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INNOVATIVE ASPECTS REGARDING UHF WAVES USED IN TEXTILE FUNCTIONALIZATION

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Abstract: *This paper we present several innovative aspects regarding the UHF (ultra high frequency) microwaves used in textile functionalization for obtain a dielectric surface. The UHF microwaves (MW) are in the range 300 MHz÷3 GHz. In general, the microwaves are in the range between 300 MHz and 300 GHz, but for our experiment was used the microwaves at the 2.45 GHz frequency. The microwaves are generated by a magnetron device and used for textile functionalization in order to accelerate the polymerization reaction.This work is a survey regarding the microwave applications for textile functionalization for setting the textile functionalization process by microwaves. The innovative technologies, such as plasma or microwave, have been used frequently in physics area research and in electronics. Both plasma and microwave devices operating in the field of radio waves, LF, UHF [1] and in general, the radio waves are used for TV signals transmission, for satellite communications and mobile telephony. The microwave radiation is is produced by magnetron microwave generator in microwave cavity (vacuum tube). However, for our experiment was used the microwaves at 2.45 GHz. Microwaves (MM) system are based on the absorption of a relatively strong radiation of this frequency in materials (plastics, textiles). The microwaves propagation on the textile materials depends on the dieletric material property.*

Key words: *microwave, functionalization, textile finishing, electromagnetic, hydrophobic, oleophobic.*

1. INTRODUCTION

The MM waves are used, for example in astronomy, while THz waves represent a radiation with a wavelength (0.1-1 mm) shorter than microwaves and is investigated and used in several practical application such as security THz spectroscopy, 3D imaging, THz tomography, submilimeter astronomy and security. The infrared radiation (light) is very helpful in the physico-chemical analyzes by spectroscopy. Also it is also used for the transmission of wireless data but at small distances, as is the case at almost all remotes for TVs and other household appliances. The ultraviolet radiation (light) is responsible for the tanning of the skin. X-rays (or an x-ray sequence) are used for a long time in medicine for viewing the internal organs. Finally, the gamma rays occur often in nuclear reactions

Even if the microwaves are in the range between 300 MHz and 300 GHz (figure 1), for experiments in the textile domain are used the microwaves at the 2.45 GHz frequency.

The microwave used in textile finishing may lead to obtain the highly hydrophobic and oleophobic textile surfaces. In this way, are significant results in using the microwave for grafting the fluorosilane in maximum 1 minute [2]. The MW radiation has been used in processes such as desizing scouring, bleaching, dyeing [3, 4], drying processes, durable press finishing, flame retardant [5, 6] and Also, the silver nanoparticles silver nanoparticles were synthesized on the pretreated silk fabric under microwave irradiation [7] and ZnO-coated textile fabric was synthesized by microwave method [8, 9].

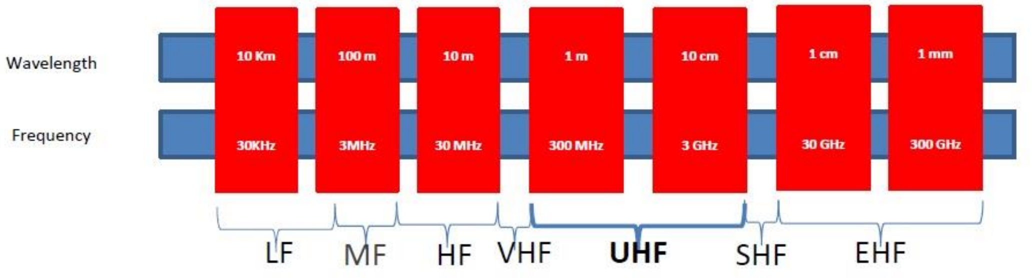

Fig. 1. *Wavelenght vs. frequency*

2. EXPERIMENTAL PART AND DISCUSSIONS

The microwaves were generated by a magnetron device and used for textile functionalization in order to accelerate the polymerization reaction. Conducting polymer coated textiles have potential can be used in absorbtion/shielding of the electromagnetic radiation.

The MW systems used in textile surface functionalization consist of three main units: magnetron, waveguide and applicator.

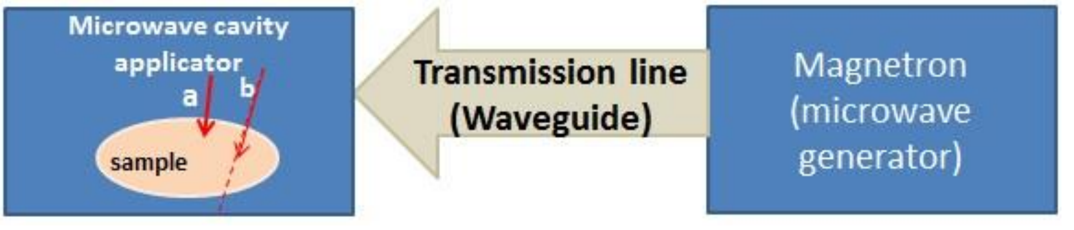

Fig. 2. *Microwave system*

Microwaves generated are spreading in the cavity of the appliance and hitting the walls and after are reflected or are absorbed in whole or in part in the fabric, generating warming up the whole material.

If the textile material is exposed to the microwave radiation, the microwaves:

-are reflected if the surface is a conductive material;

-penetrate the material without being absorbed in the case of textile materials with good insulating dielectric properties (glass fiber fabrics treated with ceramic or particle –fig1-b)

-are absorbed if the fabric has low dielectric properties. When microwave energy is absorbed by the fabric and is converted into heat.

The advantage of the MW technique is the uniformity of the treatment (heating, drying) that can improve the textile surface functionalization by acceleration of the polymerization.

A dieletric materials are electrical insulators that can be polarized by apply an electric field [11-14]. For use of textile in electronic devices, named as textronics or smart garment it is very important to have information about relative dieletric permittivity (1) ÷(4) of the material [12-13].

$$\varepsilon = \frac{E_0}{E} \qquad \textbf{(1)}$$

Where:
ε is the relative dieletric permittivity;
E_0 is the electrical field inside the dieletric material;
E_p is the field generated by the material polarization P.

$$E=E_0+E_p \qquad \textbf{(2)}$$

$$E_p = \frac{-P}{\varepsilon_0} \qquad \textbf{(3)}$$

$$\varepsilon = \frac{\varepsilon_0}{\varepsilon_r} = \varepsilon_0(\varepsilon_r' - j\varepsilon_r'') \qquad \textbf{(4)}$$

The average microwave power absorbed by a dielectric material is stated in the math expression (5) [15]. The increasing of the frequency f = (3...300GHz) means the decreasing of the wavelengths and penetration will be superficial, in broad terms the radiation will not integral absorbed in the material. The degree of the radiation absorbtion it is depending on the dieletric material property [16] and is inverse proportional with the frequency and direct proportional with the wavelength.

$$P = \omega\varepsilon_0\varepsilon_2 E_{eff}^2 V \qquad \textbf{(5)}$$

Where:
V is the volume of the dielectric material;
E_{eff} is the square of the average electric field in the volume unit (V)
ε_2 is the imaginary part of the dielectric constant ($\varepsilon = \varepsilon_1 + i\varepsilon_2$)

The moisture content can influence the dieletric property of the textile. For develop an insulator material is important to involve the intense drying of the material that can be obtained by microwave treatments. From polymers used for textiles, polyethilene and polypropilene has the lower relative dieletric permittivity.

4. CONCLUSIONS

The microwaves uses for textile functionalization *have the advantages*:
-generate less heat;
-reduced time for cleaning/activation of the textile surface;
-reduce the time allocate for polymerization (1 minute)
-the processes are in a cavity EM protected;
-do not generate water consumption;
-do not generate waste;
-generate the curing of the sample.
The *disadvantages are*:
-the energy consumption is high.
-involve sophisticated manufacturing technologies;
-involve higher costs for mentenance;
-generate a high-energy consumption;

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ANNALS OF THE UNIVERSITY OF ORADEA
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MANUFACTURING OF TUBULAR LENO FABRICS BY MODIFIED STANDARD SAMPLING LOOM

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Abstract: *Leno fabric pattern was first developed at the beginning of the 1900's. Leno weaving structures, which are net-like porous, also called gauze, cross or doup weave. There are several types of leno fabrics which included plain and fancy lenos. Although, plain leno-weave structures is used mainly to make selvedge in the industrial weaving machineries, the fancy leno-weave fabrics are used for home, industrial, agricultural, medical and geo textiles and civil engineering applications, as well. Leno structures is woven by special manufactured leno weaving to exemplify circular leno looms. In order to produce leno fabrics are used leno heddle types. Essentially, lenos fabric is formed that one warp yarn is raised and passed over from one side of adjacent warp yarn. When the two adjacent warp yarns is twisted, weft yarn is inserted them, as well. Because of porous and entangled structures, they are lighter but stronger than plain structures. In this study, Firstly, we have woven tube-like leno structure by modifying Automatic Sampling Loom. Secondly, it was woven double layered tubular leno fabrics from different types of yarns by modifying standard automatic sampling loom and measured the mechanical properties of resultant. In the last part of study, to investigate surface characteristic feature more closely, we used a stereo microscope.*

Key words: *Leno weaving, loom modification, Mechanical properties*

1. INTRODUCTION

The leno weave, which is also called gauze weave, cross or doup weave is a weave in which two warp yarns cross over each other and interlace with one weft yarn. To produce leno weave special leno heddles are used. The leno heddle picks up or down the pairs of warp yarns [1], [3], [6]. When the parallel two warps are intercrossed by leno heddle on the frame, weft yarn is inserted. The warp yarns thereby firmly hold the weft yarn and prevent the movement of it [2], [5].

The most prominent feature of leno structure is the formation of porous net-like structures. These open structures are extremely stable, strong and have sufficient strength [4], [5]. The weight of the fabric produced with gauze weave is very light because of mesh structure.

Beside of plain leno weaving, it is also possible to weave fancy leno fabrics by various combinations of crossed yarns (Fig.1). While plain leno-weave structures is used mainly to make selvedge in the industrial weaving machineries, the fancy leno-weave fabrics and some plain leno weave fabrics are used for home, industrial, agricultural, medical and geo textiles and civil engineering applications [2], [3].

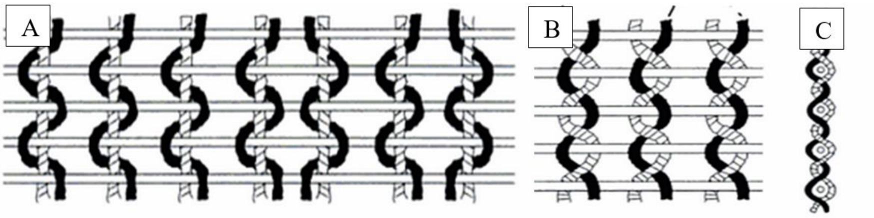

Fig.1: *Plain leno weaving structures: warp yarns white barred: stationary black: crossed, Plain white: weft [1], [3] A: one-twist two gauze B: two-weft gauze C: Crosscut view of leno fabrics.*

The aim of the study is to weave double layer tube-like leno fabrics from three different types of yarns by modifying standard automatic sampling loom (CCI) for leno weaving and to measure the mechanical properties of resultant fabric.

2. EXPERIMENTAL

2.1 Material

The standard sampling loom was used to produce fabrics. In order to produce leno structure LENO Device 330 type Leno heddles were placed on harnesses. As weft and warp yarns for leno weaving, one of the following yarns were used: 200 denier polyester filament yarn (IPET200), 200 denier Vectran staple yarn (VECT200) and 1000 denier high tenacity polyester yarn (HTPET1000) were used. Resultant tubular leno fabrics were subjected to tensile test by Zwick/Roel Z010. The surface morphology of fabrics was investigated by stereo microscope (Olympus SZ).

2.2 Method

2.2.1 Modification of Standard Sampling Loom

In order to produce leno woven fabric, heddle wires of CCI Standard Sampling loom were replaced by LENO Device 330 type Leno heddles and warp yarns were pulled through the heddles (Fig.2A). These two adjacent warp yarns were passed through from each leno heddle's in/out eyes. During leno woven fabric formation, two warps that were placed parallel were twisted by Leno heddle and crossed over each other and then weft insertion was performed to entangle warp yarns. At the same time, one group warp yarns were let off to pass over excessively because yarns of outside of leno heddle were uphold as for that inside of heddle. After changing of frames, holding up warp yarns drops respect to other warp yarn group. This caused tension differences between upper and lower warp (inside and outside) yarn group. Warp yarn tension control mechanism on standard sampling loom for leno selvedge of fabrics, was limited and not sufficient to weave fully leno fabric. Therefore, to create necessary tension during weaving, weights and tension bar were used for each warp yarn (Fig.2B).

In addition, leno structure is generally used for formation of selvedge of woven fabrics and leno warp yarns are supplied from spools under tension control. For production of leno selvedge of standard fabrics, limited number of yarns, which are winded from warp creel (Fig. 2D). However, the loom needs to let off tension controlled warp yarns from bobbins to produce leno weaving fabric. Therefore, the loom was integrated with back separation reed and warping creel (Fig. 2E) that have under tension control to prevent excessive winding problem. The aim of the using two different separation reed between the loom and creel was to prevent yarns from becoming tangled with each other.

2.2.2 Production of tubular Leno woven fabric

A leno heddle type 330 was mounted two sequential frames of the loom. Two frame was used to reinforce selvedge of the pattern for tubular fabric and remaining 16 frames were used to weave the main pattern. Tubular leno fabric, which was formed double layer woven structure, was produced from 32 warp yarns. The draft plan is given in (Fig. 3).

As a part of this study, weave main pattern for leno double layered structure was developed. There are two different warp yarn groups which are called lower and upper warp groups to produce double layers fabrics. The pattern shows that warp and weft directions are columns (bottom to top) and rows (left to right), respectively. In addition tubular leno fabric pattern includes different symbols.

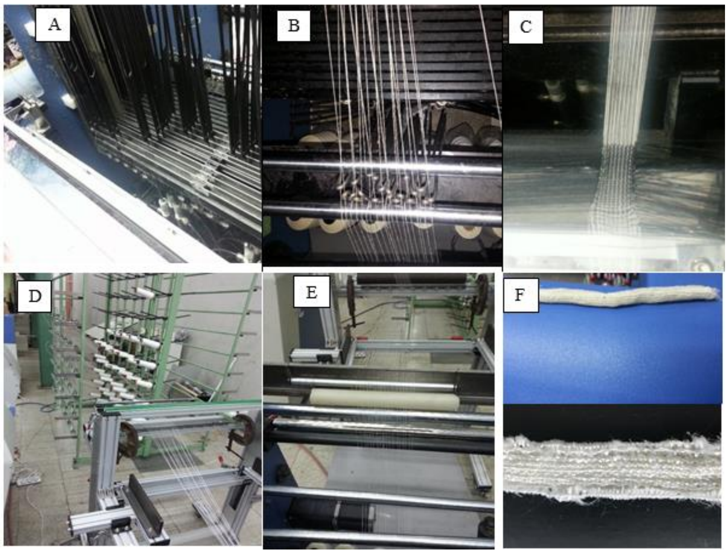

Fig. 2: *Sampling woven loom modifications A: Leno heddles and order, B: weights for tension control, C: Double layer tubular leno fabric on loom D: Creel and parallel feeding warp yarns, E: Separation and orientation reed, F: Tubular leno fabrics.*

8				O		O		O		O		O		O		
7				X		X		X		X		X		X		
6			O		O		O		O		O		O			
5			X		X		X		X		X		X			
4		O													O	
3		X													X	
2	O															O
1	X															X
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32

Fig. 3: *In order to woven double layer tubular leno fabric, draft plan. X and O: yarns inserted into inside or outside heddle eyes, respectively.*

In pattern, the latter "A" (above) and "B" (below) indicates that warp yarns are woven in the upper or lower warp groups, respectively (Fig. 4).The latter of "X" means that warp yarns including upper groups are replaced with lower warp groups and the latter of "O" indicates reverse motion of "X" with regards to border of pattern (Fig. 4).

To produce Leno tubular fabric with VECT200 yarn, yarns were twisted two ply yarns with a 300 twist per meter in the Z direction, IPET200 and HTPET1000. The Leno tubular fabrics with weft densities of 40, 50 and 60 weft/cm were produced on modified loom (Fig. 2C). In order to reduce yarn-to-yarn friction force which decrease tensile strength of warp yarns, they were coated by paraffin bars (Fig.2E).

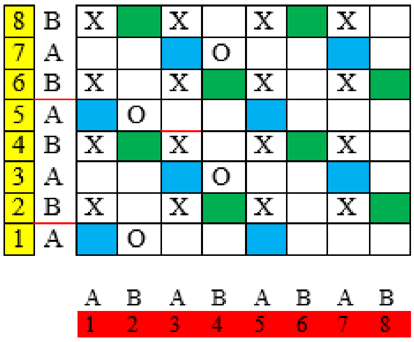

Fig. 4: *In order to woven leno tubular fabric, pattern repeat; A: Above, upper group yarns B: Below, lower group yarns*

2.2.3 Tensile properties Measurement of Tubular Leno Fabrics

The tube-like leno double layer fabrics (Fig. 2F) were conditioned in a standard atmosphere (TS EN ISO 139) for at least 24 hours before tensile test. Tensile test was performed until breaking by using a constant speed gradient dynamometer at the speed of 10 mm/min without pre-load and test sample length was 40 mm. It was used 2500 gram-force load cell and tenacity, breaking elongation and stiffness values were recorded.

