5	2.2331	0.3940	1.3134	2.0978	0.4166	1.3885
Amina 22	2.2721	0.8075	2.6917	2.0436	0.3410	1.1366

CONCLUSION

In this study, a precise and reliable method for determining aromatic amines derived from banned azo dyes specific to the textile industry have been characterized; specific UV absorption wavelength for each compound has been identified; we explained the necessity of using acid mobile phase for chromatographic separation and elution of a mixture of aromatic amines and of using gradient instead of isocratic elution; finally, HPLC-MWD and GC-MS methods specified in standard ISO/FDIS 14362-1:2016(E) have been validated for an accurate and reliable detection and quantification of multicomponent aromatic amines.

Acknowledgements

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BIOBURDEN ISOLATION OF VARIOUS MICROBIAL STRAINS FROM TEXTILE WASTEWATER TREATMENT PLANT, FOR FUTURE BIOSORBENTS

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Abstract: *The development and application of microbial biotechnologies in removal of certain pollutants from different sources of wastewater (Krishnani, 2006) has become a necessity due to rapid industrialization and urbanization phenomena. Microbial biosorbents can be used in bioremediation processes due to specific properties of microbial cells structure (Vijayaraghavan, 2008). In the present study, several microbial strains (bacteria and fungi) were isolated on synthetic and semi-synthetic nutritive media from samples of wastewater collected from along the technological processing points of wastewater treatment station belonging to Giurgiu Nord Technological and Industrial Park. Five wastewater samples withdrawal points were identified: I-entry point of total water collected following technological flow; II–chemical treatment stage with Al2(SO)4 coagulant for removal of colloidal particles; III–following mechanical filtration, chemical treatment and sedimentation; IV–water resulted after processing technological steps combined with sewage water; Soil–collection point from the soil located near the wastewater collection tanks. The strains were grown on four different selective nutritive media (Czapek-Dox, Sabouraud-Dextrose 4%-Agar, Malt-Extract-Agar and Potato-Dextrose-Agar) supplemented with 0.5% chloramphenicol. Highest level of microbial bioburden was registered on samples isolated from soil, with presence of at least four individual types of filamentous fungi strains. From samples of residual water, highest microbial load was highlighted for samples I, II and III, while plates from sample III registered lower levels of microbial development, possible due to action of Al2(SO)4 in time (as inhibitor). Preliminary isolations in pure cultures were carried out from plates that yielded good microbial growth, targeting only filamentous fungi specific structures. Visual analysis revealed both bacterial growth specific structures (possible strains of Pseudomonas) and filamentous fungi (possible strains of Aspergillus niger, Aspergillus fumigatus, Aspergillus parasiticus, Aspergillus flavus, Trichoderma viride, Trichoderma parceramosum, Trichoderma reesei, Trichoderma longi and yeast forms). The strains isolated from textile processing originated wastewater will be further used for obtaining microbial biosorbents, for their active potential of bioremediation of main wastewater pollutants, backed up on their already native adaptability to presence of pollutants in the environment*.

Keywords: *wastewater, fungi, bioremediation, textile.*

INTRODUCTION

The development and application of microbial biotechnologies in removal of certain pollutants from different sources of wastewater [1] has become a necessity due to rapid industrialization and urbanization phenomena. Microbial biosorbents can be used in bioremediation processes due to specific properties of microbial cells structure [2]. In the present study, several microbial strains (bacteria and fungi) were isolated on synthetic and semi-synthetic nutritive media from samples of wastewater collected from along the technological processing points of wastewater treatment station belonging to Giurgiu Nord Technological and Industrial Park.

Materials and methods

Five wastewater samples withdrawal points were identified: I - entry point of total water collected following technological flow; II – chemical treatment stage with $Al_2(SO)_4$ coagulant for removal of colloidal particles; III – following mechanical filtration, chemical treatment and sedimentation; IV – water resulted after processing technological steps combined with sewage water; Soil – collection point from the soil located near the wastewater collection tanks. The strains were grown on four different selective nutritive media (Czapek-Dox, Sabouraud-Dextrose 4%-Agar, Malt-Extract-Agar and Potato-Dextrose-Agar, *figure 1*) supplemented with 0.5% chloramphenicol (thermostable bacteriostatic antibiotic with broad spectrum for reducing bacterial load on inoculated Petri dishes). Each nutritive media was previously sterilised at 121^oC for 15' (moist heat), then poured in sterile Petri dishes (ø90) in a 0.5-1.0cm layer of agarized media and left to solidify at 28^oC for 2 hours. Each inoculation was carried out in duplicate and plates were kept at 30^oC (+/- 3^oC) for 14 days.

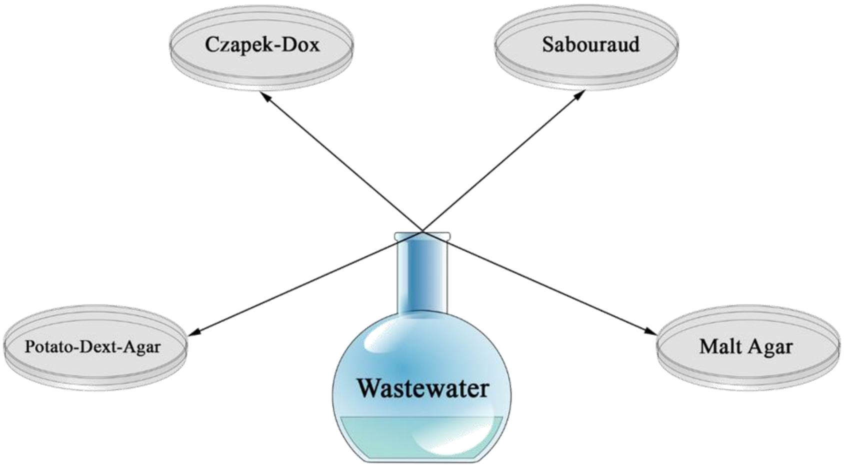

Figure 1. Inoculation scheme on nutritive media

Results and discussions

The microbial strains were isolated based on the higher frequency of occurrence in the textile effluent. Highest level of microbial bioburden was registered on samples isolated from soil (*figure 6*), with presence of at least four individual types of filamentous fungi strains. From samples of residual water, highest microbial load was highlighted for samples I (*figure 2*), II (*figure 3*) and III (*figure 4*), while plates from sample III (*figure 5*) registered lower levels of microbial development, possible due to action of $Al_2(SO)_4$ in time (as inhibitor).

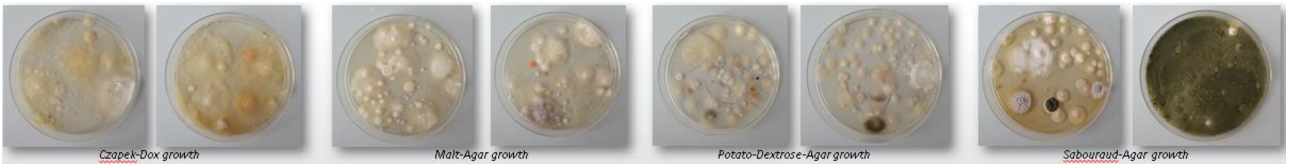

Figure 2 Post incubation plates – sample

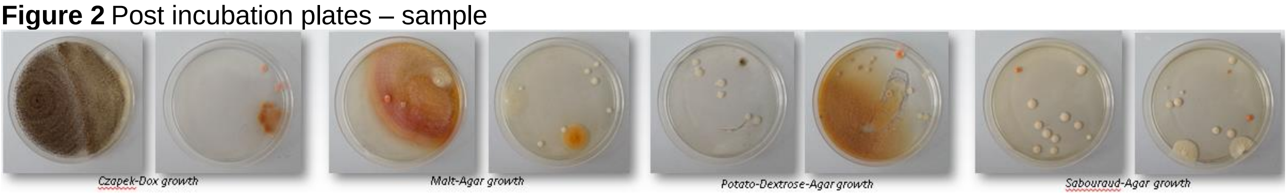

Figure 3. Post incubation plates – sample II

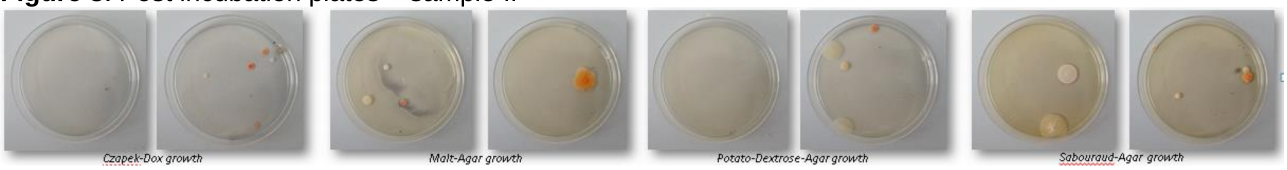

Figure 4. Post incubation plates – sample III

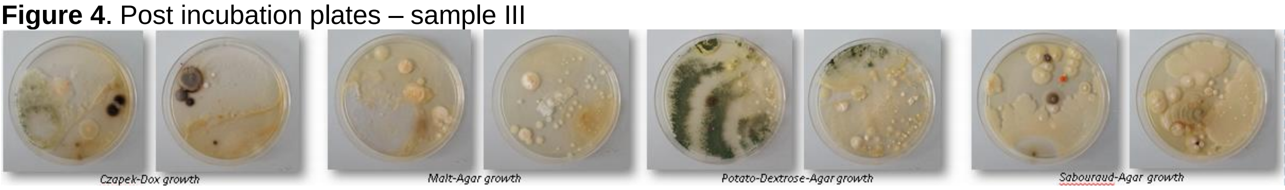

Figure 5. Post incubation plates – sample IV

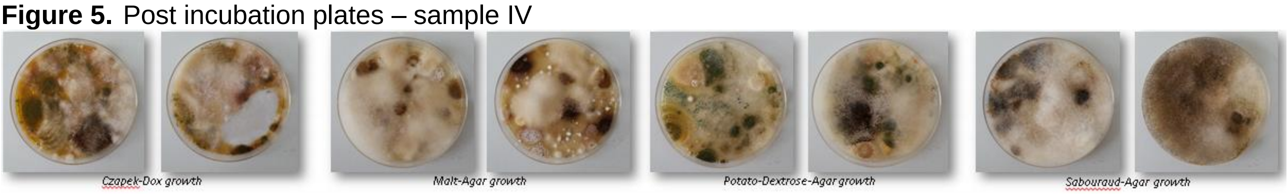

Figure 6. Post incubation plates – Soil

Visual analysis revealed both bacterial growth specific structures (possible strains of *Pseudomonas*) and filamentous fungi (possible strains of *Aspergillus niger, Aspergillus fumigatus, Aspergillus parasiticus, Aspergillus flavus, Trichoderma viride, Trichoderma parceramosum, Trichoderma reesei, Trichoderma longi* and yeast forms). Preliminary isolations in pure cultures (*figure 7*) were carried out from plates that yielded good microbial growth, targeting only filamentous fungi specific structures, on the same number of nutritive media.

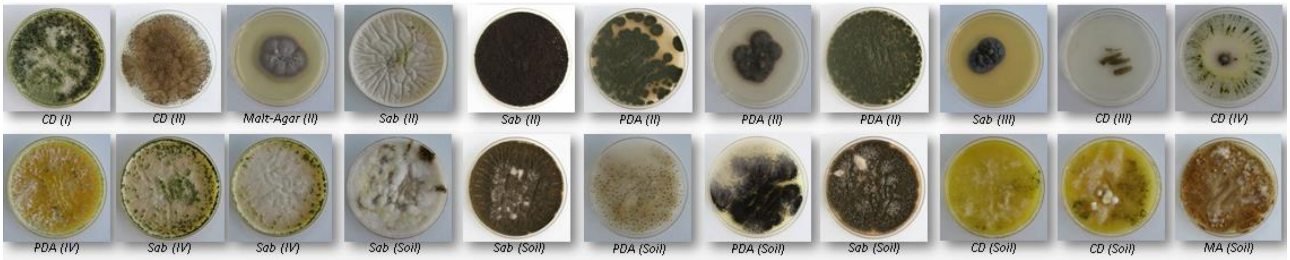

Figure 7. **.**Isolation in pure cultures

CONCLUSIONS

The strains isolated from textile processing originated wastewater will be further used for obtaining microbial biosorbents, for their active potential of bioremediation of main wastewater pollutants, backed up on their already native adaptability to presence of pollutants in the environment

Acknowledgments

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Section 13: Marketing and management

ANALYZE OF RELATIONSHIP BETWEEN THE INTELLECTUAL CAPITAL AND THE STAGES OF ACQUISITION PROCESS OF ORGANIZATIONAL KNOWLEDGE

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Abstract: *For the past years it has become obvious that society has moved from the resource-based economy to knowledge-based economy. The speciality literature reveals the existence of an interdependent relation between the intellectual capital of an organisation and the knowledge management processes. Starting from these relationships, in the present paper we attempted an analysis that approaches the connections characterising the relationship between the comprising elements of the organisational intellectual capital and the stages of the organisational knowledge acquisition and of the influences between the variables that describe these connections.*
As a result of this analysis we identified the significant relationships between the dimensions of the intellectual capital and each of the stages of the knowledge acquisition process in an organisation.
The analysis at this level is an original one, as in the specialty literature one can find only the analysis of the dependency between the organisational intellectual capital and the knowledge management processes, the analysis of the influence of intellectual capital over each of the stages of the knowledge management process at organisational level being absent.

Keywords: *Intellectual capital, Knowledge acquisition process*

1. INTRODUCTION

In the modern economy, besides other branches of management, a new branch has appeared and developed, namely knowledge management (KM). In order to be manageable within an organisation, knowledge has to be acquired, and within knowledge management the knowledge management process becomes a primary and essential process. The specialty literature reveals the existence of dependency relationships between the intellectual capital of the organisation and the knowledge management processes.
The analysis of the correlation between the dimensions of the human capital and each of the stages of the knowledge acquisition process at organisational level gave birth to the question: "*Is there, at organisational level, a dependency relationship between the dimensions that characterise the organisational intellectual capital and each of the stages of the organisational knowledge acquisition process?"*
Rusly et al (2012) identifies a direct link between knowledge acquisition and the efficiency of the knowledge acquisition process. Kim and Lee (2010) identify a direct dependency relation between the clarity of organisational objectives and the organisational knowledge acquisition process. Moreover, a direct relation can be identified between the knowledge acquisition process and knowledge management and the organisation marketing performances, the importance of knowledge acquisition being very important in the innovation process. In addition, a series of authors state that the success of a company depends on the way in which knowledge is acquired, used and shared, which leads to the increase in the company intellectual capital, which in its turn determines a significance influence in knowledge productivity, as well as an indirect influence of knowledge acquisition over the company performances through the influence over intellectual capital.

2. EXPERIMENTAL

The knowledge acquisition process at the organisation level is complex process, which requires the corroboration of all dimensions that characterise the intellectual capital of the organisation in order to eventually obtain the best results. The speciality literature declares the existence of a dependency relationship between the organisation intellectual capital and the knowledge acquisition process at organisation level.

Within the paper we conducted the analysis of a dependency relationship between the dimensions that characterise the organisation human capital and each of the stages of the knowledge acquisition process, by using the following variables:

Table1: – Notations N used for the variables taken into consideration (Luca, 2016)

N	Dimensions that characterise the components of intellectual capital	N	Stages of organisational knowledge acquisition process
HC	**HCmgt** – Organisation management	**CS**	Strategic search for knowledge
	HCskills – Employees abilities	**KAKH**	Knowledge acquisition by buying know-how
	HCteam – Employees ability to work	**KAEX**	Knowledge acquisition by hiring experts
	HCrla – Employees empowerment and freedom of action	**KASDR**	Knowledge acquisition by decoding /recoding the previously acquired knowledge
		KASIMP	Knowledge assimilation by implementation of previously acquired knowledge in procedures
		KV	Valorisation of already acquired knowledge

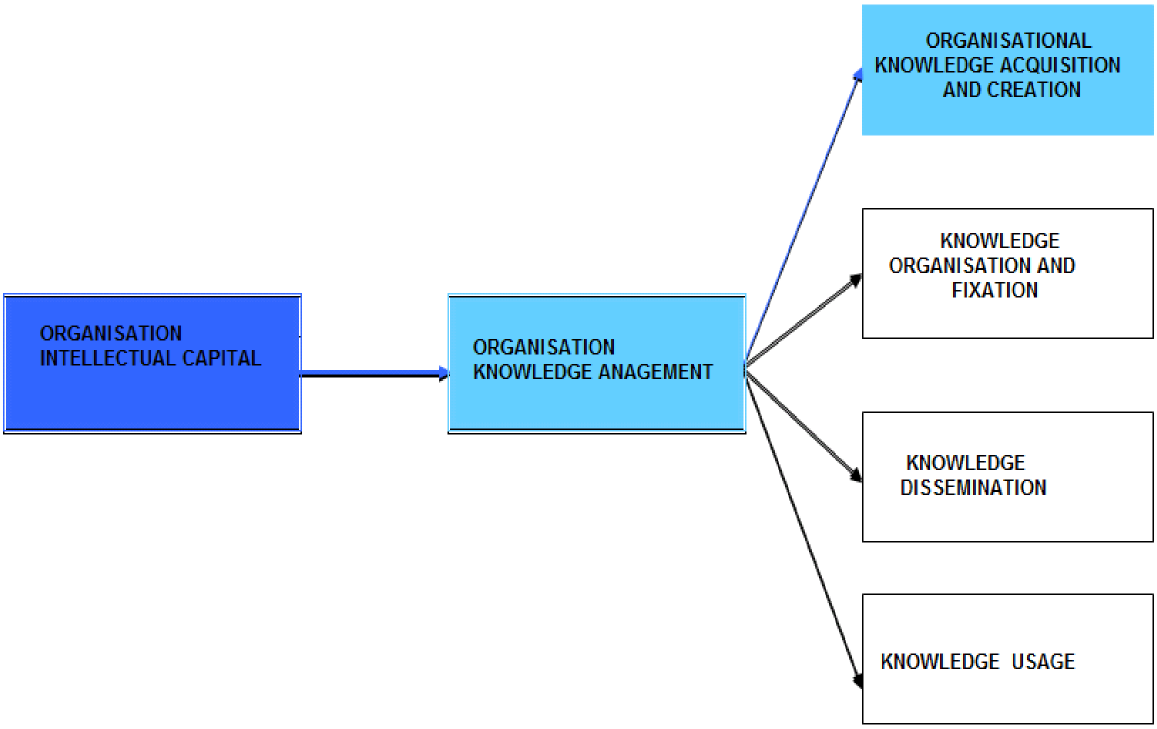
From a methodological point of view, having in mind that the variables analysed do not follow a normal distribution, the analysis of the correlation is performed with the help of Spearman quotient which allows the analysis of intensity, direction and statistic signification, but does not allow the analysis of the causality relations. For their analysis we will use ANOVA. The absolute value returned by the Spearman quotient of correlation R can be interpreted as follows:

INTERVAL	DESCRIPTOR
[0,0-0,2]	Very week, inexistent correlation
[0,2-0,4]	Week correlation
[0,4-0,6]	Reasonable correlation
[0,6-0,8]	High correlation
[0,8-1,0]	Very high correlation, which implies the existence of a very close relations between variables

The chosen sampling methods was random sampling combined with purposeful sampling among respondent subjects from SME organisations in NE Romania development area. Data collection was performed during the last two months of 2015 and the first trimester of 2016, and the surveying methods used were electronic surveying using Google-Forms application, but also paper surveying.
The targeted organisations are active in various fields of activity: industry, services, agriculture and commerce. Among the questionnaires returned 182 were validated, the rest of them (approx 10%) having a series of errors, most of them being partially filled in.

3. RESULTS AND DISCUSSION

Starting from Zhou and Fink's theory (2003), according to which the organisation intellectual capital influences the organisation knowledge management through identifying and structuring the processes connected to knowledge management which are linked to elements of intellectual capital, we come to the conclusion that within the organisation, its intellectual capital influences each of the knowledge management processes, thus influencing also the knowledge acquisition process at organisation level. Starting from these facts, in the present paper we will analyse the influence exercised by the intellectual capital of the organisation over one of the knowledge management processes, namely the organisational knowledge acquisition process (fig.1).



Caption:
Relation studied in the paper

Figure 1: - graphic representation of the relation between the organisation intellectual capital and the knowledge acquisition process (Luca, 2016)

Each of the dimensions that characterise the elements of the organisation intellectual capital influences one or more stages of the knowledge acquisition process, and each of the stages of the knowledge acquisition process develops under the influence of one or more of the dimensions that characterise the organisation intellectual capital. Each of the decisions taken at the level of organisation intellectual capital (management policies, planning and budgeting, the decision to act on certain markets etc.) has consequences over each of the stages of the knowledge management process at organisation level.
As a result of this analysis we elaborated the model that describes the most powerful influences between the dimensions that characterise the organisation intellectual capital and the stages of the knowledge acquisition process at organisation level.

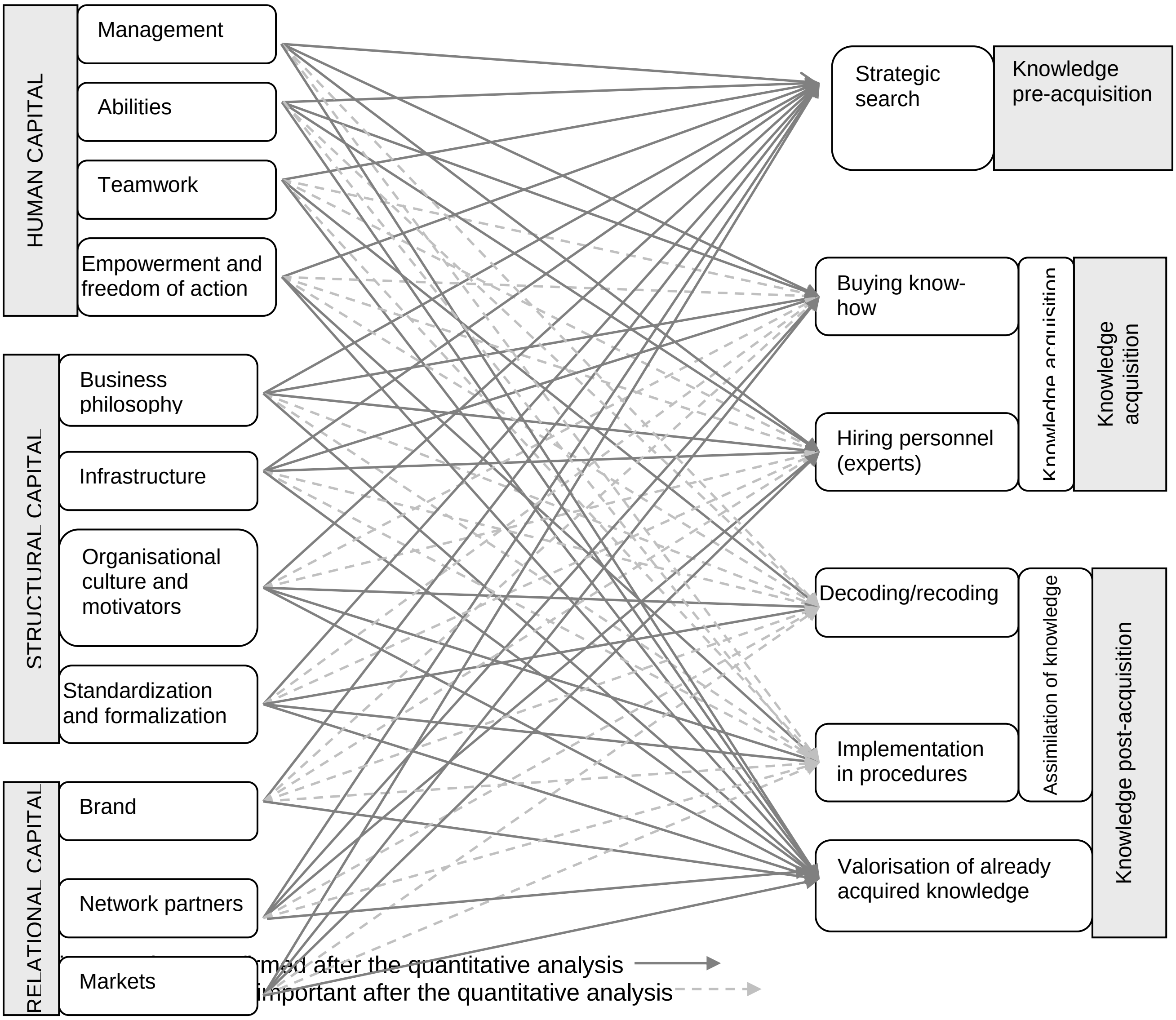


Figure 2: – framework-model for research proposed for the evaluation and analysis of the dependency relations between the dimensions that characterise the elements of intellectual capital and the stages of the organisational knowledge acquisition process (Luca et al, 2016).

By analysing the existence of certain relations between the dimensions of organisation intellectual capital and the stages of the organisational knowledge acquisition process the following emerge:

- Between the dimension of human capital and the stages of the knowledge acquisition process we identify connections, but not all identified connections are notable. Thus, we identified as being in significant relation the dimension that characterises the organisation policy management and the stages of strategic search (64%), knowledge acquisition through buying know-how (62%), knowledge acquisition through hiring personnel (experts) (62%) and the stage of valorisation of already acquired knowledge (56%). Similarly, we identify connections between the dimension that characterises the employees abilities in the field of knowledge and the stages of strategic search (87%), knowledge acquisition through know-how acquisition (73%), assimilation of already acquired knowledge through decoding /recoding of acquired knowledge (81%), assimilation of acquired knowledge through implementation in procedures (90%) and the stage of valorisation of already acquired knowledge (52%). Between the dimension that characterises employee ability for teamwork and the following stages: strategic search (78%), assimilation of acquired knowledge through decoding/ recoding (65%) and valorisation of acquired knowledge (72%). Between the dimension that characterises employee empowerment we identify important connections to the stages of strategic search (76%), the stage of assimilation of acquired knowledge through implementation in procedures (55%) and the stage of valorisation of already acquired knowledge (62%).

- Between the dimensions of the organisation structural capital and the stages of the knowledge acquisition process we also identify connections, more or less consistent. Thus, we encounter important connections between the dimension o of the organisation business philosophy and the stages of strategic search for knowledge (79%), of knowledge acquisition through buying know-how (81%), of knowledge acquisition through hiring experts (61%), and the stage of valorisation of already acquired knowledge (79%). The dimension that characterises the organisation infrastructure is connected to all dimensions that characterise the stages of the knowledge acquisition process at organisation level. The dimension that characterises the organisational culture and motivators is found again connected to the stages of strategic search for knowledge (42%), of assimilation of acquired knowledge through decoding/recoding (42%), of implementation in procedures (50%), and of valorisation of already acquired knowledge (64%). We also find significant influences between the dimension that characterises standardisation and formalisation existent at organisation level and the stages of strategic search (63%), assimilation of acquired knowledge through decoding/recoding (84%), of implementation in procedures of acquired knowledge (76%) and of valorisation of acquired knowledge (62%).
- Between the dimensions that characterise the organisation relational capital we identify, as stated by the field literature, connections to stages of knowledge acquisition process at organisation level. Thus, the dimension that characterises the organisation brand is significantly connected to the stages of strategic search (71%) and valorisation of acquired knowledge (71%). The dimension that characterises the organisation business partners is linked to the stages of strategic search (56%), knowledge acquisition though buying know-how (53%), knowledge acquisition through hiring experts (64%), and valorisation of acquired knowledge (57%). We also encounter links between the dimension that characterises the markets in which the organisation is active or intends to enter and the stages of strategic search (79%), knowledge acquisition through buying know-how (45%), of knowledge acquisition through hiring experts (61%), and of valorisation of acquired knowledge (56%).

In conclusion, at the level of organisation human capital, among the relations taken into consideration initially, only some of them are confirmed, the others being considered unrepresentative according to the current study.

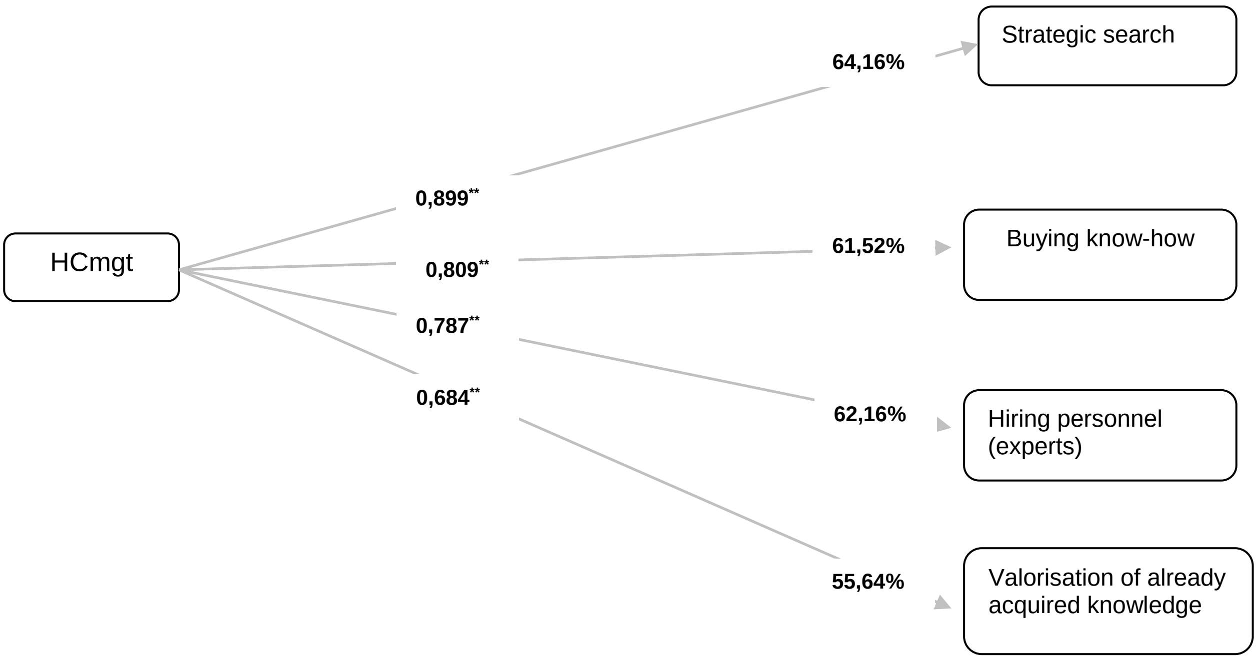


Figure 3: – relations between HCmgt dimension and the stages of the organisational knowledge acquisition process (Luca, 2016)

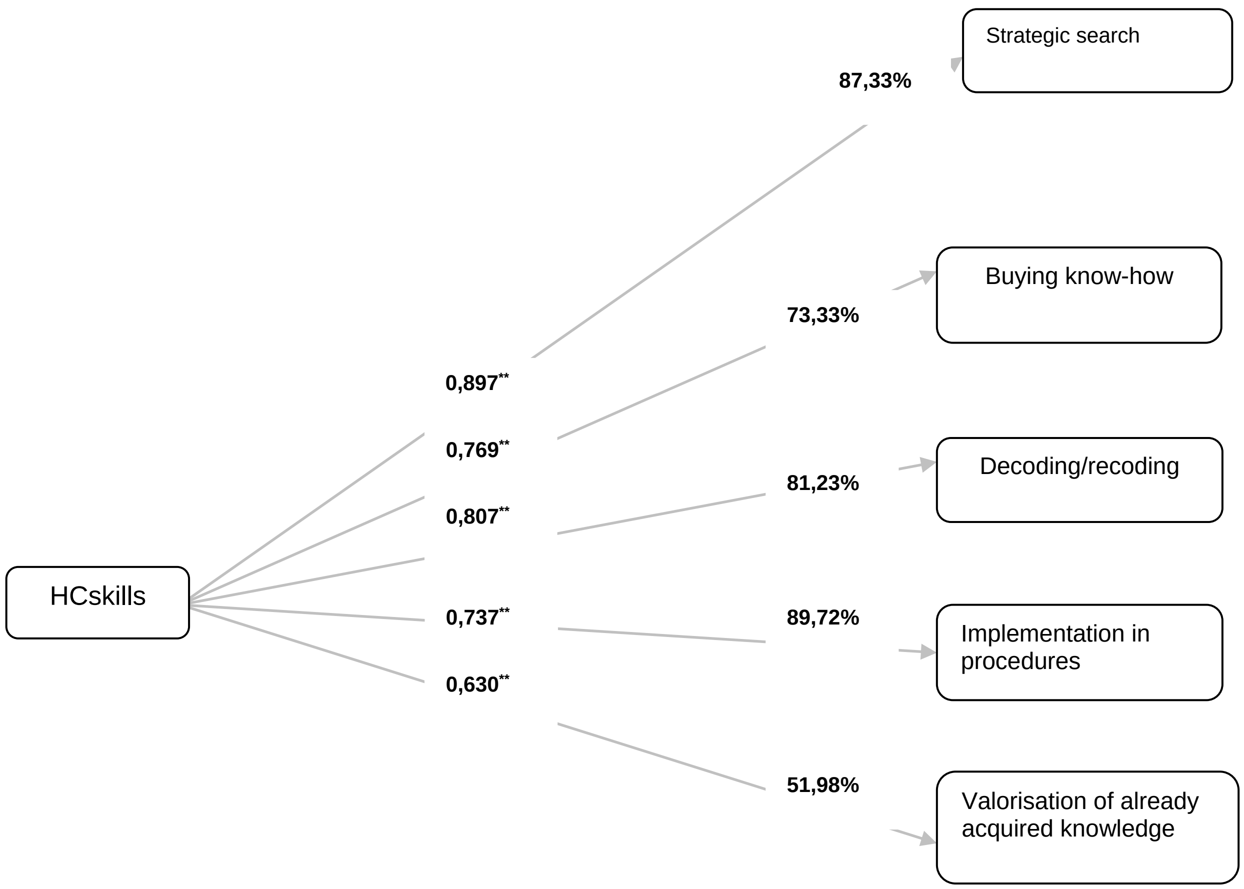


Figure 4: – relations between HCskills dimension and the stages of the organisational knowledge acquisition process (Luca, 2016)

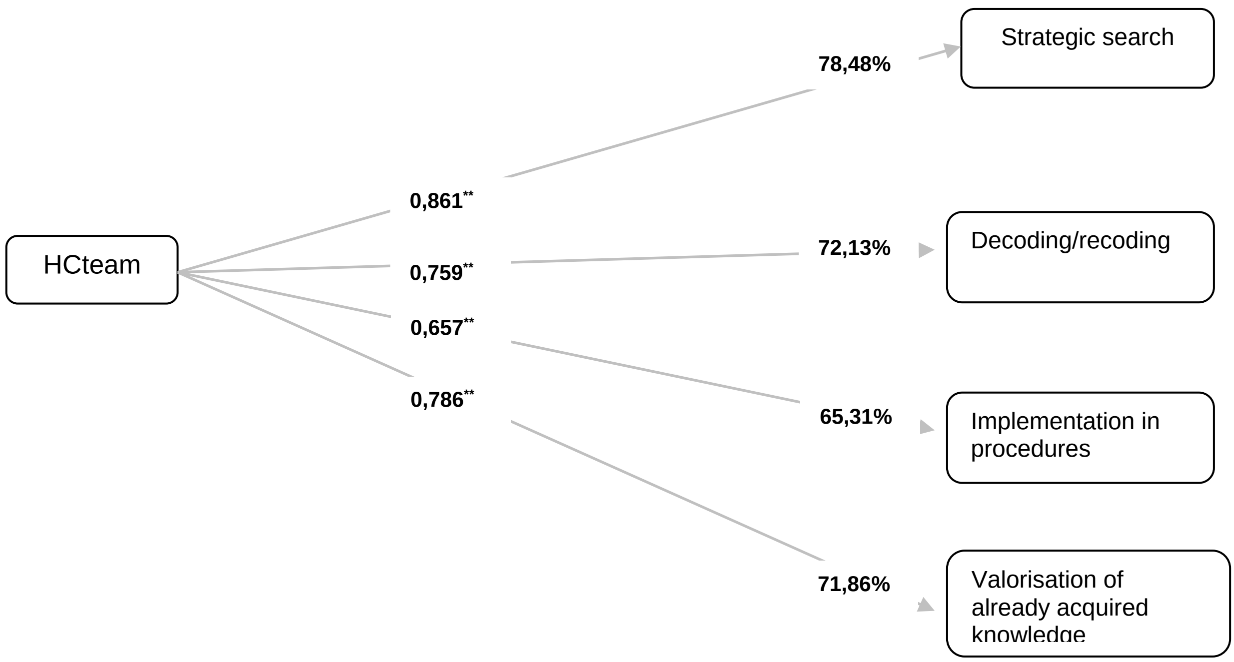


Figure 5: – relations between HCteam dimension and the stages of the organisational knowledge acquisition process (Luca, 2016)

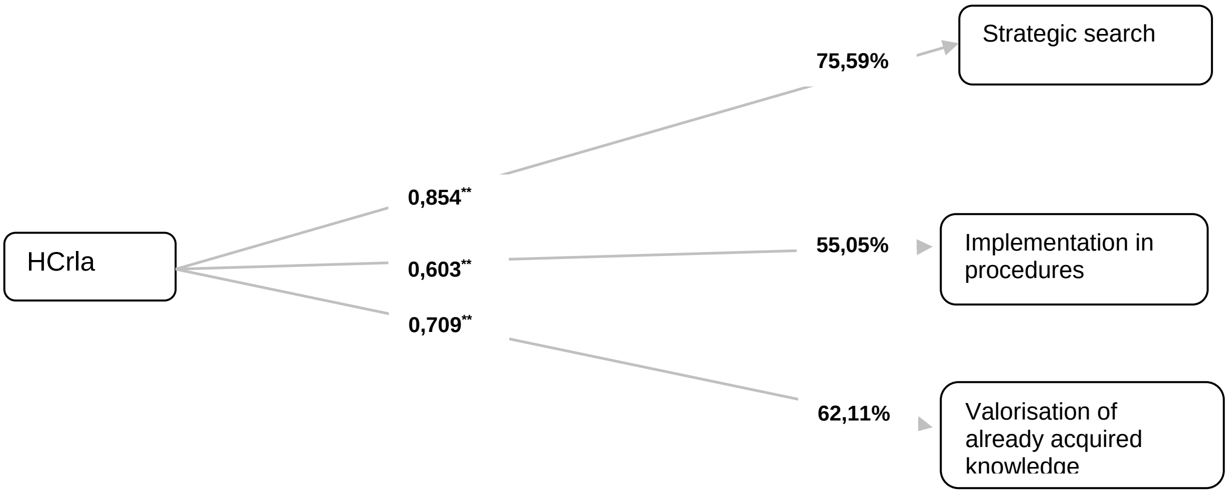


Figure 6: – relations between HCrla dimension and the stages of organisational knowledge acquisition process (Luca, 2016)

4. CONCLUSIONS

The model illustrated in fig.2 represents the framework-model for research elaborated after analysing the field literature, and is intended to be an instrument for the managers with the help of which they can perform the evaluation of the organisation knowledge acquisition process by evaluating each of the stages of this process. Based on it, managers can take correct measures in the shortest time, in the conditions of an increasingly dynamic society in which knowledge has to be analysed, acquired, implemented and capitalised within the organisation as fast as possible.