2. RESULTS AND DISCUSSION

The breaking load values of the tubular leno fabrics that woven from three different yarn types were measured and compared. The results are given in Fig. 5. The fabric made from HTPET1000 yarns had the highest breaking load. It was also found that weaving density (40, 50 and 60 weft/cm respectively) affected breaking load. In case of HTPET1000 yarn, as the fabric density was increased, breaking load of the fabric was decreased. However, leno fabric made from VECT200 high tenacity yarn showed an opposite trend. On the other hand, the breaking load of fabrics made from IPET200 yarns were not affected from the weaving density.

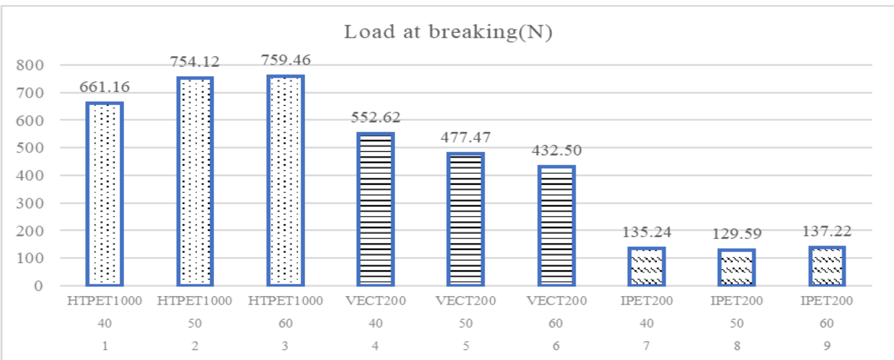

Fig. 5: *Breaking strength of several leno tubular fabrics*

It is seen from the Fig.6 that fabrics made from VECT200 yarns showed the least strain percentage. This could be attributed to high molecular orientations of vectran fibres. Weaving density was inversely proportional to the strain percentage (Fig. 6). Because, during tensile test, the force is applied leno structure longitudinally, twisted warp yarns start to squeeze weft yarns and causes to cut them easily. Therefore, leno fabric number 6 had a breaking strength less than leno fabrics number 4 and 5. It is likely that polyester leno structures were more flexible than vectran ones.

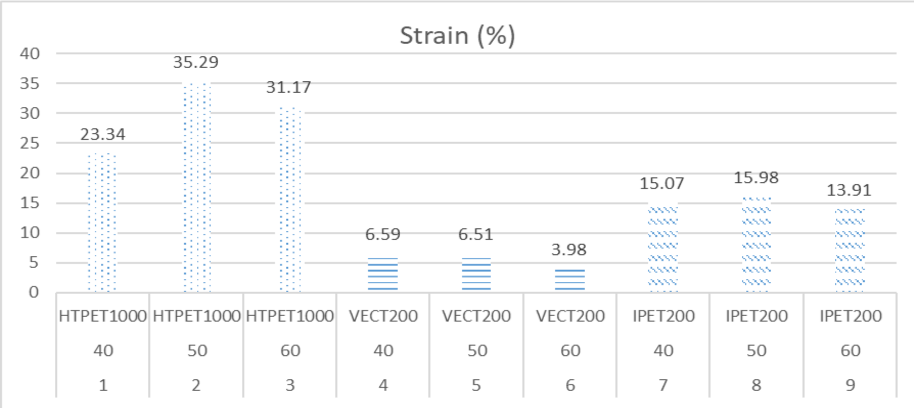

Fig. 6: *Elongation at break percentages of produced tubular leno fabrics*

One of the most important factor for leno fabric mechanical properties was stiffness. It demonstrated that stiffness of fabrics aren't only depended on material type but also fabric density (Fig. 7). Stiffness of number 4, 5 and 6 leno fabrics were extremely high. It means that breaking strength of vectran fabrics were the best against abrupt loads.

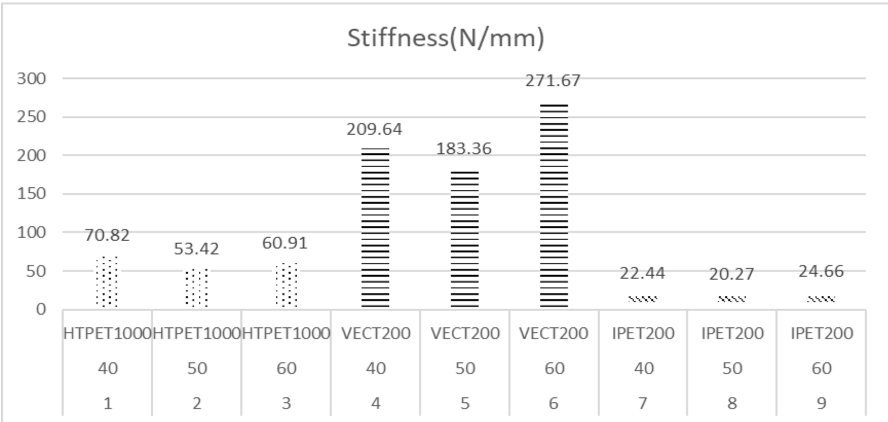

Fig. 7: *Stiffness of leno fabrics*

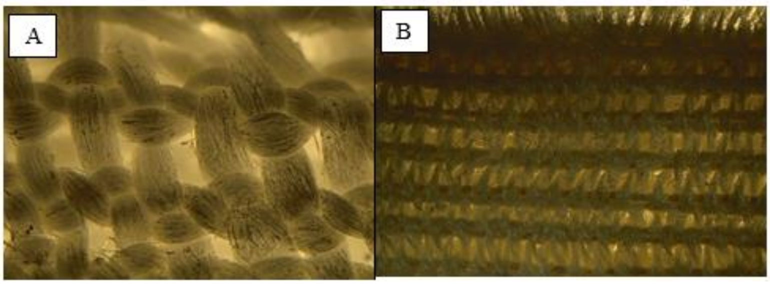

Fig. 8: *Longitudinal surface view of Leno fabrics; A: HTPET1000 B: VECT200.*

Finally, in order to investigate leno fabric surface morphology, it was taken longitudinal images by stereo microscope. Magnification rate was calculated as 10 times. It was seen that if thick count yarns are used to woven leno fabric, they are more porous structure. Using fine yarns has caused the leno fabric surface to be smoother (Fig.8).

3. CONCLUSIONS

Aim of this research was to woven tube-like leno structures from three different type yarns properly by modifying Automatic Sampling Loom and to compare the mechanical properties of these fabrics. Tensile test results show that although leno fabrics consisted of 32 warp yarns and 6-8 mm in diameter, they were durable substantially. It was seen clearly that surface pattern of fabrics are smooth and highly porous. Therefore, it is thought that in the further studies, leno could be used for medical textile for instance, especially artificial ligament or blood vessel implants.

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ANNALS OF THE UNIVERSITY OF ORADEA
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AUTOMATIC SYSTEM TO CONTROL THE ANISOTROPY OF NONWOVEN FELTED WEBS

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Abstract: *The webs produced using a card as former system generally keep the fiber orientation. This effect is not very important for a great number of applications. But if an even pore distribution is necessary or the mechanical properties are to be uniform in all directions, then this system doesn't work very well. Some years ago, it has been introduced a drafting operation of the web between the pre-needling and the final needling operations, as a solution. However, this alternative has a problem: there is no way to adapt it to variations in fiber orientation in the web. Taking into account these considerations, a new technological solution has been specifically devised to control the fibre orientation during the drafting operation in pre-needled felts. A prototype is used as drafting unit with the rolls driven by stepper motors and controlled by computer. Two video cameras collect images of the surface of the web, before and after the drafting operation, and process them in a computer. The values of the images textural descriptors, are calculated and compared. It is intended an increase in entropy which means that the web become less ordered and this is the situation we are aiming for. A computer program will adjust automatically the speed and pressure of the drafting cylinders so as to achieve the best possible situation in terms of the isotropy of the final product and, consequently, MD:CD ratio close to 1.*

Key words: *Nonwovens, Needlepunched, Drafting Control, Image Analysis, Texture Analysis, Anisotropy.*

1. INTRODUCTION

Although presently there are available several different methods for web formation, the use of a card, as a web former unit, is very common, mainly because it is a technology very well-known and accepted by the textile industry. For technical applications, the only problem present when the card is the former system is that a certain fiber orientation always occurs, which is acceptable in many cases because normally a cross lapper is used to increase the thickness of the web and to adjust the mass per unit of area. Although the mechanical properties of a product based on such a system may be similar in both principal directions, it must be considered that each layer keeps its particular fiber direction. Yet, for many applications, it is necessary that the distribution of fibers be as isotropic as possible in order to permit an even pore distribution as well as equal mechanical properties in all directions, particularly, along the MD and CD axis hence, requiring an MD:CD ratio close to 1. When the web consolidating system to be used is a needling process, a good solution consists in producing this needling operation in two steps: pre-needling and final needling [1,2]. During the pre-needling operation tufts of fibers are transported from their horizontal position to a vertical situation. If a drafting operation is introduced between these two steps, the fibers of the horizontal structure may rotate around the fibers of the vertical structure and reorient themselves. The critical point of this method is the control of the drafting operation. If it is not enough extended, then the web will keep some fiber orientation in a particular direction. On the other hand, if the drafting operation has been carried out too far, then a new kind of orientation will arise with all the inconveniences of the first one [3,4]

Characterization of web superficial properties with image analysis

Image analysis deals with images and can be summarized as a set of techniques that convert object images in numbers and prepares this data to be processed by computer methods. It is also known as digital image analysis [5]. Texture analysis, is an essential concept of image analysis that deals with primitives or elements called texels, and this mean a contiguous set of pixels with some regional property or pattern. A texture feature is a numerical value, extracted from an object image, that gives us some information about the variation of grey levels distribution and variation on an image. From a statistical point of view, image textures are complicated pictorial patterns that can be defined by statistical models, in way to characterize these same patterns.

According to the consulted bibliography, we found a prevalence of texture discrimination by the co-occurrence matrixes method in multiple researches works in many fields. This technique gives us a high dimensional texture description and puts in evidence the space relations between the grey levels. Thus, as the grey levels are a function of the mass per unit area, we have a direct characterization of the material structure [6]. The probability of spatial grey level co-occurrence is a second order density probability, which can be defined by a matrix of relative frequencies *f(i,j)* with witch two neighbouring pixels separated by a distance d on θ direction, occur on the image, one with grey level *i*, and the grey level *j*. Thus, for an image with N_G grey levels, the probability density functions can be written under the form of four squared matrices N_G X N_G for the 0º,45º,90º e 135º directions Haralick, Shanmungan and Dienstein [7] proposed 14 measures of textural features derived from the co-occurrence matrices, each one representing certain image properties. However, the textural descriptors used in this work were:

First order entropy $H = -\sum_{i=0}^{G-1} p(i)\log_2\left[p(i)\right]$ **(1)**

Second order entropy $ENT = -\sum_{i=0}^{G-1}\sum_{j=0}^{G-1} P_{d,\theta}(i,j)Ln\left[P_{d,\theta}(i,j)\right]$ **(2)**

2. MATERIALS AND METHODS

The experimental setup developed in this research work was comprised by the following elements:

1 – A Cosmatex nonwoven laboratorial line composed by a feeding/opener, card, cross-lapper and pre-needling/needling apparatus.

2 – An image analysis system composed by a Frame grabber DT3155 from Data Translation inc; 2 CCD_s Cohu model 2652-2000; Lenz system from Cosmicar – pentax; Monochromatic video monitor model TM923B from JVC and 1 PC for the drafting and pressure control and 1 PC for image acquisition and processing.

3 – A specifically devised pre-needled drafting prototype, conceived with 4 drafting zones between 5 drafting sets of cylinders and equipped with two CCD_s, one at the beginning of the process and another one at the end.


Fig. 1*: Illustration of the developed prototype and control system.*

The pre-needled webs were produced using Lyocell fibres with 6,4 dtex and 60,5 mm. The needling density was kept constant and the webs mass per unit area were170 g/m^2. The drafting operation was conducted with constant pressure on each pair of rolls (2,4bar) and constant and equal pre-drafting length for all drafting zones. The variable parameters were the drafting ratio which assumed the following values: 0%; 6,7%; 13,3%; 20%; 26,7%; 33,3%; 40% and the used drafting zone (C1; C2; C3; C4). The pre-needled web´s images were acquired at the entry (IN) and at the exit (OUT) of the drafting operation. Their textural descriptors were extracted using the spatial grey level dependence method and compared in a fully automated and real time process.

3. RESULTS

3.1 - First order entropy

Table 1*: First order entropy results*

Drafting	Zone 1 (C1 IN)	Zone 1 (C1 OUT)	Zone 2 (C2 IN)	Zone 2 (C2 OUT)	Zone 3 (C3 IN)	Zone 3 (C3 OUT)	Zone 4 (C4 IN)	Zone 4 (C4 OUT)
0	6,02	6,215	6,098	6,152	6,033	6,249	6,071	6,397
6,7	5,955	6,458	6,107	6,233	6,073	6,208	6,028	6,304
13,3	6,069	6,505	6,058	6,283	6,068	6,277	5,877	6,488
20	6,092	6,481	6,127	6,467	6,092	6,331	5,994	6,540
26,7	6,062	6,470	6,067	6,453	6,041	6,323	5,918	6,526
33,3	5,946	6,440	6,193	6,391	6,095	6,300	5,872	6,450
40%	5,962	6,411	6,23	6,376	5,979	6,294	5,915	6,387

The observation of the evolution of the 1st order entropy when dependent of the increasing drafting ratio clearly shows that, for every drafting value considered and for all the drafting zones involved, the output entropy value is always higher than their comparative entry value. Additionally, our findings point that all the drafting zones analysed present a continued growth of the output entropy value until it reaches their maximum, which occurs in the drafting zone 4 and with a drafting ratio of 20%. When surpassing this value, with a continued increasing of the drafting ratio, all the drafting zones exhibit a slight but steady decrease of the first order entropy.

3.2 - Second order entropy

The analysis of the 2nd order entropy output, for all the different studied angular directions and for all the drafting zones, exhibits a similar behaviour. The collected data are shown in table 2.

***Table 2**: Second order entropy results*

Drafting Rate	SIN 0º	SIN-45º	SIN 90º	SIN 135º	SOUT 0º	SOUT 45º	SOUT 90º	SOUT 135º	AVERAGE OUT
Zone 1									
0	10,400	10,770	10,481	10,773	10,448	10,836	11,062	10,866	10,803
6,7	10,454	10,776	10,441	10,785	10,955	11,305	10,973	11,318	11,138
13,3	10,514	10,849	10,520	10,858	10,981	11,318	10,556	11,350	11,051
20	10,550	10,979	10,673	10,986	10,932	11,383	11,156	11,397	11,217
26,7	10,496	10,865	10,564	10,870	10,942	11,341	11,095	11,331	11,177
33,3	10,355	10,701	10,397	10,712	10,912	11,318	11,079	11,338	11,162
40	10,318	10,707	10,418	10,716	10,871	11,245	11,046	11,265	11,107
Zone 2									
Drafting Rate	**SIN 0º**	**SIN-45º**	**SIN 90º**	**SIN 135º**	**SOUT 0º**	**SOUT 45º**	**SOUT 90º**	**SOUT 135º**	**AVERAGE OUT**
0	10,678	11,047	10,733	11,056	10,688	11,060	11,018	11,072	10,960
6,7	10,763	11,193	10,912	11,189	10,944	11,272	10,931	11,283	11,108
13,3	10,622	10,972	10,624	10,981	11,110	11,279	10,764	11,287	11,110
20	10,030	11,131	10,820	11,125	11,151	11,416	11,124	11,497	11,297
26,7	10,595	11,380	10,891	11,285	11,023	11,492	11,213	11,425	11,288
33,3	10,718	11,117	11,091	11,288	10,880	11,395	11,121	11,396	11,198
40	10,695	11,280	11,038	11,136	10,860	11,389	11,110	11,285	11,161
Zone 3									
Drafting Rate	**SIN 0º**	**SIN-45º**	**SIN 90º**	**SIN 135º**	**SOUT 0º**	**SOUT 45º**	**SOUT 90º**	**SOUT 135º**	**AVERAGE OUT**
0	10,577	10,982	10,664	10,990	10,880	11,285	11,425	11,336	11,232
6,7	10,744	11,191	10,956	11,196	10,850	11,335	11,351	11,273	11,202
13,3	10,715	11,226	10,968	11,232	10,981	11,534	10,991	11,382	11,222
20	10,805	11,211	10,914	11,216	11,194	11,630	11,089	11,631	11,386
26,7	10,565	11,229	11,057	11,235	11,220	11,617	11,275	11,625	11,434
33,3	10,790	11,189	10,858	11,195	11,102	11,526	11,239	11,540	11,352
40	10,593	11,100	10,888	11,106	11,081	11,380	11,226	11,532	11,305
Zone 4									
Drafting Rate	**SIN 0º**	**SIN-45º**	**SIN 90º**	**SIN 135º**	**SOUT 0º**	**SOUT 45º**	**SOUT 90º**	**SOUT 135º**	**AVERAGE OUT**
0	10,607	11,036	10,758	11,044	10,955	11,460	11,713	11,919	11,512
6,7	10,499	10,906	10,628	10,913	11,015	11,414	11,702	11,772	11,476
13,3	10,290	10,631	10,285	10,643	11,530	11,488	11,565	11,876	11,615
20	10,503	10,929	10,643	10,936	11,311	11,580	11,151	11,587	11,407
26,7	10,272	10,721	10,450	10,727	11,209	11,921	11,191	11,508	11,457
33,3	10,203	10,648	10,445	10,653	11,200	11,884	11,239	11,453	11,444
40	10,260	10,701	10,387	10,708	11,127	11,785	11,236	11,426	11,394

The 2nd order entropy for the 0º direction, thus for CD direction, presents a continued growth up to maximum value, which is nearly 20% of the drafting ratio. After this peek, a decrease of their values occur until it reaches a minimum value, approximately stable and slightly higher than the value of the initial entropy. The 2nd order entropy for the 45° direction shows a slight decrease in the initial phase, which may be caused by a minor increase in the fibrous structure orientation in this direction. However, posteriorly it increases their value to a maximum which is achieved with higher drafting rates revolving around 20% to 30%, hence compensating the initial disorientation loss. Starting from this point is possible to see yet another entropy decreasing until reaching values slightly higher than the initial input values. The 2nd order entropy for the 90º direction, commonly known as CD direction, denotes an initial diminishment for the early stages of the pre-needled web drafting process to a value close to 13,3% which produces a new reorientation of the fibrous structure along this direction and thus compensating the entropy gain obtained by the fibrous disorganization within the CD direction. Since this value, the entropy rises until reaching a maximum attained with a drafting ratio ranging between 20% and 26,7%. Afterward, we assist to an entropy decay tending to a limit value in which the output entropy is slightly higher than the initial one for all the analysed drafting zones. The 2nd order entropy evolution for the 135º direction is marked by their continuous increment along with the increasing in the drafting rate, up to is peak, which is close to 20%. After this maximum, it starts a steady but slight decrease with a tendency to stabilize. The overall behaviour for all the drafting zones exhibits only minor changes, apart from the initial stage of the drafting zone 4. As expected, the average 2nd order entropy, in all the different drafting zones, display a variation pattern analogous to their individual behaviour for all the diverse angular directions considered. It should be noted that the mean values of the 2nd order entropy demonstrate an increasing output evolution with lower values achieved with the drafting zone 1 and maximum values reached with the drafting zone 4.