The dimensions that characterise the intellectual capital of the organisation represent causes that, at organisation level, determine the quality of knowledge acquisition, which, in the modern economy, represents the main resource for added value at organisation level.

The analysis at this level is an original one, as in the specialty literature one can find only the analysis of the dependency between the organisational intellectual capital and the knowledge management processes, the analysis of the influence of intellectual capital over each of the stages of the knowledge management process at organisational level being absent.

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CONVENTIONAL WORK UNITS BREAKEVEN POINT ASSESSMENT IN THE GARMENT INDUSTRIE

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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. In addition, for unique products or for small volume lots, besides the impossibility of a proper forecast of labor standard's and production cost's computation, the traditional computation methodology of breakeven point - for production and for business turnover as well - is losing its significance, just because its own inability to correctly assign the fixed and the variable costs according to an increasingly diversified production. Under these conditions, a change of production volume into workload seems to be a reasonable solution to the firm's resource management. Based on these considerations, the present research objective is to find out a brand new way to assess the conventional work units breakeven point, in relationship with the labor volume provided by the direct productive operators, despite the production lot size. To this purpose, it is proposed both a new concept and a new computation methodology specially dedicated to the acceptance – in terms of profit – into production operations of a brand new products' lot.*

***Keywords**: production costs, production's break-even point, conventional work units, conventional work unit's breakeven point.*

INTRODUCTION

One of the challenges of production management in the industry of textiles lies in the continued growth of manufacturing systems flexibility, in conditions where the volumes of product lots are becoming smaller, the delivery times increasingly shorter, and the quality requirements more and more restrictive [1]. The technical solution to this problem is to increase continuously the automation level of various manufacturing phases, with a targeted focus on broadening the technical and decisional expertise at human resource level. We are dealing with what we have defined in our researches as being a phenomenon of "production complexification" [2], in which the economic efficiency forecast is becoming an extremely difficult task for companies' managers.

From an economic perspective, these technical aspects of manufacturing process must be accompanied by a more accurate assessment of production costs, in terms of efficient use of human, material and financial resources [3]. We have noticed that the general orientation is to rethink labor productivity by moving the practical approach from issues related mainly to realized production volume to the issues concerning the production volume, the efficient use of human resource, and the working time at its disposal [4]. In other words, the idea is to bind correctly - as much as possible - the labor potential of employees to the production cost, in order to establish a fair payment system, and to reach a real assurance that production is made in terms of profitability for company [5]. A solving solution of this specific problem is our proposal targeted to the production cost assessment according to the necessary workload to make one or several product lots, solving solution that is applicable before contracting a new order or production launching of a new product [6].

The objective of this paper is to continue our researches in the profitability assessment field of a diversified - as model and volume - production activity, by defining a new concept, "breakeven point of production expressed in conventional work units", as well as by presenting an original methodology for computation and for interpretation of the obtained results.

CLASSICAL COMPUTING METHODOLOGY FOR BREAKEVEN PRODUCTION

Defined as the *minimum amount of products* from which the company can make a profit [6], [7], the breakeven point of production constitutes an extremely effective tool in highlighting, both for the dependence of sales volume to production costs, and for the income earned by the firm - or losses incurred by it - in relation to different volumes of sales.
By revealing correlations among cost, price and sales volume, the breakeven analysis alows to clarify some aspects regarding to [7]:

- the relative importance of different categories of costs, direct and/or indirect;
- the way how these vary depending on the production volume, as well as...
- the way how these variations can be controlled;
- the anticipation of different influences - exerted by structural changes in production, by prices and costs - on the profitability of the company;
- the production capacity determination needed to achieve maximum profitability and, not least...
- the appropriateness of accepting, or not, the contracts of a certain size or nature.

Essentially, breakeven computation leads to determine the minimum volume of production, or of sales, from which a company starts to make profit. At the same time, it even can be identified the recommended maximum volume of trading to which the company needs to expand production in order to maximize profits, compared with installed production capacity or the already done investment. The clasical computation of breakeven point - in theoretical version - is starting from the following developments of various categories of costs and revenues, depending on the evolution of production volume *Q* [pcs.] (Figure 1) [5], [7]:

- the Fixed Cost (*FC*) remains invariant;
- the Variable Cost (*VC*) changes proportionally;
- the total Cost (*C*) appears as the sum of *FC* and *VC* (1);

$$C = VC + FC \qquad (1)$$

- the Income (*I*) increases in direct corelation to the volume of sold products.

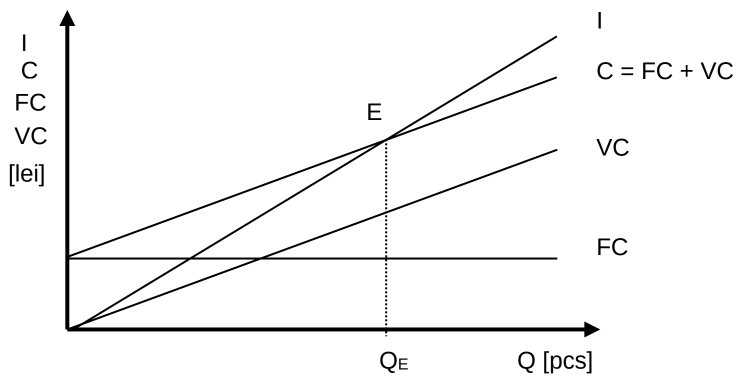

Figure 1: Graphical determination of the production's breakeven point

Point E is the intersection between revenue *V* and total cost *C* (with the corresponding production Q_E) therefore [5], [7]:

$$C_E = V_E \text{ [lei]} \qquad (2)$$

This means that the profit *B* to point E is 0 and Q_E becomes the breakeven point of production. Therefore, the acceptance to manufacture the analysed product will be considered only if the lot has a larger volume of Q_E. Starting from (1) and (2), for the determination of Q_E proceed as follows:

$$V_E = Q_E \times p; \;\; C_E = VC_E + FC_E \text{ [lei]} \qquad (3)$$

Where *p* = price per unit.

$$VC_E = Q_E \times vc \qquad (4)$$

In which *vc* = unit variable cost (sum of unit material cost and the unit direct wage);

Regarding the CF_E,, this is invariably according to the quantity of goods *Q*, therefore:

$$FC_E = FC \qquad (5)$$

Consequently, from relations (3) and (4) follows:

$$Q_E \times p = Q_E \times vc + FC \qquad (6)$$

where [6], [7]:

$$Q_E = \frac{FC}{p - vc} \text{ [pcs.]} \qquad (7)$$

Summarizing, we can say that the management of a company must be permanently concerned to provide a certain volume of production lots - and, automatically, of the sales - which will lead to overpass the breakeven point, guaranteeing the profit. Since Q_E must have positive values (representing a quantity of products), the fundamental requirement to perform this computation is that price p to be strictly greater than the unit variable expenditure (the claimed price for the product to cover the unit direct wage and the unit material cost).

CRITICAL ANALYSIS OF BREAKEVEN POINT USE IN THE OPERATIONAL DECISIONS

Classical methodology for breakeven point of production computing uses theoretical developments of various economic indicators involved, leading - from the start - to errors in a practical situation. We can say, however, that it is better to have these information - based on truth/error - than to not have any information at all, with the condition to keep the error under control. Consequently, it can be used nonlinear models of breakeven points [7], but they are difficult to model mathematically.
In addition to these general considerations, specifically in textile industry, the breakeven point becomes impossible, or unrealistic, to be calculated when there are manufactured small/unique product lots, for the following reasons:

- the fixed cost becomes difficult to be distributed on a small lot of products whose production time is also difficult to estimate;
- for a unique product, the value of Q_E can not be less than the value of Q = 1 pc., which would mean that the manufacturing of product should pass/fail from the start based on other considerations outside the breakeven point;
- the procedure becomes complicated when considering whether to launch the production of a multitude of unique products for a specific required time period;
- estimate of direct and indirect workloads rules in the case of a diversified and small lots production is made with large errors, which subsequently increase in the very obtained result for the existing breakeven point.

For these reasons, we believe that the breakeven point of production shows its limitations in the current economic context of the textile industry, the aim of our research being to find out a practical solution to this matter.

BREAKEVEN POINT OF PRODUCTION EXPRESSED IN CONVENTIONAL WORK UNITS

The starting point of our approach is the ante-computation operation for the production cost by using the conventional work units, methodology that was conceived and clearly described in our previous researches [6]. Consequently, 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 (*c.u.*), according to the relation (8):

$$Qcu = St_i \times Q_i \qquad (8)$$

where:

St = standard time (hrs x person / pieces);
Q_i = quantity of product of i type.
For an inhomogeneous production (for example, if an order contains several types of i products required in Q_i quantities, which are envisaged to be done in a specific Nt_i standard time) the workload expressed in Qcu conventional units can be calculated as follows (9):

$$Qcu_i = \sum_i St_i \times Q_i \quad (9)$$

This is the standard workload for employees who manufactured the products quantity *Q*.

The direct workload *Qcu* - which should be performed by a direct productive employee in an hour - is *1 person 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 WT_j can be calculated with relation (10):

$$WT_j = 8 \times Nwd_j \quad (10)$$

where: Nwd_j = number of working days checked in for an employee (j) during the calculation period of time.

Based on these considerations, we have to deal with the following developments of various categories of cost and revenue, depending on the evolution of production volume expressed in conventional units *Qcu [hr. x person]* (Figure 1):

- the fixed cost (*FC*) remains invariant accordingly to the workload. As we have to consider the conventional work units, *FC* is expressed in *lei* (currency units) allocated to the fixed cost for an operational hour of the company;
- the variable cost (*VC*) is changing proportionally, in the sense that:
- the total cost (*C*) appears as the sum of *FC* and *VC* (1);
- the income (*I*) increases proportionally with the done workload by the direct productive employees.

Accordingly, the graphical representation of these developments - similar to those in Figure 1 - is shown below (Figure 2):

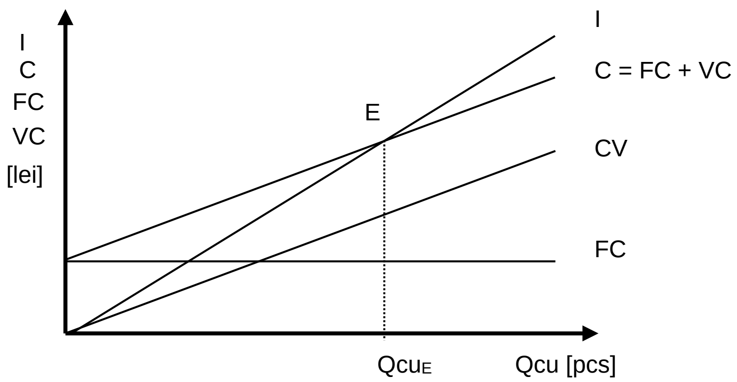

Figure 2: Graphical determination of the breakeven point expressed in conventional work units

These developments have previously led us to the breakeven point of production formula (7). If it is the case of one type of products, we use a trick of calculation by which we multiply both terms with the standard time, resulting (11):

$$St \times Q_E = \frac{St \times FC}{p - vc} \text{ [hr. x person]} \quad (11)$$

The obtained terms have the following meanings:

$$St \times Q_E = Qcu_E \quad (12)$$

In which Qcu_E = the breakeven point of production expressed in work conventional units.

Taking into account the related measurement units, we can deduce the following meaning:

St [hr x person / pcs] x FC [lei]= FCcu [hr. x person x lei / pcs] (13)

in which we introduce the concept: *FCcu* = fixed cost of work conventional unit. According to the obtained measurement unit, it would mean the amount of money allocated from product' workmanship *wks [*lei/piece*]* to the assigned work unit into the hourly fixed cost. By extending the meaning of breakeven point expressed in conventional units to make *n* products of *i* type in *Qi* quantities, we get:

$$\sum_{i=1}^{n} St_i \; x \, Q_E = \sum_{i=1}^{n} FC \frac{St_i}{p_i - vc_i} = Q^* cu_{Ei} \text{ [hr. x person]} \qquad (14)$$

where: Q^*cu_{Ei} is the breakeven point expressed in conventional units, for product's series of *i* type, on the level of each directly productive operator (it was introduced the product's standard time, meaning the assigned time to a single operator in order to do a single product unit).

Since there is available *Nwd* directly productive operators (according to the staff number of the workteam for one technological line) which produces a product variety of *i* type, then the breakeven point on the whole working team will be:

$$Quc_E = Nwd \; x \; Q^*cu_{Ei} \qquad (15)$$

Given that the company has a number of directly productive operators *Nwd*, for a work time period considered *WT*, the available workload Q^Acu will be:

$$Q^A cu = \sum_j Nwd_j \times WT_j \qquad (16)$$

Similarly, the required workload to do an order of *n* products of *i* type will be:

$$Q^O cu_i = \sum_{i=1}^{n} St_i x Q_i \qquad (17)$$

Therefore, the condition that a specific order - consisting in *Q* products of *i* type and in *Qi* amounts - to be accepted for manufacturing will be:

$$Qcu_{Ei} < Q^{Oc}u < Q^A cu \qquad (18)$$

Starting from the relationship no. 18, the condition for a full charge of the manufacturing line will be:

$$Q^O cu = Q^A cu \qquad (19)$$

As an example of computation of the breakeven point expressed in conventional units (simulation inspired by the real case of a textile firm) is presented below on the following inputs:

- *Nwd* = 24 persons
- *WT* = 5 days (40 hrs)
- Q^Acu = 24 x 40 = 960 [hrs x person]
- *FC* = 600 lei (for every hour of operation of the company, value assessed in the real company at the data of 01.07.2016)

Table 1: Computing elements based on the order's structure

Product Code *i*	Q_i (pcs)	St_i (hr. x person / pcs)	Qcu_i (hr. x person)	*wks* (lei/pcs)	vc_i (lei/pcs)	p_i (lei/pcs)	FC x St_i	p_i - vc_i (lei/pcs)	Q^*cu_E (c.u) (for a single person)	Quc_E (c.u) (for24 pers)
GB143	120	3,2	120 x 3,2 = 384	28,8	122	345	600 x 3,2 = 1 920	345-122 = 223	1920:223 = 8,61	8,61 x 24 = 206,64
GB163	12	1,8	21,6	16,2	90	214	1 080	124	8,71	209,04
GB172	89	3,8	338,2	34,2	207	429	2 280	222	10,27	246,48
			743,8						27,59	662,16

Results interpretation:

- the order' volume consists of 3 products and requires an effort of 743.8 [*c.u.*], from a total available at the firm level of 960 [*c.u.*];

- the breakeven point is achieved for every directly productive worker at a workload of 27.59 [*c.u.*], from a total available of 40 [*c.u.*];
- the breakeven point is achieved by the entire working team in 662.16 [*c.u.*], against a order' load of 743.8 [*c.u.*] and a total available of 960 [*c.u.*], that way being able to meet the requirement no. 18;
- the requirement no. 19 is not met, the technological line having a reserve of 960 - 743.8 = 216.2 c.u. which can be assigned to supplement the current order with other new quantities of products.

Therefore, the right decision in the described case is to accept in manufacturing the analyzed order, in order to optimize the technological line loading being needed to supplement the order with 216.2 [*c.u.*].

CONCLUSIONS

The technical aspects of the products manufacturing in the textile industry must be accompanied by an as more as possible accurate assessment of the efficient use of human, material and financial resources. Our research has highlighted the profitability assessment limits of production activity by using the classical methodology, and, at the same time, has led to the introduction of a new concept: the breakeven production expressed in conventional units work. In this respect, it was described an original way to interpret the various categories of direct and indirect costs depending on the direct workload, obtaining finally a methodology for determining this new type of breakeven point. The developed methodology was tested in the practical case of a textile firm, by showing an example of results interpretation, for the purposes of decision making activity of introducing a new order into production process.

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A CONCEPTUAL STUDY OF THE ROMANIAN ETHICAL FASHION CONSUMER DECISION JOURNEY

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Abstract: *This paper presents a conceptual study of the Romanian ethical fashion consumer decision journey, aimed to gain insights on how consumers purchase ethical fashion products. An analysis of existing literature of the Romanian and the ethical consumer is carried out, this being the basis for the proposed consumer decision journey model. The work presents a comparative analysis of existing decision making research methods, adaptions and models for ethical decision-making and clothing selection. Understanding consumers and their buying behavior is an essential part of marketing. However, it is complex and research on ethical behavior is a sensitive topic. Thus, an attempt is made to understand the Romanian ethical consumer by identifying main behavior found in recent research. The aim is to compare different kind of decision models and to apply an appropriate model to the Romanian consumer accordingly. Consequently, the proposed model is able to define the consumer decision journey.*

Keywords: *consumer behavior, decision making, attitude-behavior gap, ethical fashion, Romanian consumer.*

INTRODUCTION

This paper presents a conceptual study of the Romanian ethical fashion consumer decision journey, aimed to gain insights on how consumers purchase ethical fashion products. An analysis of existing literature of the Romanian and the ethical consumer is carried out, this being the basis for the proposed consumer decision journey model. The work presents a comparative analysis of existing decision making research methods, adaptions and models for ethical decision-making and clothing selection.
Understanding consumers and their buying behavior is an essential part of marketing. However, it is complex and research on ethical behavior is a sensitive topic. Thus, an attempt is made to understand the Romanian ethical consumer by identifying main behavior found in recent research. However, research on this is limited. Consumer behavior towards ethical fashion brands is still an emerging topic with limited research [1].

EXPERIMENTAL

The aim is to compare different kind of decision models and to apply an appropriate model to the Romanian consumer accordingly. Consequently, the proposed model is able to define the consumer decision journey. The proposed system is based on consumer behavior and decision making methods already applied in fashion studies, using an adaption of the widely recognized Consumer Decision Model proposed by Blackwell et al. [2], providing a full inclusion of consumer behavior, and the Theory of Planned Behavior by Ajzen [3], including beliefs, attitudes and buying intentions of consumers.

RESULTS

Consumer behavior towards ethical fashion brands is still an emerging topic with limited research [1]. Also, existing research focuses on specific consumer groups, having different ages and located in several geographic areas, e.g., [1] interviewed consumers from 18-26 years, in the area of Manchester, England, and the area of Frankfurt, Germany.

3.1 The Romanian ethical consumer

There are rankings for sustainability in general as the environmental performance index (IPA), developed by Yale University, ranking countries according to their greening level, placing Romania 86 out of 132 in 2014, [4]. The Green Barometer, carried out under the Think Green Policies project, defined in 2008 four eco-types for the Romanian urban population, given in the following in the order of low to high eco-consciousness: Eco-indifferents (8%), Eco-neutral (28%), Eco-supporters (53%), Eco-promoters (11%); also, men are generally more interested into eco aspects, and in Romania a study showed that consumers are more likely to buy eco products as a gift [4]. However, there is a scientific gap referring to studies about green consumer behavior in general in Romania, and about interest into eco fashion.

3.2 Ethical behavior

Ethics are linked to moral and pro-social behavior; accordingly, respondents are likely to give socially desirable answers. Research mentions an attitude-behavior gap [5;1;6]. As ethical refers to moral behavior, the influence of emotions and satisfaction is included in the modeling. Other key influence factors are product attributes which can have a broad variety; buying motivations and the function the fashion item performs varies strongly [7]. Two categories were defined, the functional and symbolic product attributes [8], whereby the product can also own both. Furthermore, it has been found that ethicality might not be the main purchase criteria, but other factors such as price, design and availability [4;8]. Also, in-store and online purchase causes and cultural influences are added, depending on Romanian market and background.

3.3 Customer decision making models

A widely recognized model for defining the consumer buying decision process has been developed by Engel, Blackwell and Kollat in 1968 [2], dividing the journey into five phases: Problem or need recognition, information search, evaluation of alternatives, purchase decision and post-purchase behavior. Many adaptions followed; The widely recognized Consumer Decision Model proposed by Blackwell et al. [2], provides a full inclusion of consumer behavior and of environmental and individual influences, and the Theory of Planned Behavior by Ajzen [3], highlights beliefs, attitudes and buying intentions of consumers, and is the most widely applied prescriptive model, refer to Figure 1 for an overview of the customer journey phases.
But, there has been a change of the market system from static to dynamic, involving the customer actively to contribute with customer feedback stating the satisfaction level; consumer-generated content is a key influencer within the on- and offline consumer journey, involving for example word-of-mouth or social media. It can be said that the purchase process achieved therefore more complexity, having several influencing factors.

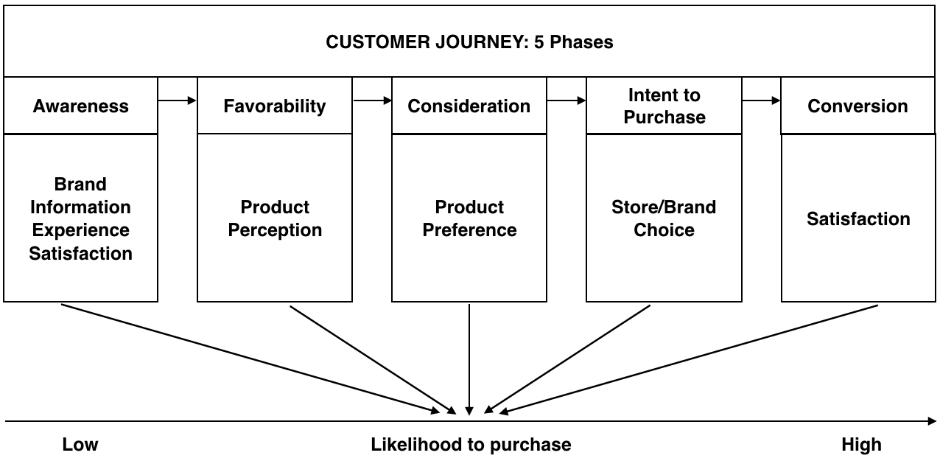

Figure 1: Customer journey phases [adapted from 9]

A model for ethical decision- making by individuals was developed by Hunt and Vitell [10], presenting a general theory of marketing ethics. Later, it has been more widely applied by Marks and Mayo [11] and Vitell et al. [12], including deontological and teleology factors, based on perception and experience as well as consequences and satisfaction. In general, ethical decision-making theories include emotion, moral principles and altruism, but general decision-making steps can still be applied for guidance.

DISCUSSION

Understanding consumers and their buying behavior is an essential part of marketing. However, it is complex and research on ethical behavior is a sensitive topic. Thus, an attempt is made to understand the Romanian ethical consumer by identifying main behavior found in recent research. However, research on this is limited. The aim is to compare different kind of decision models and to apply an appropriate model to the Romanian consumer accordingly.

4.1 Adaption of customer decision making models

The widely recognized models of decision making by [2] and [3] can still be applied. But, as there has been a change of the market system from static to dynamic, involving the customer actively to contribute with customer feedback stating the satisfaction level; consumer-generated content is a key influencer within the on- and offline consumer journey, involving for example word-of-mouth or social media. Therefore, it can be said that the purchase process achieved more complexity, and more influencing factors need to be included. Also, referring to ethical decision making adaptions has to be made. As ethical refers to moral behavior, the influence of emotions and satisfaction is included in the modeling. Other key influence factors are product attributes which can have a broad variety; buying motivations and the function the fashion item performs varies strongly [7]. Two categories were defined, the functional and symbolic product attributes [13], whereby the product can also own both. Factors such as price, design and availability need to be included as influence factors in the decision making, as well as in-store and online purchase causes and cultural influences are added, depending on Romanian market and background. Factors are represented as expectations and perceptions, refer to Figure 2 for an overview of an adapted decision making model for ethical decision making.

4.2 Limitations

As the problem statement it can be said that there is a lack of insights into the ethical market in Romania, as well as only few sources are available in other European countries such as France. Ethical fashion is a less evolved phenomenon. Also, passive research could help to cross the bias on ethical research, by taking real consumer behavior into account instead of validating consumer responses influenced by pro-social behavior.

CONCLUSIONS

Understanding consumers and their buying behavior is an essential part of marketing. However, it is complex and research on ethical behavior is a sensitive topic. Thus, an attempt is made to understand the Romanian ethical consumer by identifying main behavior found in recent research. However, research on this is limited. The aim is to compare different kind of decision models and to apply an appropriate model to the Romanian consumer accordingly. Passive research could help to cross the bias on ethical research, by taking real consumer behavior into account instead of validating consumer responses influenced by pro-social behavior. Empirical studies can help to further determine the model. Consequently, the proposed model is able to define the consumer decision journey.

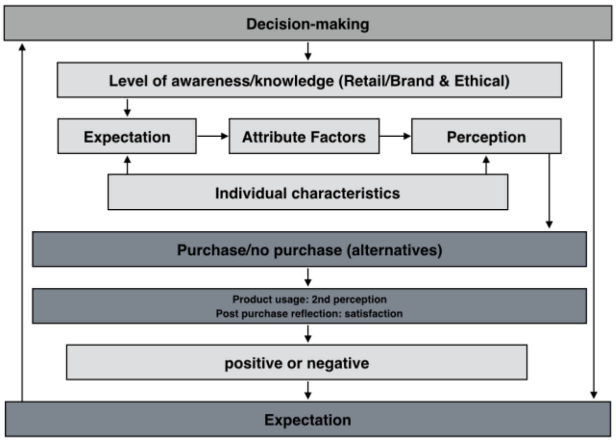

Figure 2: Adapted decision making process

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A STATE-OF-THE-ART LITERATURE REVIEW OF UPCYCLING: A CLOTHING INDUSTRY PERSPECTIVE

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Abstract:

The purpose of this study is to review and appreciate the developments in the literature of upcycling domain; (i) To comprehend the concept of upcycling and subsequently, understanding the difference among the prominent terminologies used in the literature (ii) To identify application of upcycling across various industries; (iii) To propose a framework of upcycling practices for clothing industries based on the insights. The paper has identified terminologies and definitions used in the literature. Recycling may be considered as the use of the material properties (e.g. as a fire retardant non-woven material in a mattress spring cover). Down-cycling may be conceptualized as making an inferior product or broken down into raw material. The process of redesigning is one of the important steps in upcycling. This consists of ideation, reconstruction and fitting. The limitation of redesigning is variability in size and pattern. This can overcome by; craftsmanship, time, innovation, provenance, desire, narrative.

Keywords: *Literature review, Clothes Reuse, Reverse value chain, Upcyling, Redesigning*

1. INTRODUCTION

Textile and clothing industries involve different processes right from spinning to finishing of final garments. Each of these processes tries to add some value to the product. This is a highly labor intensive industry and a huge source of employment[1]. It has been considered as the second largest industry in the world with consumption of nearly ten percent energy, after food industries. Unfortunately, many hazardous chemicals are used and emitted in the garment manufacturing processes. Many firms have taken initiatives to reduce the harmful effect of toxic chemicals. But a significant minimization seems difficult to achieve [2]. In addition, the estimated consumption of textile based goods is approximately 30 million tons per year. The situation is alarming because the disposal rate has also increased. This might pose a threat to the environment because disposed garments will ultimately go for landfilling or incineration. The degradation can be controlled by avoiding the entry of virgin (new) raw materials by closing the loop based on any of three principles: reduce, reuse and recycle [2, 3]. This will also indirectly help in providing employment by increasing job opportunities in reverse logistics field [4]. The reverse side of value chain consists of mainly three processes: collection, sorting and processing. Collection is the process of getting back discarded products from consumer. Sorting is responsible for inspection and categorisation of product according to its quality/type [5]. Processing involves different activities like repair, washing, redesigning etc. to restore functionality and enhance the utility [6]. Each process of reverse logistics are explained in details in the next section. In practice various initiatives have been taken by leading clothing and textile brands. Summary has been presented in the Appendix 1.

2. METHODOLOGY:

A scientific literature review procedure proposed by Mayring [7] was adopted to select and screen the paper which comprised of four steps; (i) *Material collection*: The collection of material is well defined and delimited based on the profiling approach. Each paper is defined as unit of analysis; (ii) *Descriptive analysis*: Different criteria are set to analyze collected materials. These are publication year, journal, methodology and author affiliations; (iii) *Material evaluation*: According to above mentioned categorization, research papers are analyzed and interpreted to form a conceptual framework. NVIVO 10 was found to be very useful software for analysis. Nodes have been created for each heading and corresponding notes were made in the same. Multiple nodes were made for each research paper. To further analyze these nodes and heading were entered in text format in MS Excel. The methodology used has been discussed with different researcher to check the credibility of steps undertaken. This approached has helped us to decrease the risk and increase the validity of right selection of scientific article [8]. This leads to proper and comprehensive review of literature.

3. DESCRIPTIVE ANALYSIS

In total 49 papers has been reviewed. Increasing trends has been found in terms of publication. In last 5 years the rise in number of publication is sharper in compare to pervious published papers. Out of 49 selected papers in total 9 papers are from the year 2012. Subsequent year 2013 stands second in terms of total number of papers.

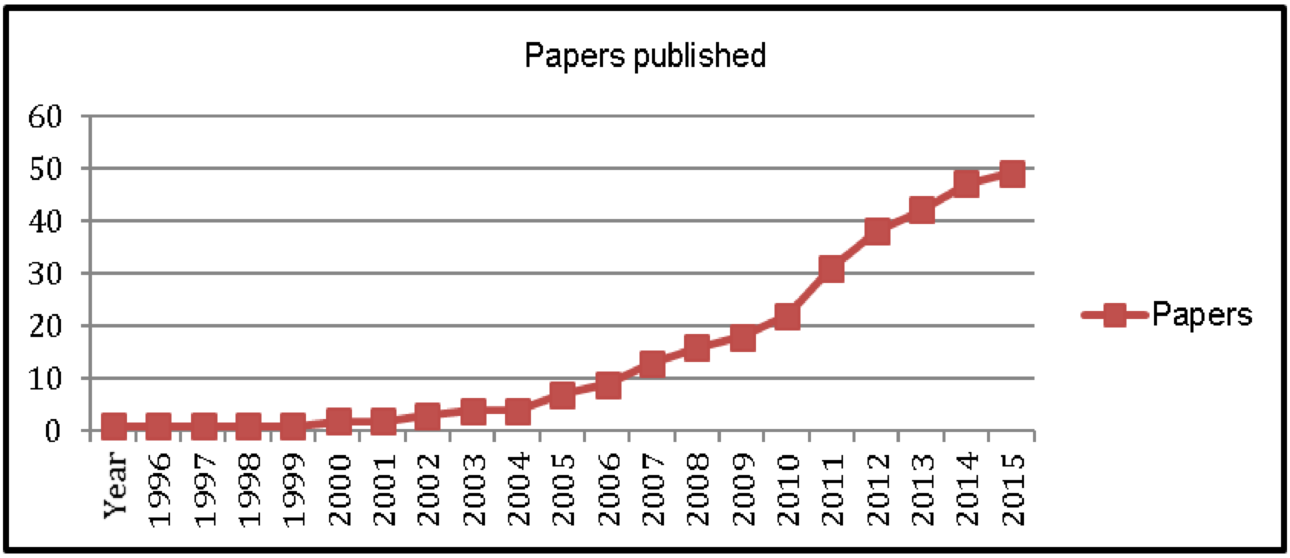

Figure 4**: Trends of published paper**

Upcycling or redesigning has been focused by two kinds of journals. First type of journal publishes paper from clothing and textile domains. Second type of journals has focus on operation and supply chain management. List of main journal published published papers in the area of redesigning and upcyling has been summarized in below table.

Table 3: **List of main Journal**

Type 1: Textile and clothing journal
International Journal of Retail and Distribution Management
Textile: The Journal of Cloth and Culture
International Journal of Clothing Science and Technology
Clothing and Textiles Research Journal
Type 2: operation and supply chain management journal
European Journal of Operational Research
International Journal of Production Economics
International Journal of Production Research
Journal of Cleaner Production
Production Planning & Control

This has been observed that mostly quantitative papers were published in the operation and supply chain. These papers have attempted to design some mathematical or statistical model to derive conclusion. Textile and clothing journal has mainly published conceptual paper.

4. REDESIGNING/UPCYLING PROCESS:

Redesigning may be considered as one of the important steps in upcycling process. This is to add value to discarded or used products. The original idea of redesign is based on the technique of pattern making or draping [9]. Extent of redesign can vary from adding minor details to complete transformation of clothes. Minor change can be done by adding decorative trims, new embroidery or print. While by complete transformation a dress can remake into tops or children garments. Scope of garment to redesign can be decided on the basis of its structure, fabric and quality [10]. The process of redesigning consists of ideation, reconstruction and fitting.

Figure 5**: Redesign Process**

However redesign is time consuming process and it takes huge time to find right transformation of particular products. The limitation of redesigning is huge variability in size, pattern, Fabric and Color of used product [11]. Size and pattern of fabric from discarded product cannot be easily accommodated for new product design. Further each fabric has different material properties and color. Hence this becomes important criteria for its use in the new product. However these limitations can also be considered as opportunity for redesigning process. As size and pattern of each fabric retrieve from used product is distinctive. This provides unique design solution for new and improved products. To convert limitation into opportunity, redesigning process requires excellent skill to achieve perfection. Further substantial amount of time needed to achieve desirable output. As each part of used product is unique, which need to be handled individually to maximize utilization. An innovative approach is also needed to tackle unpredicted quality and quantity of discarded products offered for redesign. It is impossible to run continuous process of redesign, with limited supply of each type of the input. In fast changing fashion world previous season fashion becomes precious. Hence it is important to retain its provenance. It is important to up-cycle or redesign old products with improved aesthetics or/and functional properties. Narrative of up-cycled product is another important factor, which increase its salability. Narrative of product's previous life can be an important marketing strategy. Deschamps, Carnie [12] has also highlighted the need of up-cycled brand to keep the history of product.

5. DISCUSSION:

Disassembly need a lot of efforts and incur huge wastage. So future redesigning of product should be considered at time initial production. This will help efforts and labour cost on the deconstruction at the time of upcycling. Hazardous materials should be avoided and durable material should only used in the manufacturing process. Further proper co-ordination among supply chain partner enable efficient redesigning process [13]. Natural resources are diminishing drastically while demand for energy has increased surprisingly. In this situation phenomena of redesign become important to increase product longevity and durability [14]. Products are also redesigned to consider its impact on environment. However success of redesign depends upon its future market demand and cost of redesigning process [15].
It has been found that price is the main criteria for purchase of used product. Cost of the used-product also decides its future. Hence focus should be given to reduce cost during repairing or redesigning [16, 17]. This has also been found that collaborative kind of redesigning facility will give cost advantage [18]. Technical and scientific skills of operations management people should be used for redesign location to remove all valuable accessories from waste. This will help in reusing zipper, logo, labels etc. with other products [19]. The location and type of machines/softwares available at particular location has also an impact on daily as well as long term planning. This is another crucial element which enhances the usability of product and influence performance of reverse supply chain [20]. The allocation decisions regarding repair operation will determine the success and failure of reverse logistics operations. It has been found that, an integrated system is always better and cost effective than non-integrated [21].

Re-design for textile is defined as new design made out of reused material or production spills. This can be classified as Class I (more stringent) or Class II depend upon level of modification. A Number of designers practicing redesign activities in the textile and clothing industry. Still volume of redesign textile is very less as flow of small amount of discarded item is not suitable for redesign at industrial level. Even very little amount of collection goes to upcyling or redesign out of total collection [22, 23]. Charitable organizations do various kind redesign or remake activities at small level. Where used clothes are converted into new clothing product or cushions, pillows etc. For example adult sweaters can be remade to pair of paints for the children. Some clothing companies also involved in the remake/redesign activities for their surplus stocks. They allow suppliers or intern student to reconvert unsold items to new clothing products [24]. Uniforms for offices and organizations reissued to keep up to date with latest fashion trends. This leads large amount of clothes discard much before their end of life. There is huge scope of redesigning and reuse. Various type of modification like new print or embroidery can be incorporated to stimulate interest of user [19]. These activities also generate new job opportunities in the area of tailoring, washing, Ironing and mending. Other sector jobs like handling and transport are also generated out of these activities [25, 26]. This has been estimated that income earn by poor handler, cleaner, repairers, restyles and distributor is almost equal to partly lost income in tailoring operation. Reconstruction of high valued product like jeans and trouser generally done, Shorts or garments for children are made out of it. Depend upon market demand sportswear are also made from reconstructed items. All trims and accessories taken out and stored for future use [6]. To do all these activities sufficient skill is required. Lack of proper skill to modify or upcycling leads to disposal of garments to waste bins [27]. Below table summarizes main factors affecting redesigning or upcycling process.

Personalizing and restoring the recovered items is new consumption trends. Consumers try to purchase remake items to avoid waste and landfill. The process of remake or reconstruction prolong the life time of existing products. Similar initiative has also been taken for furniture. Old furniture are painted and modified for new functions from its original [28]. This kind of initiative is almost similar to the clothing and textile industry. Hiller Connell [29] has conceptualized that clothing product has two different kind of life time i.e. technical and aesthetics. Technical life is the time for which functional property of product is intact. While aesthetics life means time for which consumer has interest in the product. Common way to extend life time of product is repairing, alternation and refashion. Many individual and volunteer derive satisfaction while performing these activities. Restyle and remade clothes are sold as per their market value [30]. Upcycling is opposite to recycling/down-cycling, where second, third, fourth and later generation of product enjoy better value life [31]. Number of process like shape modification and overprinting is done not only for improving value but also to conceal stained and damaged part. Unwanted clothes can be transformed into fashionable items by adopting this strategy [32]. Different approaches to minimize effort of disassembly are highlighted by Gam, Cao [33]. Material used need to be less diversified and permanent bound is suggested in place of fusing. Importance of longer stitch is also shown. Importance of product designing in disassembly is also highlighted by [34].

6. CONCLUSION:

The extant literature revealed that no study so far has attempted to summarize the literature in upcycling area. Thus, this could be seen as a significant and unique contribution to the literature. This has been observed that main aim of upcyling is to extend the life of products. Success of redesigning process depends upon collaboration between different stakeholder of supply chain as well as initial product design. Upcycling operation is still at nascent stage this leads to high cost of operation. Proper support of government, different partners of supply chain and volunteers can make redesigning process successful. This has various benefits, which includes environmental and monetary benefits for individual. Further, the bibliography and insights provided in the study may be used by future scholars as a ready reference for their research.

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Appendix:

Appendix 1: Practice of reuse/upcycling by company

S. No	Brand	Scheme Name	Collaboration	Reuse/Upcycling initiative details
1	Patagonia	Worn Wear	Yerdle	App based system which help consumer to exchange garments. This is not limited to Patagonia product.
		Collection	By post to Service centre or drop in store	Consumer can drop Patagonia garment in store or can send by post to customer service centre.
2	Adidas	Green Company	Own Manufacturing Premises	This has been applied to manufacturing premises through out globe to reduce waste in manufacturing.
		Sustainable Footprint	Non profit organisation and Own store	Goods were taken back after end of life. Based upon condition, It is either reuse or recycle.
3	Brooks Running	Earth Day	Soles 4 Souls	Keep container throughout store to do collection of old shoes.
4	Bestseller	Be Green	German recycling company I:CO	Company have collection bin all NAME IT store, which is used to collect shoes and textile irrespective of brand. Company donate 0.6 Euro back to charity organisation of donating countries.
5	CWS-boco	textile rental services	Certified Laundry	CWS boco has own laundry and some certified laundry. This helps them to maintain proper cycle of REUSE. This company provide complete solution to corporate and public washroom and toilets.
6	ECCO	ECCO Environmental Management System (EEMS)		Company is focusing on reduction and reuse of production waste. There is not much initiative for consumer waste.
7	Eileen Fisher Inc	Green Eileen		5 USD reward is given for donation, which can be reimbursed on the next purchase. Donation can be made to store or it can be send to recycling centre.
8	Esprit	I:CO project	I:CO	In Germany and Austria, we have been involved in the I:CO project since 2011. I:CO collects and sorts the clothes, fabrics and shoes.
9	UNIQLO	Recycling		All uniqlo products can be donated at store.
10	Gap	Blue Jeans Go Green™		Collected jeans are recycled to make insulator (UltraTouch™ Denim Insulation).
		UltraTouch™ Denim Insulation	Bonded Logic	Donation can be done at made well store. This gives 20% off on next purchase. Old product can be mailed with pre paid postage label, which can be downloaded from websites.
11	Hanes	EcoSmart Socks		Made up from recycled 55% recyclable cotton.

		EcoSmart Fleece apparel		Made up from recycled plastics bottle.
		EcoSmart Clothes		Made up from renewable energy.
		Green Advertising Campaign		The ad "For Future Generations". The ad shows the commitment of brand towards environment.
12	H&M	Garment collection initiative	I:CO	Garments are collected and 0.2 Euro per kg donated back to the collected country. Based upon condition clothes were re-wear, reuse or recycle.

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SOCIAL MEDIA AND THE FASHION INDUSTRY A CONCEPTUAL APPROACH

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Abstract: *Over the last decade social media has become an effective marketing tool, that has not only created a new dimension of marketing but has also provided companies many opportunities to create brand awareness and to develop long term relationships with their costumers.*
In this context, the fashion industry is a perfect candidate to use and exploit social media opportunities in terms of marketing and communication as it is a domain that relays on feelings, emotions and trends.
The various social media tools and instruments can provide fashion companies the opportunity to listen in and to communicate with their costumers, to ask for feed-back and to transform their clients into brand ambassadors and co-creators of products.

Keywords: *online marketing, social media, fashion industry, Facebook.*

INTRODUCTION

There’s no question that the Internet and web 2.0 has dramatically changed almost every facet of modern living, from the way we seek information, communicate, entertain and express ourselves. Over the last ten years, the proliferation of social media has represented one of the most significant phenomena in the history of Information and Communication Technologies. Global surveys [1] report an increasing use of social media tools among adults, especially in the United States [2] and in Europe [3]. Social Media applications are seen as drivers of Internet use, since increasingly people create and share their contents through social media platforms [4].
As social media continues to develop and influence trends and behaviors, it is inevitable to have an impact over more and more aspects of our life, such as the way we seek advice on fashion and we shop for clothing and accessories.
The fact of the matter is that the tools and approaches for communicating with customers have changed greatly with the emergence of social media and therefore, businesses must learn how to use social media in a way that is consistent with their business plan [5].

SOCIAL MEDIA AND THE FASHION INDUSTRY. WHY?

Kaplan and Haenlein (2010) define social media as “a group of Internet based applications that build on the ideological and technological foundations of Web 2.0, and allow the creation and exchange of user generated content” [6].
According to Richter and Koch (2007) quoted by Kim and Ko (2012) social media are online applications, platforms and media which aim to facilitate interactions, collaborations and the sharing of content; They take a variety of forms, including weblogs, social blogs, microblogging, wikis, podcasts, pictures, video, rating and social bookmarking [7].
In today’s technology driven world, social networking sites have become an avenue where retailers can extend their marketing campaigns to a wider range of consumers. Chi (2011) defines social media marketing as a “connection between brands and consumers, [while] offering a personal channel and currency for user centered networking and social interaction” [8].
Interestingly, biological research has shown that Facebook usage may be associated with a specific psychophysiological pattern [9] as the research suggests that there is a core flow state present when browsing Facebook that is significantly different from stress and relaxation on a number of indices of somatic activity. Being on a social media site is a positive experience – it feels good – and this is why we enjoy using it, so social media naturally becomes a site to mark and map our aesthetic aspirations.
By nature, fashion is a consumerist industry constructed on the very notion of aesthetics, presentation and outward perception, so in this context social media is a perfect fit. By making no distinction between lifestyle and marketing, social media is now ubiquitously interwoven into our everyday lives. Sanand (2011) quoted

by Ahmad et. al (2015) concludes that the fashion industry is welcoming social media because it is not only a marketing strategy, but it also observes and anticipates the fashion behaviors [10].

Social media has a strong influence over all industries and particularly over fashion and retail as a study conducted by DEI Worldwide (2008) [11] provided the following statistics: 70% of consumers have visited social media sites to get information; 49% of the consumers have made a purchase decision based on the information they found through the social media sites; 60% said they were likely to use social media sites to pass along information to others online; and 45% of those who searched for information via social media sites engaged in word-of-mouth. The report states that companies not engaging in social media as part of their online marketing strategy are missing an opportunity to reach and interact with consumers. With a significant percentage of people passing along information to others through social media, the value of one customer is worth far more than what he or she initially spends. Thus, firms and brands now need to factor in the value of customers and also the influence of social media on them [12].

According to the Netbase Retail Report (2013)[13] Facebook inspires fashion decisions in at least one product category (eg: casual clothing, fine jewelry or cosmetics) for 72% of social shoppers and 56% of fashionistas: before making a purchase in at least one product category, 62% of fashionistas and 64% of social shoppers consult message boards or blogs for inspiration. Approximately one half of both fashionistas and social shoppers look to Pinterest for inspiration, demonstrating the promise of visual marketing as Pinterest influences 27% of fashionista buying decisions in special occasion clothing, costume jewelry and casual clothing. Instagram inspires decisions in at least one fashion category for 42 percent of women in the 18-29 age group.

So why should the fashion industry exploit social media marketing?

First of all because it is important to be where your costumers are, and according to statista.com (2016) the number of worldwide social networking users is expected to reach some 2.95 billion by 2020, around a third of Earth’s entire population.

Plus, web 2.0 and social media offers the opportunity to provide information fast and in real-time and to target both global and niche audiences.

Secondly, today consumers are looking to be part of the conversation and not only the recipients of the one-way communication process. Thirdly, social networking offers an invaluable key component that fashion brands have been looking for and that is feed-back from the consumer.

SOCIAL MEDIA AND THE FASHION INDUSTRY. HOW?

Over the last decade social media has become an effective transparent engaging and interactive marketing tool, that has not only created a new dimension of marketing but has also provided many opportunities to create brand awareness among consumers.

The process of adopting Web 2.0 tactics as part of the company marketing programme requires new thinking and new tactics as traditional push marketing methods are incompatible with social networking [14].

According to Constantinides et al. (2008) marketers can influence the customer decision-making process using Web 2.0 tools in two main ways: passively and actively [15].

The passive approach allows marketers to learn a lot by listening to the customer’s voice, and they have done this extensively in the past by using, for example, surveys and focus groups. Today, marketers can do the same by monitoring the social media space: blogs, podcasts, forums, and online communities. Listening to the customer is especially important in order to identify market experiences, new market needs, and hear early warnings about product problems indicating the need to improve, modify or drop products. What customers say online is vital, and vital sharing of customer experiences can lead to success or failure of brands and products and seriously disrupt costly marketing actions. “Listening-in” to the customer’s voice provides companies with early warnings of customer dissatisfaction and allows for fast corrective reactions. Furthermore, the online customer voice can provide precious and high quality information at a fraction of the time and cost required in using traditional market research for this purpose [15].

In order to do that, companies have access to a multitude of digital tools such as real-time search engines for blogs like Technorati, Hootsuite, which also has a social media management function, TweetReach, which is a monitoring tool for Twitter or Social Mention which monitors over one hundred social media sites.

The active approach when using social media implies being a part of the conversation and in order to do that fashion companies can launch their own corporate blogs and discussion forums to engage costumers. The active approach allows companies to create the news, not just to be the subject of the news.

One way for fashion brands to leverage social media to their advantage is to engage the online sources of customer influence (blogs, podcasts, online forums etc.) as customer influence tools. This requires identifying, reaching and involving the "New Influencers" [15] about the firm, its brands or (new) market offers. In this case the main goal is to attract the attention of prominent bloggers or users so that they review, discuss, comment on or even recommend using the firm's products or services. Fashion bloggers are beginning to get more attention from fashion brands, because they are seen as the new journalists and regular trendsetters and sometimes they have a larger online network than established news publications. For example, agencies like Digital Brand Architects in New York represent fashion and lifestyle bloggers, brokering endorsement deals with fashion labels, signing up advertisers and, in some cases, booking lucrative television commercials; the agency is trying to position bloggers in the same category as stylists, makeup artists and photographers [16].

Another way fashion brands can leverage social media is to develop websites or online social communities where costumers can interact with the company and with the other users to share opinions and to actively participate in the co-creation process. Some of these websites have incorporated tools and instruments for consumers to offer reviews, which has two main advantages: on one hand, they are perceived as more authentic and trustworthy by other clients and they are user-generated content that can be further used by brands in their marketing campaigns.

Actively involving costumers has the advantage that it provides consumers with enhanced perceptions of human connection and the formation of emotional bonds with the brand [17] and it also increases consumption, the client return rate and generates positive word-of-mouth.

Another way of utilizing customer creativity and promoting the co-creation process is by making online tools available that allow partial or full customization of the company's products. For example, sports article manufacturer Reebok, uses collaborative development and reduces the development cycle of new sport shoes by engaging online collaboration involving suppliers, laboratories, retailers and personnel. This way, the company reduces the development costs, but in some cases can also reduce the usual 18-month development cycle to only ninety days. Another way of using social media for Reebok is to operate a shop in the well-known online community Second Life, which offers virtual visitors the opportunity to customize products in a variety of colors and styles far beyond what they are able to order in retail stores [15].

SOCIAL MEDIA AND THE FASHION INDUSTRY. WHERE?

In the past years, the communications landscape in the fashion industry has radically changed and the traditional channels of communication are beginning to be outdated, so fashion companies are leveraging the opportunities to connect and communicate directly with their consumers through social media channels.

When we refer to social media, the first thing that comes to mind is a website or an online platform that enables fashion brands to connect and communicate with their customers using the latest social networking technology.

Even if the fashion industry is still relatively new to social media, and sometimes mainstream practitioners still question the credibility of these sites and outlets, the most used social networking platforms for the fashion industry are: Pinterest, Instagram, Facebook and Twitter.

Pinterest and Instagram sites are based on individual photos pinned to profiles or boards with the option to include captions and comments. According to Caro (2012), "brands are realizing their audiences are spending more time in newer, more visually driven networks such as Pinterest and Instagram."

Pinterest is a virtual pin board where users can browse pin boards and pins by other users, share photos and links of interest, and connect based on shared tastes while Instagram is a photo-sharing program that enables users to "visually catalog life's adventures" by applying filters to photos, posting them to individual profiles, and following other users with a constantly updated stream of posts [18]. The network has over 110 million active users, out of which 71% are females.

Instagram has changed the fashion landscape dramatically as "it democratizes fashion. There's a greater connection to the customer now. Instagram enables brands to build a voice and speak more specifically to their audiences. Designers are not just thinking about the people at the shows." (Eva Chen, Instagram's Head of Fashion Partnership). The most popular fashion brands on Instagram in 2016 are Nike with over 42 million followers, Victoria's Secrets with over 36 million followers and H&M with over 13 million followers.

The ever-popular social networking site Facebook also allows users to post status updates, photos and albums, and connect with other users on the network. The social media site also permits "crosstalk between users who follow each other and between those who do not, and the intervention of browsers in the indexing of published content" [19]. The most popular fashion brands on Facebook are Converse with over 37 million fans, Adidas and H&M with over 28 million fans and Victoria's Secrets with over 27 million fans worldwide.

Another website that breaks conventions in merchandising and advertising is Twitter. "Twitter has been singled out for its ability to facilitate public conversations through its reply function, which is available for all to see," [20]. Despite its 140-character restriction for posts, Twitter has been recently successful in its ability to attract users by allowing re Tweets, links to photos and other sites, and its ease in use and following. Twitter allows direct conversation through the @ function, where one user can "tweet" directly at another's Twitter handle, despite the public being able to follow. "Part of Twitter's power is that it feels as intimate as talking to a friend" [21]. The most popular fashion brands on Twitter are: Chanel, with over 12 million followers, Victoria's Secrets, with over 9 million followers and H&M with over 7 million followers.

These kinds of social media sites have updated traditional press venues and values, as press releases can be written and sent out to traditional media sources, then can be posted to the company Facebook page, and then a few words on the story can be tweeted on Twitter with a link back to the release wherever it was originally posted [22].

The investments fashion companies make in social media marketing pays off, as the 2016 Social Media Impact Report: B2C Industry Edition revealed that fashion and apparel brands have the largest median audience sizes on Instagram (952.000 followers), Twitter (545.000 followers), and Pinterest (18.000 followers).

Fashion brands also have the third largest median Facebook audience out of the 10 B2C industries analyzed, Facebook being the place where fashion and apparel brands see the greatest number of followers, with a median audience size of 2,3 million page likes.

The report also shows that Instagram is the most effective channel for fashion brands, with an average engagement ratio of 13,71 average interactions per post per 1.000 followers [23].

CONCLUSIONS

The world of web 2.0 and the rise of social media has a tremendous impact over all aspects of our daily lives and individuals and companies alike have to understand and leverage the advantages offered by the new technologies.

Even if social media marketing is a lot different from traditional marketing in terms of transparency and lack of control over what is being said online, the right strategy and a consistent implementation does not diminish the role of traditional media, but it provides another channel for consumers to experience and communicate with the brands they love.

The fashion industry is the perfect candidate to leverage social media as it relays more on desires and feelings and this way the costumers can not only buy the products but "fell" the brand and its personality.

Plus, social media provides fashion companies a key component that they have struggled to collect for years: feedback, in order to create, test and refine the products and the marketing campaigns.

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LINKING EMPLOYEE PERFORMANCE TO STRATEGIC HUMAN RESOURCE MANAGEMENT

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Abstract: *The current article discusses the role of strategic partner of human resource in organizations related to the accomplishment of company's strategy and enhancement of overall organizational performance. The literature emphasizes human resource strategies, practices and policies which represent fundamental issues of strategic human resource management, encompassing the human resource system. The current paper highlights the importance of the strategic role of human resource in organizations, relating the strategic human resource management field to the employee performance management. The results of the scientific paper show the impact of employee performance management and appraisal, as activities related to the strategic human resource management, on increasing employee performance, organizational performance and financial performance in organizations.*

Keywords: *Employee performance, strategic human resource management, strategic partner, employee performance appraisal.*

INTRODUCTION

Human resource management in organizations includes activities such as directing and managing individuals and has a double role: motivating people to work and develop, the second role referring to the organization and the accomplishment of the organizational objectives, including value creation and obtaining a sustainable advantage in relation to other organizations [1].
Thus, human resource management represent a fundamental activity in each organisation, having as main actors, the employees, and being defined as “the management of work and people towards desired ends” [2]. Another definition of human resource management emphasizes that this field “deals with the design of formal systems in an organization to ensure the effective and efficient use of human talent to accomplish organizational goals” [3].
An effective management of human resource represents a competitive advantage for companies by valuing the human resource and human capital and by motivating employees to obtain high work performance, in the framework of a high performance work system.
Accordingly, the importance of human resources in organizations is highlighted in the literature and mentioned as “among an organization's most valuable assets” [4]. Human resources are the most valuable resources of the company, representing the human capital, which “means the organization's employees, described in terms of their training, experience, judgment, intelligence, relationships, and insight – the employee characteristics that can add economic value to the organization”[5]. In such a context, the company may gain a competitive advantage on other competitors, by valuing the human capital, by creating the organizational framework for enhancing the motivation and individual performance, and the premises to a high organizational performance.

ANALYSIS

The framework of this scientific paper is based on a set of research papers in the field of human resource management, strategic human resource management and employee performance management. The research discusses the relationship between these research fields, emphasizing the employee performance management research placed in the context of strategic human research management. Accordingly, the paper highlights author's contributions to creating a framework of analysis of the strategic role of human resources, with emphasis on key aspects regarding the impact of strategic human resource management in organizations. Moreover, the analysis of the literature highlighted the current research in employee performance management, in the large context of strategic human resource management. In conclusion, the paper emphasizes the strategic role of human resources in organizations, linking the strategic human resource management to employee performance management field.

2.1 Key aspects regarding the impact of strategic human resource management: the role of human resource as a strategic partner in organizations

Human resources in organizations play a strategic role and this view conducted to a new research field in the literature, known as strategic human resource management, a field that lies at crossroads between strategic management and human resource management [6]. Thus, the strategic human resource management was defined in the literature as "an approach to managing people that deals with how the organization's goals will be achieved through its human resources by means of integrated HR strategies, policies and practices" [7]. It may be observed the fundamental role of the human resources in organizations as a competitive advantage in relation with other companies. Also, it should be outlined the value of the human capital, as the employees implement the company's strategy to which are also aligned human resource plans and strategies [7].
The literature indicates a strong relationship between strategic human resource management and the organizational performance, as a result of the high productivity, enhanced efficiency and increased profitability [8].
Thus, within strategic human resource management framework, a similar importance to what performance management is provided to a high performance work system [9]. Moreover, studies from this research field emphasize a positive correlation between high performance work practices implemented within organizations and the employee performance [10]. In such a context, employee performance management refers to "a strategic and integrated approach to delivering sustained success to organizations that focuses on performance improvement and employee development" [11].
Furthermore, a key aspect of the strategic human resource management is highlighted in recent studies within the relationship between HR practices and policies and overall strategic organizational objectives and the organizational environment [12]. In this context, HR performance management practices represent fundamental issues of the strategic human resource management, as the HR managers and top managers cooperate for establishing the company's strategy, which provide the framework for the human resource activities, as recruitment, selection, employee performance management, employee performance appraisal, etc. [12].
Among these human resource activities aligned to company's strategy, the performance management policies outline an integrated approach of an organization regarding employee performance appraisal which aims to ensure that employees focus on work efforts and contribute to organizational goals accomplishment [13].
Consequently, we can conclude that within strategic human resource management, HR systems influence the most important financial results which depend on the impact of the HR system on employees' performance [13]. Thus, the role of an employee performance management system may be outlined, and also the strategic role of a performance management system, supposed to link "the organization's goals with individual goals, thereby reinforcing behaviours consistent with the attainment of organizational goals" [14].
All in all, employee performance management represents a key process within strategic human resource management on which companies should focus, considering human resource as a strategic partner who may produce positive results for maintaining a competitive advantage in relation to other competitors.

2.2 Human resource system

The activity of human resource management could be integrated in a human resource management system which includes: HR philosophies, encapsulating the values and principles adopted in managing people; HR strategies, which highlights the overall direction in which HRM intends to go; HR policies, referring to guidelines defining how values, principles and strategies should be implemented; HR processes, including formal procedures and methods to put HR policies into practice; HR practices, comprising informal approaches used in managing people; and HR programmes, which enable HR strategies, policies and practices to be implemented according to a plan [15].
Thus, the literature emphasizes the strategic role of human resource and the contribution which employees have on attaining the company's strategy. The existence of a HR system represents the basic pillar of the strategic role of human resource in organizations [16]. This systemic approach represents that any component of the system and the connection between these components of the system contribute to highlighting the inter-relations between system's components [16] and the HR role of leverage to attaining performance in organizations.

RESULTS

The findings we highlighted in this current study, according to the literature we analysed, provide an integrated framework linking employee performance to strategic human resource management field research. Thus, the current paper brings into light the newest approaches in this field, outlining the strategic role of human resource in organizations in attaining a high level of organizational performance.
Moreover, the literature highlights that HR practices enable employee performance enhancement and an overall high level of organizational performance, by motivating employees [17]. Accordingly, the model emphasizes a direct association between strategic human resource practices (e.g. recruitment, training and development, performance appraisal, reward systems, etc.) and the organizational performance, mediated by the influence on employees' motivation [17].
Another study outlines the role of high performance work practices regarding the enhancement of employee motivation and performance, which determine employees to contribute to increasing the overall organizational performance [18]. Thus, the level of employee motivation represents a premise for anticipating employee performance, and human resource management practices may influence the employee motivation by encouraging them to work harder and to obtain high performance [19].
A study elaborated by Guest et al. (2000) highlights the link between human resource management through human resource practices and the financial performance obtained, and also how human resource management influence the organizational performance [15]. According to the figure below, human resource management represents a strategic player, as the HR department is directly involved in providing the strategic direction of the company by adding value to the business strategy and by human capital recruitment and by organizational design and strategy development [20].

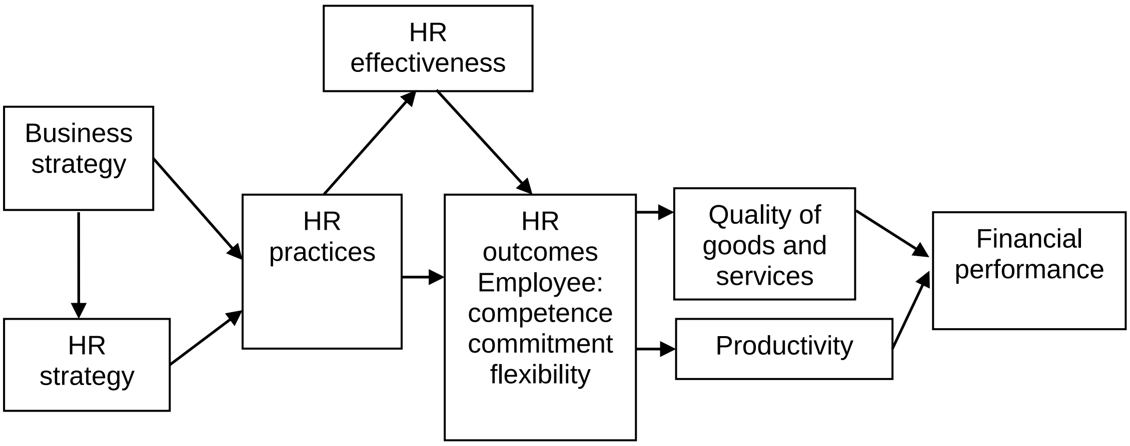

Figure 1: The model of relationship of human resource management and performance, according Guest et al. (2000) [15]

Employee performance management: key activity related to strategic human resource management

Employee performance management and employee performance appraisal represent the most important practices, with direct impact on increasing employee performance, organizational performance and financial performance [1]. Employee performance management incorporates key aspects regarding company's strategy, human resources, company's goals, management, which includes the employee performance management process within strategic human resource management in organizations and considers human resource a strategic partner contributing to attaining company's strategic goals and to enhancing work performance and overall company's performance. Thus, employee performance management is placed in the context of strategic human resource management and aligned to company's strategy, to the strategic objectives, organizational culture and other elements of the organizational context specific to each organization.

CONCLUSIONS

Starting from the human resource management and strategic management, the study brought into light an actual research field, strategic human resource management. The study emphasized the strategic role of human resource in organizations, mentioning the most important components of the human resource system which have a significant impact on increasing employee performance in organizations.

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THE IMPACT OF FASHION DESIGN TO THE EUROPEAN UNION'S ECONOMY

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Abstract: *Regardless of the term used, fashion design (or just fashion), as part of the creative industries, is a relatively small industry, but registering an important economic spillover effect on a range of industry sectors, including advertising, textile, and tourism. Most businesses belonging to fashion sector are small business, with only one to three employees. Despite of this, and of the lack of consistent data in this sector, it is indubitable that Europe plays a central role in the economy of fashion.*
The aim of this paper is to explore and identify the social and economic impact of the creative industries, through the medium of the fashion design, at the European Union level. The foreseen result is to highlight the importance of the fashion design sector among the other sectors belonging to the creative industries, at the European Union level.

Keywords: *creative industries, design, fashion design, social and economic impact*

INTRODUCTION

The design is one of the thirteen sectors of the creative industries. Even though the most used definition and classification of the creative industries, especially at the European Union level, belongs to the Department for Culture, Media and Sport from United Kingdom (DCMS), there are few others quite relevant to better describe and understand these industries. One of them belongs to Charles Leadbeater, British author and Tony Blair's former advisor, who believes that creative industries are conducted not by trained professionals, but by creative entrepreneurs which take full advantage of others' talent and creativity. In the creative industries, large organizations provide access to market through retail and distribution, but creativity comes from a lot of independent producers of content [1].

In Romania the term design appeared much later in the 70s, unlike the West, where the design gradually emerged once with the industrialization and the establishment of the Bauhaus School of Applied Arts back in 1919. Unfortunately the Romanian industry is still not fully ready to recognize the design. The country is still in a phase of educating the society about the meaning of design. At the same time one can say about the definition of design that is always on the stage of completion due to the rapidity of the field's movement.

In terms of design trends, there are two main trends [2]:

- ✓ *Luxury design, fashion*, contributing to the maintenance of the society's dream that tends more and more to the expansion of affordable luxury that favors the excessive consumption of products simply from an aesthetic and a "social image" / the "look" necessity. The design is often believed to be expensive and for elite while the today's society is pretending to an individual to be an elite (the capitalist competition's policy). Most design products are related to different well known VIPs, and some of the manufacturers seek new strategies in order to broaden their production, such as to create commercial ideals. Unfortunately, with the help of marketing and advertising he/she succeeds, transforming different personalities in stereotypes.

- ✓ *Efficient design* directs its demand towards the human - social - ecological sphere, for conscious and beneficial evolution. The second category designer focuses on issues of ecology, innovation, the evolution of ideas, of responsibility towards society, not just the surface, but the content also. The trend in the contemporary efficient design is to increasingly involve in the experiment, innovation, scientific research, recoverable energy, futurology area. It is present and is actively involved in interdisciplinary scientific research.