4. CONCLUSIONS

The analysis of the variation of the studied textural descriptors - first and second order entropy – as a function of the variation of the drafting ratio permits the following conclusions:

The evolution of the first order entropy along with the drafting ratio increasing, evidence a continuous growth until a maximum peak followed by a slowly, but steady, diminishment with the continued increase of the drafting rate. The behaviour of this variable is in accordance with the theoretical assumption, in which the fibrous disorganization induced by the rotation movement of the fibres (web horizontal structure) around the tufts (web vertical structure) is caused by a drafting rate limited to a set of optimal values. Higher drafting rate values will produce a new reordering of fibres, but in the opposite direction from the initial one and, consequently, the decrease of the entropy of exit of 1st order entropy. The analysis of the variation of 2nd order entropy along with the increasing drafting ratio, for all the different angular directions studied, also favours some interpretations consistent with the behaviour demonstrated by the 1st order entropy. The comparison of the behaviour of the 2nd order entropy variation, when a function of the drafting ratio increasing, for the concrete case of this experimental setup, allows to infer that the optimum drafting value to carry out the correction of the MD:CD ratio to values close to the intended unit value, revolves around, approximately, 20% a value from which a new reordering of the web fibres occurs in the opposite direction to the initial situation and induces a similar mechanical behaviour, but with an opposite value.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

IMPROVING THE AESTHETIC ASPECT OF A KNITTED PRODUCT FOR WOMEN

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Abstract: *These days fashion is in a continuous advancement and the producers are looking to adapt to the needs of the market. Due to this tendency they resort to different techniques and procedures for making, finishing and decorating the clothing products. In this sense, computerized graphical programs can be used to increase productivity and improve the quality and design of the products made. This paper comes as a response to these needs, completing the knitting process of a clothing product with embroidery techniques. The product is represented by a woman's knitted jacket, made in 2:2 lincs structure cred ca așa e, being a knitwear with three-dimensional effect. The chosen yarn is 50% wool, 50% acrylic, fineness 2/25. The product presented in this work was made on the SES 122FF flat knitting machine, the fineness 8 E. This is a machine with electronic control and selection, with two knitting systems and a useful width of 90" (229 cm). The machine is fitted with a presser foot with two systems of integrated cams. The DSCS device (patented by Shima Seiki). These knitting machines use the knitting programs, the SDS-One graphics station or the latest generation APEX graphics station. After the product has been completed, the embroidering step has been finished. This stage highlights the degree of difficulty of embroidery on a three-dimensional knit.*

Key words: *Knit, embroidery, knitting design, programming.*

1. INTRODUCTION

Nowadays fashion is in a continuous ascension and the producers are looking to adapt to the needs of the market. Because of this tendency specialits in this domain resort to different techniques and procedures for making, finishing and decorating the clothing products. In this way, computerized graphical programs can be used to increase productivity and improve the quality and design of products made [1]. This paper comes as a response to these requirements, finishing the knitting process of a clothing product with embroidery techniques.

The product is a woman's knitted jacket, made in 2:2 lincs structure, being a knitwear with three-dimensional effect. The chosen yarn is a 50% wool, 50% acrylic, 2/25 fineness, which harmoniously blends the hygienic-functional and comfort features that is so demanded from a knitted product and a high processability due to the acrylic component. Since high quality raw material has a high cost, contoured panels are made to minimize raw material losses.

To achieve a certain level of quality of the knitted product, it is necessary to correlate the knitting technological parameters with the raw material processed on the machine, the structure obtained, and the parameters of the structure, the physico-mechanical and hygienic-functional characteristics of the knits [2], [3].

2. THE EXPERIMENTAL PART

The product presented is made on the SES 122FF knitting machine, fineness 8 E, produced by Shima Seiki in Japan, in the S.C. CONFECTOR S.R.L. Santana. This is a sewing machine with controls and electronic selection with two knitting systems and a multipurpose width of 90" (229 cm). The machine is fitted with a presser foot with two systems of integrated cams. The DSCS device (patented by Shima Seiki) is the most important improvement in the knitting technology on the rectilinear machine. The device controls and adjusts the length of the yarns that is used digitally, keeping it constant, with a tolerance of ± 2%. This device is essential for contour knitting and integral knitting, so that it keeps the knit dimensions constant.

These knitting machines use for completing the knitting programs, the graphics station SDS-One or the latest generation APEX graphics station (Figure 1).

Operation is done on a single monitor, using the digitizer tablet format A4, the trackball, and the keyboard with 104 keys. Both hands can be used for efficient operation.

Programming on this station is done using graphical conventions called color codes.

In order to get a knit on the flat machines equipped with the PC command one must go through the following steps:

- knitting design - structure, printing, design, etc
- designing the knitting program
- processing – translating the program for the knitting machine language
- making adjustments to the knitting machine
- performing knitting on the knitting machine

Programming the Knitting Machine

In order to get a knit with a desired structure and shape according to the specified knitwear parameters, this means adjusting the following parameters:

- working speed;
- thickness of knit material;
- the pulling force.
- planning the production
- delivery of products.

Fig. 1. *StationSDSOne–Shima Seiki*

After making the design drawing of the knit – the design and the pattern, the design of the knitting program is carried out in order to create the contoured panels (adjustments on the body decreases, increases - the armhole, sleeve and the collar neckline respectively)

The next step is the shift to development and processing - that is, the translation of the computer program for computer knitting machines language.

The following figures show the right front, left, back, sleeves, collar parts on different stages (Figure 2; 3; 4; 5.)

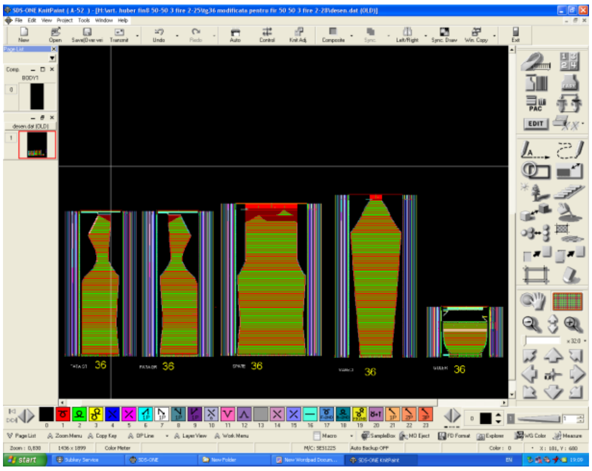

Fig. 2. *Highlights: Right front, left front, back, sleeves, collar*

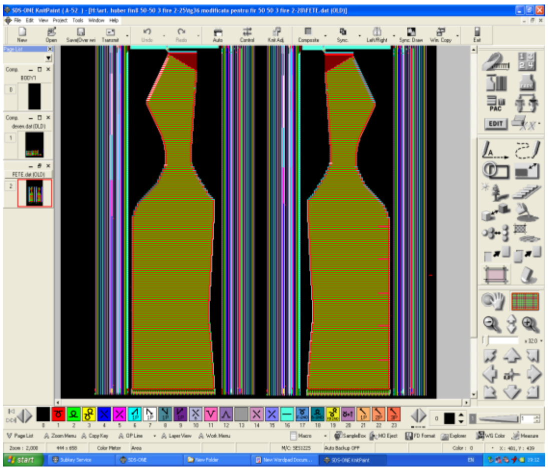

Fig. *3.* *Highlights: Right front*

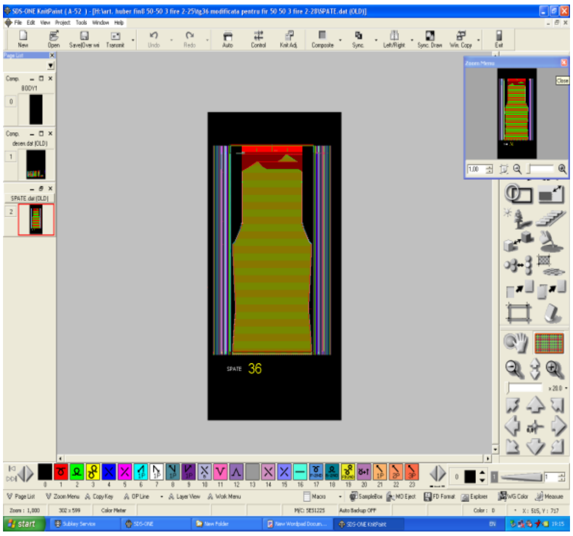

Fig. 4. *Highlights: front back*

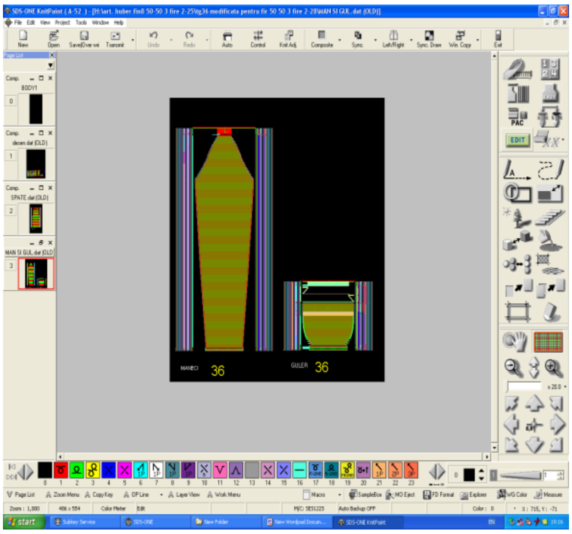

Fig. 5. *Highlights:sleeves, collar*

A very important step is the operation of the knitting machine settings:

- knit thickness
- pulling force
- working speed
- arranging the yarn feeders according to the edge of the fabric (Figure 6)

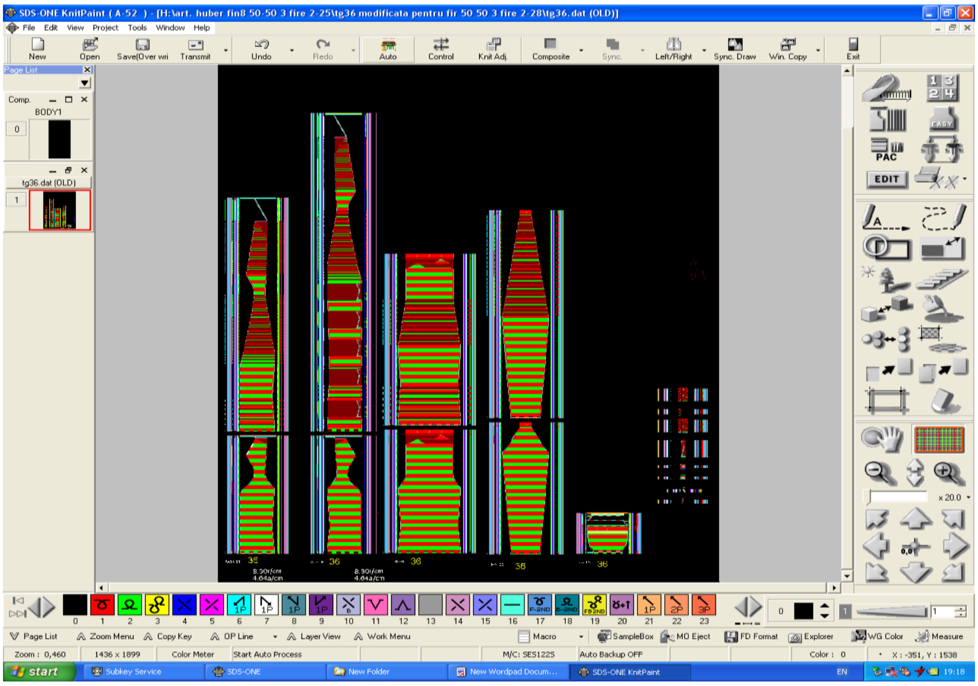

Fig. 6. *Processing the designed drawing, and transformed into the computer language of the knitting machine*

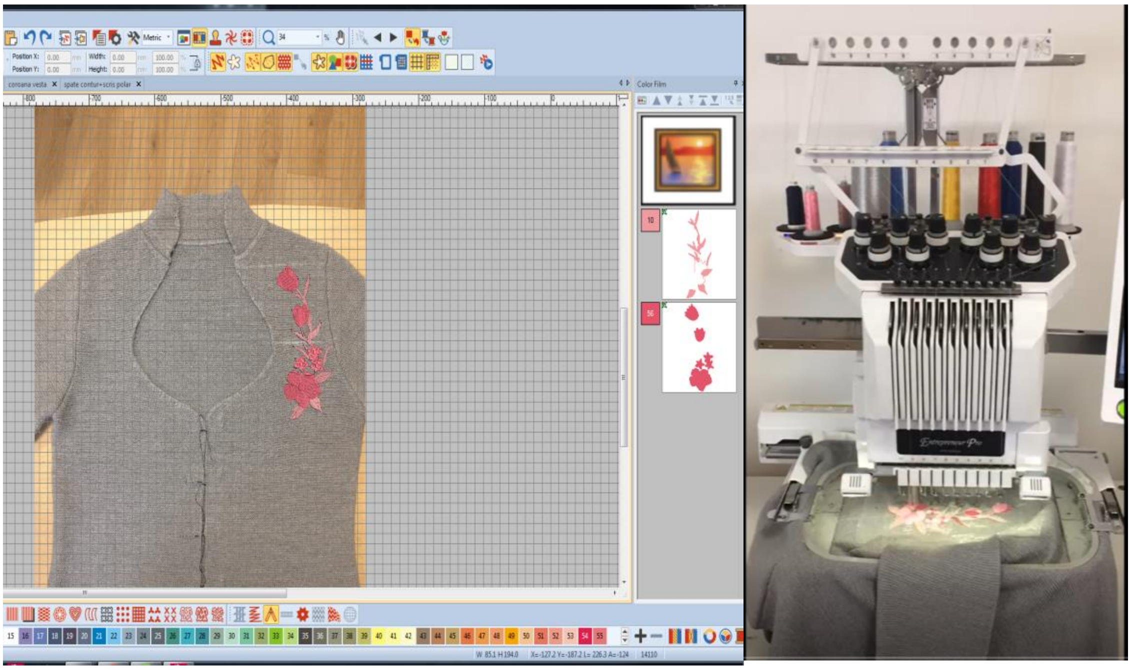

Fig. 7. *Embroidery [4], [5], [6]*

In order to meet the demands of fashion which is in permanent change, a simple embroidery is added to the product to improve the look of the product and to fit it into a family of models or to reinterpret a model in a new style.

The embroidery was carried out using the Happy embroidery machine at S.C. CONFIDEX S.R.L Oradea. The embroidered pattern was made using the BERNINA Embroidery Software Designer Plus software (Figure 7) [7].

Fig. 8. *Final product*

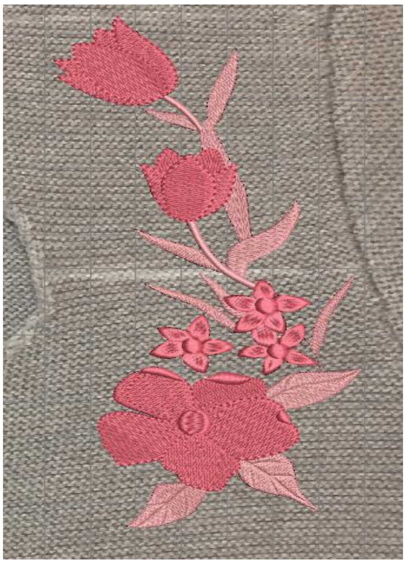

Fig. 9. *Final effect embroidery*

3. CONCLUSIONS

We want to conclude by saying that using computers and performing knitting machines in this case has a lot of advantages. First and foremost, expenses and time are greatly reduced due to the possibility of making contoured panels, thus reducing manufacturing times and raw material losses, and computer graphics programs are used to increase productivity, improve quality and the design of the product executed. In this way, manufacturers employing these techniques and modern machines manage to be always trendy and efficient.

As a comparison of embroidery on a three-dimensional knit, we want to emphasize that it is much harder to apply it compared to a fabric or a bidimensional knit. This difficulty comes from neregularity os knit structure and it's elasticity, but the final effect has a significant value in improving the appearance of the knitwear. For the future we want to study how we can fix these issues to make it possible to apply these embroidering processes to as many types of textile surfaces.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

CLASSICAL AND MODERN VISIONS ON BOW TIES

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Abstract: *The bow tie is a ribbon of material tied around the collar in a manner that forms symmetrically opposed two loop-shaped ends. The craft originated around the 17th century during the Prussian wars, when the Croatian mercenaries attached scarves around their neck to keep their shirts closed. They have been associated with certain professions such as architects, businessmen, lawyers etc. When choosing a bow tie it is very important that its size does not exceed the right size, so it can be a vulgar appearance. Style experts know that it is very important for the bow to be worn according to the size of the neck and depending on the shape of the face to create a balanced and harmonious outfit. Analyzing the evolution of the paper, the inventions of the creators and the producers' proposals identified 6 criteria for their classification. The paper presents a collection of bow ties made by the author. It is characterized by the following criteria: by the ornamentation mode (without ornamentation, embroidered, printed); by number of layers (single layer, two layers); by the nature of the materials used (textiles, natural leather); according to the fastening method (elastic fixed models, needle-mounted models); by wearing (neck, chest). Even though it has existed since 1870, today's bow tie is an elegant accessory that should not be missed in the wardrobe. It's perfect for shirts to complete a bussines-elegant outfit or to add extra elegance to casual wear.*

Key words: *collection, criteria, classification, history, bow tie, patterns.*

1. INTRODUCTION

The bow ties an alternative for those who do not wear a tie, but want to be dressed properly, at least in terms of formal wear. In addition, the bowie is so unusual today that it is an accessory that draws attention immediately [1].

They are made of any textile material, but most are made of silk, polyester or cotton. The bow tie consists of a ribbon of material tied around the collar in a manner so that it forms symmetrically opposed two loop-shaped ends. A modern bow tie is tied with a twig [2].

Not limited to rigid rules, the bow tie has been restructured, redesigned and redesigned into an accessory that any individual may include in his personal style. Bow tie can be worn casual wear such as jeans, shirts and sneakers. These offer the character of the dress and highlight the originality of the clothing.

2. GENERAL INFORMATION ABOUT BOWTIES

2.1 History bow ties

The craft originated around the 17th century during the Prussian wars, when the Croatian mercenaries attached scarves around their neck to keep their shirts closed. Later, the upper classes in France adopted these accessories under the name of "tie", and then its popularity flourished in the 18th and 19th centuries [2-4]. It is uncertain if those Croatian scarves have evolved into a bow tie and then in the tie or the first time a tie has been born that has led to the evolution of the bow tie.

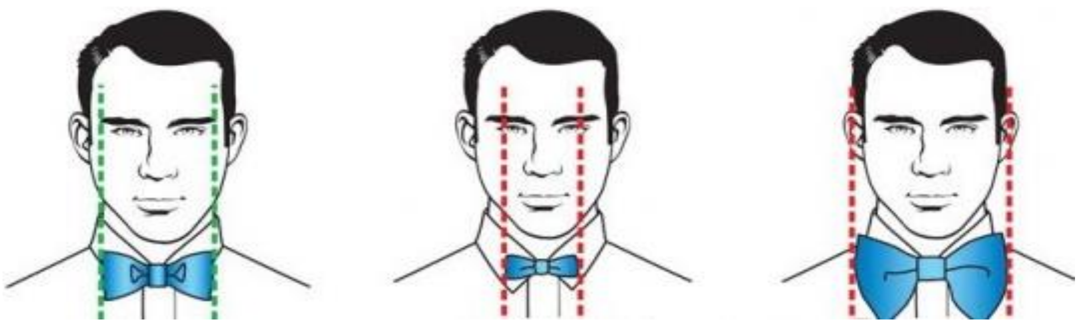
In 1663 Luiza de Lavarier, the mistress of King Louis XIV, changed the way to tie the scarf, giving it a butterfly shape [5].

In the eighteenth century and nineteenth century, bow tie fashion reaches its peak in time. It is known that the classic black bow tie dates back to 1886 when it was invented by Pierre Lorillard V. [6]. History has preserved the memory of Beau Brummel, a dandy famous mid nineteenth century, which had spent hours before the mirror to create a knot perfect bow tie so that the image is on measure of fame [2]. Papers were associated with certain professions such as architects, businessmen, lawyers, university professors, waiters and politicians. Even doctors wore bow ties to pediatricians could not grasp the tie children when consulted. And clowns sometimes use oversized bow ties for maximum comic effect. The musicians are traditionally matching bow ties white or black toy coats they wear during concerts. Bow ties made their place in the attire of women, especially the business. By the 1980s, career women, active in the banking, legal and corporate world, adopted a very conservative, male-like attitude. They were often seen wearing blouses and closed shirts with shoulder-to-chest pockets, pleated front and accessory with bow ties. Materials, colors, and patterns were virtually the same [2].

With the evolution of fashion, the bow tie also evolved from classic black to a multitude of colors, from a simple node to more interesting knots and loops, and the materials they are made of became more and more diverse. After more than two centuries bow tie keeps its actuality and remains one of the main fittings, wardrobe both male and female.

2.2. Choosing the right bow ties

When choosing a bow tie it is very important that its size does not exceed the right size, so it can be a vulgar appearance. Properly sizing the bow ties is shown in figure 1 [7]. Experts know that style is very important that bow tie to be worn by the size of the neck and by face shape to create a balanced and harmonious outfit.



Normal Too Little Too Big

Fig. 1. *Correct dimensioning of the bow tie [7]*

2.3. Classification bow ties

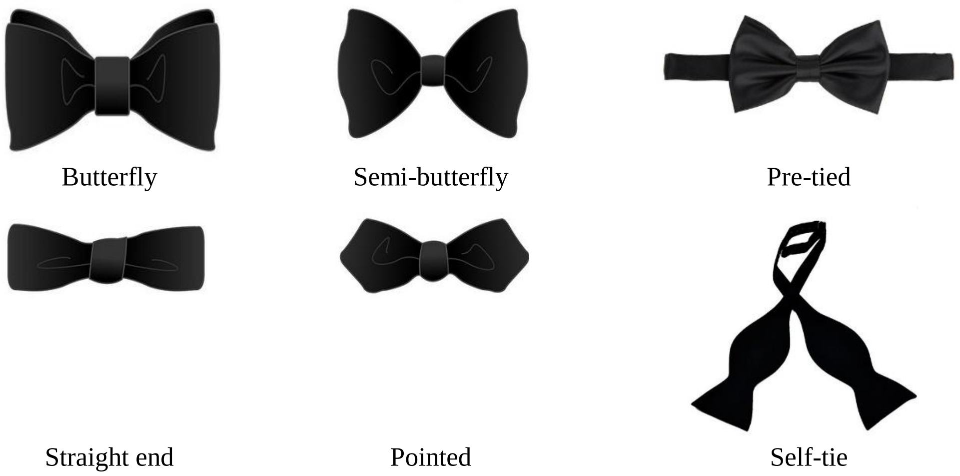
Analyzing the evolution of bow ties inventions proposals creators and producers have identified the following criteria to classify them:

a) According to the appearance of the bow tie (figure 2 a.) [1; 4; 7]: butterfly, semi-butterfly, Straight end and Pointed.

The butterfly model usually has a "wingspan" of a width of between 7,5 and 9 cm. The butterfly pattern specific type is suitable for those with a neck, face and chin. *The semi-butterfly model* is generally characterized by a "wing" of a width of 5,5-7 cm, enjoying the most popularity. It's a good choice for almost anyone, regardless of height or weight. *The straight end model* is less formal, but it is always accepted in casual and formal dresses alike. Narrow pattern looks good on weak men with a long face. *The pointed* pattern is recommended for those who want a unique look while wearing the tuxedo.

b) After the node made (figure 2 b.) [4; 8]: a pre-tied bowtie (with a knot made from the store) and a self-tie bow tie (loosened as a tie, to which you must make the knot before each wearing).

c) By color: unicolour and multicolored.
d) By destination [9; 10]: casual and official.
e) By order of appearance [9; 10]: classic and modern.
f) By sex and age group of the wearer [9; 10]: men, women, children.
g) By nature of the materials used: silk, polyester, cotton, fabric mixture, etc.



a. [7] b. [8]

Fig. 2. *Types of bow ties*

3. BOW TIE AGE ACTUAL

To attract consumers, bow tie must be original and interesting. Following this strategy, the firm will always stay in the trend.

In figures 3-6 shows some selected models bow ties collection of products made by the author. The collection of bow ties made by the author is characterized by the following criteria:

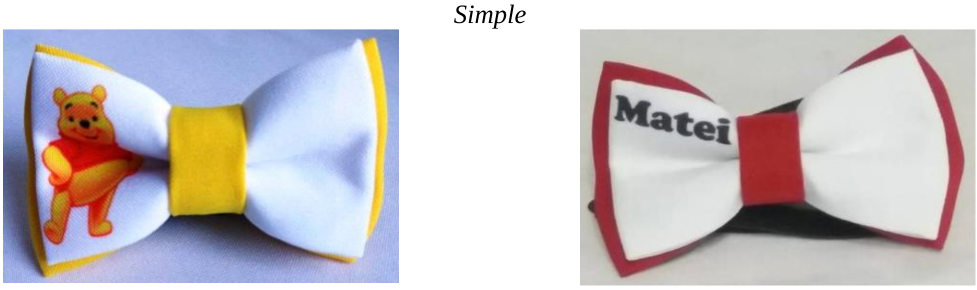
a) According to the mode of decoration: without ornamentation; embroidered; printed.
b) Number of layers: single layer (single); in two layers (double).
c) By nature of the materials used: textile materials; natural skin.
d) According to the fastening method: elastically fixed models; needle-like patterns.

e) By wearing: at the throat; to the chest.

Fig. 3. *Bow ties of textile materials*

Fig. 4. *Embroidered bow ties*

Simple



Double

Fig. 5. *Printed bow ties*

At the throat

To the chest

Fig. 6. *The way of wearing bow ties*

The following work techniques were used to make the collection:

1. Embroidery. It has been highly appreciated for hundreds of years and remains popular among people of any social status. Shifts styles, new trends appear, but embroidered things always remain fashionable.

In the trends of 2017-2018, embroidery clothes are noted, both by hand and by machine. Embroidery is current not only for handles, but also for accessories. The cuffs, collars, pullovers and other embroidered accessories look very interesting and current.

2. Printing. With the development of technology, personalizing promotional items has also experienced a natural evolution over time, gradually producing increasingly spectacular effects and increased applicability [11]. Among the most recent and most modern personalization methods are digital printing techniques, namely digital transfer and digital print directly to material (DTG). DTG Print is one of the fastest and most modern methods for customizing textiles, also known as digital printing or printing directly on the material. This printing method uses water-based, eco-friendly, elastic and wear-resistant and wash-resistant inks. The best results are obtained on cotton 100% cotton or cotton fabrics, for example 50% cotton and 50% polyester.

Even though it has existed since 1870, today's bow tie is an elegant accessory that should not be lacking in the wardrobe [1]. It's perfect for shirts to complete a bussines-elegant outfit or to add extra elegance to casual wear.

4. CONCLUSIONS

The origin of the tie knot makes us think about the way the scarves are connected. An argument in this regard would be that with the passage of time, they have diminished, resulting in the resemblance to today's bow tie. After more than two centuries bow tie keeps its actuality and remains one of the main fittings, wardrobe both male and female.

With the evolution of fashion, bow tie has evolved from classic black to a multitude of colors, from a simple knot in knots and loops more interesting and the materials they are made have become increasingly diverse. The knowledge of the trends of the fashion, the needs and the requirements of the beneficiaries, the application of the principles of diversification of the models, allowed elaboration collection of bow ties by the author. Those who implement new, exciting ideas and are not afraid to experience new collections will always be trending, recognized and appreciated by consumers.

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FUNCTIONAL TEXTILES BY APPLYING OF BIOLOGICALLY ACTIVE COMPOUNDS: REVIEW

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Abstract: *In the last years the cosmetic industry using plant derivatives grow significantly for whole domains in which activates. Essentials oils and plant extracts are assumed to be ecologically sound and there is generally an absence of unwanted side effects arising from the use of them. Essential oils present a particular interest due to multiple benefits it shows such as antiviral, antifungal, antibacterial, antioxidant, insecticidal, radical scavenging properties, anti-inflammatory, antiseptic, germicide, healing and cosmetic effects. As people are used to wear textile materials in their daily life, thus it is also logical to use textile as the possible basis for the delivery system of cosmetic substances. Bioactive systems are applied to the textile materials by a variety of techniques. Microencapsulation technology offers many opportunities to improve the properties of textiles or enhance them with value added functions. One major advantage of using microencapsulation technology that acts as the delivery system of cosmetic substances is its ability to protect active ingredients from hazardous environment. Another important advantage is its controlled release properties that seem to be the best choice for increasing the efficiency and minimization of environmental damage. When different active substances for body care or health are embedded into textiles, they are then later releasing them systematically being gradually transferred to the skin by natural movement, pressure or the effect of the skin's natural warmth and enzymes. Microcapsules can be applied to the textiles by different methods: padding, coating, spraying or immersion methods.*

Key words: textiles for cosmetic use, microcapsules, wellness, controlled releasing

1. INTRODUCTION

In recent years, world textile industry is moving rapidly toward the manufacture of high added value textile structures and functional products such as medical textiles, protective textiles and smart textiles and some products, including cosmetic textiles and healthcare textiles, are currently available in the market [1]. However, with the growing demand of enhancing beauty with health, customers request that the apparels and home textiles not only have the original basic characteristics such as maintaining warmth and providing comfort, but also carry extra functions such as antimicrobial, odor absorption, UV protection, self-cleaning properties, moisture and temperature management, in an attempt to provide a more natural and healthier life [2]. The current "green" trend is moving away from the use of chemical and non-sustainable products, in favor of those considered not harmful to nature. In addition, health and wellness benefits, the replacement of artificial scent with essentials oils that are naturally derived can be considered environmentally friendly.

With a growing market share in herbal products, research shows that the uses of essential oils for fragrance are underrepresented in everyday product applications as compared to chemical fragrances. Essentials oils and plant extracts are assumed to be ecologically sound and there is generally an absence of unwanted side effects arising from the use of them. Essential oils present a particular interest due to multiple benefits it shows such as antiviral, antifungal, antibacterial, antioxidant, insecticidal, radical scavenging properties, anti-inflammatory, antiseptic, germicide, healing and emollient effects.

2. ESSENTIAL OILS WITH COSMETIC EFFECT

The whole essential oil has to be considered in all its complexity, which comprises the mixture of possibility, hundreds of different of molecules, their molecular energy and their overall synergy. The main effects induced by essential oils on the body systems are: refreshing, relaxing, calming, balancing, provides astringent, antiseptic and decongestant properties, therapeutic properties, toning, fortifying, cooling and so on. The essential oils present also extraordinary antioxidant effects having an important role in the prevention of cell aging, wrinkles, sunspots, or hyperpigmentation caused by the free radicals coming from internal and external damage factors (Table 1).

Table 1: *Essential oils with cosmetic application*

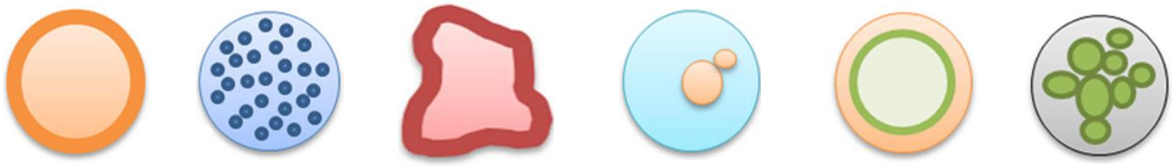
Essential oil	Effect
Kenaf seed	Antioxidant
Red pepper seed	Antimicrobial
Jojoba	Antioxidant, anti-aging, moisturizing, increases skin elasticity, smoothness
Nut	Antioxidant and anti-aging
Sea buckthorn	Therapeutic role in atopic dermatitis
Avocado	Moisturizing and antioxidant
Oregano	Antioxidant, antimicrobial
Mint	Antimicrobial and antioxidant
Basil	Antibacterial, antifungal and antioxidant
Rosemary	Antibacterial, antifungal, antiseptic, astringent and antioxidant
Lippia sidoides	Antiseptic, anti-infective, antimicrobial and acaricide
Lemongrass	Antimicrobial
Lemon myrtle	Antimicrobial and antioxidant
Cinnamon leaf	Antimicrobial, antifungal, antioxidant and anti-inflammatory
Tea tree	Germicidal and antibacterial, antiseptic, acne treatment
Thyme	Antimicrobial and antioxidant
Coffee	Reduction of the wrinkles and pigmentation
Coconut	Emollient, toning and healing properties
Pomegranate seed	Regenerating the skin and even lightening the pigmented skin

3. EMBEDDING TECHNIQUES OF ESSENTIAL OILS

Losses by evaporation and difficulties in their controlled release make the essential oils in commercial application to be limited. In this case, nanocarrier systems (lipid-based particles, nanoemulsions and biocompatible polymer-based particles) can provide an ideal solution for realizing a controlled and targeted delivery of the essential oil.