Design's trends are primarily visual projections of an intellectual process on an issue.

DESIGN/FASHION DESIGN: A CREATIVE INDUSTRY SECTOR

Even though there is no specific definition for design, today the term is widely associated with the applied arts as initiated by Raymond Loewy and teachings at the Bauhaus and Ulm School of Design (HfG Ulm) in Germany during the 20th century.

3.1 Types of design

Applied arts have been used as an umbrella term to define the fields of the design, such as:

- ✓ industrial design,
- ✓ graphic design,
- ✓ fashion design,
- ✓ web design,
- ✓ product design,
- ✓ Interior design, etc.

"Industrial Design is a strategic problem-solving process that drives innovation, builds business success, and leads to a better quality of life through innovative products, systems, services, and experiences. Industrial Design bridges the gap between what is and what's possible. It is a trans-disciplinary profession that harnesses creativity to resolve problems and co-create solutions with the intent of making a product, system, service, experience or a business, better. At its heart, Industrial Design provides a more optimistic way of looking at the future by reframing problems as opportunities. It links innovation, technology, research, business, and customers to provide new value and competitive advantage across economic, social, and environmental spheres." [3]

As for fashion design, this was considered to have appeared in the 19th century with Charles Frederick Worth. Worth was actually the first designer to have his label sewn into the garments that he created. So, fashion design is defined as the art of design and aesthetics or natural beauty application in clothing and accessories [4]. Fashion design is influenced by both cultural and social attitudes, and has varied over time and place. Fashion designers work in different ways in designing accessories and clothing, such as bracelets, rings, belts, gloves and necklace. Because of the time required to bring a garment onto the market, designers must firstly Prognose the changes based on the consumer's tastes, desires, at a certain moment.

Considering both that fashion design develops products that usually are subject to serialization, and the definition of creative industries given by DCMS: those activities, products, services which have their origin in individual creativity, craftsmanship, talent and have industrial potential, generating prosperity and job creation through the generation and exploitation of intellectual property [5], fashion design can easily become a part of industrial design.

The question if fashion design is an industrial design or not, often arises around us, mostly in Romania. In this regard, a pertinent answer was provided in the social media by Ioana Avram, lecturer at Bucharest National University of Arts. Of course that "a cloth with a seam and two stripes" is not design. But it can become one if it is controlled from a project point of view, involving marketing, costs, vital themes of the paradigm that responds to, shape, ratio of details (in itself and as a whole with the human body), codes and chromatic structures, fabrics and textures, prints (graphic content, composition), promotion channels, measurement keys, right answer to those who would want this object's aspirations, but that cannot express themselves what they want, the fine relationship, almost merging, with the textiles and prints' creators, with the buttons' designers, or with the technology. There is also a very good chance that, on the basis of all the above, and many other criteria, consciously accepted and fulfilled, "a stitch cloth with two straps" becomes a serious luxury prototype or product based on profitable investment. "It is a project that does not differ from a plane draft than the breadth and complexity", assures Ioana Avram.

3.2 The social and economic impact of Fashion design at EU level

The literature offers different classifications of the creative industries, in which fashion design can be found in three ways:

- ✓ as design, including fashion as well,
- ✓ as fashion design, separate from the design's other activities
- ✓ or just as fashion.

For example, in the classification offered by the International Trade Centre [6], and DCMS [7] the terms fashion and design are considered separately, both being part of the Visual Arts group. United Nations Conference on Trade, Art and Development classification refers to fashion as a part of the design's group.
Regardless of the classification, Thorsby establishes fashion's place in the market with the help of The Concentric Circles Model that he proposed. According to this, fashion is placed in the second outer layer, the layer that includes economic activities that operate outside the cultural sphere, but whose products have a significant cultural size, together with advertising, tourism, architecture and design. The first outer layer includes those industries whose products qualify as cultural products, but which also produce other non-cultural goods and services (editorial and publishing work, television and radio, journalism and film, as well as new activities such as computer games). The core consists of traditional creative arts (music, dance, theater, literature, visual arts, crafts, and new forms such as video art, computer art and multimedia, etc.), often subsidized by public authorities [8].

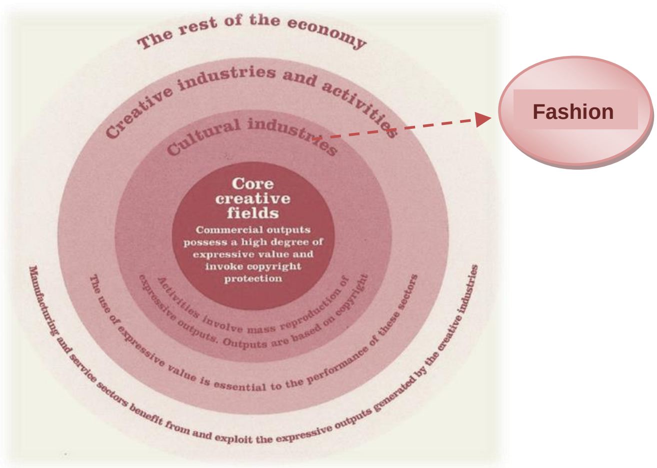

Figure 1: The Concentric Circles Model proposed by the Work Foundation (Source: Flew, 2012, p. 26)

The businesses that can be found in the fashion sector, as part of the creative industries, are mostly very small businesses, with only one to three employees. Actually, most businesses from creative industries are very small micro SMEs. Even though large-scale enterprises are less than one percent, statistics have proven that they are responsible for more than 40% of the annual turnover.
According to Eurokleis (2009), Fashion is the creative industry sector that registered, at the European Level [9]:

- the most workers employed: 2.230.534 (31,41% of total employees), followed by Design with 1.428.645 employees (20,12% of total employees), and Architecture with 762.142 employees (10,74% of total employees). This first position of the fashion sector may be explained by the inclusion of the retail sector.
- the largest industry turnover: 248.189.494 TH EURO, or 24% of the total revenue, followed by Design (157.115.932 TH EURO) and Radio&Television (155.192.531 TH EURO).
- 51% of the fashion companies consist of less than 4 employees, being responsible for the 9% of the total revenue.
- 27% of the fashion companies consist of 4 to 10 employees.
- 3% of the fashion companies consist of 50 to 249 employees, being responsible for 50% of the total revenue of the sector.

Some of the largest competitive players can be found in the fashion design sector. At the European Union level, France and Italy are very famous for fashion design. Also, in Spain fashion is the most important economic sector and together with related activities: design, fashion, food and taste, and handicraft industries, contributes more than 50% of employment above the whole sector [10].

One cannot talk about fashion design without mentioning the world's two largest luxury groups: LVMH and PRR, which are based in France, world leaders in terms of turnover, together with Prada Group, and Giorgio Armani Group both based in Italy (Milan).

Table 1: Revenues of top 4 European leading fashion groups in 2005 [11]

Europe's fashion leaders	Revenues 2005 (euro million)
LVMH: Louis Vuitton, Christian Dior, Givenchy, Fendi, Kenzo, Donna Karan	4,812
PPR: Gucci, Yves-Saint-Laurent, Balenciaga, Sergio Rossi	3,036
Prada Group	2,750
Giorgio Armani Group	1,428

As in France and Italy, fashion sector in the UK has a great contribution to the country's creative economy. It is known as the largest employer of all the UK' s creative industries, estimated to have supported 797,000 jobs in 2014. The UK fashion industry's direct value to the national economy has increased from £21bn in 2009 up to £29bn in 2014, according to Oxford Economics' data (British Fashion Council). It was also estimated the fact that fashion's wider contribution to the UK economy in influencing in other industries has risen from £37bn in 2009 to over £46bn in 2014 (a 23% increase) [12].

CONCLUSIONS

Fashion design plays an important role in promoting the Europe's image as a creative hub. London, Milan and Paris have been recognized for a very long time so far, on a global level, as capitals of fashion. Besides these, Europe is also the home to a series of large and small fashion houses which offer a significant contribution to local and nation creative economies. The added-value of design is not limited to aesthetic characteristics, but impacts the whole production process.

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BUSINESS ECOSYSTEM HEALTH: LINKING PERFORMANCE TO ACTORS ROLES

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Abstract: *Various interdisciplinary theories were developed based on ecosystem’s analogy. Although current research points out clearly the structure of business ecosystems, analogy usage within different industries, the relations between ecosystem’s actors, there still remains the necessity to define and analyse how opportunities can be created and identified based on collaborative relations within this structure. From this point of view there will be presented literature review of business ecosystem health, the term which was further researched and embraced the means of vitality or performance. Based on performed review, there will be highlighted the most relevant theories concerning ecosystem performance assessment based on three main criteria: robustness, productivity and niche creation. Thus the main outcome of this paper is to emphasise the linkage between performance measurement criteria and actors’ roles within a business ecosystem.*

Keywords: *business ecosystem, performance indicators, ecosystems healthiness, robustness, productivity, innovation, interconnectivity*

INTRODUCTION

Business ecosystem’s health (BEH) was proposed for the first time by Iansiti and Levien [1], [2] as an alternative for performance assessment, by borrowing the term from ecology theory. The authors took in consideration the major importance of interrelated actors and their affiliation to a specific keystone within their ecosystem [2], [3]. However they pointed the importance of the assessment mechanisms and assessment criteria rather than conceptualization and definition of the term [1]. According to Iansiti and Levien assessment framework, business ecosystem health depends on position of the actors within business ecosystem, their roles and mutually beneficial interactions among them [1]. Wan et al. introduced the importance of stability, collaboration and control within health definition [4]. Similar to Iansiti and Levien, the authors emphasise the importance of collaboration between ecosystems’ actors, but they considered as crucial the methods and mechanisms for health assessment.

As the main objective of a business ecosystem, there are opinions that suggested that BEH represents the ecosystem capability to create products and / or services continuously and efficiently [5]. Basically the ecosystem itself is important for performance assessment rather than its actors, as an ecosystem can be characterised by stability, resilience and sustainability [6].

Li, Li and Zhang suggested that not only actors activity is important, there should be taken into consideration also actors’ results in order to understand and define business ecosystem health [7]. From this point of view, BEH can be defined and assessed as sum of individual performances of its actors [8], [9]. The collective effort seems to gain recognition and importance as each actor within an ecosystem is highly specialised and actors’ interconnectivity is encouraged through collaboration [3], [9].

Another relevant aspect for BEH assessment is presented by the existence of keystones within an ecosystem [2], [10]. Their existence can be essential for evaluation and measurement of individual performances, as keystones acts as attractors for niche players and can influence individual performances [11].

From this point of view it can be summarised that business ecosystem health represents a common effort of interrelated actors, and can be assessed through individual results of ecosystems’ components. However, there remains undefined clearly a common framework for business ecosystem performance evaluation.

BUSINESS ECOSYSTEM HEALTH ASSESSMENT

Iansiti and Levien pointed that BEH assessment depends on continuous opportunity creation. From this point of view, the authors proposed a framework based on three main evaluation criteria: productivity, robustness and niche creation [1]. There should be mentioned that an essential premise for criteria proposition is that each actor adopts specific behaviour concerning new technology development [12], which the authors identified as actors' roles: keystones, dominators and niche players. According to Iansiti and Levien BEH assessment framework, productivity refers to the produced benefits within the ecosystem. As well as in case of productivity, robustness depends on keystone presence within the ecosystem. Basically this criteria reflects the ecosystem's survival rates concerning competing innovation [12]. Niche creation, on the other hand, derives from the ability to develop new dynamic capabilities (tangible or intangible resources) through continuous innovation [12]. Iansiti and Levien criteria definition can be seen in figure 1.

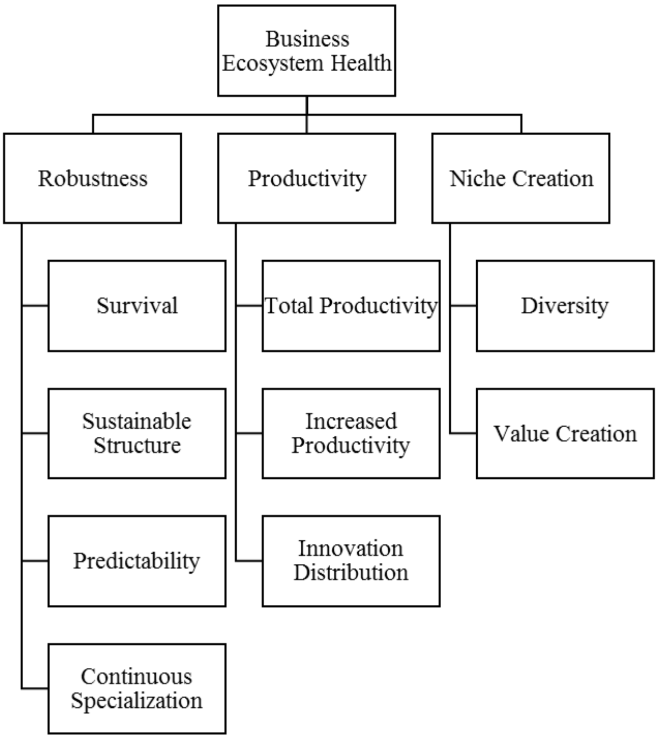

Figure 1: Business Ecosystem Health Assessment Criteria by Iansiti and Levien [12]

Iansiti and Levien health assessment criteria were adopted by other scholars (table 1).

Table 1: Business Ecosystem Health Assessment Frameworks [4], [8], [9], [13]

Author	Criteria	Key features
Kim, Song, Rhee (2010)	Productivity	Actors' value adding activities Simplified common objectives Ensures actors' interconnectivity
	Robustness	Retaining and gaining new actors within the ecosystem
	Expansion	Opportunities identification and assessment
Anggraeni, Den Hartigh and Zegveltd (2007)	Productivity	Network ability to transform existing resources into value adding activities Essential are the features which implies the power of relations and integrity
	Robustness	Network ability to resist technological influences Resilience and network complexity
Wan, Zhang, Wan și Luo (2011)	Stability	Resistance mechanisms to the change
	Sustainability	Exploration and exploitation of ecosystem's own potential

Author	Criteria	Key features
		Ecosystem vitality
Ben Hadj Mhadia (2013)	Productivity	Establishes inter - organisational processes Attracting new members
	Robustness	Resistance to external threats Ensures information and experience flows between actors
	Creativity	Product diversity so that ecosystem can provide choice options Encourage the actors' innovation
	Clients satisfaction	Use the satisfaction metrics Can be measured by ecosystem's actors

Opposite to the theories presented below, is the BEH assessment framework introduced by Li et. al. [7]. According to their vision, business ecosystem health assessment can be realised by taking into account ecosystems life cycle theories. The authors' proposed new framework based on life cycle attributes linked with ecosystems functions and structure [9]. According to their vision BEH assessment can be realised through ecological attributes (include features from the analogy with ecology and complex adaptive systems theories), structural attributes (actors proximity and affiliation to the core organisation, comprise also support and complementary mechanisms), functional attributes (include key aspects concerning platform development, vitality and creativity, financial value adding activities), operational attributes (reflects ecosystems' growing and development activities, ensures ecosystem functionality), life cycle attributes (includes features and metrics related to each stage of business ecosystem life cycle).

2.1 Productivity

Represents an essential criteria for the process of transformation of existing resources [8], [13]. The actors' interconnectivity, orchestrated by a keystone, is the key aspect in productivity definition. According to the current theories, productivity can be defined by specific metrics such as (table 2): *total productivity* (increasing benefits and reducing costs; can be evaluate through common effort – individual performances) [4], [9], [13]; increasing productivity (innovative mechanisms for efficient resources conversion [7] and innovation distribution (instruments created and designed for ecosystem monitoring and its compatibility with interrelated actors) [4], [12].

Table 2: Productivity Criteria for BEH Assessment [4], [8], [9], [13]

Assessment Criteria	2nd Level Criteria	Metrics / Indicators	Correspondent Role
Productivity	Total Productivity	Benefits	Keystone
		Cost Reduction	
		Summarised performance	
	Increased Productivity	Innovative Mechanisms	
		Actors , interconnectivity	
		Resource Conversion Efficiency	
	Innovation Distribution	Innovation Instruments	
		Platform Compatibility	

2.2 Robustness

Robustness represents an assessment criteria related to ecosystems' resistance against external influences or threats. However, resistance is defined from network perspective in terms of density, connectivity or relatedness of actors [13]. Li et. al. pointed that in combination with stability metric in can represent the vitality of business ecosystem [7]:

Resistance + Stability = Business Ecosystem Vitality

For this criteria, actors positioning within its ecosystem (specific niches, markets or business networks) is essential, as the resource or experience flows depends on actors continuous specialisation [8]. Jansen et. al. proposed as assessment indicator recovery rate, where resilience is defined as ecosystem ability to recover and surviving rate in case of missing keystone [14].

Table 3: Robustness Criteria for BEH Assessment [8], [13], [14]

Assessment Criteria	2nd Level Criteria	Metrics / Indicators	Correspondent Role
Robustness	Resistance	Surviving Rate	Niche Players
		Network Density	
		Resistance Mechanisms	
	Stability	Positioning	
		New Entrants Success Rate	
		Resilience	
	Resource Flow	Continuous Experience	
		Resource Diversity	

2.3 Interconnectivity

Interconnectivity can be defined by the actors' ability to engage into collaborative relations, mutually beneficial [8]. This criteria requires the existence of trust and image consolidation mechanisms [7]. Also, this criteria can be related to value creation and promotion in order to gain and attract new entrants into already existing ecosystem [8]. Li et al. pointed that along with operational stability can be achieved through actors' mutual trust and conflict solving aspects [7].

Table 4: Interconnectivity Criteria for BEH Assessment [7], [8]

Assessment Criteria	2nd Level Criteria	Metrics / Indicators	Correspondent Role
Interconnectivity	Symbiosis	Mutualism	Niche Players; Keystone
		Relations Stability	
		Mutual and Beneficial Communication	
	Strategic Clarity	Strategic Orientation	
		Positioning	
		Value Creation	
	Operational Stability	Image and Trust	
		Conflict Solving and Coordination	

2.4 Innovation

Commonly used in case of keystones, niche players and dominators. Iansiti and Levien pointed the importance of diversity derived from the product and / or services novelty rate [12]. Also, within this criteria, there was included adaptability aspects [8] in terms of transformation of threats into opportunities, which contributes to business ecosystem expansion [7], [8]. From this point of view the anchor point within this criteria is the linkage between innovation stimulation mechanisms and ecosystems' actors [8].

Table 2: Innovation Criteria for BEH Assessment [7], [8], [12]

Assessment Criteria	2nd Level Criteria	Metrics / Indicators	Correspondent Role
Innovation	Diversity and Differentiation	Novelty Grade	Keystone, Niche Players, Dominators
		Products Diversity	
		New Markets Entry	
	Adaptability	Adjusting Negative Influences	

		Innovation Stimulation	
		Innovative Management	
	Opportunity Creation	The Type of Innovation	
		Ecosystem Expansion	

FINDINGS, DISCUSSION AND CONCLUSION

Business Ecosystems Health, concept which was borrowed from ecology theory, gained special recognition and provided valuable insights on how can be measured ecosystems' performance.

According to the current research BEH can be assessed only by taking into account the whole ecosystem, its actors and their roles. The key role within an ecosystem is performed by keystone organisations. Their presence can influence the productivity measurement. Although different theories proposed different criteria for business ecosystems' health assessment, just four criteria were identified to be common: productivity, robustness, interconnectivity and innovation. Another found similarity was related to the assessment level. All theories suggested that performance assessment of the whole ecosystem depends not only on the role of actors, but also individual performances.

In terms of interconnectivity, actors' image and mutual trust contribute to the evaluation of established collaborative relations. It can be perceived and applied especially in case of keystone – niche player relation, as first type of actors acts as attractors and develop platforms for other stakeholders within the business ecosystem.

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THE ROLE OF INNOVATION IN COMPETITIVE ADVANTAGE ACHIEVEMENT

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Abstract: *This paper thoroughly examines whether it is possible for an innovative organization to achieve a competitive advantage and where possible, how the internal or external resources and unique core competencies of the organization can be leveraged to achieve this level of competitiveness. Moreover, this article discusses whether companies can turn this advantage into sustainable competitive advantage. It is argued that innovation can generate competitive advantage achievement. We infer there is a complex relationship between the degree of competition and the levels of innovation regarding firms that face intense competition and which, from this angle, show a tendency towards innovation. Joseph Schumpeter's concepts regarding entrepreneurship as innovation resembles much more relevant to our current days, when the dynamic hypercompetitive environment has been facing a serious economic crisis in the context of globalization.*

Keywords: *innovation, competitive advantage, core competence, sustainability.*

INTRODUCTION

Global businesses today face many challenges in the context of the globalization trends which have created a new competition. Competitiveness's structure has been increasingly extending due to organizations successful knowledge and intellectual capital management. Currently generating more than half their revenues from commercial services, while many other services available are based on manual labor, facilitates many opportunities to leverage enabling technologies to provide efficient and agile innovative services and products. Most often, a company achieves superiority through innovation. Innovative products, processes or new business models all offer a dominant competitive detachment due to the player's edge of initiating the first move. We started the synthesis of our paper by introducing the Theory of Innovation pioneered by Professor Joseph Schumpeter (1934), as a driving force of economic development, then we persevered on defining the concept of competitive advantage that can be achieved internally or externally as valuable resources, capabilities, dynamic capabilities, position within the industry or market, lower costs and differentiation (Reed & DeFillippi, 1990), all these shaping the form of competitiveness that implies an accumulation of economic, social, and policies which contribute to the welfare of a country (Lopez- Claros et al., 2007: 3).
Our main objectives are:

- Identifying research trends in the areas of competitiveness and innovation management;
- Identifying contributions of international and national scientific research in the development of competitiveness and innovation;
- Undertaking a critical analysis of these perspectives and outline our own view in respect of their meaning and interpretation. The essential contribution of the study is to introduce more concepts and methods through which organizations can support their competitive strategies and can measure and sustain their innovations on a large scale.

LITERATURE REVIEW

2.1 Theoretical concepts on innovation

We begin the paper by rendering a concise literature review. On the whole, Professor Schumpeter's theory suggests that the entrepreneur who, in short, has the qualities of a leader who influences the economy's circular flow which, ruling out any type of innovations and innovative activities leads to a stationary state. Schumpeter states that "creative destruction" is "the essence of capitalism" (1942) where change is the essence of economic growth. According to Schumpeter's seminal work, the entrepreneur's main feature, that of "carrying out innovations is the only function, which is fundamental in history" (1939). Half a century after Schumpeter introduced "The theory of economic development" and a decade after his death, around 1960, there was a real rising interest in researching innovation. Considerably important contributions appeared from various research disciplines, such as economics (Nelson, 1959 Schmookler, 1966), management (Penrose 1959; Burns & Stalker, 1961) and sociology (Rogers, 1962). Starting from that point forward, this field research proliferated and experienced a particularly strong increase in the year 1990.

Subsequently to the original key contributions of Schumpeter (1911, 1942) and Nelson and Winter (1982), research regarding the innovation process has focused on business innovation. A great part of literature with respect to innovation at the entrepreneurship level includes a variety of subject matters such as the sources of innovation (Leonard-Barton, 1995; von Hippel, 1988), innovation processes (Rosenberg, 1982; Kline & Rosenberg, 1986), diffusion of innovation (Rogers, 1962 Mansfield, 1961, 1985), innovation networks (Freeman, 1991; Powell et al., 1996), knowledge and learning (Arrow, 1962; Cohen & Levinthal, 1989 1990; Grant, 1996; Nonaka & Takeuchi, 1995; Senge, 1990), resources and capabilities (Penrose 1959; Barney, 1991; Teece et al., 1997; Wernerfelt, 1984), the behavior of firms (Cyert & March 1963 ; Greve, 2003), strategies (Brown et al., 2000; Chandler, 1962; Porter, 1980; Kanter et al., 1997), success and failure (Christensen, 1997; Henderson & Clark, 1990; Rothwell et al., 1974), competitiveness (Teece, 1986; Prahalad & Hamel, 1990), economic growth (Dosi, 1988) , technological change (Mansfield 1968; Mansfield et al., 1981), organizational change (Burns & Stalker, 1961; Romanelli & Tushman, 1994) and strategic deployment of quality-improving innovations (Luís Almeida Costa & Ingemar Dierickx, 2005).

Innovation is generally regarded as the main engine of economic growth in today's global economy. By introducing practical innovations we can obtain products acquiring improved quality features, service quality, new and enhanced production processes, more efficient and uncluttered (green) advanced models of business management system, modern management and workforce methods, sustainable environments, higher education etc. The ramification of Schumpeter's innovation theory proposed long ago, initially focused on the role of small-sized firms as the true source of change, has been apprehended as entrepreneurs being able to submit radical innovations on the market that could ruin the value of existing firms ("creative destruction," Schumpeter, 1911). Later on, he presented a second theory where he fully emphasized the relevance of knowledge and other resources accumulated by the large companies, for example, through research and development, in the course of their innovation ("creative accumulation", Schumpeter 1942: 84).

Knowledge is widely perceived as the engine of economic growth (Griliches, 1979; Grossman & Helpman, 1993; Romer, 1986, 1990). Conceivably the most striking characteristic of knowledge in comparison with other economic assets is the tendency to generate strong externalities (Foray, 2004). As a result, the productivity of investing in science symbolizes a complex function that includes existing knowledge as external inputs (Cohen & Levinthal, 1990; Jaffe, 1986, 1989). Therefore, for all we know, considering the diffusion of knowledge and its impact on innovation attainment is paramount, in order to uncover the underlying mechanisms that lead to economic development.

The term "innovation capability" is observed on different levels and from different perspectives, depending on market conditions and strategic guidelines of the company (Guan & Ma, 2003; Martinez-Roman, & Tamayo Gamero, 2011). In order to foster innovation, it is imperative to examine the influence of external and internal determinants on innovation (Zirger & Maidique, 1990; Neely et al., 2001; Llorens, Ruiz & Garcia, 2005; Hjalager, 2010).

Building on the idea of the entrepreneur disturbing the equilibrium and representing the prime source of economic development, comes the six-year study of Professor Clayton M. Christensen (2009) from Harvard Business School, which has led to the identification of five "discovery skills" that distinguish great innovators of the other corporate executives: associating, questioning, observing, networking, and experimenting. Dyer, Gregersen and Christensen (2009) found that innovative entrepreneurs (Chief Executive Officers) spend up to 50% more time on these cognitive and behavioral skills than other CEOs who do not have any track record in terms of innovation. Together, these skills embody what the authors call the "innovator's DNA." They distribute these skills into two categories: action and thinking, which allows innovators to look beyond the borders of conventional aspects and to consider new possibilities. Concluding their article published in Harvard Business Review, the authors stated that: "Innovative entrepreneurship is not a genetic predisposition, it is an active endeavor" (ibid), in the sense that one can mold into an innovative entrepreneur, without being born with these extraordinary skills.

Professor Christensen is also the precursor of the disruptive innovation theory which explains "the phenomenon by which an innovation transforms an existing market or industry by introducing simplicity, convenience, accessibility, and affordability where complication and high cost are the status quo. Initially, a disruptive innovation is formed in a niche market that may appear unattractive or inconsequential to industry incumbents, but eventually the new product or idea completely redefines the industry. (Christensen Institute, 2015, paragraph 2).

In an article published on Harvard Business Review Clayton M. Christensen, Michael E. Raynor and Rory McDonald give the definition of "disruption" which describes a process whereby a smaller company with fewer resources is able to successfully challenge established incumbent businesses (p.1). As described by Christensen et al. (2015) disruptive innovations set in motion in low-end or new-market footholds and one

must regard disruption as "a positive force that make products and services more accessible and affordable, thereby making them available to a much larger population" (Christensen Institute, 2015, paragraph 2).
Three notable critics of Professor Christensen's disruptive innovation, namely Constantinos Markides, Constantinos Charitou and Jill Lepore, found Christensen's theory flawed mainly because "different kinds of innovations have different competitive effects and produce different kinds of markets" (Markides, 2006). Constantinos Markides concurs with the idea that these innovations are disruptive to incumbents, but he strongly recommends that they must be "treated as distinct phenomena" (p. 19).
Peter Thiel, a technology entrepreneur and investor, co-founder of PayPal and Palantir Technologies, argues that, currently, disruption has come to mean something entirely different: "disruption has recently transmogrified into a self-congratulatory buzzword for anything posing as trendy and new. This seemingly trivial fad matters because it distorts an entrepreneur's self-understanding in an inherently competitive way" (2014: 44).

2.2 Innovation dimensions

In their quest to understand the process of innovation within organizations, Pelz, Jenstrom and Munson (1978) set a broad conceptual framework of three dimensions (p. 35): characteristics of the innovation as a product; stages of the innovation process and key actors in the innovation process.

A broader perspective on innovation dimensions is described in the article "The 12 different ways for companies to innovate" published in MIT Sloan Management Review (2006) by Mohanbir Sawhney, Robert C. Wolcott and Inigo Arroniz from Kellogg School of Management. The authors identify a new framework of twelve dimensions of business innovation, namely: offerings, platform, solutions, customers, customer experience, value capture, processes, organization, supply chain, presence, networking, and brand. Figure 1 presented below shows four key dimensions of innovation – "WHAT?", "HOW?", "WHERE?", "WHO?" - and eight additional dimensions taken into consideration for a fully detailed outlook of product innovation, where the ultimate goal is to generate a sustainable profit by increasing revenues, reducing costs differentiation, and sustained differentiation.
Nowadays companies improperly perceive innovation only as synonymous with novel product or service advancement or the conventional research and development way. This constricted vision may have a serious impact on the methodical disintegration of competitive advantage, leading to the theory that firms competing in the same markets start to gradually exhibit some similarity[3].

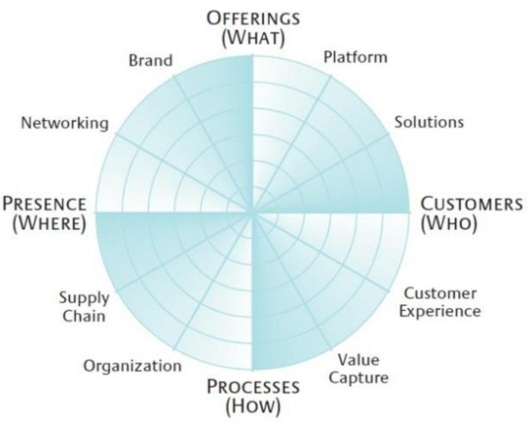

Figure 1: Innovation radar

(Source: Robert C. Wolcott si Michael J. Lippitz, 2006)
Throughout history invention duplication and multiple discoveries proved to be the common and logical results of scientific and technological progress (e.g. Galileo Galilei claimed the invention of the thermometer in 1596, afterwards also claimed by Van Guericke and Porta in 1606, by Drebbel in 1608, by Santorio Santorio in 1612 and by Paul and Fludd in 1617). Nonetheless, in economic terms, duplication in the fields of research and innovation may depict a concern of great importance (Bonaccorsi et al., 2009; Dasgupta & David, 1994 Jorde & Teece, 1990; Scotchmer, 1991). It can be argued that the overlapping of research and

[3] A process referred to as "isomorphism." M.T. Hannan and J. Freemen, "Organizational Ecology" (Cambridge, Mass.: Harvard University Press, 1989).

development results diminishes the return on investment in research and development (Gómez, 2011; Jones, 2009, 1995; Jones & Williams, 2000; Kortum, 1993, Venturini, 2012). Furthermore, several factors, such as technological advances in communication technologies, could reduce duplication rate of innovation (Brannigan & Wanner, 1983). Additionally, the duplication probability increases along the side of inventors' density and the conglomeration of aggregated knowledge, which creates difficulties for future generations of inventors to come up with novel innovations and discoveries (Jones, 2009). Specifically, Bessen and Meurer (2008) collected data which prove that the number and cost of lawsuits involving patents have steadily increased over the past three decades and concluded that: "a significant and growing number of very expensive lawsuits take place every year, as companies have invested millions of dollars in research, development and technology commercialization allegedly owned by others". The patent system suppresses innovation instead of nurturing it and also discourages business leaders to innovate (Bessen & Meurer, 2008: 121). The authors call out for law enforcers and policymakers to find a rapid and viable solution for stopping this trend as the vigor and competitiveness of the economy depend on it.

2.3 Role of innovation process in gaining competitive advantage

Innovation has created many opportunities for companies not only to improve their current operations and competitive advantages, but also to engage in new ones in order to achieve a greater performance of growing their business (Forsman & Temel, 2011). Today, companies increasingly rely more on innovation to differentiate themselves from actual or potential competitors, to create value for their customers and to intensify growth (Australian Chamber of Commerce, 2011). Innovation requires strong managerial support and entrusting resources (Covin & Slevin, 1991; Cromer, Dibrell & Craig, 2011). Despite the fact that a company proving a higher business growth accomplishment is regarded as having a competitive advantage due to its valuable, rare, and inimitable resources and capabilities, its sustainable competitive advantage may hinge on its innovative capacity (Porter, 1980; Barney, 1991). Companies are able to integrate innovation into their management and organizational practices, within commercial operations which they carry out and their marketing methods (Ghobadian & Gallear, 1996; Vossen, 1998). The connection between economic success and innovation within firms has been highlighted in previous research (O'Dwyer, Gilmore & Carson, 2011). Based on their innovation potential, companies can have a positive attitude in the sense that they see the obstacles as learning opportunities, rather than simply as problems (Mahemba & De Bruijn, 2003). Until now, the extent to which firms know how to take advantage of the innovation process is still questionable, considering their size and the limitation of their resources and capabilities.
In summary, the definition of innovation- according to a traditional source such as the Oxford dictionary- may represent: "Making changes in something established, especially by introducing new methods, ideas, or products". Gemünden & Salomo (2004: 505) defined innovation as: „the results of a creative process involving different actors from one or more organizations, which leads to a qualitatively new means-end combination that is introduced to the market or the operations of a firm for the first time". In addition, Smith & Barfield introduced the differentiation of invention from innovation to the market (1996: 21). In relation to the above mentioned interpretations, innovation bears a temporal and a dynamic aspect, which can make it possible to conceptualize it as a process, a sequence of steps that transform a set of inputs into a set of outputs (Limberg, 2008: 14). Therefore, we may conclude that the fundamental principles of innovation are the ideas that add value both to the customer and the organization.

2.4 Competitive advantage

Noteworthy in the strategy literature review is the fact that competitive advantage can be achieved internally or externally throughout valuable resources, capabilities, dynamic capabilities, position within the industry or market, lower costs and differentiation (DeFillippi & Reed, 1990). The multitude of factors that can contribute to the achievement of such an advantage, makes the term "competitive advantage" hard to explain (Cockburn, Henderson & Stern, 2000). So far, there have been various theoretical frameworks and perspectives formulated in an attempt to explain the competitive advantage. The market-based point of view (Porter, 1980, 1985, 2001), resource-based competitive advantage (Barney, 1991; Prahalad & Hamel, 1990) and the point of view of hyper-competitiveness (D'Aveni, 1994; Brown & Eisenhardt, 1998), are the most well known. Barney's view on competitive advantage at an organizational level defines firms that are "implementing a value creating strategy not simultaneously being implemented by any current or potential competitors" (1991: 102). Further, for Barney and Hesterley, competitive advantage represents the situation when a firm "is able to create more economic value than rival firms" (2006: 12). Pivotal work of Harvard Professor Michael Porter differentiates the concept of competitive advantage into two forms, as two main options available for firms: one is based on reducing costs while the other is based on differentiation (1991).

2.5 Market-based view

The market-based view – or market positioning view – describes the market conditions in the context of developing the firm's strategy. Its antipode is the resource-based view which resorts on the firm's resources and capabilities, assets and knowledge base. Barrett et al. (2001: 2) suggested that the ability of the organization to align its strategies with identified enablers and constraints found in the environment has a great influence on its competitive advantage. According to market-based view the firm singles out the external opportunities and threats with the help of a series of tools and methods such as the Product Life Cycle, Porter's Five Forces Model to assess competition within an industry, Strategic Groups, Porter's Generic Competitive Advantage Strategies, Customer Matrix and Mintzberg's 5P's Model. Competitive advantage occurs when the firm has the ability to provide identical benefits, as its competitors, at a lower price (cost leadership) and / or the firm may offer benefits superior to those offered by competing products (differentiation). Combined, these basic concepts constitute Porter's Generic Competitive Strategies that could be applied to all products or services. "Focus" is the third generic strategy, which is a division of the previous two (Porter, 1985: 11-15). The company usually faces the probability of getting "stuck in the middle", as Porter describes the manager's inability to choose between these strategies, thus losing its competitive advantage and lowering its profits.
Michael Porter's ubiquitous framework of the five forces indicates that an industry's attractiveness is determined by five competitive forces that shape the business strategy development and opportunity for superior performance in an industry, determining its weaknesses. These forces are: rivalry among existing competitors, the bargaining power of suppliers, the bargaining power of customers, the threat of new entrants or the threat of substitutes (Porter, 2008:1).The market-based assets and capacities are oriented versus the market, leveraged through core processes in order to convey superior value and benefits for the customer and simultaneously gaining competitive advantages. One of the most fervent criticisms addressed to market-base view targets the resource homogeneity and its mobility within an industry. Market-base perspective concentrates on the structure of an industry as a condition external to the firm, and thusly it neglects a firm's internal characteristics, structures, and resources (Wolf, 2005: 41).

2.6 The resource-based view

As opposed to Harvard Business School's perspective, the resource-based paradigm underlines the specific, valuable, imperfectly inimitable, non-substitutable and rare resources and capabilities that bestow a competitive advantage on the firm that possesses them (Barney, 1991). Resources may be associated with "stocks of available factors that are owned or controlled by the firm" (Amit and Schoemaker, 1993: 35) and "inputs into the production process" Grant (1991: 118), grouped by Andriessen (2001) into: tangible assets, financial assets and intangible assets. The opinions found in the literature review claim that resources must be levered through capabilities in order to generate a competitive advantage (Eisenhardt & Martin, 2000), as there is a key difference between resources and capabilities; resources are inputs into the production process and the organization has ownership over them, while capabilities refer to an activity that a set of resources can perform (Grant, 2005: 119). Grant also defines the resource as being the source of capability and the capability as the basic originator of the firm's competitive advantage.
Prahalad and Hamel (1990) promoted the resource-based view through their paper "The Core Competence of the Corporation" and consider that the firm's competitive advantage draws from its core competencies difficult for competitors to reproduce (activities, internal organizational structure, where collective knowledge is essential); it is more feasible to reinforce the skills and resources into competencies that support the company to adapt rapidly for each different opportunity. The two major inferences of the resource-based perspective - as an "inside-out" strategy defining process - are that resources must also be heterogeneous Peteraf (1993) and immobile Hall (1993) in order to secure the longevity of the company's competitive advantage.
The resource-based view as regards to innovation argues that a firm through its own resources and skills provide a solid ground for successful innovative strategies, developing unique configurations of resources (Davies & Brady, 2000). Baumol (2002) expressed the dependency path of innovation, as a cumulative process which "leads to economic developments, which in turn stimulate and facilitate the innovation process" (p. 284). In the phrase "innovation breeds innovation" we can actually visualize an idea leading to another idea and so on and so forth.

2.7 Sustainable competitive advantage

In 1984 the concept of a "sustainable competitive advantage" emerged, altogether with Day's types of strategies that may help to "sustain the competitive advantage" (p. 32). In a broader sense, in 1985 Porter elaborated the fundamental types of competitive strategies developed by firms (cost leadership or

differentiation) in order to achieve it. We may argue that the fundamental basis of a successful firm on a long period of time is the achievement and maintenance of a sustainable competitive advantage
A number of strategists (Fiol, 2001; Useem, 2000) doubted that sustainable competitive advantage based on any particular core competency even existed. Achieving it was not possible, even less so to maintain it; the advice given was that organizations should create constant competitive advantages. This specific strategic technique was characterized by Useem as „Renewable Competitive Advantage‟ or „Leverageable Advantage‟, in the sense of "using one temporary position of strength to hopscotch into another" (2000: 104). This article agrees upon Jay Barney's understanding of the formal conceptual definition of the sustainable competitive advantage: "A firm is said to have a sustained competitive advantage when it is implementing a value creating strategy not simultaneously being implemented by any current or potential competitors and when these other firms are unable to duplicate the benefits of this strategy (1991: 102). Deducing from the above, it is obvious that there is a need for transformation within the organization so that it can become more qualified and dynamic on the marketplace.

RESULTS

The results of McKinsey and Co. global study show that "80 percent of executives say innovation is extremely or very important to their companies' growth strategy". The 2010 survey gathered 2240 responses from executives around the world and indicated that innovation has turned into a priority. Furthermore, the need to innovate the organization seemed fundamental for 42 percent of the executives who stated that this alone would a higher performance of their business.
Emulating Tidd's assertion while depicting innovative organizations as those that survey the environment to assimilate and refine the information in regard to potential innovation (Tidd et al., 2001), we discovered that: "conceptually, it is not difficult to identify the contribution that innovation can make on competitiveness" (Tidd, 2001: 169), as shown in Table 1.

Table 1: Innovation and competitive advantage

Type of innovation	Competitive advantage
Disruptive	Rewriting the rules of the competitive game, creating a new "value proposition"
Radical	Offering a highly novel or unique product or service, premium pricing
Complex	Difficulty of learning about the technology keeps entry barriers high
Continuous incremental innovation	Continuous movement of the cost/performance frontier

Source: Tidd, J. (2001: 170)

Also Tidd (2001) discussed the methods of empirically measuring the effect of innovation in relation to performance, as being weaker at a firm level, as opposed to an industry level. One method to weigh in the innovation is cumulating the public sector indicators, such as: "research and development expenditure, number of patents and new product announcements". The second method implies a more far-reaching spectrum of indicators such as: "the proportion of technical, design or research personnel and the proportion of sales or profits by products launched in the past three to five years" (2001: 170). There has always been a level of uncertainty and randomness related to these indicators and the literature review has stated that we cannot find a sole outstanding way of measuring innovation.

CONCLUSIONS

We may conclude that significant progress has been made over the last decade on the subject of conceptual defining the implication of innovation as the core provider of a firm's sustainable competitive advantage in the strategy filed.
On the whole, innovation has proved to have the potential to globally address social, environmental and human challenges. Nowadays the business industry strives to eliminate the tradeoff between domains such as health, environment, safety, and short-term economic growth through a more aware approach on innovation so that new technologies will sustain this goal and overcome the current shortcomings. According to Porter and Stern (1999) innovation has been identified as "perhaps the most important source of

competitive advantage in advanced economies, and building innovative capacity has a strong relationship to a country's overall competitiveness and level of prosperity" (p.15).
To create a sustainable future there is an urge for fundamental changes in the attitude and behavior of society and entrepreneurship both at individual and universal levels. The change is successful when there is a real understanding of individuals, of their habits and their motivations, and through a set of innovative strategies being able to enable a competitive environment which creates values that contribute to growth and well-being.

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TRENDS OF OBSTACLES TO INNOVATION IN ROMANIAN FIRMS

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Abstract: *Innovation matters for economic development in every country. Improving our knowledge of firms' activities in aspects associated with their behavior and determinants related to innovation is important in monitoring the strengths and weaknesses of the national innovation systems. This paper analyses the evolution of the main obstacles encountered by Romanian innovative firms. Our concern is justified by the fact that Romania has been consistently situated in the modest innovators group according to the composite indicator of innovativeness (EIS, European Innovation Scoreboard) in the period 2006-2015. Despite of the difficulties that can be encountered in terms of available data structured according to the main findings in the literature associated to obstacles to innovation and their variable structure over time, a qualitative analysis can be conducted which can reveal the existence of persistent weaknesses which adversely affect innovation in firms. Using two consecutive intervals by using CIS 7 and CIS 8 data, new factors and persistence of previous obstacles to innovation are shown. Innovative firms are negatively affected by the lack of adequate finance which can negatively impact the dimension and the structure of innovation expenditure. Moreover, the lack of adequate finance is a persistent factor that reduced drastically the number of innovative firms. Other persistent factors are related to firms' market, but the variable structure of data does not allow the main elements of persistence to be specifies. In the same context, new factors of hampering innovations are identified, such as the lack of qualified personnel and high costs of meeting regulations. We discuss the measures that can be adopted by government policies and show that availability of adequate data is very important in order to implement successful measures*.

Keywords: *development, innovation, obstacles to innovation, firm, Romania, trends.*

INTRODUCTION

Innovation is source of advantage to firms, allowing them to survive and grow on the national and international markets. The interrelation between the ability of firms, industries and nations to advance technologically and the long-term economic performance has become obvious in the modern society. This is why a growing interest of many governments is manifested to track the innovation indicators systematically and monitor the strengths and weaknesses of the national innovation systems.

Currently, the literature on the factors that affect the decisions of firms to innovate is well developed, including empirical studies using firm-level data in that framework as well. Despite the increasing number of studies (a survey is conducted by Smith, 2006), they have been made especially in European leaders and major innovators countries (Mohnen et. al, 2006; Mairesse and Mohnen, 2002 etc.). Few studies on the firm innovativeness and factors affecting innovation, including obstacles to innovation, have been conducted on the case of CEE countries.

Maybe one reason of the few existing studies related to factors hampering innovation can be found in the lack of available data. For example, an important source of data is Commission Innovation Survey (CIS) conducted by Eurostat, which centralizes data every two years, the last were published in 2015, it refers to the period 2010-2012 (CIS 8) and provides information including on barriers to innovation resulting from interviewing both innovative and the non-innovative firms. CIS 8 incorporates aspects such as the market (dominant market share held by competitors, strong price competition, market demand, strong competition), costs of meeting regulations, availability of qualified personnel and adequate finance. In the same context, CIS 7 which corresponds to the interval 2008-2010 includes dimensions associated to the market (information on markets, market dominated by established enterprises, demand for innovative goods of services), technological opportunities (information on technology, difficulty in finding cooperation partners), financing innovation (lack of funds within the enterprise or group, lack of finance from sources outside of enterprise, innovation costs too high), the lack of qualified personnel. Separated data referring to a unique interval can be used in identifying hampering factors to innovation in various countries and sectors or by firms size. However, despite their informational content, data provided by Eurostat cannot be used in time series analysis, given the fact that many elements in their structure vary significantly. Their comparability would be beneficial in terms of a better understanding of the obstacles to innovation due to the (major) changes operated in its structure. On the other hand, data available for a longer period of time are missing. In this respect, only CIS 4, CIS 7 and CIS 8 centralizes information on barriers to innovation.

Nevertheless, an overview of the main characteristic aspects can reveal the existence of persistent weaknesses which can adversely affect innovation in firms. In this case, the qualitative analysis of data on two consecutive intervals, by using CIS 7 and CIS 8 data, can highlight the difficulties faced by firms at the beginning of the economic crisis in 2008.

We look on how the main obstacles encountered by the Romanian innovative firms evolved in this period of time. Our concern is justified by the fact that Romania has been consistently situated in the modest innovators group according to the composite indicator of innovativeness (EIS, European Innovation Scoreboard) in the period 2006-2015. Section 2 reviews the literature on the factors affecting innovation in firms and the main constraints faced by innovative firms. Section 3 analyses trends in the main obstacles to innovation activity in Romanian firms and section 4 concludes.

LITERATURE REVIEW ON INNOVATION FACTORS AND BARRIERS

The innovation process of developing of new products and services needs funding resources. The investment projects in the field of innovation have some characteristics (Hall, 2009 and 2010; Hall and van Reenen, 2000) which condition their adoption by firms, such as the market size (Schmookler, 1966), technological opportunities and appropriability (Jaffe, 1998). All variables differ from one firm to another and they can be functions of the firm's size (Acs and Audretsch, 1991; Cohen and Kepler, 1996; Cohen, 2010).

The firm's size and its incidence on innovation is the subject of countless investigations in the literature aiming at testing in differences on enterprise groups. In this respect, clear evidences exist regarding the relative advantage of large firms through greater opportunities for funding of high-risk R&D projects, obtaining higher yields to the total turnover on which the fixed costs are spread or, due to complementarities between R&D and other activities that are seen to be developed more easily in large companies, and higher capacity to diversify business yields and reducing risk of innovation activity. Counterarguments have also been suggested (especially in Scherer and Ross, 1990) in associating of the large enterprises with the diminishing of managerial control or, conversely, with an excessive control that would not be favorable to research caused, inter alia, by the lower salaries to individual researchers and reducing of creative impulses.

Over time, the research on the relationship between the firm's size and R&D expenditure has generated lots of models starting, in one form or another, from the assumptions summarized above, followed by their testing using the R&D intensity as the dependent variable and a measure of the firm's size as regressor. R&D increases proportionally with the firm's size in association with a lower increase in output (Cohen et al., 1987; Lerner, 2006) and R&D productivity is reduced when the firm's size increases (Acs and Audretsch, 1991). Also, although it is suggested that the large firms have the advantage of sharing of fixed costs in achieving yields from R&D, that feature results from their better capacity of revenue collection, so that the relative disadvantage of small firms can be mitigated by technology licensing or by rapid growth due to innovation (Cohen, 2010).

Regardless of its size, the firm must have *financial resources* in order to innovate. An increase in the proportion of R&D expenditure of total funds involves features in projects financing. As an investment activity, R&D distinguishes from other investments in real assets. First, a significant amount of financial resources are allocated to the staff (scientists and engineers) salaries. Their efforts to the increase to knowledge and creation of intangible assets are sources of future profits for firms, but these adjustment expenses can be made over time (Hall, 2009, 2010). Second, the R&D investment is expected to generate larger net revenues with higher standard deviation. Uncertainty is higher when the projects are implemented, which implies that the R&D strategy has an options-like character and should not be analyzed in a static framework. Also, investments are made over time, new information arrives, which reduces or changes the uncertainty. The consequence of this fact is that the decision to invest has to be reassessed throughout the life of the project. Third, innovation does not imply only significant amount of financial resources, but also determines the decrease in guarantable assets, alongside the increase in proportion of intangible assets that are incorporated in the human capital, determining that the debt financing to be inadequate as the R&D increases of the total expenditures. Innovation by adopting new technologies and processes incorporates training costs of personnel, and registers non-recoverable expenses as well. The uncertainty nature of returns to innovation and the intangible character of the assets determine that the financing of innovation to be more difficult than ordinary investments by using financial market mechanisms.

The increase in capital costs due to the perceived risk at the capital providers' level can be a consequence of the decrease in internal financing resources. A higher cost of capital and its size above the rate of return (expressed more strongly for R&D) involve discouraging innovation by reducing expenditure. The financial markets are recognized to be imperfect, resulting low investment expenditures that are manifested especially in small firms.

The innovation expenditure can be correlated with the *product demand* on the market. A part of the literature is focused on the effects of market concentration on innovativeness. The various theoretical models have adhered either to the Schumpeterian position that firms in concentrated markets have pronounced propensity to innovate or, on the contrary, it is argued (Gilbert and Newebery, 1982) that firms with monopoly power are more innovative and aim at avoiding the costs associated with the loss of market power and entry of new companies in the markets space. Initially, the empirical models have investigated simple causal links, often between R&D expenditure and market concentration (expressed as market share) with non-convergent results.

As Cohen (2010) states, the market concentration (structure) is not itself an independent factor affecting innovation but that can be a function of other variables, including even innovation. As a result, the observed correlation between the market structure and the R&D intensity can reflect either their co-determination and the impact of innovation on the market structure, and those facts create many difficulties in interpreting of the results. Gilbert (2006) suggests that a low incidence of the market structure on innovation in the empirical studies is due to the industrial effects, which blurs the relationship between the two variables, not using of control variables of theoretical importance, the limited data that are used in the econometric approaches or inadequate methods of investigation were used.

Demand, technological opportunities and appropriability are considered explanatory variables "more fundamental" than market concentration (Cohen, 2010) affecting firms' decision to innovate. Since the 1960s, numerous studies have been conducted to assess the importance of the demand as determinant of the propensity of firms to innovate. Market pull type assumptions are highlighted for the first time by Schmookler (1966), suggesting that the demand for new products determines the rate and direction of innovation. The theoretical literature shows two main aspects in which inter-industry differences in demand can affect the inclination of firms to innovate. The first can be related to the market size, as it is shown by Schmookler. Benefits from product or process innovation are proportional to the size of the market. Inventiveness will intensify on the largest market when the cost of capital is constant; innovation will intensify as market is expected to grow rapidly. The second can be linked to the price elasticity of demand, that can affect the marginal return to R&D investment. The benefits of reducing production costs (process innovation) are even higher as the demand is more elastic. On the other hand, the gains from product quality improvement (through product innovation) will be even higher as the demand becomes more inelastic. Both the current market size (that, in general, has the greatest impact on the introduction of new products) and future (projected) market size influence innovation (Acemoglu and Linn, 2004).

The technology push approach emphasizes the importance of *technological opportunities* as determinants of innovation. The concept of technological opportunity incorporates a variety of phenomena, including the possibility of transformation of knowledge into new products or processes, interactions with third parties (other firms, customers, suppliers, research institutions) that generate innovation activities, as well as easiness of knowledge externalities exploitation etc. Even since the 1970s it was emphasized the importance of acquiring of new knowledge in innovation. In particular, Nelson and Winter (1982) argue that knowledge narrows the research options and allows attention to be focused on the most productive approaches. The consequence is that the research process is more efficient, fewer attempts are needed and fewer errors are recorded, and fewer options are necessary to be evaluated in order to obtain the desired result. From this perspective, scientific knowledge provides an authentic guide to processes of technological change. Increasing the knowledge that is acquired in other organizations as collaborating firms on the market or higher education and research institutes can have a positive impact on the propensity of firms to invest in R&D, representing an important dimension of industrial technological opportunities. However, the empirical research in this direction is still one minor, and the results on the incidence of various factors on innovation will be different from one country to another. For example, obstacles concerning the availability of financial resources and the technical knowledge are significant for firms in Catalonia (Segarra-Blasco et. al., 2007), the availability of funds and market demand are found as barriers of innovation in UK (D'Este et. al, 2008) etc. Also, the distance from the technological frontier can involve specific barriers; the more firms are closer to it, as the more so their inability to identify qualified staff and partners becomes the main obstacle. The external financing shapes another significant barrier to firms that are far from the technological frontier (Hölzl and Janger, 2011).

TRENDS OF THE MAIN OBSTACLES TO INNOVATION IN ROMANIAN FIRMS

Romania was constantly situated in the group of modest innovators, according to EIS (European Innovation Scoreboard), alongside other countries such as Bulgaria and Latvia in the period 2006-2015, with a trend showing that progress in innovation has not been recorded so that repercussions to be more favorable on the composite index. Data related to EIS evolution based on various sub-indicators, as well as CIS data, World Economic Forum data etc., display realities of significant spreads from various averages in aspects such as much smaller proportion of innovative enterprises of the total firms, the extremely modest size of public and private expenditure of GDP allocated to research and development, the insignificant participation of venture capital to financing of innovative companies and modest innovation output.

However, keeping low and reducing public spending for education and research have serious negative consequences on R&D performance within the innovation system. Although various initiatives have undertaken in order to define the strategic research areas and by trying to strengthen the links between universities and industrial innovation by implementing science parks located in several university centers to promote local economic development, they have remained in a declarative stage in the National Strategy of Research, Development and Innovation since many years. The current weaknesses of the NPRDI consists in R&D underfunding from public resources, the lack a normative framework in assessing the effectiveness of R&D programs, and the poor correlation between R&D and the needs of restructuring and industrial development.

In the same framework, the innovative firms allocate the lowest level of funds for research, below the EU average. That can lead to low capacity to innovate through creative effort, low collaboration with other companies and research institutes and it is an expression of the effects of industrial structure which is dominated by low-tech groups and significant proportion of non-innovative SMEs (Diaconu, 2013).

Innovation in firms remains affected by weaknesses and significant discrepancies compared to the EU average such as the lack of financing from internal funds, equity funds from business angels and venture capital firms, the lack of financial support from public resources, weak collaboration with other firms and public research institutions and fragile entrepreneurship. Obviously, the lack of funding of high risk projects, low technological opportunities resulting from poor collaboration in business, the lack of information on markets etc. are obstacles to innovation intensity, and they vary from one firm to another depending on firm's size, sector of activity, composition of innovation expenditures etc.

The CIS questionnaire includes questions about highly important factor of hampering innovation activities (FH) resulting groups of innovative or non-innovative responding firms according to them, summarized as in the table below:

Table 1: Important factors of hampering innovation in Romanian firms

Variable	Description
CIS 7	
FH1	Enterprises with lack of qualified personnel
FH2	Enterprises with lack of information on technology
FH3	Enterprises with lack of information on markets
FH4	Enterprises with difficulty in finding cooperation partners
FH5	Enterprises with markets dominated by established enterprises
FH6	Enterprises with uncertain demand for innovative goods or services
FH7	Enterprises with no need to innovate due to prior innovations
FH8	Enterprises with no need to innovate due to no demand for innovations
FH9	Enterprises with lack of funds within the enterprise or group
FH10	Enterprises with lack of finance from sources outside the enterprise
FH11	Enterprises for which the innovation costs too high
CIS 8	
FH1	Enterprises considering high costs of access to new markets

Variable	Description
FH2	Enterprises considering innovations introduced by competitors
FH3	Enterprises considering dominant market share held by competitors
FH4	Enterprises considering a lack of adequate finance
FH5	Enterprises considering a lack of demand
FH6	Enterprises considering strong price competition
FH7	Enterprises considering a lack of qualified personnel
FH8	E nterprises considering strong competition on product quality
FH9	Enterprises considering high costs of meeting regulations

Source: Eurostat database (CIS 7 and CIS 8).

According to the CIS 7 data, the firms with technological innovation introduce new or significant improved products or processes. The analysis of the data by types of factors of hampering innovation is shown in figure 1, considering the proportions of firms affected by them depending on the firm's size (small - with a number of employees between 10 and 49; medium - with a number of employees between 50 and 249; large - with more than 250 employers) in manufacturing industries where the innovative firms are more concentrated than in services. We note that the factors assimilated with the cost of innovation incorporate the main obstacles, followed by those concerning the product market. In the same framework, the small firms appear to be the most affected by all factors of hampering innovation, followed by the medium firms. In fact, the total proportion of small innovative firms (13.46%) is much lower than that of the large firms (44.42%) according to the CIS data, and the same characteristics can be found in services (where the proportion of innovative small firms is 10.36%, while large firms summarize 29.69%).

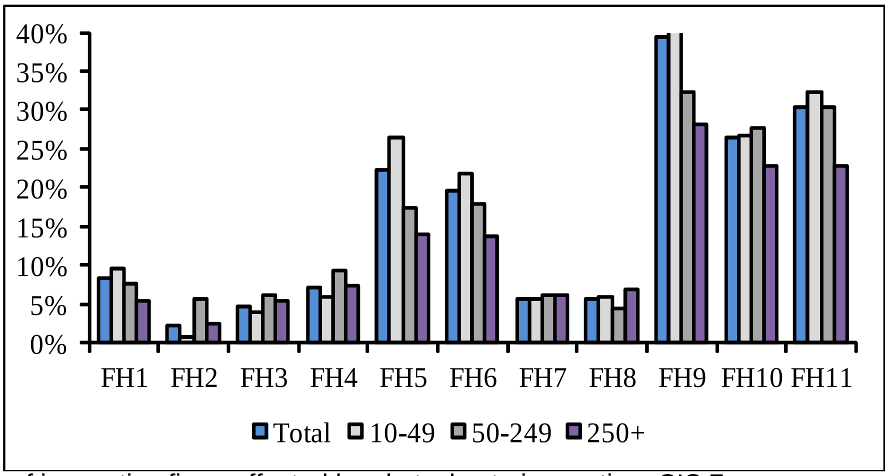

Figure 1: Proportion of innovative firms affected by obstacles to innovation, CIS 7
Data source: Eurostat database (CIS 7) – all core NACE activities.

Similar proportions between firms which claim obstacles, depending on size, are recorded in the group of non-innovative firms (not showed on the graph), resulting that the main factors of hampering innovation can be found in the sphere of financing ones.

Correlations can exist between these factors due to the existing complementarities. In this respect, the lack of funds within the enterprise or group (FH9), the lack of finance from sources outside the enterprise (FH10) and the innovation costs too high (FH11) are closely linked. The lack of internal resources determines the increase in funding costs of projects, and the lack of external financial resources limits the size of the projects to the level of internal funds. In the same framework, the lack of qualified personnel (FH1), the lack of information on technologies (FH2), the lack of information on markets (FH3) or the difficulty in identifying collaboration partners (FH4) can be seen as obstacles related to the lack technological opportunities. Objectively, the qualified personnel can be considered as facilitator of innovation which allows access to specialized knowledge, including from collaboration with various partners and identification of potential markets. Also, the market dominated by established enterprises (FH5) and uncertain demand for goods and services (FH6) increase the operational risk of projects impacting the financing mode, the projects size and type. Ultimately, the firm's decision to innovate in the current period can be affected by projects undertaken in the previous periods (FH7) or by the lack of demand for innovations (FH8).

39.62% of the total Romanian innovative firms claimed the lack of internal funding (FH9) and this proportion was exceeded only by companies in Croatia (46.28%), Bulgaria (40.10%), Spain (39.95%) and Portugal (39.63%). In this context, the lack of internal funding encountered by Romanian firms was one of the highest from EU and they appeared to be the most financially constrained. The lack of external financial resources (FH10) was shown for 26.42% of innovative firms in Romania according to CIS 7 data, being exceeded by the firms in the states above. Finally, the proportion of Romanian firms in which the cost of innovation was considered to be too high (FH11) was 30.43% and it was one of the highest in the EU as well.

The obstacles to innovation related to financial factors can also be followed in the next period. Although a single indicator related to financial problems faced by innovative firms has its drawbacks (FH4, figure 2), its one of the highest dimension displayed in the next period reflects persistence over time. Its variation among firms by size is not significant. However, by manifesting continuity, the funding problems faced by firms demonstrate that they cannot be solved by themselves.

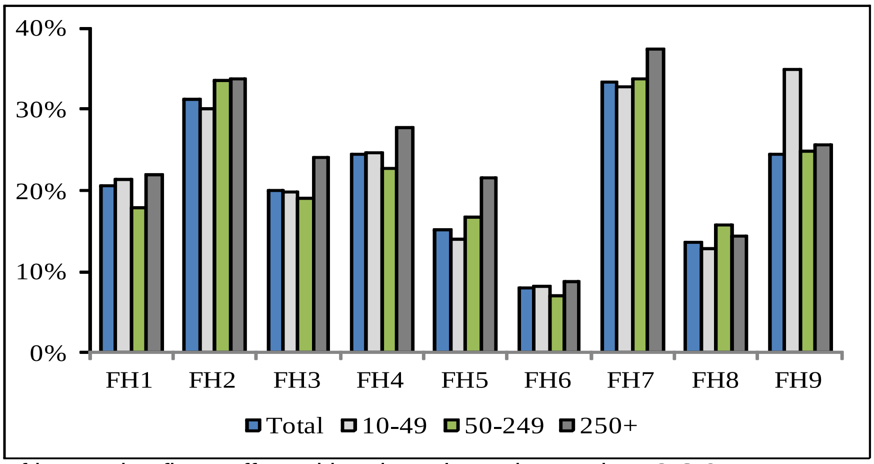

Figure 2: Proportion of innovative firms affected by obstacles to innovation, CIS 8
Data source: Eurostat database (CIS 8) – all core NACE activities.

The highest obstacles to innovation showed in figure 2 are placed on the lack of qualified personnel (FH7), innovations introduced by competitors (FH2) and high costs of meeting regulations (FH9). Other problems associated with firms' marked continued to be of relevance, mainly through high costs of access to new markets (FH1) and this can be similar in its effects to markets dominated by established enterprises (FH5, CIS 7). Thus, new factors and persistence of previous obstacles to innovation are shown.

CONCLUSIONS

Summing up, our analysis identifies that innovative firms are negatively affected by the lack of adequate finance which reduces the innovation expenditure severely affected by the low level of expenditure on research and development performed by firms. Also, low levels of funding can reduce the number of innovative firms. In this respect, according to Eurostat, the proportion of innovative firms dropped massively, from 30.82% in 2010 to 20.5% in 2012, registering an alarming trend. The lack of adequate finance is a persisting factor and involves enhancing measures to be taken by the government policy especially in supporting research and development in firms. Also, various government initiatives aiming at promoting collaborative relationships between firms or groups of firms, between research institutions and the private sector are needed in order to promote behavioral additionality. The options for various mechanisms of boosting innovation must take shape in relation to variables that characterize the innovation activity by sector and its obstacles.

Financial and technological opportunities factors that might hamper innovations are complementary. For instance, it is known the importance of active diffusion of knowledge where firms innovate through interaction and collaboration with other enterprises or institutions, as well as the non-interactive diffusion using open source or acquisition of technologies. The knowledge transfer through collaborative innovation activities can provide the missing inputs and learning processes that the firm cannot easily acquire. The role of collaboration in the creation and diffusion of innovations has received special attention, especially in recent years, by observing the decrease in innovation costs, facilitating the identification, adaptation and acquisition of relevant information and risks sharing that maximize the innovation results. The active diffusion through collaboration has positive impact by reducing barriers associated with failure to obtain funding for projects due to the uncertain results or low absorption of knowledge.

Despite the potential benefits of collaboration agreements, Romanian firms were the least involved in collaboration. The most common are cooperation agreements with suppliers and customers, and the least practiced are agreements with higher education institutions (less than 5%) and research (less than 3% of the total innovative firms). These results are the consequence of reducing public financial support for innovation through direct and indirect mechanisms, including through a low access to research results funded from public funds. Firms in Romania are characterized by a level of collaboration among the lowest in the EU (Diaconu, 2013), stimulating firms to engage themselves primarily in research in partnership with higher education institutions and research being necessary, providing knowledge and technological opportunities, which would increase the innovative capacity.

The hampering factors related to firms' market, although not showed continuity in their structure due to the lack available data, are very significant. No other country of the EU space display such a large proportion of innovative firms, of 31.5% in 2012, claiming that innovations introduced by competitors are obstacles to innovation. Often, incumbent firms that introduce innovations on the market have a greater market share in their sector, while acquiring or adopting innovations that have been introduced by competitors can be associated with a lower market share. More data are needed in order to investigate what type of firms claim such barriers to innovation and what industry they operate in.

The lack of qualified personnel and high costs of meeting regulations (costs of environmental regulations, licensing costs etc.) are perceived as ones of the highest obstacles to innovation as well. Although the lack of qualified personnel can be identified as a result of R&D underfunding from public funds and the poor correlation between R&D and the needs of industrial development that must be properly addressed, firms must be able to identify and encourage talents they need and to remunerate them accordingly. Complaining about the lack of qualified personnel and acting in ways that cannot retain valuable talents within organization at the same time is not a practice to follow. Regarding the high costs of meeting regulations, they must be properly specified in the available data to a better understanding of their contribution and impact on innovation, as well as the type of measures to be adopted to facilitate every type of activity that require those costs.

In the same framework, the supply side of financial resources needs a special attention. Stimulating both the demand and supply sides could mitigate significant vulnerabilities that hinder economic development in Romania: the concentration of economic and creative capacity in a few sectors that cause the dependence on imported technologies and external sources of knowledge of the other sectors, as well as insufficient funding from venture capital.

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RESEARCH ON INFORMATION SECURITY MANAGEMENT

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Abstract: *Given the rush of all organizations and of the society we live in to gather as much important information as possible in order to defend and strengthen their position, the fact that information represents one of the most important resources that an organization has, if not the most important one (in the present context), is no longer a novelty. The purpose of this research is to identify the role of information security management (ISM) in organizations. The research methodology involves ISM literature research on four directions of investigation, identified by [*1*] and the results show that security attacks represent an extremely actual, frequent and increasing worldwide phenomenon. The findings of this research show that organizations can suffer heavy casualties after security attacks, that they can be attacked from both inside and outside, and that information security depends on a number of internal and external factors.*

Keywords*: information; security; management; role.*

INTRODUCTION

Given the rush of all organizations and of the society we live in to gather as much important information as possible in order to defend and strengthen their position, the fact that information represents one of the most important resources that an organization has, if not the most important one (in the present context), is no longer a novelty. According to statistics and studies in the field, attacks are numerous, fast-growing, and information systems, however updated, are subject to security risks. Moreover, a very important role in their proper functioning is played by human resources. Also, information security management is required and can be applied in any field (including in the textile industry), regardless of type, size, or object of activity of the organization.

This paper structures literature research on the four directions of investigation [1]:
1. Research on the need of information security within organizations;
2. Research on designing a model of evaluation of the organization in terms of information security;
3. Research on designing an Information Security Management System that should consider all the criteria, internal and external factors, to improve Information Security Management;
4. Research on enhancing the efficiency of the organization through information security.

EXPERIMENTAL

The study is based on **Angheluță and Lupu, (2016)** research directions and consists in bibliographic research for them and quotation of the most relevant bibliography.
The research directions are[1]:

1.Research on the need of information security within organizations [1].