In the last few years, the application of biocompatible and biodegradable polymer-based formulations as a controlled release form has generated an immense interest [3]. Bioactive systems are applied to the textile materials by a variety of techniques. Microencapsulation is actually a micro packaging technique that involved production of microcapsules or microspheres which act as barrier walls of solids or liquids. One major advantage of using microencapsulation technology, which acts as the delivery system of bioactive substances, is its ability to protect active ingredients from hazardous environment (oxidization, heat, acidity, alkalinity, moisture or evaporation). Another important advantage is its controlled release properties that seem to be the best choice for increasing the efficiency and minimization of environmental damage. The biocompatibility of the delivery system of biological active substance should be nontoxic and noncarcinogenic with no interest in the related issues of mutagenicity and teratogenicity. Being an ex-vivo application, the body care textiles should not cause any irritation of skin while releasing the active ingredients in the same time.

The microcapsules are formed from an active ingredient which represents the core and the external phase which represents the shell. Usually, the shell of the microcapsules gives the properties, such as: size, shape, releasing type of active compound, the process efficiency or the stability of microcapsules and depending on the destination, it choice the methods to prepare them. In the shell construction polymers and natural biomaterials (carbohydrates and proteins) are used [4]. In Fig. 1 the main microcapsule models are presented.



a) b) c) d) e) f)

Fig. 1: *Various types of microcapsules: a) simple microcapsule, b) matrix (microsphere), c) irregular microcapsule, d) multicore microcapsule, e) multiwall microcapsule, and f) assembly of microcapsule.*

The microencapsulation technology presents various advantages such as: protection of active compound against environmental conditions prevents the interaction between active ingredient and other chemical species from system and controlled releasing of active compound [5], [6]. In order to maintain the unaltered properties of the core material, the microcapsules can present spherical or distorted shape and according to the Table 1, they have sizes between 0.1–200 μm, containing one or more active compound wrapped into a synthetic or natural material, which dictates the release type. The core may contain a solid or liquid substances, solutions or suspensions and mixture of solids or liquids.

The efficiency of the microcapsules is given by the compatibility between core and shell material. The size of the core material is a parameter which plays an important role in the diffusion, permeability and the releasing of the active compound, when most often the material type of the shell consists of a polymer which must present: physical-chemical compatibility with the core, flexibility, impermeability and stability. The shell of the material offers temporarily or permanently protection of the core from external influences and may be: permeable, semipermeable (impermeable to the active compound and permeable to liquids with low molecular weight), waterproof (active ingredient is released following degradation of the shell) [7]. The biocompatibility of the delivery system of biological active substance should be nontoxic and noncarcinogenic with no interest in the related issues of mutagenicity and teratogenicity.

Table 2: *Physical-chemical characteristics of microcapsules obtained through the main industrial processes*

Procedures	Size (□m)	Particle size distribution	Morphology	Encapsulation rate (%)	Release type
Polimerization in dispersed medium	0.1-15	Narrow	Microsphere	<50	Prolonged release by diffusion Triggered release pH effect, dehydration, mechanical effect, dissolution, enzymatic attack
Interfacial polycondensation	0.1-50	+/- large	Microcapsule	<80	
Interfacial polyaddition	0.2-5	+/- large	Microcapsule	<80	
Spray-drying	1-50	large	Microsphere	<40	
Complex coacervation	5-200	+/- large	Microcapsule	70-90	
Simple coacervation	20-200	+/- large	Microsphere Microcapsule	<60	Prolonged release
Emulsion - solvent extraction	0.5-200	+/- large	Microsphere	<25	
Thermal gelification of emulsions	10-100	+/- large	Microsphere	<20	
Extrusion / spheronization	>200	Narrow	Microsphere	<50	
Spray drying	>100	Narrow	Microcapsule	60-90	Triggered release by thermal effect or pH effect
Gelification or freezing of gout	>200	Narrow	Microsphere	<30	

4. APPLICATION METHODS OF MICROCAPSULES ON TEXTILES

Many textiles are excellent media for transferring bioactive compounds (essential oils, plant extracts, vitamins, moisturizing and anti-aging agents) and have the relatively lower incidence of adverse effects of herbal products as compared to modern synthetic pharmaceuticals. In the textile industry the development of cosmetic textiles by nano- and micro- technologies represents a dynamic field in scientific research. It is wanted to develop sustainable cosmetic textiles to reduce the necessity for daily application of the cosmetic or medicinal ingredient.

A replacement variant of ointments, creams or lotions by using the textile materials containing cosmetic or medicinal ingredients is a more efficient way from volume control point of view, uniformity and by controlled releasing of active ingredients directly from the reservoir attached to the polymer fibers on the superficial layer of the skin, without additional steps. Current, cosmetotextiles in the market claim to be moisturizing, cellulite reducing, perfumed, body slimming, energizing, rejuvenating, refreshing, improving the firmness and elasticity of skin, or reducing the appearance of fine lines and wrinkles. When different active substances for body care or health are loaded/embedded into textiles, they are then later releasing them systematically (that means they interact with the body), being gradually transferred to the skin by natural movement, pressure or by the effect of the skin's natural warmth and enzymes (Fig. 2).

Bioactive systems are applied to the textile materials by a variety of techniques. Microencapsulation technology offers many opportunities to improve the properties of textiles or enhance them with value added functions. Many textile chemical companies have put forth much investigation in this area and offer various microencapsulation treatments that aim for body care benefits. Also, many effective approaches to microencapsulation bioactive compounds are based on using of cyclodextrins which are the best regarding safety to the human body, because β-cyclodextrin has no skin irritation, no skin sensitization and no mutagenic effect [8], [9].

Furthermore, cyclodextrins embedded on textile materials do not affect the material properties, and keep their ability to form inclusion complexes with other suitable molecules. Also, chitosan and sodium alginate are two kinds of commonly used natural polymers that have no toxicity, are good biodegradable, have high biocompatibility properties and are widely applied as wall materials.

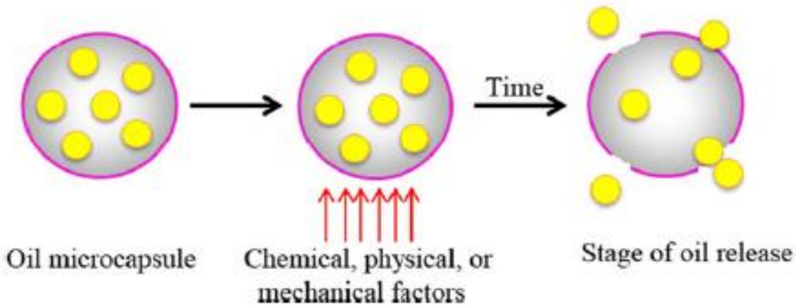


***Fig. 2**:* Schematic representation of essential oil controlled release mechanism

One of the manufacturing processes of textiles for body care is based on functionalization of synthetic fibers (e.g. Novarel, Nilit Breeze, Emana) or of man-made fibers (e.g. Tencel C) by fixing microparticles (e.g. bioactive minerals, chitosan) or microcapsules (with content of Vitamin E, Aloe Vera, natural oils) in their structure. Another method to manufacture textile materials for body care benefits consists in the fabrics functionalization by microcapsule fixing on the external surface of the fabric, resulting in an end-product for beauty, healthcare and wellbeing. When microcapsules are applied to textiles, commonly used shells are not reactive otherwise, they would stick together. As a result of that chemical stability, no chemical reaction can be applied between microcapsule and fibers. Thus, in order to improve durability to washing or the handle, some auxiliary products based on acrylic, polyurethanes or silicone resins are used to fix the microcapsules to the fiber surface.

Microcapsules can be applied to the textiles by different methods: padding, coating, spraying or immersion methods [9]. The padding technique assumes the impregnation of the textile support in a chemical solution which contains microcapsules and other functionalization agents using cylinders under pressure, being followed by a curing process where the functionalization agents are fixed onto the textile surface. One of the most significant factors in the padding process is represented by the absorption capacity of chemical solution. In the case of exhaustion process, the functionalization agents (microcapsule dispersions) are dispersed in a solution and, in this manner, the microcapsules are transferred to the textile fibres due to the affinity between functionalization agent and fibre [9]. Another way to apply the microcapsules can be the finishing by spraying. Regarding this technique there are two main options: compressed air spraying and hydraulic spraying. In the first case, the technology is based on the applying of chemical substances to spray media or spray guns using compressed air. This technique presents the disadvantage of an inhomogeneous distribution of the finishing agents. In the second case the minimum quantity of the required solution is scattered under very high airless pressure as a carrier medium for application finishing agents (microcapsule dispersions) in homogeneous behaviour on the textile support. The main advantages of this technique consist in: the absence of the cylinders under high pressure may contributes significantly to the risk elimination of solution breakdown, the reduction of water consumption, the reduction of energy costs, the decreasing consumption of chemical agents and shorter times than other techniques [9].

5. CONCLUSIONS

The desire for a healthier and more productive lifestyle will continue to generate a market for textiles that promote 'well-being'. Textiles that 'interact' with the consumer, reducing stress, promoting comfort and relaxation, are possible through active delivery of microcapsules. The cosmetotextiles field is growing year by year and is starting to use natural ingredients, which are more eco-friendly than synthetic alternatives. One challenge in this field is represented by the optimization of procedure for the incorporation of active ingredient with wellness effects in a polymeric shell and the application of microcapsules on the surface of textile supports.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

STRUCTURAL INFLUENCE ON THE THERMAL BEHAVIOR OF JUTE FABRICS TREATED WITH PCMs

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Abstract: *Paraffin is often used as an organic phase change material PCM incorporated in textiles for enhancing said texiles' thermal behavior. This material is a substance with a high heat of fusion which, melting and solidifying at a certain temperature, is capable of storing and releasing large amounts of energy In this paper, two different densities of jute fabric was used. These phase changes take place at constant temperature and for certain materials the process of melting and crystallizing can be repeated over an unlimited number of cycles with no change to their physical or chemical properties. The aim of this work is to study the influence of structural jute fabrics treated with PCMs microencapsulated on thermal behavior, to carry aout the study two plain fabrics with different structural characteristics were used. Thermal behavior of both untreated fabrics was tested by balancing it above a heating plate. Consequently, the fabrics were measured with a TESTO 865 thermal imager. Afterwards, treated samples both with and without PCMs in printing paste were tested in the same way. The wanted effect was reached during cooling cycle of both textiles. Only the heating cycle of the treated lightest jute sample was found to be warmer than the untreated sample. More experimental testing is needed on this sample. Furthermore, the heating cycle of the densest jute sample was according to the expectations.*

Key words: *phase change material, paraffin, microcapsules, heating, cooling.*

1. INTRODUCTION

According to Iqbal et al. [1], phase change materials (PCMs) have the ability to store and release a large amount of energy in the form of latent heat. The materials absorb energy without any change in temperature when changing their physical state from solid to liquid. The same amount of energy is released when the material changes from liquid to solid state.

The PCM used in the experiments in this paper is paraffin. Paraffins are long-chain or branched saturated hydrocarbons. The general chemical formula for unbranched paraffin molecules is C_nH_{2n+2}. Because paraffin is not a pure substance, but rather a mixture of long hydrocarbon chains, the transition from solid to liquid has a large range of several degrees Celsius. Paraffin is prone to solid/liquid and solid/solid phase changes [2-5]

According to Erkan (2004) [6] humankind has developed several ways for keeping body temperature regulated, for example humans have been wearing clothes since prehistoric times, built shelters and ate food regularly. By applying PCMs on textiles the amount of thermal energy that can be stored in these textiles will increase. Because of the nature of PCMs and latent heat, when one is wearing clothes incorporated with PCMs, that person would feel cooler when his body temperature rises and hotter when his body temperature decreases. This is because the heat from his body will be used to melt the PCMs in the fabric, essentially cooling the person down. When the temperature around him decreases again, the energy stored as latent heat will release again, which in turn will keep the person warmer for a longer duration.

The aim of this work is to study the influence of the characteristics of jute fabrics treated with PCM's on thermal behavior.

2. EXPERIMENTAL

2.1 Materials

Plain jute fabrics were used as textile material in order to carry out the treatment. In table 1 the characteristics of these samples are shown.

Table 1: *Characteristics of jute fabrics used.*

Sample	g/m^2	Warp density (ends/cm^2)	Weft density (picks/cm^2)
Jute_220	220	4	4
Jute_300	300	6	5

To add thermal properties to the fabric microencapsulated phase change material (PCM's), Centerfinish C-25 (dust) provided by Color Center are used. Acrylic resin, STK-100 suministrated by Color Center, was used as a binder as PCM's don't show any affinity to textile fibers and Lutexal CSFN liq, provided by Archroma, was used as thickening agent.

2.2 Methods

PCM microcapsules were applied to the jute fabrics by coating. To carry out the process 100 g/Kg of PCM's, 10 g/Kg of acrylic resin and 30 g/Kg of thickener in order to increase the viscosity of the bath were used.

To study the influence of the characteristics of jute fabric treated on the thermal conductivity, samples were tested with a thermochromic camera. The tests were performed taking meassuarements each 15 seconds for 120 seconds of heating cycle and 120 seconds of cooling cycle.

3. RESULTS

In the introduction, the expectations of the results were stated as followed: during the heating cycle, the measured temperature will be lower on PCM treated samples than untreated samples. Consequently, during the cooling cycle, the measured temperature of treated samples will be higher, due to the latent heat being slowly released. In Fig. 1, this thermographic behaviour of jute_220 is shown. This sample does not follow the expected results completely. This might be due to the fact that the pores in a jute_220 sample because of its lower density.

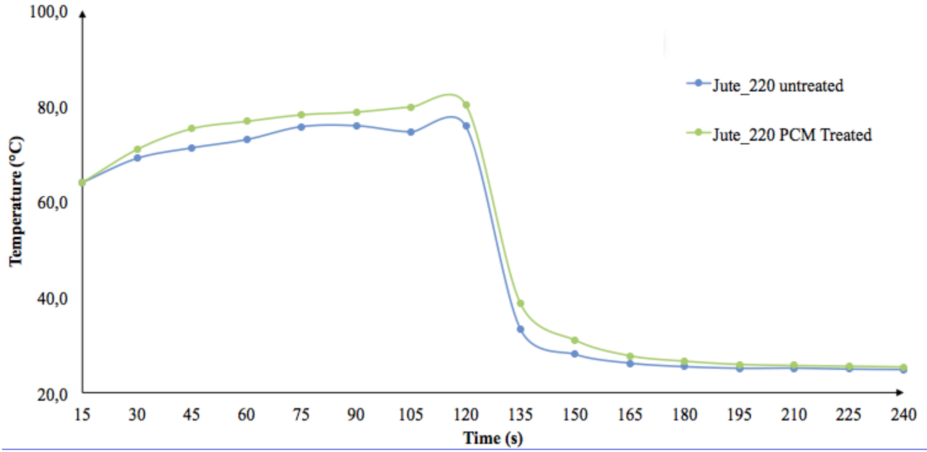

Fig. 1: *Thermal behaviour of untreated and treated jute_220*

In the case of jute_300 sample, which results are showed in Fig. 2, this thermal behaviour follows the expected results completely. During the heating cycle, some of the energy is used to melt the paraffin. The energy is absorbed as latent heat, causing the jute to be cooler when fabric is treated with PCMs. When the fabric was laid to rest on a table, the heat was slowly being released again. The PCM treated sample holded on to this heat much longer thanks to the residual latent heat left in the PCMs. Consequently, jute_300 shows the most promising results.

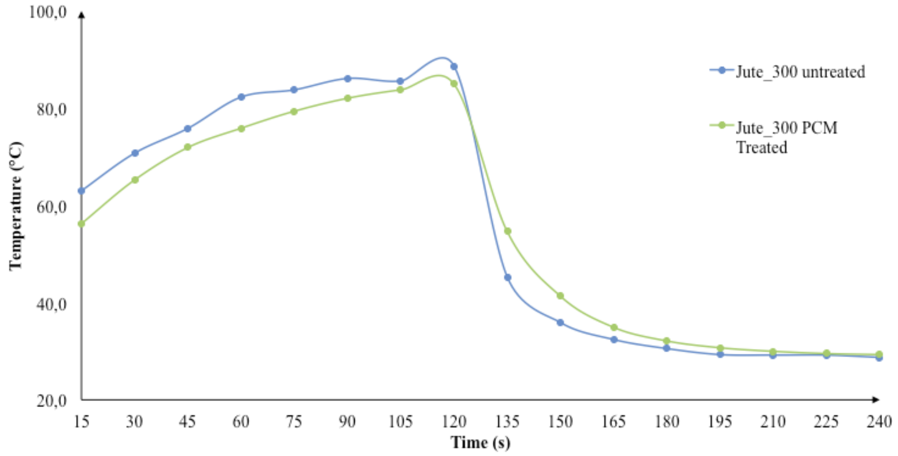

Fig. 2: *Thermal behaviour of untreated and treated jute_300*

In Fig. 3, the measured temperatures of both untreated jute samples and PCMs treated samples are compared. The figure clearly shows that the denser jute sample naturally absorbs a lot more heat, with an average maximum temperature of 84.9 °C, while jute_220 only reached 77.9 °C. After the cooling cycle, the jute_300 sample was still an average of 3.9 °C higher.