To achieve the objective of the first investigation direction, is proposed the following research [1]:
- Determining the need of information security
- Research of the risks in the context of information security
- Research of losses and damages in the context of information security
- Research on protection against risks in the information security context

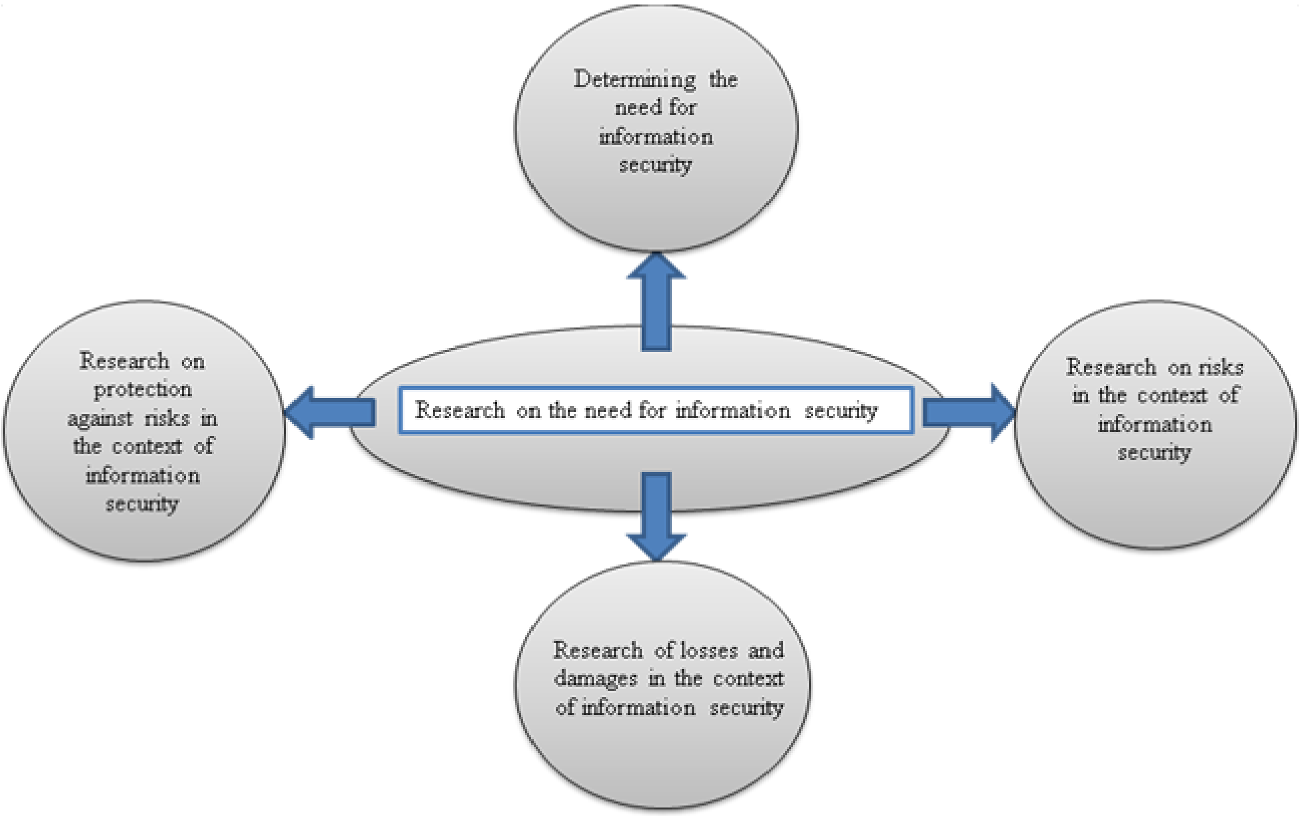

Figure 1. The need for information security research

Information security directs and supports the organization and its collaborators in protecting information assets from intentional or unintentional disclosure, from their modification or destruction, from refusal to implement appropriate information security policies, by planning to resume business processes, procedures and guidelines; also, the manager / expert in information security is responsible for the security program of the organization, including risk management [2].

2. Research on designing a model of evaluation of the organization in terms of information security [1]

To achieve the objective of the second investigation direction, is proposed the following steps [1]:

- Assessing the current situation of information security
- Assessing the need of information security increase or decrease
- Assessing the training of the organization in order to implement the information security management system

Organizations need different levels of security, but regardless of the need for a lower or increased level of security, each company should have an optimum level of security [3]. Employees' awareness and behaviour are important for an efficient information security in an organization [4]. Also, since employees have direct access to the networks of organizations, they may become targets of attackers who will obtain information through social engineering techniques; however, organizations underestimate this fact and focus heavily on technology in order to solve security problems [5].

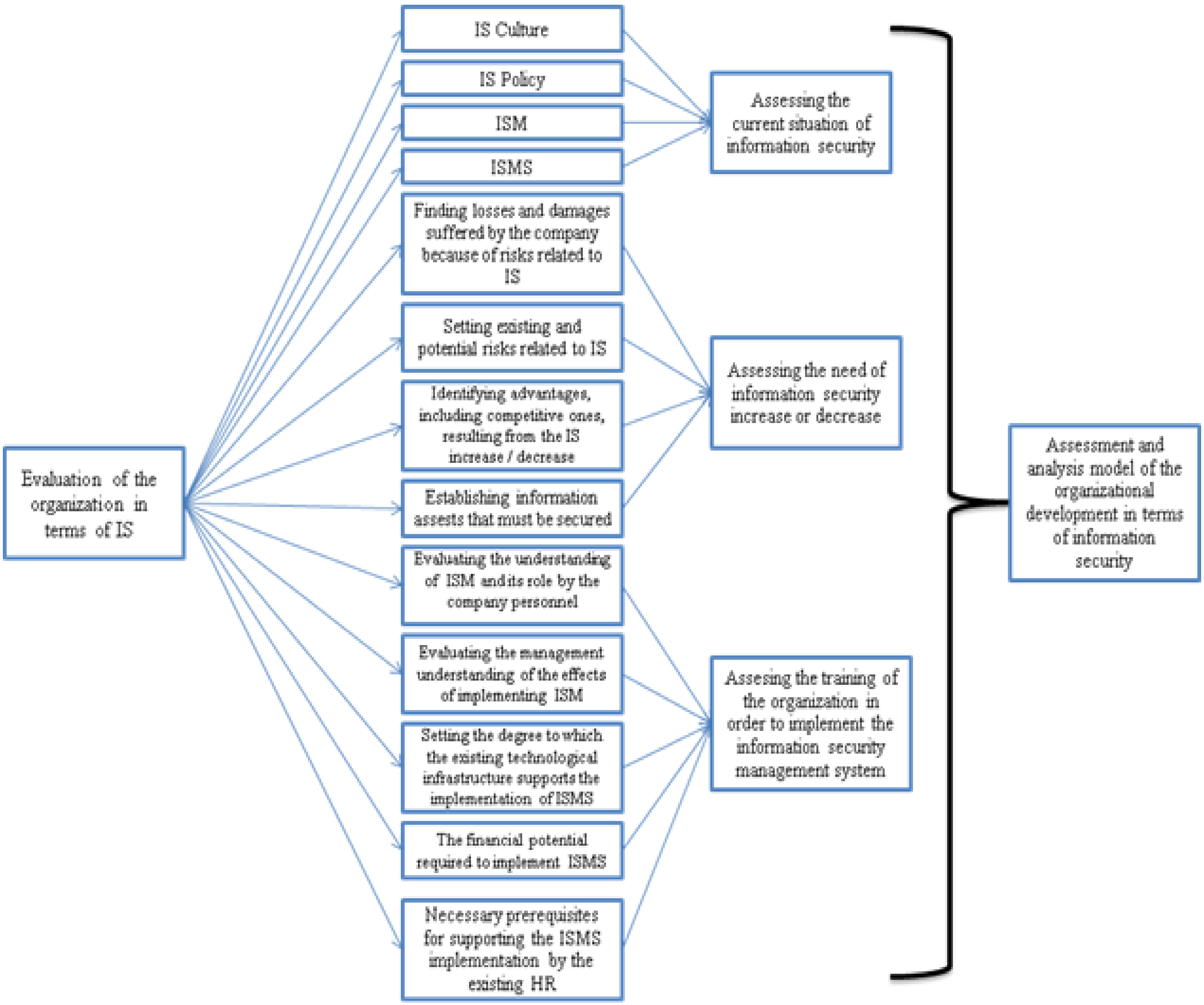

Figure 2. Model for evaluating the organization in terms of information system security, [1]

3. Research on designing an Information Security Management System that should consider all the criteria, internal and external factors, to improve Information Security Management [1].

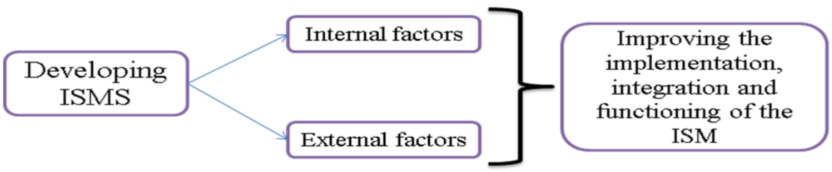

Figure 3. Purpose of developing ISMS, [1]

The course and focus on information security in an organization depend on the environment in which it operates; moreover, the case studies research revealed that there are organizations that are forced to comply with external audit and government requirements [3]. Security is effective only if the human resource knows, understands and accepts the necessary precautions [6].

4. Research on enhancing the efficiency of the organization through information security [1]

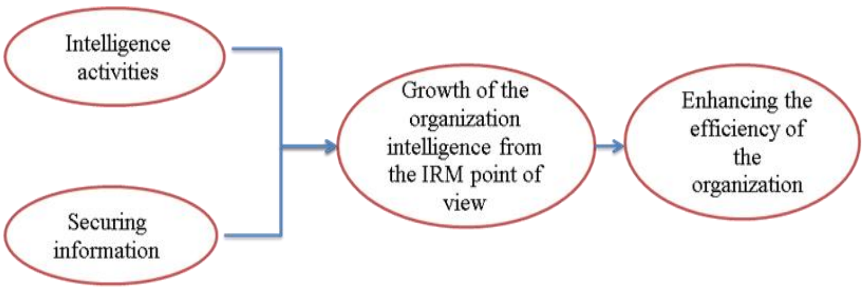

Figure 4. Enhancing the organizational efficiency by securing information and intelligence activities, [1]

On the level of risks it is necessary to define a system of constant monitoring of indicators specific to each type of risk or opportunity, in order to warn the leadership of the organization regarding their possible occurrence. This fact aims to adopt decisions that protect and facilitate the promotion of business interests; the authors also argue that companies should use more effective means and methods than those of competitors [7].

RESULTS AND DISCUSION

The results of the research show that information security management includes technology, human resource and infrastructure available in the organization, that it combines engineering with management and (hardware and software) IT, and that it can be influenced by various (internal and external) factors.
Furthermore, it has been found that information security is a current field of interest, given the increasing security attacks that exist all over the world, under various forms (either cybernetic, caused by HR or by vulnerability manipulation achieved by third interested parties). Henceforth, the attention of organizations in terms of information security has increased.
It is also worth mentioning the growing interest of organizations not only in securing their information assets, but also in obtaining important information that can ensure their own stability and development. One of the ways of obtaining important information is the use of intelligence activities.
After carrying out the literature study on the four directions of investigation identified by Angheluţă and Lupu (2016), and after their examination, the authors of this paper completed a scheme (Figure 5) which brings together all four research directions, shows their interrelationships and key vault model, namely, the need for information security.

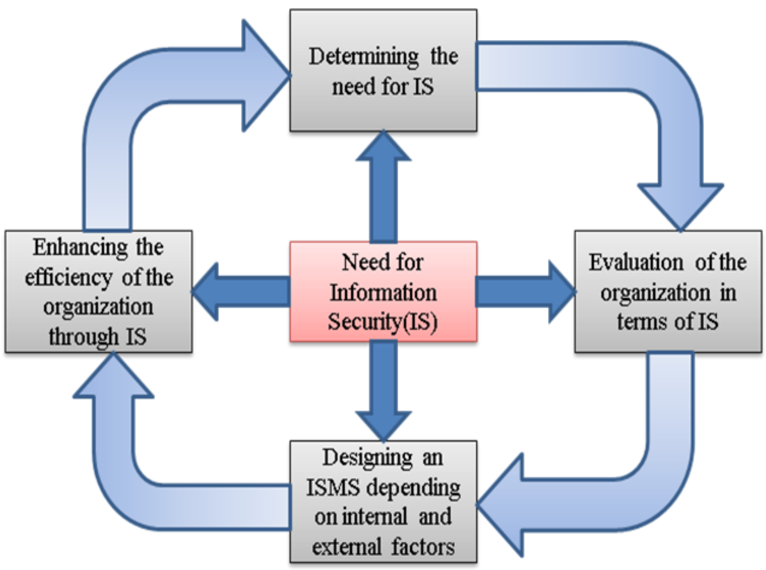

Figure 5. ISMS model in 4 steps, starting from the IS need (own model)

CONCLUSIONS

The findings of this research highlight the following facts: organizations can suffer heavy casualties after security attacks, they can be attacked from both inside and outside, and information security depends on a number of internal and external factors. Human resource has an essential role in ensuring information security and its vulnerabilities can be exploited by different bodies in order to compromise information security. Also, information security management is required and can be applied in any field (including in the textile industry), regardless of type, size, or object of activity of the organization. Not least, a continuous process of updating and adapting information security management to internal and external factors is compulsory in order to ensure security.

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Section 14: Engineering education

CONTINUING EDUCATION FOR ROMANIAN T&C SMEs – SKILLS GAINED THROUGH e-LEARNING

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Abstract:
The aim of the paper is to critically review continuing education of Textile and Clothing (T&C) SMEs in Romania and assess the perceived need of the new skills and further training using online training.
Data collection based on TECLO Project where only Romanian SMEs from the T&C Sector had been analyzed. The results of extensive literature review on Textile and Clothing Sector were used to anticipate the New Skills for the Future T&C. Information collected from expert knowledge and interviews with practitioners, experts and academics was used in questionnaire development and pilot phase prior to survey.
The survey confirmed the company's interest in training directions through high scores for both perceived need and importance of all seven proposed modules.
SMEs managers from the T&C sector need the new blend of technical and management skills, especially entrepreneurship in order to increase their competitiveness and export.

Keywords: *Continuing education, T&C SMEs, e-Learning*

INTRODUCTION

The clothing and textile industries in the European Union are characterized by very intense international competition. EU producers face fierce competition from exports of new industrialized countries whose low wages and social charges give them a considerable competitive advantage. At the same time the financial crisis has severely affected small and medium textile and clothing enterprises (SMEs) in the EU. The SMEs in the EU textile and clothing sector seem to lack the potential to reach international emerging markets, lacking an export oriented growth plan and a capability to create the conditions necessary for exports [1, 2, 3].

Changes in qualification requirements combined with changes in lifestyle and a growing concern for environmental guidelines and sustainable solutions have not been met by corresponding changes in education and vocational training causing a lack in qualified staff especially in the management and strategic sectors. Essential managerial skills, like leadership, communication skills, collaboration skills, finance skills, project management skills and critical thinking will always be on the forefront of any vocational training [4, 5].

In this context, the project TECLO targets the creation of a framework that will anticipate necessary skills and result in better qualified professionals. The main aim is bridging the gap between education and production in order to foster stronger synergies between innovation, skills and jobs, within an adaptive, global context. Collaboration among professional associations, employers and higher education institutions in the formation of future courses is vital to the sector's survival and growth. Educational centres are collaborating with T&C companies to some level, especially through ad hoc consultation on educational issues and regular dialogue with companies through student work placement or internships.

As a first step toward defining a new qualification framework for future managers in the European textile and clothing sector was to assess the needs of European SMEs in the textile and clothing sector, focusing on growth, innovation and sustainability. The assessment was carried out based on a survey involving T&C SMEs and HEIs (High Education Institutions) from all participant countries, including Romania. The participants were asked to rate the need and importance of new skills considered significant. They stated their opinion regarding, the incentives and barriers for the introduction of MOOCs and the use of online training and blended learning.

The paper presents and discusses the results of the survey conducted among Romanian SMEs from T&C sector and their perceived need and importance for new skills to be gained through e-learning.

METHODOLOGY

The methodology and tools that were adopted for the execution of the field survey were flexible and ensured the interaction between investigators and subjects [6, 7].

The final outcome is a comparative research report, stressing the main elements to be considered when planning the strategy for future knowledge intensive and innovative textile and clothing SMEs.

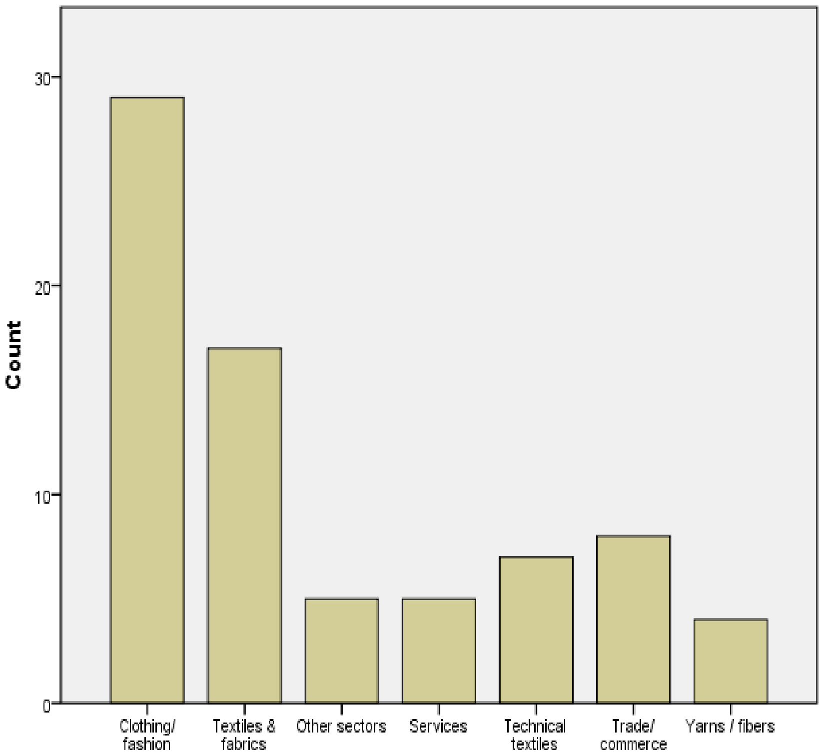

Figure 1: Distribution of industry sub-sector of Romanian Companies

The field research is based on survey questionnaires that are designed according to a standard research methodology.

The questionnaires were applied to two main target groups, European SMEs/micro enterprises and HEIs belonging to the textile and clothing sector, in all the partners' countries.

The two questionnaires have the same structure (Introduction; Body of the questionnaire; End of the questionnaire) but differ by the questions contained in their body. Basically, they contain structured questions of closed-ended type: multiple choice, rating, ranking and scaling. There are also a few open-ended questions included that seek a free response from the participants when they are asked for their opinions or additional comments. The final form of the questionnaires was obtained after testing the drafts among the TECLO partners.

This paper analyse only the Romanian sample. The respondent's distribution according to industry sub-sector is depicted in figure 1, where most of the companies are in clothing/ fashion and textiles and fabrics. Few companies are in technical textiles and trade/commerce (see figure 1).

Sample distribution is exhibited according to company's size, export as percentage of sales, the respondent's position within the company and respondent's higher qualification (see table 1).

Table 1: Sample distribution of SMEs respondents from Romania

Size of the company	1 to 9	10 to 49	50 to 249	More than 249		
	2	11	29	15		**48**
Export as % of sales	No export	Less than 24%	25% to 49%	50% to 75%	More than 75%	
	5	4	2	4	33	**48**
Respondent's position in the Co.	Owner/ CEO	Head of Marketing	Head of Manufacturing	Head of Export	Other position	
	24	2	9	1	12	**48**
Respondent's highest qualification	Bachelor	Master (MBA)	PhD			
	32	11	5			**48**

Total

RESULTS

There are on two areas of SMEs perceptions regarding continuing education through e-learning that are analysed in this paper: the need and importance distribution scores for each of the 22 lessons and the distribution of perceived *overall* need for the each of the seven MOOC modules providing new skills and knowledge according to company's size and exports as percentage of sales

Need and importance distribution for the new knowledge and skills

SMEs assessed both their perceived need and importance for all twenty-two lessons and the overall need and importance for each of the modules to be taught in MOOCs (see table 2). All received scores above 3.0 on Likert scales ranging from 1 (Not important at all/ need No training) to 5 (Extremely important / Need a lot of training). All respondents reported values above 4 for each of the "*Overall need / importance*" of every proposed module of training.

Whilst the reported scores are greater than three, "Intellectual property rights" and "Manage relations with research centres" received consistently very low scores on both need and importance. Both may be explained through little need through their size and relationship with their customers for training in these domains. The largest scores on both need and importance were allocated for recognition and implementation of opportunities of business growth (see table 2).

Table 2: Need and importance of knowledge and skills perceived by Romanian SMEs

KNOWLEDGE and SKILLS	Need		Importance	
	N	Mean	N	Mean
Implement export oriented strategies within the T&C sector				
Proper distribution policies	39	3,59	39	3,72
Intellectual property rights (IPR)	39	3,08	40	3,20
Access to export credit and instruments to commercialize innovation	42	3,40	43	3,67
Overall need / importance to implement export oriented strategies	28	3,68	28	4,04
Implement non-technological innovation within the T&C sector				
Handle mass customization trends	43	3,74	43	4,00
Implement new org. methods	43	4,16	43	4,21
Manage relations with research centers	42	3,17	42	3,21
Overall need / importance to implement non-technological innovation	28	3,46	27	3,63
Implement marketing innovation				
Proper product placement	42	3,79	42	4,05
Promotion of products through new ICTs and social media	42	3,64	42	4,00
Pro-actively understand customers' needs	44	4,07	44	4,50
Overall need / importance to implement marketing innovation	29	3,79	29	4,03
Re-engineer processes for sustainability, CSR and quality				
Implement environmental management methods	41	3,27	42	3,38
Supply chain management and sustainability	42	3,45	42	3,71
Implement small-scale/ specialized production	41	3,76	41	3,88
Overall need / importance to re-engineer processes for sustainability. CSR and Quality	29	3,38	30	3,53
Leadership skills				
External orientation and network	41	4,17	41	4,15
Realistic vision accepting constraints	41	3,54	42	3,79
Perseverance in the execution of strategy	40	4,10	41	4,10
Motivational skills towards workers	42	4,12	43	4,23
Overall need / importance to improve leadership skills	28	4,21	25	4,24
Take better risks				
Sense of initiative	41	4,02	43	4,30
Decisions taken based on risk and information analysis	42	4,14	43	4,49
Turning ideas into action	41	4,12	42	4,31
Overall need / importance to take better risks	30	4,03	28	4,18
Act more creatively				
Change-orientated approach	40	4,00	42	4,07
Identification of market developments and trends	41	4,20	42	4,43
Recognition and implementation of opportunities for business growth	41	4,41	42	4,52
Overall need / importance to act more creatively	29	4,10	27	4,26

Distribution of perceived needs according to size of the company and export as percentage of sales

For each of the seven proposed modules we analysed the SMEs perceived needs for knowledge and skills according to company's size and export as percentage of sales (see figures 2 to 15).

Graphs must be interpreted with care due to uneven distribution of both size of the company and export. There are less than 5% of micro companies and over 60% medium sized and over 30% large companies. There are about 10% of companies that reported no export, whilst nearly 70% of respondents reporting more of 75% export as percentage of sales (see table 1).

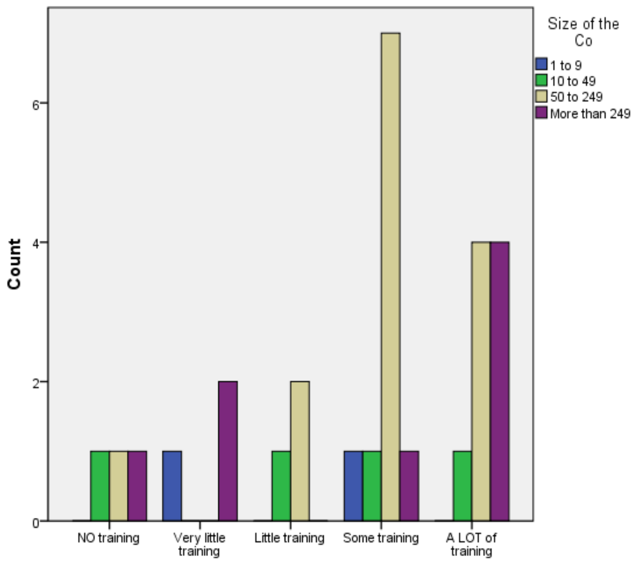

Figure 2: Distribution of the overall need to implement export oriented strategies by the size of the company

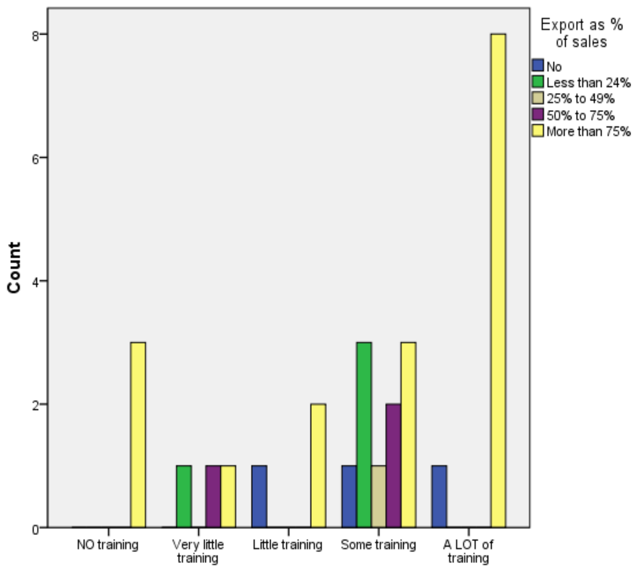

Figure 3: Distribution of the overall need to implement export oriented strategies by the company's export levels as percentage of sales

Both medium and large companies covered the whole range of need for training from "No need" to "A lot of training" (see figure 2) for skills regarding the *overall* need to implement export oriented strategies. A similar distribution is exhibited by the companies that declared to export more that 75% of their sales (see figure 3).

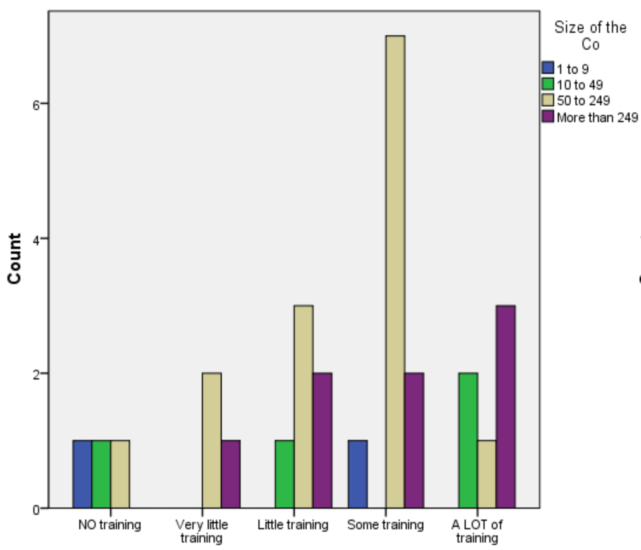

Figure 4: Distribution of the overall need to implement non-technological innovation by the size of the company

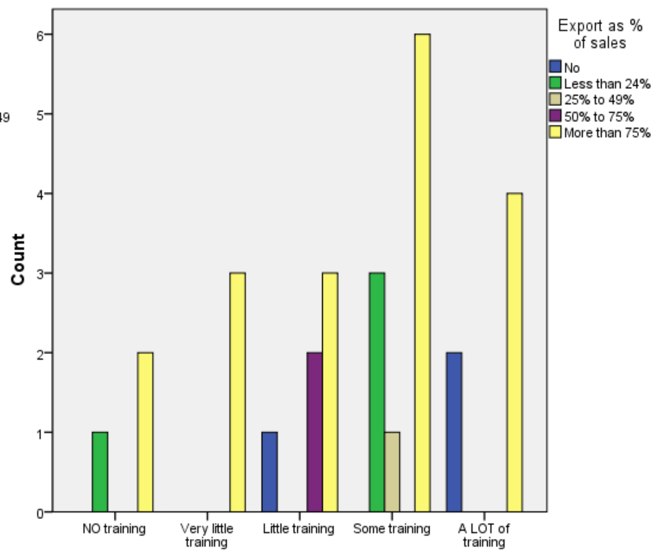

Figure 5: Distribution of the overall need to implement non-technological innovation by the company's export levels as percentage of sales

The distribution of responses for the *overall* need to implement non-technological innovations also covers all range from medium sized companies (see figure 4) and those exporting more than 75% of sales (see figure 5).

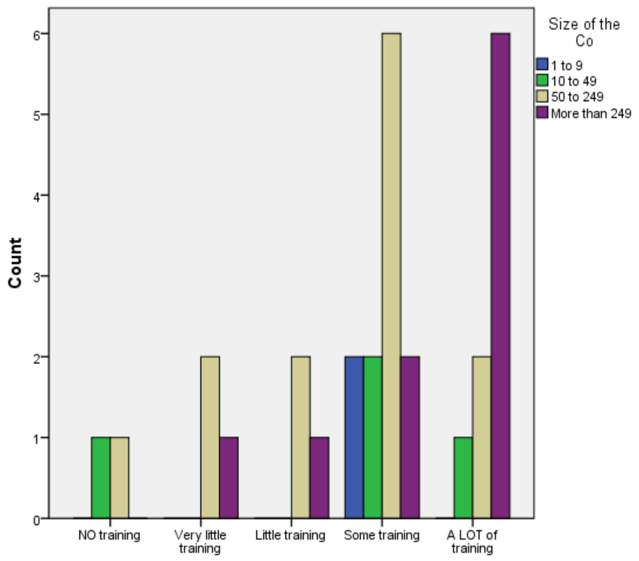

Figure 6: Distribution of the overall need to implement marketing innovation by the size of the company

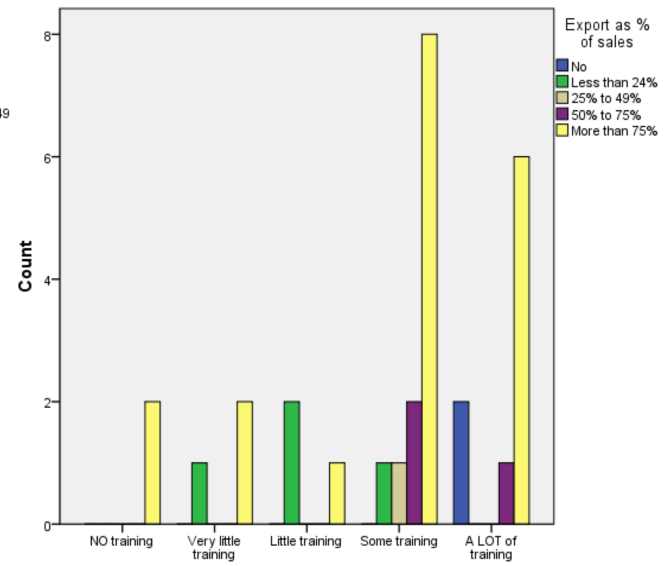

Figure 7: Distribution of the overall need to implement marketing innovation by the company's export levels as percentage of sales

Overall need to implement marketing innovation was particularly important by those that export more than 25% of sales (see figure 7) and by micro and small companies (see figure 6). The companies that do not export exhibited a particular interest in *overall* need to re-engineer processes for sustainability and CSR (see figure 9) whilst there is a relative even distribution according to company size (see figure 8).

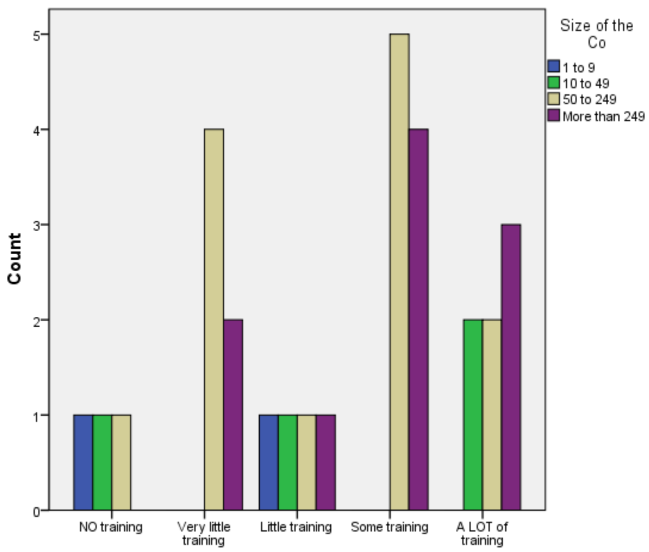

Figure 8: Distribution of the overall need to re-engineer processes for sustainability, CSR and Quality by the size of the company

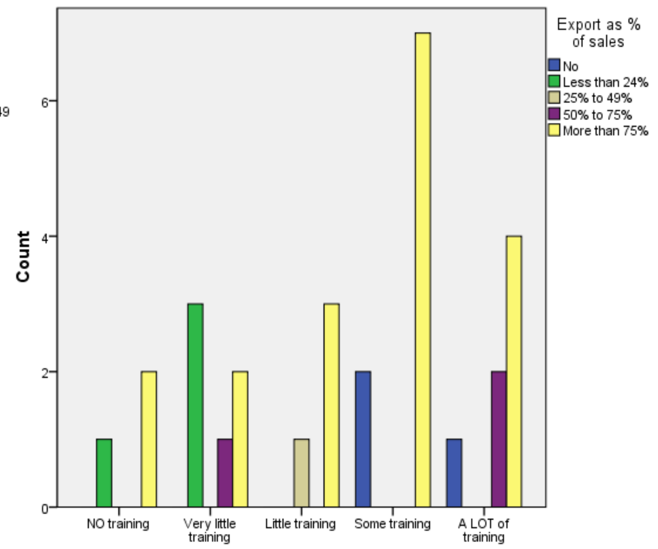

Figure 9: Distribution of the overall need to re-engineer processes for sustainability, CSR and Quality by the company's export levels as percentage of sales

A particular interest in the *overall* need to improve the leadership skills was expressed by the large companies (figure 10) and by those that export more than 75% of their sales (see figure 11).

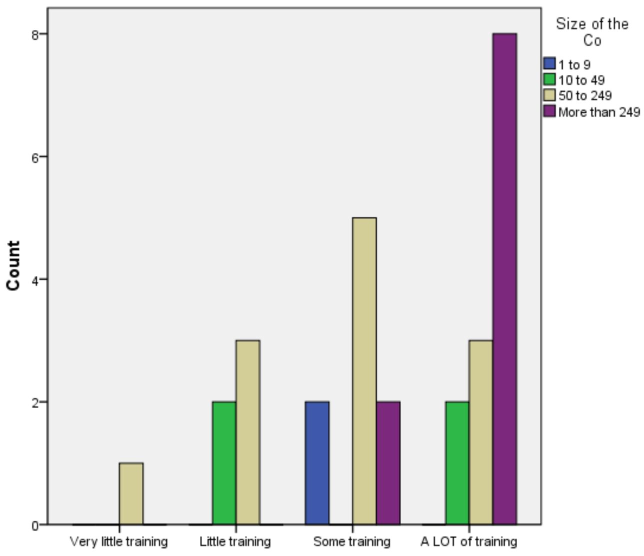

Figure 10: Distribution of the overall need to improve leadership skills by the size of the company

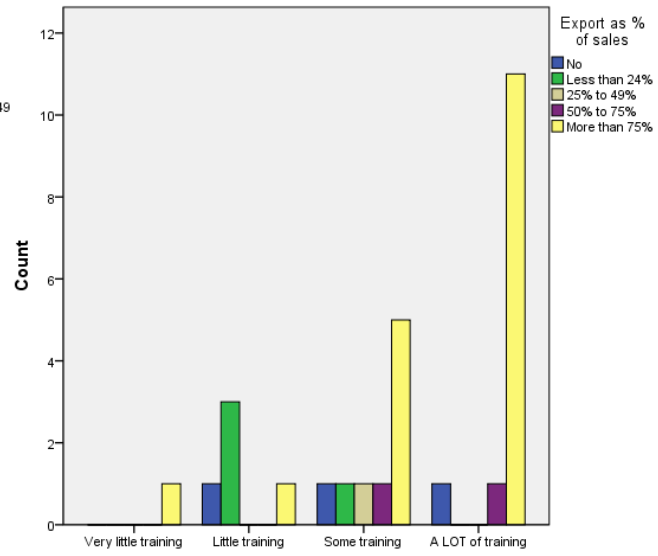

Figure 11: Distribution of the overall need to improve leadership skills by the company's export levels as percentage of sales

Most of the companies regardless of size perceived that requires "Some" and "A lot of training" regarding the *"Overall* need to take better risks" (see figure 12) and with particular interest from those that export more than 50% of their sales (see figure 13).

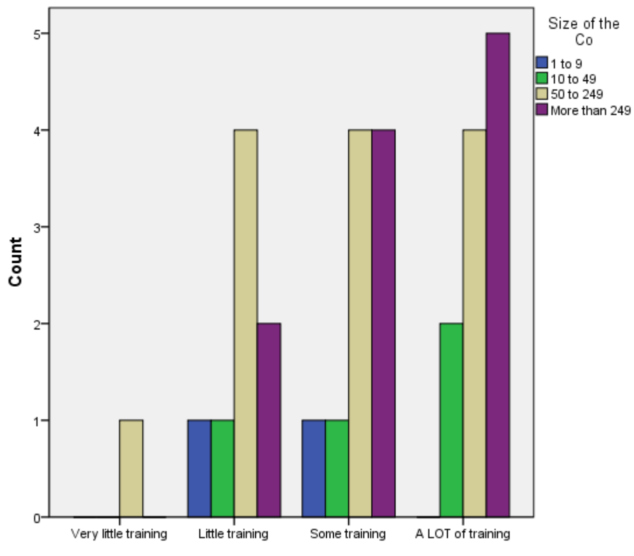

Figure 12: Distribution of the overall need to take better risks by the size of the company

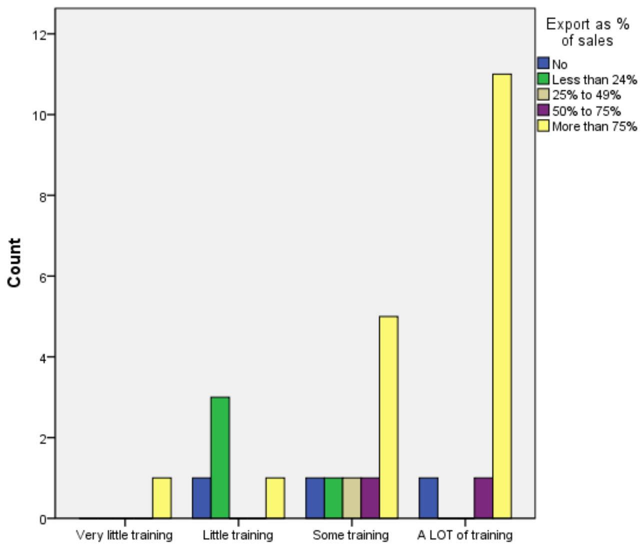

Figure 13: Distribution of the overall need to take better risks by the company's export levels as percentage of sales

The micro-companies expressed a slightly smaller interest for the *overall* need to act more creatively compared with the companies of different sizes (see figure 14). A smaller interest in this module was exhibited by the some of the companies that export less than 24% and some that export more than 75% of sales (see figure 15)

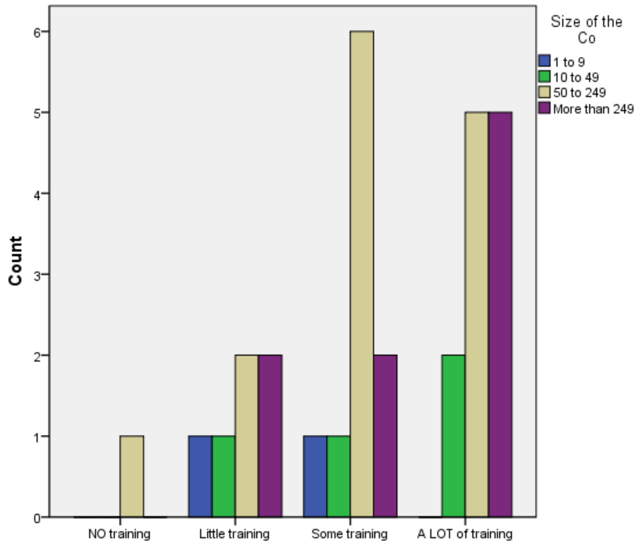

Figure 14: Distribution of the overall need to act more creatively by the size of the company

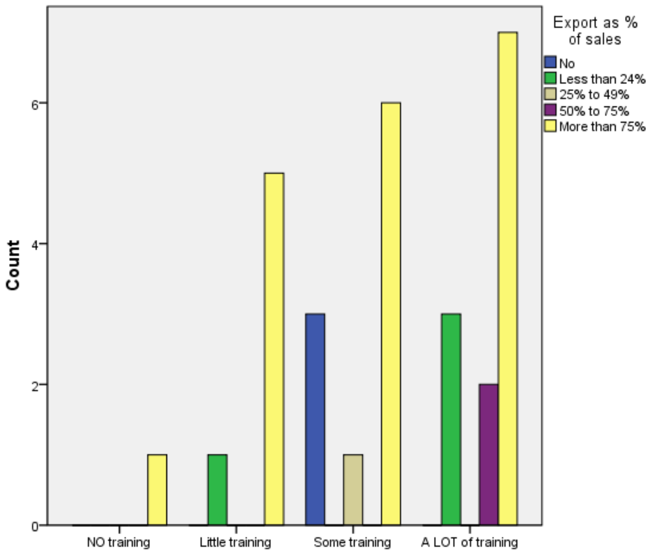

Figure 15: Distribution of the overall need to act more creatively by the company's export levels as percentage of sales

DISCUSSION

The analysis of the seven proposed training modules reveals two modules where all lessons received ratings above 4 for perceived need – importance responses of all lessons: Take better risks and Act more creatively Such behaviour may be associated with companies committed to grow and improve their competitive position through initiative based on recognition and implementation of business opportunities, risk and information analysis and followed by concrete and rapid actions that envisage change to follow market development and trends.

Detailed rating distribution of the need and importance across all the twenty two lessons and overall perception for each module is exhibited in table 2. Whilst all ratings were above 3, there are two modules where all lessons received ratings below 4 for perceived need – importance responses of all lessons: *Implement export oriented strategies within the T&C sector* and *Re-engineer processes for sustainability, CSR and quality*. Such behaviour may be driven due to the lessons contained in each module and organizational context. Thus if the companies work in CMT or have a similar low negotiating power over their customers, they may be less interested in proper distribution policies, Intellectual property rights (IPR), or Access to export credit and instruments to commercialize innovation. The same reasons may drive a limited interest in sustainability and CSR through their customer's drive and resources use for environmental management methods, supply chain management and sustainability and lack of human and engineering resources for small-scale/ specialized production.

A relative even distribution of the company according to their size was observed for all the *overall* needs expressed for each of the seven course modules. That leads to the need for further analysis of the factors that determine the interest for each lesson and course module such as industry sub-sector, respondent's position or higher qualification or other variable that may explain such individual behaviour for SMEs..

CONCLUSIONS

The Romanian results confirmed the interest in TECLO online training through high scores for both perceived need and importance of proposed knowledge and skills for all twenty-two lessons of the seven modules. The most important modules are "Take better risks" and "Act more creatively".

SMEs managers from the T&C sector need the new blend of technical and management skills, especially entrepreneurship in order to increase their competitiveness and export.

Acknowledgement
The paper publishes results obtained in the project “Future textile and clothing managers for export, marketing, innovation, sustainability and entrepreneurship oriented companies - TECLO" (2014-3267_554167-EPP-1-2014-1-IT-EPPKA2-KA2) co-funded by ERASMUS+ Programme of the European Union

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CONTINUING EDUCATION FOR ROMANIAN T&C SMEs – CHALLENGES FOR HEIs

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Abstract:

The aim of the paper is to critically review the collaboration between the HEIs and T&C SMEs in Romania, assess the need and importance of the new skills and further training perceived by Romanian HEIs, the incentives and barriers for the introduction of MOOCS and use of online training and blended learning.
Data obtained from an extended survey carried out in the TECLO Project where Romanian HEIs had been analyzed indicate that the seven proposed skills and training directions are perceived to be very important and requiring a lot of training.
Whilst there is room for improvement, the survey shows that there is cooperation between Romanian HEIS and T&C SMEs.
Despite the small number of respondents from Romanian HEIs, the findings identify specific dimensions of the cooperation in research with T&C SMEs, confirm the company's interest in TECLO online training.
The paper explores the challenges of developing blended and online training in the Higher Education in Romania and reveals intense incentives and barriers for introducing MOOCs.

Keywords: *Universities, T&C SMEs, skills, MOOC*

INTRODUCTION

The clothing and textile industries in the European Union are characterized by very intense international competition. EU producers face fierce competition from exports of new industrialized countries whose low wages and social charges give them a considerable competitive advantage. At the same time the financial crisis has severely affected small and medium textile and clothing enterprises (SMEs) in the EU. The SMEs in the EU textile and clothing sector seem to lack the potential to reach international emerging markets, lacking an export oriented growth plan and a capability to create the conditions necessary for exports [1, 2, 3].

Changes in qualification requirements combined with changes in lifestyle and a growing concern for environmental guidelines and sustainable solutions have not been met by corresponding changes in education and vocational training causing a lack in qualified staff especially in the management and strategic sectors. Essential managerial skills, like leadership, communication skills, collaboration skills, finance skills, project management skills and critical thinking will always be on the forefront of any vocational training [4, 5].

In this context, the project TECLO targets the creation of a framework that will anticipate necessary skills and result in better qualified professionals. The main aim is bridging the gap between education and production in order to foster stronger synergies between innovation, skills and jobs, within an adaptive, global context. Collaboration among professional associations, employers and higher education institutions in the formation of future courses is vital to the sector's survival and growth. Educational centres are collaborating with T&C companies to some level, especially through ad hoc consultation on educational issues and regular dialogue with companies through student work placement or internships.

As a first step toward defining a new qualification framework for future managers in the European textile and clothing sector was to assess the needs of European SMEs in the textile and clothing sector, focusing on growth, innovation and sustainability. The assessment was carried out based on a survey involving T&C SMEs and HEIs (High Education Institutions) from all participant countries, including Romania. The participants were asked to rate the need and importance of new skills considered significant. They stated their opinion regarding, the incentives and barriers for the introduction of MOOCS and the use of online training and blended learning.

The paper presents and discusses the results of the survey conducted among Romanian academics that are involved in the management and textiles. Their responses give a clear picture of the HEIs position on the cooperation with SMEs in the field of education. The results help defining the ways to improve the cooperation with SMEs for the education of future managers.

METHODOLOGY

The methodology and tools that were adopted for the execution of the field survey were flexible and ensured the interaction between investigators and subjects [6, 7]. The field research seeks to identify the barriers / incentives met by the textiles and clothing HEIs in introducing innovative MOOCs, as well as the main evidence based advantages of teaching transversal skills, esp. entrepreneurship to SMEs.

The final outcome is a comparative research report, stressing the main elements to be considered when planning the strategy for future knowledge intensive and innovative textile and clothing SMEs.

The field research is based on survey questionnaires that are designed according to a standard research methodology. The questionnaires were applied to two main target groups, European SMEs/micro enterprises and HEIs belonging to the textile and clothing sector, in all the partners' countries. The two questionnaires have the same structure (Introduction; Body of the questionnaire; End of the questionnaire) but differ by the questions contained in their body. Basically, they contain structured questions of closed-ended type: multiple choice, rating, ranking and scaling. There are also a few open-ended questions included that seek a free response from the participants when they are asked for their opinions or additional comments. The final form of the questionnaires was obtained after testing the drafts among the TECLO partners.
This paper depicts and analyse only the Romanian sample (see table 1).

Table 1: Sample distribution of HEIs respondents from Romania

Size of the University	Small (up to 7499 students)	Medium (7500 to 24999)	Large (over 25000)			
	2	13	1			**16**
Type of University	Technical	Comprehensive				
	12	4				**16**
Respondent's Scientific title	PhD	Missing				
	15	1				**16**
Respondent's position in the Uni.	Dean	Vide-Dean	Head of Dep.	Other	Missing	
	2	2	4	4	4	**16**
Respondent's teaching degree	Professor	Associate prof.				
	6	10				**16**
Age of the respondent	40-49	50-59	60+			
	7	6	3			**16**
Gender	M	F				
	12	4				**16**
						Total

RESULTS

Data analysis focus on four areas: cooperation between Universities and SMEs, perceived assessment of the needs and importance of the new skills, the incentives and barriers for the introduction of MOOCs and the use of online training and blended learning.

Cooperation of Universities with HEIs

Several dimensions of the distribution of the cooperation of the Universities with SMEs are depicted in figures 1 to 6. All the large universities reported to cooperate with SMEs (see figure 1), and all respondents from the survey reported to be satisfied with the joint research cooperation (see figure 2).

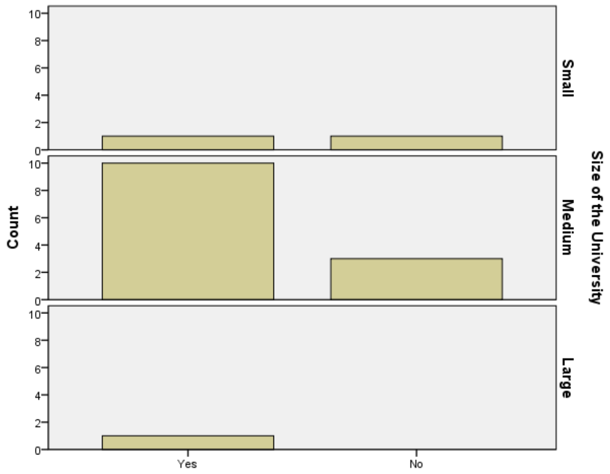

Figure 1: Cooperation of the Universities with SMEs by the size of the University

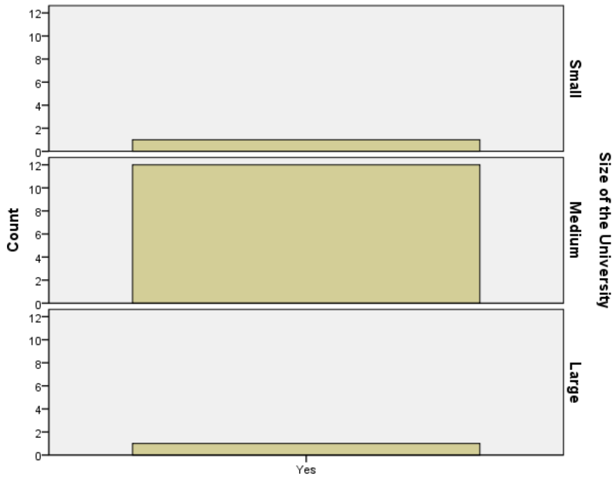

Figure 2: Satisfaction with joint research cooperation by the size of the University

Most of the universities neither did not involve SMEs in curricula development during the last three years (see figure 3) nor received internship offers from SMEs (see figure 4). However some medium and small universities did so (see figure 3 and 4).

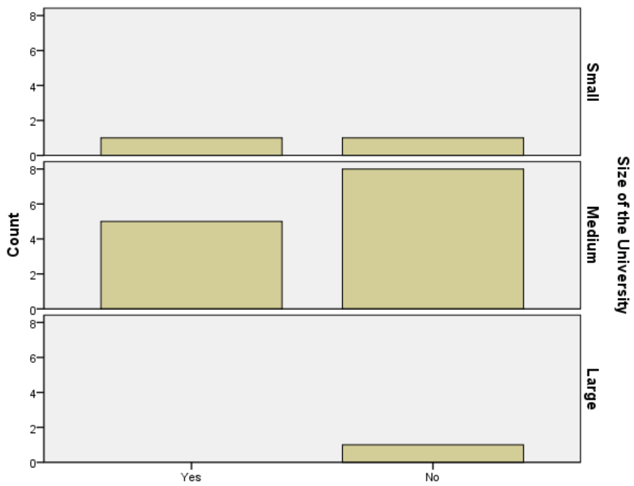

Figure 3: Involvement of SMEs in curricula development during the last three years by the size of the University

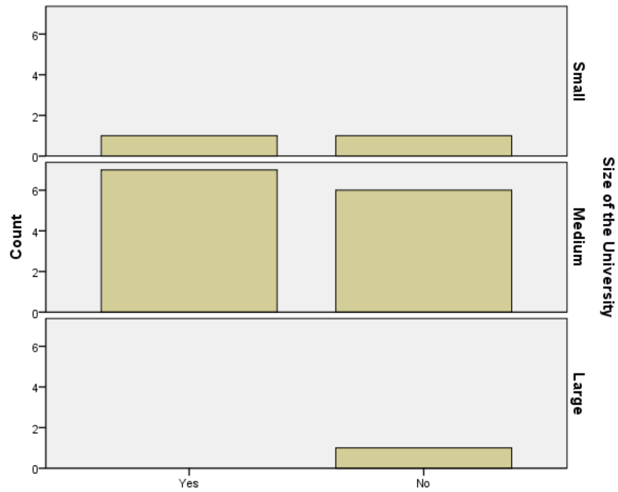

Figure 4: University received internship offers from SMEs by the size of the University

Some of the SMEs did not hire internship students after graduation (see figure 5) that is seems natural as some of the companies are quite small and the graduate's skills and competences are not suitable for their needs. All universities reported cooperation with SMEs for their graduation thesis during the last three years (see figure 6).

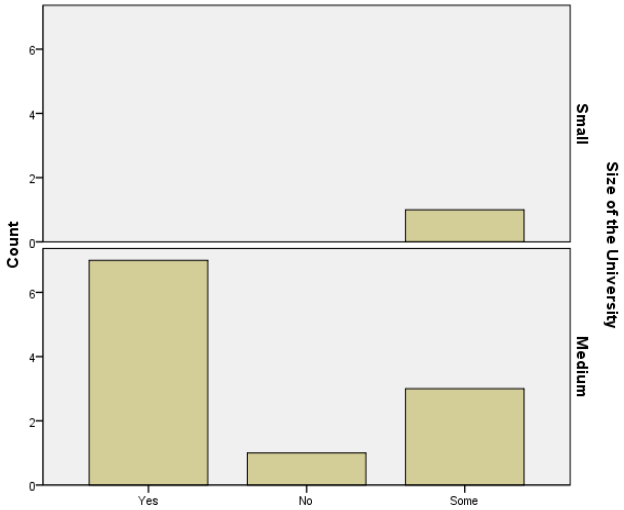

Figure 5: SMEs that provided internships hired those students after graduation by the size of the University

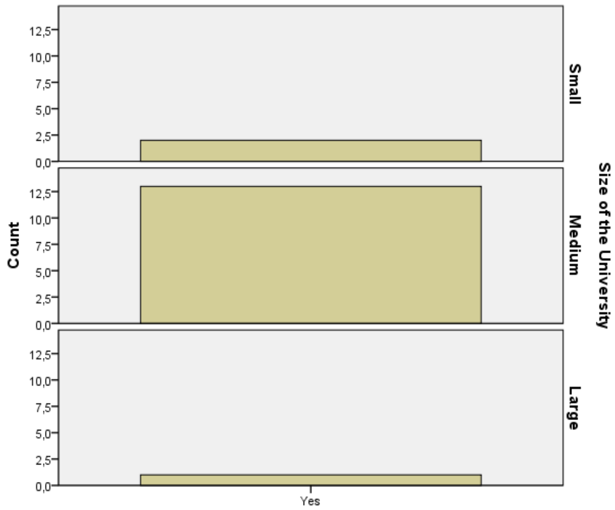

Figure 6: University cooperated with SMEs for BSc/ MSc thesis during the last three years by the size of the University

Perceived need and importance of the new knowledge and skills

Respondents from HEIs assessed both their perceived need and importance for all twenty-two lessons and the overall need and importance for each of the modules to be taught in MOOCs (see table 2). All received scores above 3.5 on Likert scales ranging from 1 (Not important at all/ need No training) to 5 (Extremely important / Need a lot of training). All respondents reported values above 4 for each of the "*Overall need / importance*" of every proposed module of training.

Table 2: Need and importance of knowledge and skills perceived by Romanian HEIs

KNOWLEDGE and SKILLS	Need		Importance	
	N	Mean	N	Mean
Implement export oriented strategies within the T&C sector				
Proper distribution policies	16	4,25	16	4,31
Intellectual property rights (IPR)	15	4,00	16	3,81
Access to export credit and instruments to commercialize innovation	16	3,37	16	4,56
Overall need / importance to implement export oriented strategies	15	4,47	15	4,47
Implement non-technological innovation within the T&C sector				
Handle mass customization trends	16	4,06	16	4,25
Implement new org. methods	15	4,07	15	4,33
Manage relations with research centers	16	3,63	16	4,06
Overall need / importance to implement non-technological innovation	13	4,31	13	4,31
Implement marketing innovation				
Proper product placement	16	4,56	15	4,47
Promotion of products through new ICTs and social media	16	4,19	16	4,56
Pro-actively understand customers' needs	16	4,38	16	4,63
Overall need / importance to implement marketing innovation	14	4,36	14	4,36
Re-engineer processes for sustainability. CSR and quality				
Implement environmental management methods	15	4,00	16	4,06
Supply chain management and sustainability	16	3,75	16	3,94
Implement small-scale/ specialized production	16	3,81	16	4,13
Overall need / importance to re-engineer processes for sustainability. CSR and Quality	14	4,29	15	4,27
Leadership skills				
External orientation and network	16	3,87	16	4,06
Realistic vision accepting constraints	16	3,94	16	3,87
Perseverance in the execution of strategy	16	3,81	16	3,94
Motivational skills towards workers	16	4,06	16	4,25
Overall need / importance to improve leadership skills	15	4,27	15	4,60

Take better risks				
Sense of initiative	15	4,00	15	4,20
Decisions taken based on risk and information analysis	16	4,00	16	4,25
Turning ideas into action	16	4,06	16	4,38
Overall need / importance to take better risks	15	4,13	15	4,27
Act more creatively				
Change-orientated approach	16	4,19	16	4,13
Identification of market developments and trends	15	4,27	16	4,19
Recognition and implementation of opportunities for business growth	16	4,13	16	4,38
Overall need / importance to act more creatively	13	4,31	13	4,38

Perceived incentives and barriers for the introduction of MOOCs

The assessment of barriers and incentives for introducing MOOCs uses a Likert scale (1 is Totally disagree to 5 Totally agree). Some of the highest perceived barriers refer both to University (low experience and low level of knowledge about MOOC) and staff (requiring new pedagogy and rethinking the curriculum). Respondents did not fear the decrease in the role of the instructor (see table 3).

Table 3: Barriers for the introduction of MOOC perceived by Romanian HEIs

Barriers	N	Mean
Staff needs working knowledge on online pedagogy	16	3,69
Staff need new pedagogy when using MOOC	16	4,00
Staff need to rethink the curriculum delivery models and courses	16	4,00
University needs a proper e-infrastructure	16	3,94
University respects the intellectual property rights	16	3,06
University has low experience in using MOOC	16	4,19
University has a low level of knowledge about MOOC	16	4,06
Fear for the decreasing of the central role of the instructors	16	2,88

Some of the main incentives perceived by the respondents include improvement in the institution's visibility and better cooperation with other institutions. The weakest incentives refers to positive influence on student's motivation to learn, staff gaining knowledge and experience in online pedagogy and increasing the institution's reputation. Such low incentives may occur due to the perceived need for change of the academic staff that requires both effort and little control on the student's motivation to learn.

Table 4: Incentives for MOOC introduction perceived by Romanian HEIs

Incentives	N	Mean
Supporting teachers for developing instructional materials	16	4,06
Rewarding the efforts of teachers in using MOOCs	16	4,44
Increasing the institutions' reputation	16	3,87
Increasing the institutions' visibility	16	4,56
Reducing costs of teaching and learning	16	3,87
Positive influence on students' motivation to learn	16	3,63
Staff gains knowledge and experience in online pedagogy	16	3,69
Opportunities for learners to access free courses	16	3,94
Opportunities for HEIs to gain a competitive advantage	16	3,94
HEIs develop study programmes in the new provision means	16	4,31
HEIs reach international students	16	4,37
HEIs increase collaboration with other institutions	16	4,50
Increased learners' access to a variety of non-traditional courses	16	4,31
Better response to the demands for continuing education	16	4,13

Use of online training and blended learning

Research analysed whether and how universities organized and were using online training and integrated blended learning into conventional teaching. The distribution of universities that did so according to their size and type of university are depicted in figures 7 to 9. It is interesting to notice that all small universities reported to be involved in both online training and blended learning. This may be due to their need to innovate and be close to student's needs in their pursue to become more competitive and attract students (see figures7 and 8) as compared with the majority of medium universities that did not organized online training (see figure 7) and only some of the medium universities that integrated blended learning (figure 8).

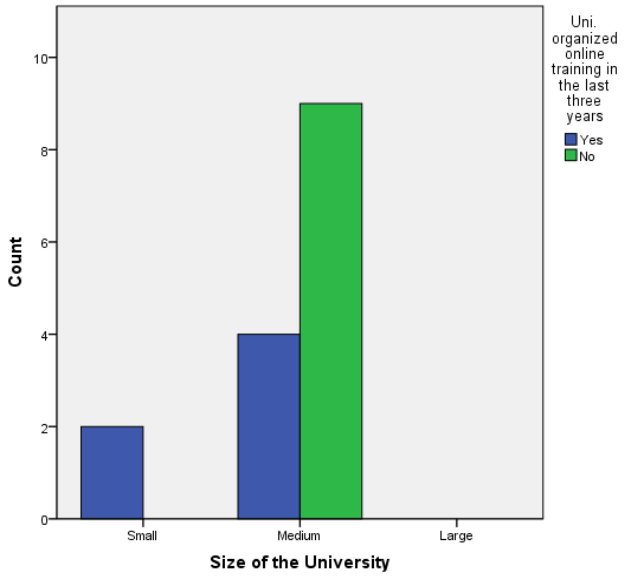

Figure 7: University organized online training during the last three years, by the size of the University

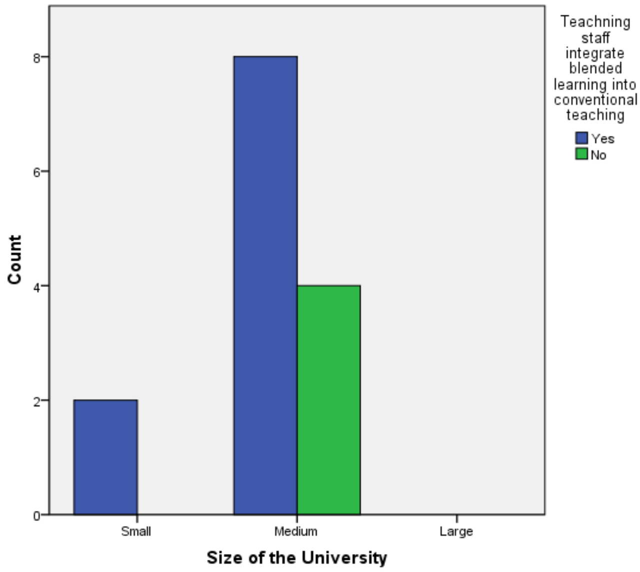

Figure 8: Teaching staff integrated blended learning into conventional teaching organized by the size of the University

Most of the technical universities did not organized online training (see figure 9) response that may be due to the strong applicative and laboratory work associated with the technical education. Those that reported the existence of such courses during the last three years may had done so due to the use of MOODLE line platforms where some teaching staff had created online versions of the course to support student learning.
Integration of the blended learning was reported by majority of respondents (see figure 10) from both comprehensive and Technical Universities.

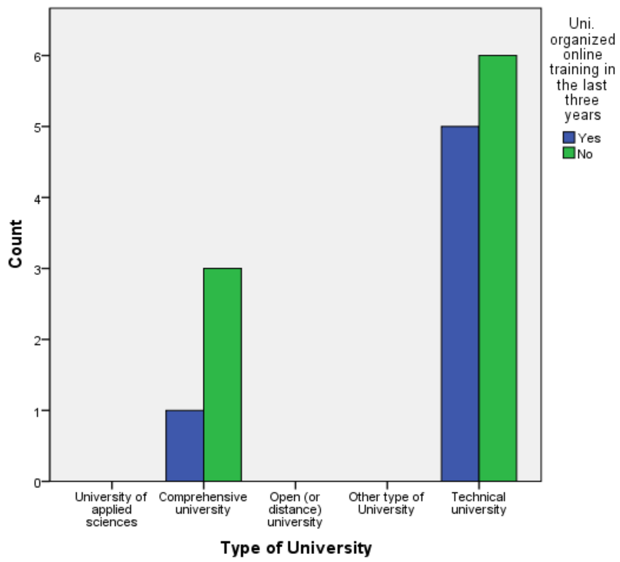

Figure 9: University organized online training during the last three years, by the type of the University

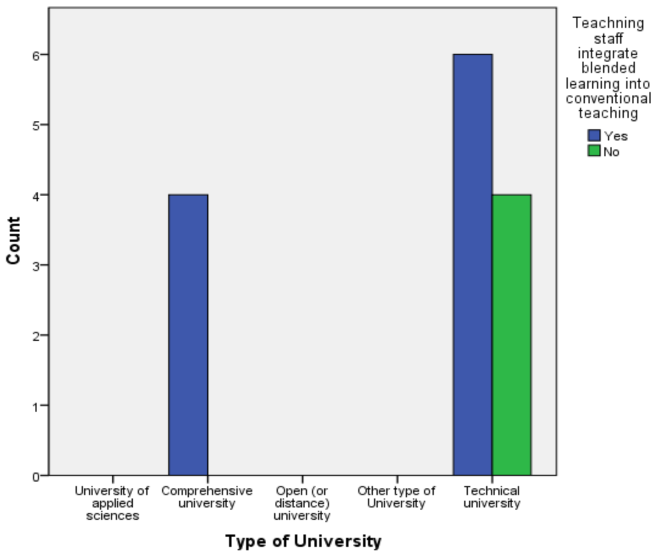

Figure 10: Teaching staff integrated blended learning into conventional teaching organized by the type of the University

DISCUSSION

In order to build effective and engaging MOOCs, TECLO project analysed both advantages for partnership between companies and HEIs and the main barriers for successful cooperation. Expert knowledge and interviews were also used in questionnaire development and pilot phase prior to survey.

The paper analysed the cooperation between Universities and SMEs and whether the universities had already organized online training and integrated blended learning into conventional thinking in order to understand the context and starting point of the introduction and use of MOOC lessons.

Despite the small sample of Romanian HEIs, the findings identify specific dimensions of the cooperation in research with T&C SMEs. Whilst there is room for improvement, Romanian HEIS and T&C SMEs cooperates. Due to their size, most of the universities neither involved SMEs in curricula development during the last three years nor received internship offers from them. For the same category of companies it would be impossible to hire graduates after internship because they may either not grow or the graduate's skills and competences may not be suitable for their needs. All universities were satisfied with the joint research cooperation. Universities reported that cooperated with SMEs for BSs/MSc graduation thesis.

There are some modules where all lessons received scores over four for both perceived need and importance all related to innovation: in marketing, non-technology, act more creatively and take better risks. Such behaviour may be related to the perceived pressure to become more competitive though providing better value to their customers.

CONCLUSIONS

The Romanian results confirmed the company's interest in TECLO online training through high scores for both perceived need and importance of proposed knowledge and skills for T&C sector.

The main challenges for introducing MOOCs relates to perceived university's low level of knowledge and institutional determination required in both investment and working procedures to design and implement this new type of learning. Part of the significant institutional renewal is the academic staff that requires to endeavour in significant change in acquiring and using new pedagogical approach to MOOCs and adjustments of the curriculum and delivery mechanisms.

SMEs managers from the T&C sector need the new blend of technical and management skills, especially entrepreneurship in order to increase their competitiveness and export. Universities may become a major resource for innovation in SMEs through better means of cooperation that would enhance the other partner's performance and results.

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BLENDED LEARNING AS A NEW APPROACH TO EDUCATION

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Abstract: *The role of teacher and student in the current period has changed significantly due to the impact of technology. The teacher must understand the nature and philosophy of such education, which is why further will be addressed key elements of learning system. Blended learning combines online learning with traditional learning (in the class), learning online with contact to teacher, simulating with materials received, practical training with individual information sessions, management training activities with virtual environment. Models of blended learning: is based to classical course structure and use online resources for homework or replace face to face meetings with online or interactive activities or total give up to face to face meeting which will be replaced by learning platforms.*

Keywords: *blended learning, pedagogical methods, education, platform*

INTRODUCTION

The concept of blended learning developed in discussion on education at the beginning of the XXI century, when the concepts of e-learning and virtual classroom began to lose credibility. Thus, this new concept of blended learning was invented not to completely replace the virtual classroom, but to add new dimensions to the concept.
According with Graham, C. R., Allen, S., & Ure, D. (2003), blended learning combines: a) online learning with traditional learning (in the class), b) learning online with contact to teacher, c) simulating with materials received, d) practical training with individual information sessions, e) management training activities with virtual environment. So blended learning combined face to face instruction with computer based instrunction.