If we compare samples treated with PCMs, even though PCM treated jute_300 starts off better than jute_220, after around 60 seconds the fabric gets warmer than jute_220. However, jute_300 holds on to this heat a lot better than jute_220 in the cooling cycle. The results of Fig. 3 show that the PCM treated samples are closer together during heating cycle and at the end of the cooling cycle.

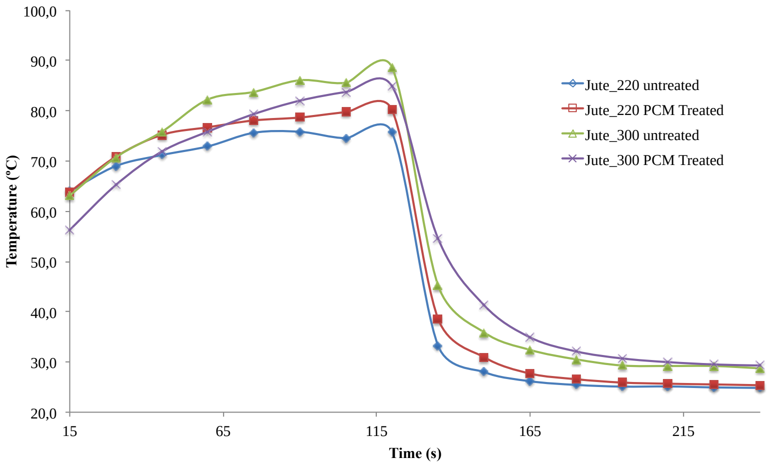

***Fig. 3**: hermographic behaviour of jute_220 and jute_300 untreated*

4. CONCLUSIONS

Applying paraffin PCMs to jute fabrics has the desired effect on its thermal behaviour during all cooling cycles. However, during the heating cycle of jute_220, the thermal behaviour showed counterproductive. More experimental research is needed to resolve this problem with measuring jute_220 during the heating cycle. However, the heating cycle of jute_300 showed the thermographic behaviour expected from paraffin PCMs.

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COMPARISON OF MOISTURE RELATED PROPERTIES OF PET/CV BLENDED NONWOVEN FABRICS

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Abstract: *Moisture related properties of polyester (PET) / viscose (CV) nonwoven fabrics were investigated in this research. Four different nonwoven fabrics, PCV0, PCV1, PCV2 and PCV3, having different viscose proportion namely 0%, 30%, 50% and 70% were selected, respectively. The manufacturing techniques and fabric thickness values were kept the same for the comparison of tested fabrics. Moisture absorption, vertical water wicking, air and water vapor permeability tests were carried out and also moisture transmission performance of the blended nonwoven fabrics was examined in order to evaluate the effects of fiber ratios on moisture related properties of the blended fabrics. It was determined that higher viscose content in the blended fabrics result in higher vertical water vicking performance of the fabric. The moisture content of the fabrics also increased with increasing viscose proportion. This is most probably because of the high moisture absorption capacity of the viscose fibers. The wetting time and wetting radius results are in reverse ratio with the viscose proportion of the fabrics in moisture management test. It can be also stated that permeability properties depend not only viscose content but also fabric structural parameters.*

Key words: *nonwoven, moisture, permeability, viscose fiber, polyethylene teraphtalate fiber*

1. INTRODUCTION

The demands from textile fabrics are not only for style and durability but also for psychological comfort by means of moisture absorption and transmission performance. Fiber type is one of the main factors affecting the clothing comfort. To improve comfort properties and to impart functional performance such as soft hand and easy care of textile fabrics, blending of fibers is very popular in textile industry. Fiber blends have been widely used to combine the superior properties of different types of fibers. Blending of fibers can enhance the functional features and extend the end-uses of the fabrics. It is taken into account that the fibers having different material types (man-made or natural, protein or cellulose based fibers), different moisture absorbing capability (hydrophilic or hydrophobic) and/or mechanical performance are selected when blending fibers.

In the related scientific literature, number of studies was carried out to investigate the effects of structural parameters (especially hydrophilic fiber proportion %) on different performance properties of nonwoven fabrics made of blended fibers. Das et al. stated that blending has a critical role in moisture related comfort properties [1]. They found out that viscose fiber positively influenced the water vapor permeability and absorbency with increasing the hydrophilicity of polyester (PET) / viscose (CV) fabrics. Mahish et al. revealed that the increase in bamboo fiber proportion increases water wicking and UV protection ability of bamboo/PET knitted fabrics [2]. It is also pointed out that polyester fabrics with higher bamboo content will be more suitable to wear in summer. Das et al. investigated the effects of structural parameters such as yarn count, twist and polyester content on moisture related properties of PET blended fabrics [1]. Moreover, some other papers focused on finishing processes to improve properties and to impart functionalities of blended fabrics. İbrahim et al. focused on the incorporation of different additives to improve UV protecting performance of cotton/wool and CV/wool blended fabrics [3]. In another research paper, İbrahim et al. experimented several finishing methods using different chemical agents to enhance multifunctional properties of polyester/cellulose blended fabrics [4]. CV/PET fabrics were chemically and physically treated to examine the usability as CO and CO_2 capturing filters by Elnagar et al. Hydrophilic fibers especially cellulose based fibers absorb higher number of water molecules and have high hygroscopic moisture content as compared with synthetic fibers [5]. Cellulose based fibers exhibit high absorbency, breathability and comfort for wear [3,4]. PET fibers are more resistant to microbial and bacterial attack, stronger and wrinkle resistant. Despite their advantageous properties, their highly hydrophobic nature results in lack of comfort for wear. Blending CV with PET gives them combined properties which encourage their use more than each separate fabric [5].

The aim of this research is to study how hydrophilic fibers affect moisture absorption and transmission properties of blended nonwoven fabrics. For this purpose, PET and CV fibers were selected, which were commonly and widely used in textile industry, due to their different moisture absorbing natures. Four types of nonwoven fabrics were utilized having different viscose proportion (0%, 30%, 50% and 70%). Fabric thickness and manufacturing techniques were kept the same to compare effects of fabric mass and viscose proportion on tested properties of the fabric samples. Air and water vapor permeability, vertical water wicking, moisture content and moisture management tests were carried out to evaluate the influence of CV fibers and fiber structural parameters on moisture related properties of PET/CV nonwovens.

2. EXPERIMENTAL

2.1 Materials

In this experimental study, four types of PET/CV nonwoven fabrics having different PET and CV ratios were utilized. Fabric mass per unit area (g/m^2) and fabric thickness (mm) of the fabric samples were measured in accordance with ASTM D 751-06 and ISO 5084:1996, respectively. Fabric thickness of the test specimens were measured by using James Heal RxB Cloth Thickness tester under constant pressure. The sample codes and some technical details of the fabric samples are given in Table 1.

Table 1: *Technical details of the fabric samples*

Sample Code	Material	Mass per area (g/m^2)	Fabric thickness (mm)	Manufacturing technique
PCV0	100% PET	31.7	0.3	Spunlace
PCV1	30/70% CV/ PET	44.1	0.3	Spunlace
PCV2	50/50% CV/ PET	47.3	0.3	Spunlace
PCV3	70/30% CV/ PET	48.0	0.3	Spunlace

2.2 Methods

All fabric samples were in preconditioned in standard atmosphere of 65±2% relative humidity and 20±2ºC at least for 24h before all testing.

Air permeability of the fabric samples were tested by using TexTest FX3300 Air Permeability Tester at a pressure of 200Pa in accordance with ISO 9237. Ten measurements for each test samples were performed to check for repeatability.

Water vapor permeability of the fabric samples was measured in accordance with BS 7209 using the evaporative dish method or control dish method. Water vapour permeability of the fabric samples was calculated by using equation 1.

$$WVP(g/m^2/24) = 24\ \frac{M}{A\times t} \qquad \textbf{(1)}$$

where WVP, A and t indicate water vapor permeability, the internal area of the dish (m^2) and the time between weighings in h, respectively. And also M indicates the loss in mass.

Vertical wicking performance of the fabric samples were tested in accordance with DIN 53924. The specimens of each fabric samples were prepared in the dimensions of 25mm x 150mm. The specimens were suspended and immersed in 1% w/v $K_2Cr_2O_4$ aqueous solution which is used for tracking the movement of the liquid along the fiber due to its no affinity to man-made fibers. The height reached by the solution was measured and recorded at time intervals of 1min, 5min, 10min, 15min, 20min, 25min and 30min.

Hygroscopic moisture contents of the fabric samples were determined by using the gravimetrical method.

Moisture management capability of the fabric samples were tested by using SDL ATLAS Moisture Management Tester (MMT) according to AATCC test method 195-2009. The tester is equipped with two moisture sensors, upper and lower. This tester measures the liquid moisture transport from upper face to lower face of the test specimens and also wetting time, wetting radius and wetting spreading speed at these two different faces, separately. The top surface of device is simulated the surface in contact with the skin and the bottom surface is simulated exposing to the atmosphere [6].

2. RESULTS AND DISCUSSION

Air and water vapor permeability of the fabric samples were tabulated in Table 2. Nonwoven fabrics are porous structures that can easily allow the transmission energy and also substances [7]. The porosity of these types of fabrics is affected by fabric structural parameters such as fabrics mass and fabric thickness, etc. The absorption, uptake and permeability properties depend on the porosity character of the fabrics. There are noticeable differences between air permeability values of the fabric samples (Table 2). As given in Table 1, the blended fabric samples with changing viscose proportion have same fabric thickness but different fabric mass values. The decrements in air permeability values from PCV0 to PCV3 fabric samples can be explained by systematic increase in fabric mass of the fabric samples.

It is also pointed out from Table 2 that water vapor permeability of the fabric samples changes non-systematically according to the viscose proportion or fabric mass, separately. These differences may be explained the combined effect of these two parameters. Water vapor transmission mechanism of fabrics involves the diffusivity and sorption-desorption of the fabrics which is influenced positively with moisture regain and hygroscopicity of the fabrics, respectively [1, 8]. It is figured out from Table 2 that the greatest increase (8.3%) in water vapor permeability from PCV0 (100% PET) to PCV1 (30/70% CV/PET) can be a result of the viscose proportion although fabric mass increase by 39.1%. The hygroscopic viscose fibers cause higher diffusivity and higher sorption-desorption by absorbing water vapor (humidity) and releasing it to dry air as compared with PET fibers. However, PCV0, PCV2 and PCV3 fabric samples have similar water vapor permeability results. In comparison with PCV0, fabric mass and viscose proportion of PCV2 fabric sample increase by 49.2% and 50% whereas these parameters increase by 51% and 70% for PCV3 fabric sample, respectively. The increase in both two parameters may neutralize their own effects.

Table 2: *Air permeability and water vapor permeability of the fabrics*

Sample Code	Air Permeability ($l/m^2/s$)	Water vapor permeability ($g/m^2/24h$)
PCV0	4623.5±180.5	777.1±14.4
PCV1	3848.5±282.5	841.8±3.90
PCV2	3487.0±133.7	784.5±1.30
PCV3	3093.0±273.2	789.1±34.0

Figure 1 shows the moisture content of the fabric samples which was tested by using gravimetrical method. As clearly understood from Figure 1, the viscose fiber proportion has a great positive effect on moisture content of 100% PET fabric sample (PCV0) as it is expected. Because of highly hydrophilic nature of viscose fiber, the PET/CV blended fabric samples achieved moisture absorption property.

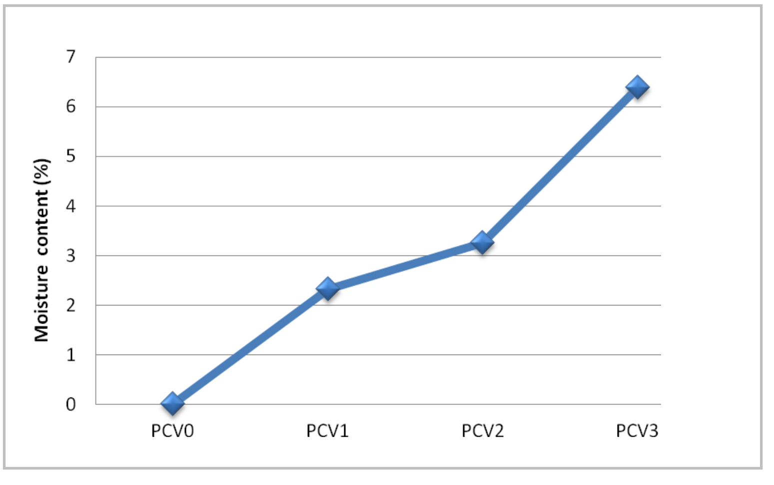

Fig. 1: *Moisture content of the fabric samples*

Representative results presented in Figure 2 that water wicking height increase with increasing proportion of viscose fiber in the fabric samples. No wicking height was observed PCV0 fabric sample in any time interval due to its highly hydrophobic nature. The influence of increasing the proportion of viscose fiber from 30% (PCV1) to 50% (PCV2) on water wicking performance is more evident in cross direction. This finding is not in agreement with previous research by Das et al., 2009 [1]. In this study, this positive contribution on water wicking can be explained by absorption behavior of viscose fibers. Due to their excellent water absorbency based on their hydrophilic character, viscose fibers can easily form hydrogen bonding with water molecules. Close examination of the values in Figure 2, maximum increase in water wicking height was recorded at 0-1min for all types of the fabric samples. Water movement became slower with increasing the time intervals.

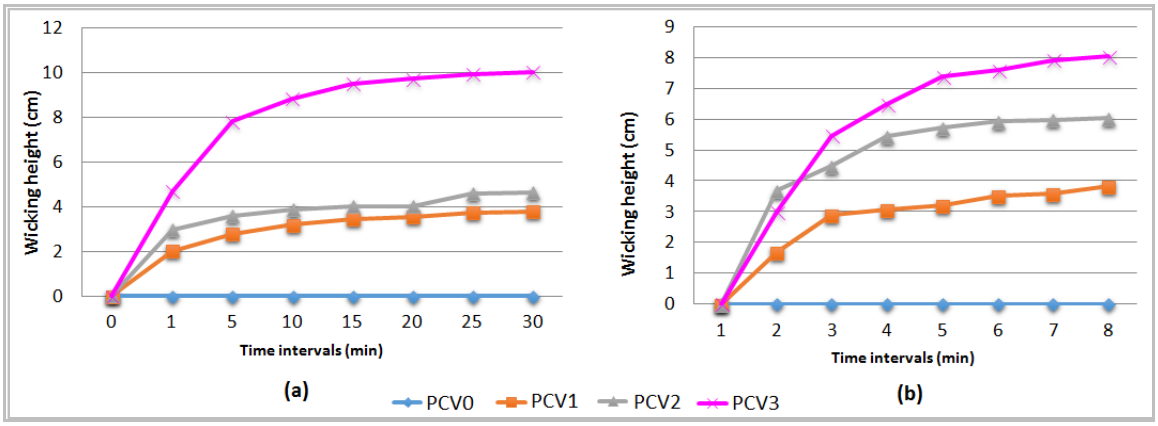

Fig. 2: *Vertical wicking heights of the fabric samples in both directions (a: machine direction, b:cross direction)*

Moisture management mean values of the fabric samples can be seen in Table 3. PCV3 fabric sample has the lowest wetting time at both the bottom and the top as compared with other fabric samples. When the liquid dropped at the top surface of the fabric sample, the liquid absorption occurred immediately, but wetting of top and transportation of the liquid to bottom occurred slowly. This may be due to the high absorbability of viscose proportion of the blended fabric sample. The viscose proportion increased the wetting radius of 100% polyester fabric sample in both top and bottom surfaces. The absorption of liquid by viscose proportion in the blended fabric samples can be responsible for the wetting radius of top surface. Because there is no wetting radius detected at the top of PCV0 fabric sample. But wetting radius values at bottom surfaces are the results of capillary forces [6]. Test results also reveal that overall liquid moisture management capability (OMMC) value is 0 for PCV0 fabric sample which means that 100% polyester fabric used in this study has no ability to transport the liquid moisture. The blended fabrics have higher OMMC values but no general tendency observed according to the viscose proportion. OMMC values exhibit the capacity or ability of the fabrics to transport the sweat from skin to outer surface of the fabrics.

Table 3: *Mean values of moisture management properties of the fabrics*

Sample code	Top wetting time (s)	Bottom wetting time (s)	Top absorption rate (%)	Bottom absorption rate (%)	Top max wetted radius (mm)	Bottom max wetted radius (mm)	OMMC
PCV0	7.44	120.0	54.50	0.00	5.00	0.00	0.00
PCV1	4.05	6.09	28.81	64.81	29.00	29.00	0.60
PCV2	2.59	2.59	62.38	66.82	30.00	30.00	0.45
PCV3	2.13	2.19	61.21	62.50	30.00	28.33	0.44

3. CONCLUSIONS

PET/CV fabrics were examined to study the effect of viscose ratio (0, 30, 50 and 70%) on moisture related properties of the nonwovens. The moisture content and vertical wicking performance of the fabrics increased with increasing viscose fiber ratio. This is due to the highly hydrophilic structure of the viscose. Air permeability is in reverse ratio with fabric thickness as expected. However, water vapour permeability results are affected from both fiber content and fabric unit weight. The fabric sample having the highest viscose content has the lowest wetting time at both the bottom and the top as compared with other fabric samples. When the liquid dropped at the top surface of the fabric sample, the liquid absorption occurred immediately, but wetting of top and transportation of the liquid to bottom occurred slowly. This is due to the high absorbability of the viscose. A geometrical and physical model which considers the moisture related properties of blended nonwoven fabrics can be constructed for future study to predict the thermal comfort properties of nonwovens.

ACKNOWLEDGEMENTS

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STUDYING VARIATION IN LOOP LENGTH IN A COTTON INTERLOCK FABRIC AFTER THE WEAVING AND DYEING PROCESS

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Abstract: *The 100% cotton interlock structure has been widely used to produce winter garments thanks to its thermal properties and comfort. However as with all weft-knitted fabrics, it presents much dimensional instability. For a long time now, companies have attempted to minimise this problem by optimising production processes and implementing quality controls to obtain more dimensionally stable fabrics. The dimensional instability of knitted fabrics from their production stage until a finished fabric is formed is subject to wide variability and, therfore, needs to be minimised. One of the variables that intervenes in fabric shrinkage is loop length.The process followed to analyze this in accordance with regulation UNE-EN 14970 is somewhat bothersome as it is necessary to identify wales and the direction samples unravel in, cut all along a course, count the number of loops along a given length, remove yarn from the fabric, place the measuring machine pincers by foreseeing loss of twist to measure its length, and repeat all this 10 times to then calculate its mean. This study proposes finding the relationship between loop length and the variables wales/cm, courses/cm, stitch density/cm*^{2}*, weight, tightness factor,* K_c, K_w and K_r *to obtain knitted fabrics with an optimum dimensional stability to thus guarantee end product quality.*

Key words: *Interlock fabrics, skrinkage, knitted fabric, loop length, cotton.*

1. INTRODUCTION

At the beginning of the 20th century, Chamberlain [1] attempted to discover the loop shape of a knitted fabric.

Doyle and Hurd [2] found that the knit density in plain-knitted fabrics in a dry relaxation state depends only on loop length and is independent of other knitted fabric variables.

Munden [3,4] showed that the natural loop shape is determined by minimum energy conditions, which mean t only similar loops, and the following equations were proposed: ($K_c = c \times l$, $K_w = w \times l$, $K_r = K_c/K_w$), where c and w are courses/length unit and wales/length unit. These equations have been applied for many years to plain-knitted fabrics.

Nutting and Leaf [5] introduced another variable, called count, and proposed making a minor modification to the basic equation.

Knapton [6] not only demonstrated that dimensional stability in plain-knitted fabrics can be achieved by mechanical means, relaxation techniques or chemical treatments, but stable loop geometry is almost identical for wool and cotton in plain-knitted fabrics.

By way of conclusion, almost all the found studies refer to the variable *loop length* as one of the most important factors that intervenes in the dimensional variation of knitted fabrics. The objective of the present study was to find the existing relationships between the variable *loop length* and the variables *wales/cm*, *courses/cm*, *stitch density/cm²*, *weight*, *tightness factor*, K_c, K_w and K_r.

2. MATERIALS AND METHODS

2.1 Description of the fabric manufacturing process

The linear yarn density used to manufacture the fabrics with an interlock structure (I1 and I2) was 30 Ne (combed cotton). The machines employed to make pieces are shown in *Table 1*.

Table 1: *The circular machines used to make fabrics I1 and I2.*

MODEL	DIAMETER (inches)	GAUGE	NEEDLES	No. SETS
MAYER IHG II	12	E20	2x756	20
MAYER IHG II	14	E20	2x876	36
JUMBERCA DVK	16	E20	2x1008	32
MAYER IHG II	17	E20	2x1056	32
JUMBERCA DVK	18	E20	2x1128	36
MAYER IHG II	20	E20	2x1260	40
JUMBERCA DVK	22	E20	2x1380	44
JUMBERCA DVK	24	E20	2x1512	48
MAYER OV 3,2 QC	30	E20	2x1872	96

To undertake this study, 15 pieces were manufactured of each fabric (I1, I2), which weighed no more than 15 kg, for each machine diameter. Thus 270 pieces were produced in all. The difference between the two fabrics produced for each machine diameter is loop length. Fabrics were obtained whose mean loop length in I1 was 0.331 cm and 0.356 cm in I2 after the weaving process.

After weaving, the following relaxation state was differentiated: *"Weaving and dry relaxation (WDR)"*

Next lots were submitted to an exhaustion bleaching process in overflow machines. To analyse the obtained fabric, two relaxation states in fabrics I1 and I2 were differentiated after the dyeing process:

- ***Dyed and dry relaxation (DDR)***. The dyed fabric was submitted to a conditioning environment until a constant mass was obtained
- ***Dyed and wash relaxation (DWR).*** The fabric was dyed and conditioned until a constant mass was obtained to be then submitted to a dimensional stability analysis according to procedure 4N of Standard UNE EN ISO 6330, of September 2012. This status is considered a completely relaxed one.

2.2 Description of the variables to be analysed

The variables analysed for relaxation states *WDR*, *DDR* and *DWR* were: wales/cm (*P*), courses/cm (*C*), Stitch density/cm² (*DM*), weight (*G*), loop length (*LM*), tightness factor *(TF)* and Munden's constants (K_c, K_w and K_r).

To determine the variables *P*, *C* and *DM*, Standard UNE-EN 14971 was followed. *G* was calculated according to Standard UNE-EN 12127, while Standard UNE-EN 14970 was followed to determine *LM*.

To calculate the constants (K_c, K_w and K_r), Munden's equations were used. To calculate the variable *TF*, the equation below was used:

$$TF = \frac{\sqrt{Dl}}{LM} \qquad \textbf{(1)}$$

3. RESULTS AND DISCUSSION

The mean, standard deviation and the 95% confidence interval (CI) of the results from the analysis done of the obtained pieces made from fabrics I1 and I2 in relaxation states *WDR*, *DDR* and *DWR* are provided in Tables 2 and 3.

Table 2: *The experimental results of fabrics I1 and I2 after weaving*.

Sample No.	Variable	WDR Relaxation state		
		M	**s_i**	**CI**
I1	P	27.4	0.4128	[27.2;27.6]
	C	11.7	0.3750	[11.5;11.9]
	DM	321.8	8.7182	[317.1;326.4]
	G	216.4	4.3756	[214.0;218.7]
	LM	0.341	0.0088	[0.336;0.345]
	TF	13.032	0.3394	[12.851;13.213]
	K_c	4.00	0.1191	[3.94;4.06]
	K_w	9.34	0.3062	[9.18;9.51]
	K_r	0.43	0.0181	[0.42;0.44]
I2	P	23.6	0.6418	[23.4;23.9]
	C	11.9	0.6002	[11.7;12.2]
	DM	281.9	13.7145	[276.6;287.2]
	G	198.7	7.3539	[185.8;201.5]
	LM	0.365	0.0123	[0.360;0.370]
	TF	12.166	0.4046	[12.010;12.323]
	K_c	4.36	0.1855	[4.29;4.43]
	K_w	8.62	0.3527	[8.48;8.76]
	K_r	0.507	0.0327	[0.49;0.52]

Table 3. *The experimental results of fabrics I1 and I2 after the dyeing process.*

Sample No.	Variable	Relaxation States					
		DDR			DWR		
		M	**s_i**	**CI**	**M**	**s_i**	**CI**
I1	P	27.4	1.6821	[27.1;27.7]	29.2	1.4390	[28.9;29.4]
	C	14.5	0.5668	[14.4;14.6]	13.7	0.5071	[13.6;13.8]
	DM	396.8	24.5142	[392.9;400.7]	398.5	24.9974	[394.6;402.5]
	G	251.3	8.7335	[249.9;252.6]	262.4	11.3890	[260.6;264.2]
	LM	0.331	0.0082	[0.330;0.333]	0.331	0.0118	[0.329;0.333]
	TF	13.40	0.3297	[13.35;13.46]	13.42	0.4622	[13.35;13.49]
	K_c	4.80	0.1785	[4.79;4.83]	4.52	0.2007	[4.49;4.55]
	K_w	9.08	0.5728	[8.99;9.17]	9.65	0.3996	[9.58;9.71]
	K_r	0.53	0.0446	[0.52;0.54]	0.47	0.4694	[0.46;0.47]
I2	P	24.6	0.7250	[24.4;24.7]	26.2	0.9654	[25.9;26.4]
	C	14.2	0.4743	[14.0;14.3]	13.4	0.4457	[13.3;13.5]
	DM	348.2	13.8521	[345.2;351.3]	351.8	19.474	[347.5;356.1]
	G	239.0	6.4395	[237.5;240.4]	251.8	7.0314	[250.2;253.3]
	LM	0.356	0.0082	[0.354;0.358]	0.356	0.0097	[0.354;0.358]
	TF	12.46	0.2937	[12.39;12.52]	12.47	0.3459	[12.39;12.54]
	K_c	5.05	0.1497	[5.02;5.08]	4.78	0.1615	[4.75;4.82]
	K_w	8.76	0.3417	[8.68;8.83]	9.33	0.3888	[9.24;9.42]
	K_r	0.58	0.280	[0.57;0.58]	0.51	0.0206	[0.51;0.52]

Figures 1-8 represent the mean of the variables *P, C, DM, G, TF*, K_c, K_w and K_r for fabrics *I1* and *I2* The average loop length of fabric I1 was 0.331 cm and it was 0.356 cm of fabric I2.

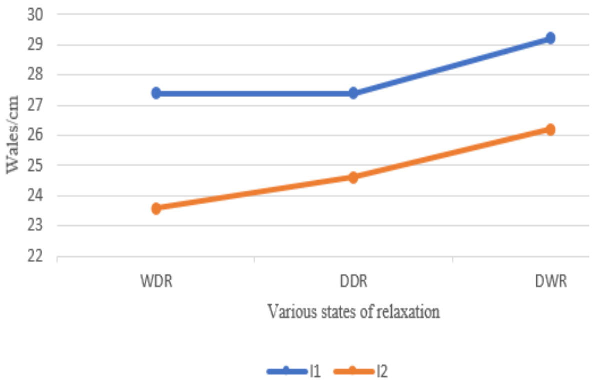

Fig.1. *Relationship between the loop length (LM) of fabrics I1 and I2 and wales/cm (P) in relaxation states WDR, DDR and DWR.*

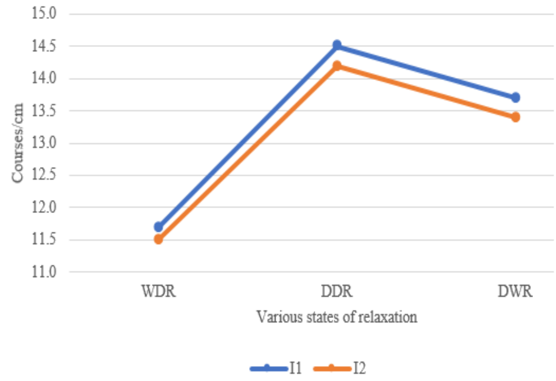

Fig. 2. *Relationship between the loop length (LM) of fabrics I1 and I2 and courses/cm (C) in relaxation states WDR, DDR and DWR.*

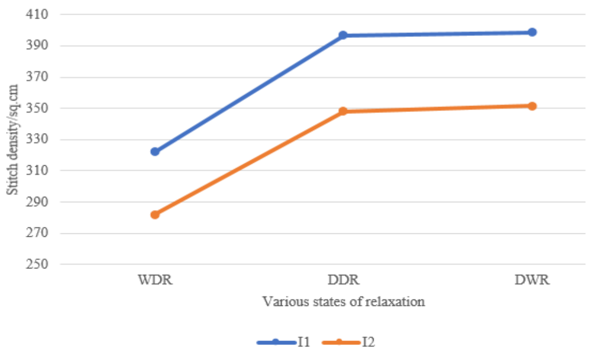

Fig. 3. *Relationship between the loop length (LM) of fabrics I1 and I2 and stitch density (DM) in relaxation states WDR, DDR and DWR.*

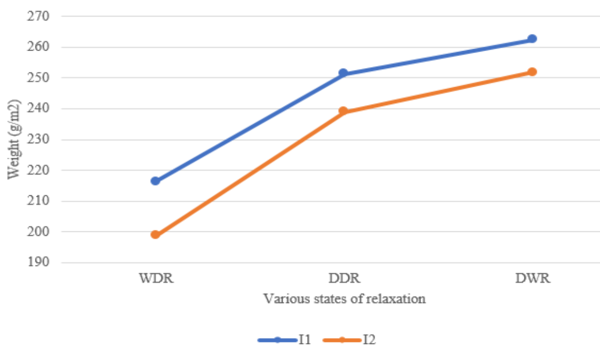

Fig.4. *Relationship between the loop length (LM) of fabrics I1 and I2 and weight (G) in relaxation states WDR, DDR and DWR.*

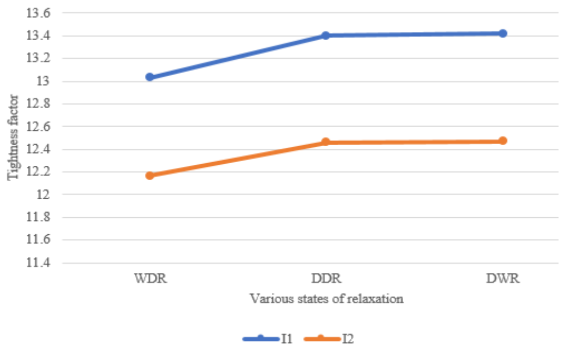

Fig. 5. *Relationship between the loop length (LM) of fabrics I1 and I2 and tightness factor (TF) in relaxation states WDR, DDR and DWR.*

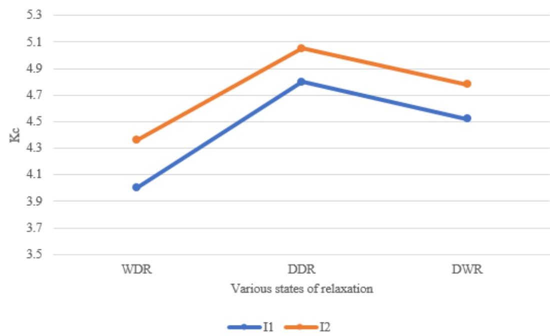

Fig. 6. *Relationship between the loop length (LM) of fabrics I1 and I2 and* K_c *in relaxation states WDR, DDR and DWR.*

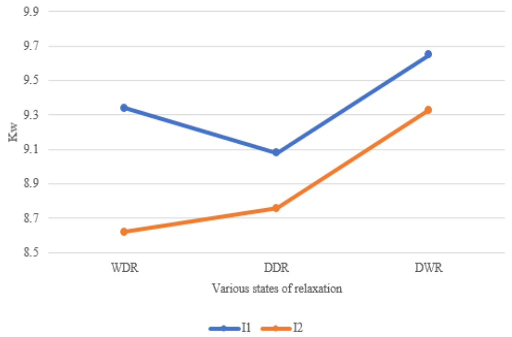

Fig. 7. Relationship between the loop length (LM) of fabrics I1 and I2 and K_w in relaxation states WDR, DDR and DWR.

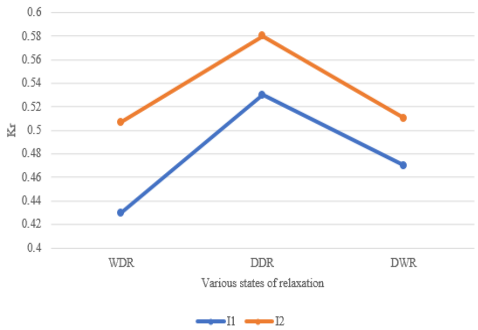

Fig.8. Relationship between the loop length (LM) of fabrics I1 and I2 and K_r in relaxation states WDR, DDR and DWR

According to the results shown in *Figure 1* we can see how *loop length* is inversely proportional to wales/cm for all the relaxation states. There is a marginal difference in the variable *wales/cm* for both fabrics: *I1* (with a shorter loop length) and *I2* (with a longer loop length) in all the relaxation states, and the value obtained for fabric *I1* of 3-4 wales/cm is higher than that of fabric *I2*. We can also see how the *wales/cm* value for shorter *loop lengths* tends to be similar between relaxation states *WDR* and *DDR*, while wales/cm vary more with higher *loop length* values. The *wales/cm* value for both fabrics *I1* and *I2* increases proportionally and significantly, and peaks in relaxation state *DWR* in both cases.

The results provided in *Figure 2* show that *loop length* is inversely proportional to *courses/cm*, although the difference obtained with the variable *courses/cm* between the higher and lower *loop length* values is not as marked as it is for the variable *wales/cm*. Very marked growth is seen for fabrics *I1* and *I2* between relaxation states *WDR* and *DDR*, which diminishes in relaxation state *DWR*.

Figure 3 evidences how the relationship between *loop length* and *Stitch density* is inversely proportional. Marked and proportional growth is noted for both fabrics *I1* and *I2* between relaxation states *WDR* and *DDR*, which becomes stable in relaxation state *DWR*.

Figure 4 shows how the relationship between *loop length* and *weight* is inversely proportional. A positive and very pronounced slope that is proportional to both fabrics *I1* and *I2* is observed between relaxation states *WDR* and *DDR*, which diminishes for relaxation state *DWR*.

Figure 5 evidences how *tightness factor* increases when *loop length* is shorter in all the relaxation states. The variable *tightness factor* grows between both relaxation states *WDR* and *DDR*, and becomes stable for relaxation state DWR.

From the results in *Figure 6*, we can see how the relationship between *loop length* and K_c is directly proportional. Marked and proportional growth is observed for fabrics *I1* and *I2* between relaxation states *WDR* and *DDR*, which diminishes for relaxation state *DWR*.