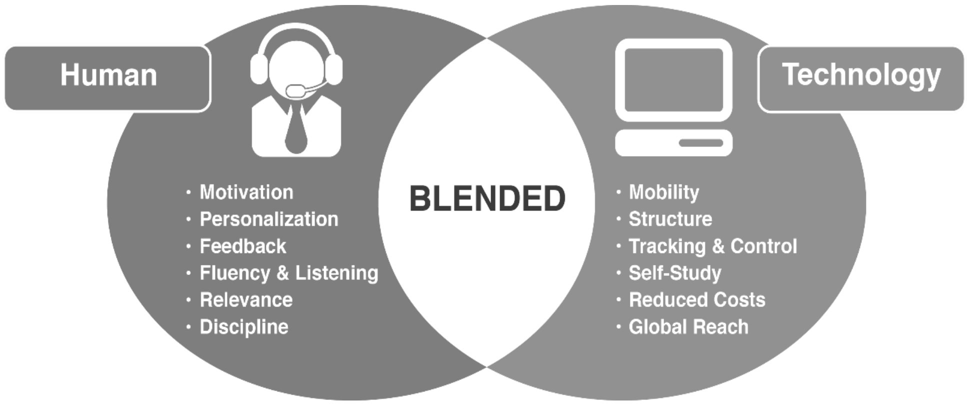

Figure 1: Blended learning models

Are three models used in blended learning:

- It is based on the traditional course structure and uses online resources to complement traditional reading and manuals. Although the technology is incorporated, it does not change course structure. Students work online and receive their materials through passwords and user names. However, students meet with students as often as in a traditional lecture, meeting face to face is the model further.
- Replace face to face meetings with online interactive activities. Students may notice significant changes during face to face meetings: online resources are integrated into the learning experience.
- Dismiss all face to face meetings, which are replaced with learning platforms. They offer access to online materials and support. Traditional lectures are not available and the communication is done exclusively through the internet

All three models are very flexible and presents both advantages and disadvantages.

Table 1: Advantages or disadvantages of blended learning

Advantages	Disadvantages
• Teachers should be better prepared to present their courses online. Also, teachers should pay more attention to how they present instructions for various activities, which was not the case in classroom activities, where students could copy the behavior of classmates • easier access to education, opportunity to interact with people from different parts of the country or worldwide, lower costs (especially if many universities use the same platform) able to evaluate several students simultaneously. • Increased flexibility because students can choose they come into contact with others and when to carry out research on their own, without time pressure that exists in a classroom. This may mean that they can find online platform simultaneously, so the relationship with the IT team must be excellent, so we can based on technology	• Some students are not accustomed to the latest technology, which does not mean they are less prepared than others when the time comes to assessment of knowledge gained at the end of the course; • Teachers are not accustomed with the technology and in many cases they will not learn new technologies; • Achievement of the difficulty and lack of control about it. You do not know who can log in to place the student or learner in the assessment stage.

To determine the right combination of face to face interaction and online activities should be assessed needs of students to course content and teacher preferences.

STRATEGIES IN BLENDED LEARNING

Certainly, student satisfaction compared to learning course handed should be evaluated. Evaluations can be used for students to understand that a blended learning course is not an disordely bunch of: face to face meetings, online activities and materials, but a well-focused structure that takes into account the needs and demands of students.
According with the “e-learning industry” blended learning is better because, at the level strategies, tools and learning objectives are achieved important changes regarding student-teacher relationship.

Table 2: Blended learning strategies, tools and resources

Strategies, tools and resources			
Goal	**Classroom Learning**	**Blended Learning**	**E-Learning**
Communication between teacher and students	• Full group lessons • Small group lessons or tutorials • Individual conferences Marked assignments and rubrics	• Full group lessons • Small group lessons or tutorials • Individual conferences • Marked assignments and rubrics • Digital course materials • Online discussions • E-mail • Instant messages • News announcements • Online calendar • Dropboxes • Online grade tool • Rubrics	• Digital course materials • Online discussions • E-mail • Instant messages • News announcements • Online calendar • Dropboxes • Online grade tool • Rubrics • Web conferences
Collaboration among students	• Learning centres or other room arrangements	• Learning centres or other room arrangements • Class discussions	• Online group work • Online discussions • Chat sessions

	• Class discussions Face-to-face group work	• Face-to-face group work • Online group work • Online discussions • E-mail • Instant messages • Blogs Electronic portfolios	• E-mail • Instant messages • Blogs • Electronic portfolios Web conferences
Demonstration of learning	• Paper-and-pencil tests and assignments submitted in person • Live presentations, labs, performances, or exhibits of skill Models, works of art, posters, and other physical artifacts submitted in person	• Paper-and-pencil tests and assignments submitted in person • Live presentations, labs, performances, or exhibits of skill • Models, works of art, posters, and other physical artifacts submitted in person • Blogs • Electronic portfolios • Online discussions • Online surveys and quizzes • Assignments, such as essays, worksheets, slide shows, photographs, and videos submitted to electronic dropboxes	• Blogs • Electronic portfolios • Online discussions • Online surveys and quizzes • Assignments, such as essays, worksheets, slide shows, photographs, and videos submitted to electronic dropboxes Web conferences

Source: https://elearningindustry.com/why-blended-learning-is-better

E-learning industry and blended learning process are influenced by economic development or people's ability to accept new technologies. The data collected from Training Magazine it is observed that the educational environment is still a reluctance on the use of blended learning in learning. In Figure 2 may be noticed that blended learning is used extensively in trainings carried out by the consulting firms for different categories of people in sales, IT, industry, etc. It can be seen that the management or executive development courses organized in e-learning system not attract participants.

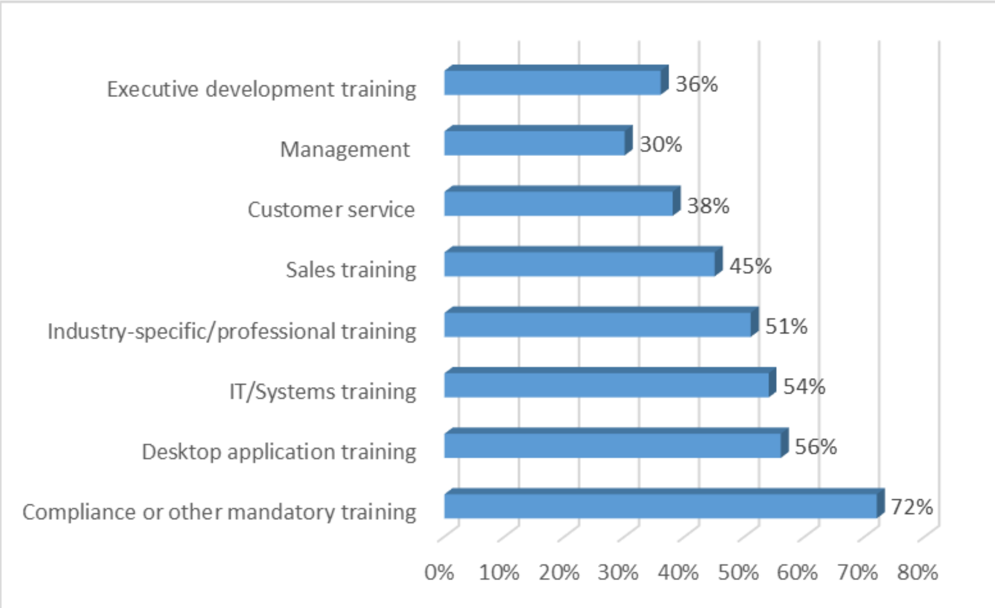

Figure 2: Impact of e-learning in training industry

According with Ambient Insight the e-learning market services in Romania is an important growth hovering four position at globally level after countries with a much larger number of inhabitants such as China and India.

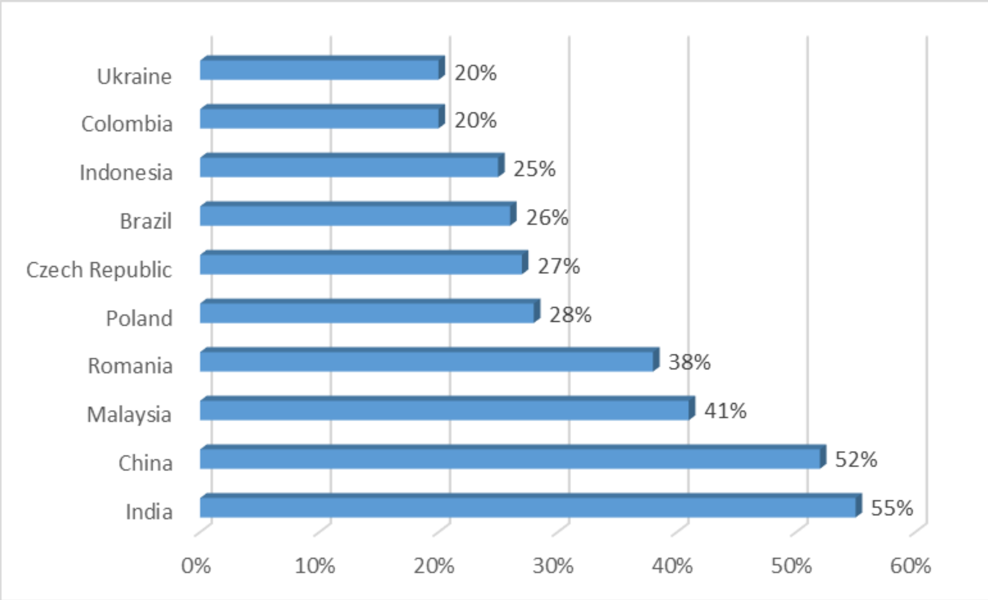

Figure 3: E-learning market growth in period 2012-2016
Source of dates: Ambient Insight

At the level of regions Figure 4 recorded growth of e-learning activities the area has great development in Latin America, followed by Asia, Africa. It is possible that in many of these areas access to education to be inhibited by the lack of qualified people or be inaccessible areas. Technology development in disadvantaged areas will enable access to education by e-learning or Latin American countries where access to education in Spanish or Portuguese.

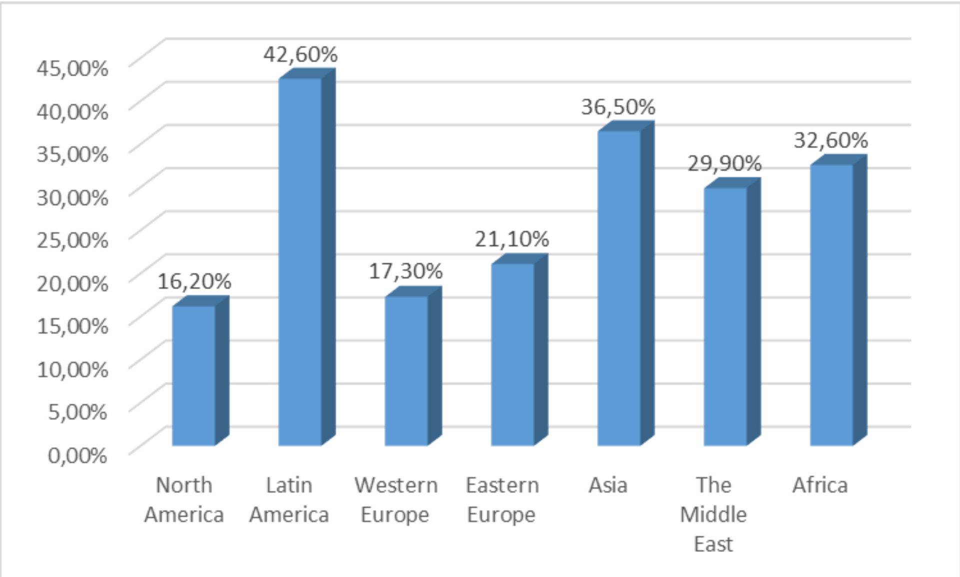

Figure 4: E-learning regions growth in period 2012-2016
Source of dates: Ambient Insight

Europe and North America does not have a significant growth in this direction of online learning because exist the possibility that European countries have developed such systems when this learning method are invented and during in this period growth has stopped or is very traditionalist on such methods of learning.

CONCLUSIONS

Blended learning known during the last period a significant increase in Romania and in developing countries. According to statistics this increase is based on people's need to have access to quality education in many cases they prefer these methods and want to participate at training realized by the experts from various fields. In Romania for example are some universities who purchased e-learning systems are used only for distance learning but not at the maximum level. Reluctance to use such technology appears in the evaluation period because there is a fear about the difficulty and lack of control.The new generations of digital natives students have dropped out these paradigms and faculties must change their strategies to meet the new educational needs and purchased thin king of technologies.

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HOW TO USE H5P FOR LEARNING IN ENGINEERING

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Abstract: *The H5P platform is designed to allow other people to develop new content types, either from scratch or as customizations of existing types. The specification for .h5p packages is online, with definitions in the form of .json text files. There's plenty of support info on the H5P web site, plus a lively forum. People with intermediate level tech skills can develop their own content. New users can sign up for an account on H5P.org within a minute, create content, share it and use it. It is very spreadable. The embed content has download options will accelerate the network effect further. In this article it shows how it can be created interactive content for online courses using h5p platform.*

Keywords: *learning, H5P, eLearning, course presentation.*

INTRODUCTION

Learning can broadly be defined as any process that in living organisms leads to permanent capacity change and which is not solely due the biological maturation or ageing, [1]. This definition of learning is necessary because this concept include a very sophisticated set of processes: nature of learning and all the conditions that influence or are influenced by learning process. An important condition that is implied in process is an external interaction process between the learner and his social, cultural or material environment. Another condition is internal, respectively the intern psychological process of elaboration and acquisition.

According [2] learning has three dimensions. The first dimension is the content what is learned. This is described like knowledge and skills, or other things like: opinions, insight, meaning, attitudes, values, ways of behavior, methods, strategies, etc. These things are involved as learning content and contribute at developing of understanding capacity of the learner. The endeavor of the learner is to construct meaning and ability to deal with the challenges of practical life.

Second dimension of learning process is the incentive. This dimension provides the mental energy that is necessary for the learning process to take place, and comprises: feelings, emotions, motivation and volition. The volition must continuous assure mental balance of the learner and develop a personal sensitivity.

The third dimension is interaction between the first two. For example, the learning content is influenced by learner incentive (desire to learn, interest, necessity or compulsion), but also conversely. The interaction provides the impulses that initiate the learning process, which take place like: perception, transmissions, experience, imitation, activity, participation, etc., [1]. It serves to personal integration in community and society.

Student behavior towards the content presented will be influenced by internal conditions (health at some moment) and external conditions (the environment where learns, the existence of clear deadlines, etc.). An important role in stimulating the student to learn the material presented its play by content, content to allow interaction and that is not static.

High quality content, polished design and easy navigability are three important ingredients of any successful eLearning course. However, one of the most essential elements of an eLearning course design and development is often overlooked; and that is no other than interactivity. Note that even high quality eLearning courses are going to fall short of expectations if the learner isn't fully engaged and motivated to learn. Not to mention that learners won't reap the many rewards your eLearning course has to offer, given that they are less likely to actually acquire and retain the information you're providing, [3]. The content must fulfill some conditions:

1. Keep it relevant and on-topic! This condition mean that the eLearning course must offer high quality and meaningful content will keep learners fully engaged and motivated to learn. On the other hand, including information that is general and not specific won't bring any added value to the eLearning course, and may

even make the learner question the value of the eLearning course as a whole. The key to finding what's relevant for your interactive online courses is to not simply include what the teacher think is important, but include what you believe the learner may find valuable.

2. Exploration is the key to learner engagement. It's essential that learners are given the opportunity to explore the eLearning course if you want it to be fully interactive. Include links that learners can just click on in order to learn more about the topic, create stories that they need to interact with, integrate visual components that make the topic more eye-catching, and encourage them to explore the module by hyper-linking to other pages that may be of interest. [3].

3. Include interactive, reality-based scenarios. The most powerful tool that teacher have at his disposal, when developing an interactive eLearning strategy is reality-based eLearning scenarios. Integrating real life examples and problems into eLearning course will give you the chance to draw in the learners and show them, first hand, how knowledge acquired can be applied outside of the learning environment. Teacher can design a scenario that allows the learners to tap into the skills they have learned during the eLearning course, such as technical problem solving or customer service, they gain experience that can be used on-the-job later on. These interactive scenarios can be made by including video, images, and audio.

4. Integrate quizzes or assessments at the end of each module or lesson. By including the quizzes and tests at the conclusion of each module not only allow teachers and creators to assess the effectiveness of the eLearning course, but also offer learners the opportunity to gauge their progress and summarize the content they have learned. These assessments must, include real-life problems that learners must solve by using their newly acquired skills. Offer point-and-click games that test their knowledge while steep keeping them engaged. These end-of-lesson quizzes can not only help to avoid boredom, but boost knowledge retention rates as well, [3].

5. Tap into their emotions. Emotional responses can also help learners to better acquire and retain new information or skills. Including videos that may obtain an emotional response or images that may allow them to personally relate to the subject are keys to interactive experiences.

6. Encourage group collaboration. The teacher must permit the students to communicate with one another. This is possible by using group discussions on online forums, encourage them to solve problems collectively via group chats online, and integrate social media sites. Group collaboration enables teacher to include the human element in eLearning courses, despite the fact that learners may not be meeting face-to-face.

7. Make eLearning course aesthetically appealing. An eLearning course that includes a variety of different multimedia elements and is aesthetically appealing is going to be more interactive than one that relies upon solely text content. Use fonts that are visually pleasing and videos that make a potentially repetitious or dry topic more engaging and attractive. Making your eLearning course attention grabbing and unique will help the learners to connect with the curriculum and get more from the educational experience.

To sum up, videos, images, and other interactive elements you include should not take away from the core content. For example, you should avoid using an abundance of graphics on any given page if you believe that it may distract the learner from the content itself. Only use multimedia and visual components that are relevant to the eLearning course and will help to highlight the principles/ideas, rather than abstract from the important aspects of the eLearning course, [3].

DEVELOPING H5P CONTENT FOR ELEARNING TEXTILE COURSES

H5P was originally developed by the Norwegian company Joubel (in Tromsø) for the National Digital Learning Arena, a Norwegian publicly funded learning portal. Its development was motivated by the need to move away from Flash based content. It is an "MIT licensed community development project".

H5P provides 26 types of self-contained HTML5 interactive content. All very slicks, stylish and compatible with the full range of web browsers and devices – with touch interfaces enabled for phones and tablets. There are 26 types of content that can be embedded into web pages, and which are useful for learning – but have wider applications as well (a nicely designed multiple choice quiz, an interactive timeline, flashcards). Two of the content types are more complex, allowing some of the other kinds of content to be embedded into "interactive videos" and "course presentations". Along with "timeline", these more complex content types can also include videos, images and (in the case of timeline) embedded PDFs and audio. In this way they can act as wrappers for “open educational resources” drawn from other sources (e.g. videos from YouTube). It can therefore create many different activities that draw upon the same set of generic resources. For example, a course presentation that takes a set of generic videos in a way that makes them meaningful for a specific course. Or we could provide the same video to a group of students and get each one of them to turn it into an interactive video, presenting their own interpretation. Each content type is accompanied by a simple wizard and wysiwyg drag-and-drop system for creating content.

Activities may be created, hosted and used in the H5P.org web site. Or it can install a plugin for Drupal and WordPress web sites that adds the same set of creation and hosting tools to those systems. A Moodle plugin is available (launched July 15th 2016) and should be in widespread use soon. That will accelerate adoption of H5P significantly, [4].

2.1 Course presentation

An example of course presentation editing is presented in figure 1. It is a course presentation with questions, media files which are embedded into the page. As with many of the H5P content types, it looks especially good when displayed at full screen (there is a button at the bottom right of its frame to go full screen).

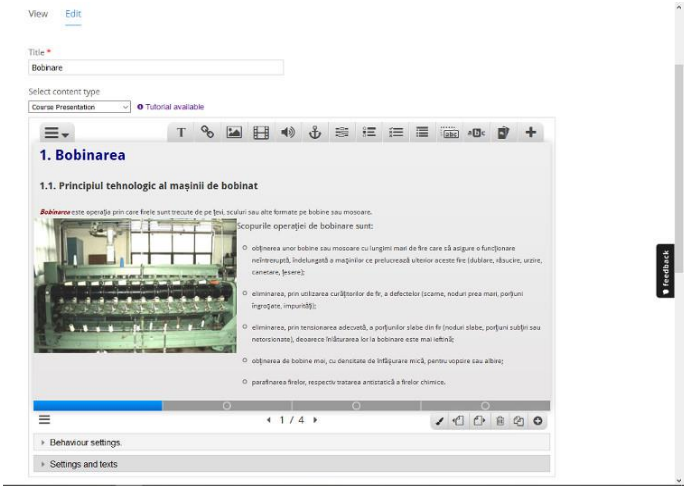

Figure 1: Course presentation editing

H5P does not present major technical challenges to authors – nothing greater than they might experience in using PowerPoint for example. The creative-pedagogic challenge of applying it is more demanding, and does require more sophisticated capabilities. For the individual author it looks good. When an author creates a H5P activity for the first time, or revisit a content type creates sometime after having first learned to do it, content creation is sufficiently intuitive and recognizable. Perhaps the biggest hurdle is in knowing which content type to use and how to use it. For example, when creating course presentations teacher still struggle in deciding which of the types of multiple choice activity he should use for which purpose. Fortunately the authoring interface makes it easy to try one out and then change it, figure 2.

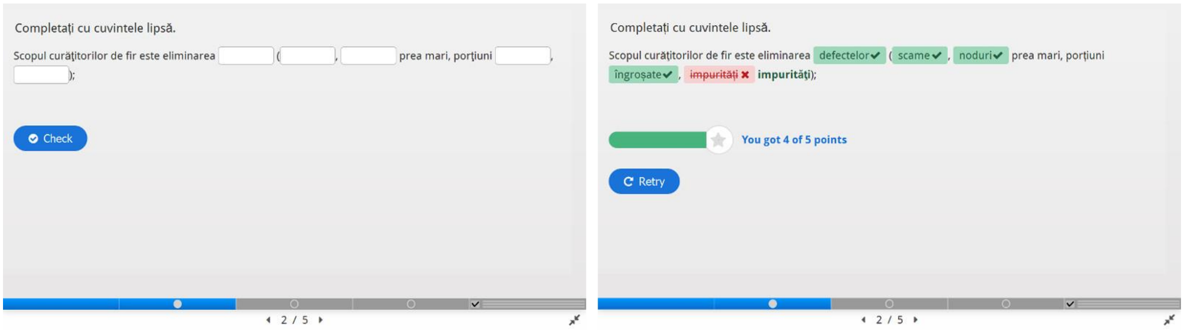

Figure 2: Course presentation – fill in blanks interactive activity

The content types themselves divide into two camps, with perhaps different likely areas of fit. The simpler content types probably have less of a clear fit in high education, and perhaps are more suited to schools. These elements can be used independently, but although one can imagine their integration into a well-designed web site as a coherent learning experience. The more complex composite types of content have great potential as OER (open education resources) wrappers, or for building immersive learning experiences – more coherent, flowing and hence immersive than we can easily achieve with conventional Moodle activities (for example). A wide range of people can create H5P activities. This has included medics learning to teach (doctors, nurses and paramedics), languages teachers, social science researchers (the timeline is especially useful), learning technologists and children.

However, for universities that encourage students to be creative, to be researchers, then perhaps the most exciting area of fit will be where students create H5P content. This might, for example, be a project in which they annotate a sequence from a movie from a philosophical perspective. Or they create a timeline as an assessed activity.

CONCLUSIONS

The H5P platform is designed to allow other people to develop new content types, either from scratch or as customizations of existing types. The specification for .h5p packages is online, with definitions in the form of .json text files. There's plenty of support info on the H5P web site, plus a lively forum.

People with intermediate level tech skills can develop their own content. New users can sign up for an account on H5P.org within a minute, create content, share it and use it. It is very spreadable. The embed content has download options will accelerate the network effect further.

Long term hosting of content is a problem. The H5P.org web site will can't host content that may be needed again in the future. Institutions should develop their own hosting arrangements, its can developed own Learning Management Systems like Drupal, WordPress and Moodle. Moodle will be a better option for institutions, but then limits the openness of content. A better approach would be to host and serve H5P from an OER repository.

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TECLO PROJECT – "TEXTILE AND CLOTHING MANAGERS FOR EXPORT, MARKETING, INNOVATION, SUSTAINABILITY AND ENTREPRENEURSHIP ORIENTED COMPANIES" – RESULTS AND FUTURE ACTIONS

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The Textile and Clothing Knowledge Alliance -TECLO is a two-year project, co-funded by the European Commission under the Erasmus+ programme. It aims at answering the new skills needs of the European textile and clothing industry, through:
- the development of sectorial methods for anticipation of skills needs;
-the set-up of the EU curricula for the new professional profile of the Textile and Clothing Managers (TECLOM);
-the development and pilot of a Massive Open Online Course (MOOC) for the new TECLOM focused on professional and transversal skills associated with entrepreneurship.

The main results obtained so far are as follows:

- A report containing a description of the new skills needed by future textiles and clothing managers and references to main sectoral observatories, research center and Higher Education Institutions;
- A report illustrating the results of a filed survey aimed at defining the profile of the new textile and clothing manager, involving 400 European SMEs, micro enterprises and Higher Education Institutions belonging to textiles and clothing sector;
- The »Decalogue« for future Textile and Clothing SMEs – motivational guidelines for companies (A document illustrating the 10 competitive advantages of co-investing and participating in the activities of higher education institutions, research centers and business centers to address new skills requirements);
- The new European Qualification Framework of the "Textiles and clothing manager for efficient and innovative SMEs;
- MOOC for future textiles and clothing managers that provides an easy access to a learning pathway for textile and clothing managers and HEIs students wishing to develop the future skills needed by the labour market .

Further actions:

- Piloting the TECLO Massive Online Open Course (MOOC) for the new TECLOM;
- Building an European Developmental Network for TECLO, pooling the assets of universities, research centres, SMEs and large Companies together and enabling them to continue the cooperation.

Keywords: *higher education, curricula, marketing innovation, new skills, massive open online course.*

REFERENCES*:* *http://teclo.eu*

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DEVELOPING NEW SKILLS FOR THE EXTROVERSION SPECIALIZATIONS OF FASHION INDUSTRY IN EUROPE – EXTRO SKILLS –

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Abstract: *The "Developing new skills for the extroversion specializations of fashion industriy in Europe" – EXTRO SKILLS, is a 30 months project, co-funded by the European Commission under the Erasmus+ programme. It aims at answering the new skills need of the European fashion industries through designing and developing of an innovative and comprehensive training protocol for export personnel of fashion industries, using ICT-based learning approaches and methodologies. The context of the Extro Skills project is the need of the fashion industries for a flexible workforce that can respond to the development and the globalized and internationalized market. The new curricula that will be developed will offer essential transversal skills for a quick and qualified response to the international trade and market demands and for enhancing the extroversion and the competitiveness of the fashion industry. The project products will follow a learner-centered approach and will provide SMEs with a high quality ICT Tool. The certification framework will be based on acquired knowledge, skills and competences, according to the European Qualification Framework (EQF). It is expected to be defined a professional profile for the exports and fashion marketing experts.*

Keywords: *online training, fashion industry, export and fashion marketing, new skills, curricula.*

INTRODUCTION

Over the years, fashion industries have played and continue to play key role in the competitiveness of the European economy. According to the European Commission "European fashion and high-end industries represent European cultural heritage and know-how. These industries are a significant part of the creative economy and form complex and strongly interlinked value chains from design and manufacturing to the distribution and retail of fashion goods" [1].

Nowadays, the fashion industries is subjected to a continuing restructuring and modernization that is due to many causes, resulting from the trade liberalization and increasing external competition, consumer developments, technological advances, changes in production costs and environmental issues.

Despite the economic crisis, many European companies have managed to defend their market positions in the international competition. This is mainly owing to their move to innovative, high-added value products, niche markets and new business models. With demographic expansion and economic growth leading to the increase of revenues in certain third countries, new export markets opened up for EU fashion products. Recent years have seen an increase in European exports, both to some of the rapidly growing emerging markets such as China, United Arab Emirates and Saudi Arabia as well as to developed countries, including USA and Japan. Taking into account the stagnating internal demand, exporting is currently the driving force for fashion industries. To benefit from this trend, more and better support is needed for companies, in particular SMEs, for which it is more difficult to sell or invest in new markets [2].

This change indeed requires a more qualified workforce to deal with new technologies, stimulate innovation, ensure quality management and develop international strategies and marketing. Therefore, the availability of adequately skilled workers has become one of the major issues for the fashion industries. Fashion industries faced the shortage of trained and qualified personnel for their export and fashion marketing departments.

Recognizing their critical role, recent European efforts, such as the European Skills Council of Textile Clothing Leather & Footwear and the European Fashion Industries Alliance, have come together in order to strengthen the comparative advantages of the fashion industries which include, among others, the well-educated and high-skilled professional workforce of the industry. Other factors include the rapid advance of digital technologies, the globalization of networks and the deregulation of media. It is, therefore, necessary to adopt a holistic, end-to-end approach to ensure that the industry workforce is adequately equipped with that skillset that brings out their talent, effectively address the challenges of the fashion sector in the new global environment.

Employees from the fashion industries, students and SME's, who would like to succeed, have to adapt to globalised market and ICT-based vocational education and training. Therefore a precise and effective ICT training tool for development, enhancement and boost of their transversal skills, is inevitably demanding.
Fashion industries need a flexible workforce that can respond to the development and the globalized market and the trend and need for internationalization. The workforce needs to be well qualified and ready to face the increased competition and rapid technological changes. To be compete in the global market fashion industries have to be smarter and able to adapt to changes. To achieve this, fashion industries need new education and training systems and tools for their existing and potential workforce in order to respond to the demands of the labour market and the global competition. In a framework of global competition, innovation and development are crucial elements to provide fresh impetus to a sustainable and competitive industry.

In this context, the project aims to design and develop an innovative and comprehensive training protocol for export personnel of fashion industries, using ICT-based learning approaches and methodologies that will offer essential transversal skills for enabling them be ready to respond to international trade and market demands and enhancing the extroversion and the competitiveness of the industry as a whole. Bringing together the different sectors of fashion industries, the proposed protocol will follow a comprehensive learner-centered approach and will be coupled with an integrated certification framework, based on acquired knowledge, skills and competences, in line with the European Qualification Framework (EQF).

PROJECT OBJECTIVES

The overall objective of EXTRO SKILLS project is the design and implementation of an innovative and comprehensive training protocol. The platform will focus on online training and will facilitate dissemination of knowledge and sharing of experience. Moreover, it will serve as a medium for all stakeholders in the field to share concerns and advice, as well as promote employment opportunities.

Generally, the work-based training ICT tools in fashion industries exist but are outdated. Also their availability is often not sufficient, the content is out-of-date and its distribution is not organized satisfactorily. Majority of present information materials regarding exports and global market information are at disposal only in paper form and most of them don't cover modern trends, materials and fashion. Therefore, such a professional tool is considered extremely useful, since it helps to enhance the international extroversion of the sector especially for SME's.

The platform will respond to fashion marketing skills and for that scope will concentrate information and data regarding third countries market mechanisms and their function market's technical requirements, recent trends of fashion marketing and expo's evaluation in the global market, market's development, development of the demand of sector' s products, consumer's behaviors and habits, trend analysis, demand chain, mechanisms for directs distribution of a product to international markets (by identifying customers; meeting their needs; implementing sales plans).
The Extro Skills project will bring this gap between fashion industries and lack of specific expertise and experts in fashion industries SME's.

The sub-objectives of the project:

- Improvement and extension of high quality learning opportunities tailored to the needs of export and fashion marketing personnel
- Provide SME's with a high quality ICT Tool Establishment of close cooperation between formal education providers and businesses in order to increase the market relevance of the proposed training protocol
- Define a professional profile for the exports and fashion marketing experts

EXPECTED RESULTS

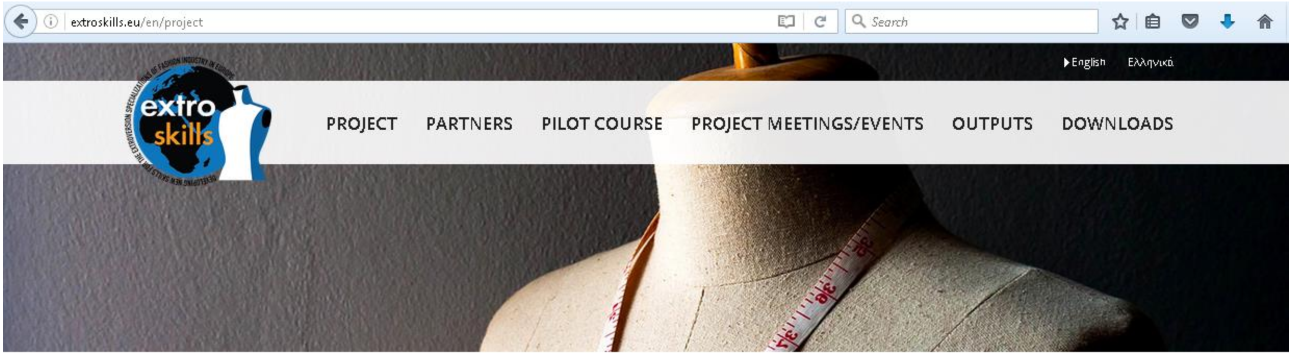
The main expected results of the project to be achieved during the 30 month of project implementation are the following:

- Development of a new European ICT-based training protocol to enhance knowledge, skills and competences of export personnel and brand managers following a holistic, end-to-end approach that brings together different sectors of fashion industries and views them under a common training umbrella;
- Piloting of the developed platform, as an innovative initiative in lifelong learning in a non-formal, business setting, based on experiential, work-based, problem-based and self-directed learning, and a learning outcomes approach;
- Establishment of an integrated framework for cross-sector certification of export and fashion marketing personnel, increasing transparency, comparability and validation of qualifications (European standard as per EQF);
- Define and develop a Curriculum for the VET as an European Standard, including a qualification and recognition framework;
- Establishment of a digital training platform which will bring together fashion industries managers across Europe, provide online training and facilitate dissemination of knowledge and sharing of experience. Moreover, it will serve as a medium for all stakeholders in the field to share concerns and advice, as well as promote employment opportunities;
- Improvement and extension of high quality learning opportunities tailored to the needs of export and fashion marketing personnel, operating within the entire spectrum of fashion industries;
- Provide SME's with a high quality ICT Tool, which will facilitate the organisation and function of export departments;
- Establishment of close cooperation between formal education providers and businesses in order to increase the market relevance of the proposed training protocol;
- Define a professional profile for the exports and fashion marketing employees (focused on SME's);

Partners involved:

1. The Hellenic Fashion Industry Association, Greece - Coordinator
2. The Huddersfield and District Textile Training Company, UK
3. TEXFOR Association, Spain
4. GNOSI ANAPTIXIAKI NGO, Greece
5. "Gheorghe Asachi" Technical University of Iasi, Romania
6. EURATEX, Belgium

Project Website: http://extroskills.eu/en/project



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