According to the results indicated in *Figure 7*, the relationship between *loop length* and K_w is inversely proportional. The variable K_w is seen to grow in the fabrics with a longer *loop length* (*I2*), while the opposite is true for the fabrics with a shorter *loop length* (*I1*), between relaxation states *WDR* and *DDR*. Yet between relaxation states *DDR* and *DWR*, both fabrics display proportional growth.

Figure 8 indicates a directly proportional relationship between *loop length* and K_r, and the growth of K_r between relaxation states *WDR* and *DDR*, which diminishes between *DDR* and *DWR*.

4. CONCLUSIONS

The present study analysed the relationship between *loop length* and the variables *wales/cm* *courses/cm*, *stitch density/cm^2*, *weight*, *tightness factor*, K_c, K_w and K_r for the interlock structure. The variable *wales/cm* displayed better dimensional stability for the *loop length* value of 0.331 cm than for that of 0.356 cm, which was not differentiated in the variable *courses/cm*, and behaved similarly. The reduction in courses/cm in relaxation state *DWR* was due to the fabric reaching its maximum relaxation in this state. Evidently throughout the production process, the fabric was submitted to stretchings and, thus, to transversal shrinkage, which allowed its equilibrium state to be recovered in relaxation state *DWR.* The variables *stitch density/cm^2* and *tightness factor* obtained higher values in the fabric with a shorter *loop length*, but were proportional to that with a longer *loop length*, and a notable increase was noted between relaxation states *WDR* and *DDR*, before it stabilised between relaxation states *DDR* and *DWR*. The value of the variable *weight* increased with lower *loop length* values, but they were proportional to the higher loop length values in all the relaxation states. The variables K_c and K_r obtained higher values in the fabrics with longer *loop lengths*, but were proportional to the fabrics with shorter *loop lengths*. Evidently they performed like the variable *courses/cm* as K_c was a dependent variable of *courses/cm*. The variable K_W increased in the fabric with a shorter *loop length*..

Finally, we reached the conclusion that as *loop length* increased for all the relaxation states, *wales/cm*, *courses/cm*, *stitch density/cm^2*, *weight*, *tightness factor* and K_w lowered, while K_c and K_r increased, and *vice versa*.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ENSURING KNITTED PRODUCTS QUALITY BY IMPROVING THEIR ECOLOGICAL FUNCTION

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Abstract: *Worldwide, recent years are characterized by an increasingly acute manifestation of the ecological phenomenon, seeking solutions for obtaining products that are based on natural components, as well as the safe use of products. In this respect, in the textile industry, the concept of eco – fashion has developed: manufacturers and designers increasingly using eco – friendly materials and technologies.*
Any approach to designing, evaluating or improving the quality of a product is based on establishing the technical dimensions of product functions and adopting the representative quality features that can best meet the demands of the beneficiaries.
Achieving and continuously improving the ecological function of clothing products is presently a major requirement, being addressed in both research and production. This function is in a relationship of interdependence with the comfort functions (thermophysiological and sensorial), the ergonomic function, the safety in use and the availability function.
The paper presents some key aspects of the ecological function of clothing products, its components, ways and solutions for implementation and product quality assurance, as well as the advantages offered by the creation and use of ecological products.179

Key words: *ecology, products, knitted, functions, quality.*

1. INTRODUCTION

In the textile industry, the last years have been marked by the eco-fashion concept, manufacturers and designers increasingly using organic materials and technologies.

Ecofashion aims at:

- ✓ protecting users health;
- ✓ maintaining and securing the integrity of the environment;
- ✓ improving working conditions for service staff in the textile industry.

Eco-friendly products have the following characteristics:

- ➢ are manufactured from organic and eco-friendly textiles (a wide variety of natural and recycled fibers) obtained in controlled systems without pesticides, herbicides or synthetic fertilizers;
- ➢ have a low impact regarding carbon content, water and energy consumption for production and processing;
- ➢ create less waste during production;
- ➢ are less polluting to the environment, compared to the standard methods of production for knitted materials and clothing;

- are hypoallergenic, antimycotic, antibacterial;
- are more durable and resistant to UV radiation;
- can be worn by all wearer groups (including babies);
- are certified by an international governing body. For example: Control Union, IMO-Institute for Marketecology or One-Cert.

2. THE IMPORTANCE OF THE ECOLOGICAL FUNCTION IN EVALUATING THE QUALITY OF KNITTED PRODUCTS

2.1 Requirements – functions – characteristics correspondence

The interface between user requirements and quality characteristics is the set of functions that products have to meet. The share of functions (their degree of importance in quality assurance) differs from one type of product to another, being determined by the requirements imposed in use.

The ecological function expresses the ability of a product to not affect the health and life of the user and to protect the environment by [1]:

- ✓ the products capacity to withstand the action of contamination factors;
- ✓ products resistance to ignition;
- ✓ products resistance to the action of biological factors;
- ✓ products ability to degrade in the natural environment.

The main quality features through which textile product manufacturers can potentiate the ecological function and its divisions are presented in Table 1.

Table 1: *Quality characteristics in correspondence with the ecological function*

No.	Ecological function subdivision	Quality characteristics
1.	Products capacity to withstand the action of contamination factors	- noxious substances contained by the products - product resistance to radioactive contamination
2.	Products resistance to ignition	- non-flammable
3.	Products resistance to the action of biological factors	- breaking resistance under the action of biological factors
4.	Products ability to degrade in the natural environment	- biodegradable

2.2 Components of the ecological function of knitted products

Achieving and continuously improving the ecological function of clothing products is a major requirement, being addressed in both research and production.

The ecological function is in a relationship of interdependence with the comfort functions (thermophysiological and sensorial), the ergonomic function, the safety in use and the availability function. Depending on the nature of the raw materials used, application of special processing and finishing treatments, the ecological function can be divided into four components, corresponding to its production, product, its maintenance and the possibility of recycling or degradation of the product into the environment. These components, accompanied by a series of observations, are presented in Table 2.

Table 2 *Ecological function components*

No.	Ecological function components	Observations
1.	**Ecological function of production**	It refers to the effects that manufacturing technologies have on human health as well as on the environment. This component involves work safety, levels of water and energy consumption, waste water treatment, personnel exposure to noise and dust, etc.
2.	**Ecological function of the product perceived by the user**	Is expressed by the fibrous composition and the content of materials and chemical substances associated with the product, which could influence both the sensory and thermophysiological comfort status and the health of the user.
3.	**Ecological function manifested during product maintenance**	Refers to the effects that household maintenance (washing, chemical cleaning, ironing etc.) have on the user and the environment.
4.	**Ecological function for waste administration following products fabrication and use**	It consists in the ability of products to be recycled, degrade in the biological environment and be eliminated from the environment.

Considering the desires of product and life quality assurance, the adoption and implementation of solutions for the realization and use of ecological products is of paramount importance. For the four components of the ecological function, table 3 presents some of the quality assurance modalities and solutions, namely non-quality conditions (non-fulfillment of the ecological function).

Table 3 *Quality assurance conditions, respectively non-quality conditions for the ecological function*

Nr. crt.	Ecological function component	Quality assurance conditions	Non-quality condictions
1.	**Ecological function of production**	- implementing protection measures for people and products against harmful factors (toxic substances, extreme temperatures, excessive humidity); - reducing the degree of phonic pollution); - reducing air pollution with dust and fly waste; - equiping production and storage spaces with ventilation and air purification installations; - permanent control of the microclimate parameters (temperature, humidity).	-lack of protection measures against harmful factors; - high degree of phonic pollution; - high degree of air pollution; - lack of ventilation and air purifying installations; - absence of apparatus for measuring and controlling the microclimate parameters.
2.	**Ecological function of the products perceived by the user**	- reduced content of nocive substances; - pleasant touch (soft, smooth); - elasticity and flat appearance of the seams; -low flammability (reduced capacity to ignite or spread the flame).	- high content of nocive substances; - unpleasant touch (rough, coarse); - rigid and uneven seams; - high flammability (ignites and easily spreads the flame);

Nr. crt.	Ecological function component	Quality assurance conditions	Non-quality condictions
3.	**Ecological function of products manifested during maintenance**	- lowered soiling capacity; - efficient maintanence (short time, low consumption of cleaning or washing solutions); - cleaning with biodegradable substances.	- high soiling capacity; - lower cleaning capacity (long time, increased consumption of cleaning or washing solutions); - cleaning with non-biodegradable substances.
4.	**Ecological function for waste administration**	- product manufacturing from biodegradable materials and components; - recycling possibility for the product or its components	- product or components non-degradable partially or totally in the biological environment; - inability to partially ot totally recycle.

3. IMPLEMENTING THE SOLUTIONS FOR THE ECOLOGICAL FUNCTION IMPROVEMENT AND QUALITY ASSURANCE OF KNITTED PRODUCTS

3.1 Directions for the implementation of technical solutions in product quality assurance

In order to answer the explosive rise in demand and taking into consideration the ecological problems, research has progressed more and more. The most dynamic sectors are interdisciplinary, combining the research in medicine, textile industry, metrology, transport etc. New generation of ecological clothing has become more solicited. Their market already covers 30% of textiles sold in Europe and 40% in the United States and Japan, and could well exceed 50% in the future [2, 4, 5].

Research regarding the improvement of protective functions and ecology of clothing product had as objectives:

- **using of natural fibre** (cotton, flax, silk, wool, etc.) **organically cultivated**, with the capacity to absorb and remove moisture, air penetrable, thermal regulation capacity (cooling sensation, respectively warming according to extern temperature), protection against bacteria and UV protection, contributing to the increase in environment and life quality [2];
- **using ecologic, biodegradable or recyclable fibres,** with antibacterial effects, auto-sterilizing and auto-cleaning, with high UV radiation protection;
- using a mix of natural, ecologic and synthetic fibres that will offer superior quality characteristic tu products and high UV radiation protection;
- **using yarn realized through performant technologies** to insure protection against insects, bacteria, fungi and acariens and UV protection;
- **using intelligent fibers/yarns/materials** that can influence health by adapting the temperature of the textile material according to ambient temperature fluctuations, as well as modifying the intensity of the color thus increasing the degree of UV protection;
- **using performant processing and manufacturing techonologies** for all categories of knitted products;
- **washing the materials with special detergents** or treating them with chemical substances with UV screen role, but at the same time reducing the waste of chemical treatments.

Some examples that illustrate the results of the research and improvement to ecological and protective functions are presented below.

1. **Naturally colored cotton** (different shades of brown and green) Fox Fiber and Top Cot with superior tensile strength and flame resistance.
2. **Biowool -** ecological wool fibers (Biotex company), with superior characteristics (count, volume, strength), hypoallergenic characteristics and body temperature control capacity [3].
3. **Bamboo fibres** are fabricated out of 100% **bamboo** pulp. Being completely biodegradable and sustainable, the bamboo is the most ecological material of the 21st century. Materials made out of bamboo fibres have antibacterial, anti-allergic, antiperspirant and absorptive proprieties. Articles realized from these material are light, nice to touch, natural sheen, don't cause allergic reaction, but protect the skin from UV rays perfectly (reflecting 98% of damaging rays). They have antibacterial proprieties and prevent the development of pathogenic organisms, fungi and acariens (on a bamboo fibre, 70% of bacteria is killed), and keep these proprieties even after a hundred washings.
4. **Fibres realized from Cocona (derived from coconut husks), Pineapple** [2] **–** combines the principles of UV protection improvement and the following characteristics:
   - Fabricated from Cocona and PES with Polartech Power Dry technology – a material that is part of the Next To Skin category, with absorptive capacity and humidity removal, air permissive and thermal regulation capacity;
   - Anti-odorizing natural treatment, without involving any chemical antibacterial treatment;
   - Offers resistance and good protection to UV rays;
   - Knitted structure type mesh, and the tailoring of the product is adjusted, with a high coverae degree of the body.
5. **Biodegradable vegetable fibers type PLA** (contain poly-lactic acid, polymer extracted from corn) offering a very good protection by blocking the UV rays.
6. **Alginate fibers -** made from brown algae (which are naturally renewed) biodegradable ecological polymers are obtained by treating them according to the content of gluconic and manuronic acids, the basic components of the alginated copolymers. Alginate fibers are mainly used in manufacturing dressings in the medical sector because they have the advantage of creating a healing field with high absorption power (20 times their mass) and healing in a wet environment [3].
7. **Chitin and dibutyrylchitin bioactive fibers - DBCH** (Chitin is a natural polysaccharide with bioactive properties, insoluble in common solvents) [3].
8. **Wear – internationally brevetted anti-radiation weave** [2] for articles of clothing for adults and children (is certified Oeko-Tex – Baby class), linens, covers, sleeping bags, etc. Characteristics: - is realized from cotton and copper/silver (copper wire wrapped in silver has 0,02 mm thickness being integrated almost invisible in the weave of cotton fibres); is bio - compatible because of the protective polyurethane cover, hypo-allergic and antiseptic recommended especially to chemicals sensible persons; very good screening power, that remains unchanged even after 30 washings; has high density;
9. **Meryl products** (Rhône Poulenc France - [2]) – are made out of polyamide PA 6 and PA 6, 6 type fibres. The sheen of Meryl products can be: shiny, semi-matter and ultra - matte. From Meryl type yarn can be realized materials wind and waterproof, with goo thermal isolation, good behaviour in humidity and OV radiation protection. It is used mixed (with wool, rayon, or other types of fibre) with varied systems or yarn under the trademark Nylstar® that has loose and comfort qualities. There have been realized varied fibres Meryl®: Meryl anti UV, offers protection to UVQ and UVB; Meryl Satine, creates a light reflective effect, Meryl Tango, for weaves with a natural silk aspect etc.
10. **MERINO Perform™ products** (23% merinos wool and % polyester) – combine the principles of UV protection improvement with the capacity of thermal regulation.

3.2 Advantages offered by using ecological products

Increasing the ecological functions in the textile industry has the following advantages:

- **scientific and technical impact** through:
  - implementing competitive technologies for sustainable textile engineering;
  - setting up waste analysis and monitoring networks;
- **economic impact** through:
  - increasing the competitiveness of economic agents;
  - ensuring sustainable economic development;
  - supporting the process of integration into the EU's economic and social area;
  - preserving the environment and natural resources;
  - expanding / strengthening multiple cooperation relations;
  - capitalizing on research potential in the field of textile and leather waste;
  - achieving international quality and environmental standards;
- **social impact**:
  - creating better conditions in work, health and life;
  - opportunities for teaching, improving and raising the level of education;
  - population awareness in the spirit of environmental protection;
- **impact on the environment**:
  - complying with the conditions regarding the quality of the working environment;
  - increasing the level of biosecurity;
  - decreasing the level of soil and air pollution.

4. CONCLUSIONS

Building on the desires of product and life quality assurance, the achievement and continuous improvement of the ecological function of clothing is a timely requirement, being addressed in both research and production.

The ecological function is in a interdependent relationship with comfort functions, ergonomic function, safety in use and availability functions. As such, the research, design, development and use of eco-friendly textile products in line with current requirements for the preservation and protection of users' health and environmental integrity are the new vital goals.

The paper presents systematically the characteristics of the eco-friendly textile products, the components of the ecological function, the quality assurance methods, as well as the main solutions implemented in the technological practice, which allowed taking the best decisions, fully informed and obtaining the most advantageous benefits.

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ANNALS OF THE UNIVERSITY OF ORADEA
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LIGHT-INDUCED STRENGTH LOSS IN JUTE AND POLYPROPYLENE CARPET BACKING FABRICS

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Abstract: *The closed-loop recycling of mechanically shredded post-consumer wool-pile carpets as fertiliser was demonstrated previously, where it increased the yield of grass by up to 82%. When cultivated into the soil, the shredded carpet inevitably left fragments on the surface, which included jute and polypropylene components of the carpet backing. To determine their likely persistence in the environment, jute and polypropylene carpet backing fabrics were subjected to intense light from a 500-Watt lamp, which provided a reasonable approximation to sunlight outdoors. The changes in mechanical properties and microscopic appearance of the fabrics were monitored. Over 500 hours of exposure to light (equivalent to 125 days of strong sunlight), the jute lost 60% of its strength. The polypropylene lost strength more rapidly than the jute, i.e. 88% loss over 250 hours. In an outdoor situation, the jute and polypropylene would be subject to rain and microbial action, as well as sunlight, so degradation will be faster than was measured under laboratory conditions. The results of this study suggest that fragments of jute and polypropylene carpet backing, on the surface of soil, may not constitute an environmental hazard, and that photodegradation of microplastic fibres on land (such as those in waste water sludge applied to land), reduces the risk they pose to aquatic environments.*

Key words: *wool carpet recycling, jute, polypropylene, photodegradation, mitigating microplastic pollution*

1. INTRODUCTION

There is growing interest in reducing the amount of textile waste that is disposed of in landfills or by incineration [1]. The increasing consumption of textiles, fuelled by the growth of fast fashion, has contributed to this interest [2]. Consumers who choose wool, tend to be well informed and environmentally aware, so the wool industry has endeavoured to stay at the forefront of sustainability, by developing many new technologies [3], including the recycling of carpets [4]. In addition, wool can be used in non-traditional products designed to enhance the environment, by for instance, removing heavy metals and dyes from waste water [5],[6] and removing pollutants from indoor air [7].

Wool is unique amongst the fibres commonly used in carpet piles, as it is biodegradable in the soil [8] and oceans [9]. This biodegradability in soil enables wool to be used as a fertiliser. The recycling of post-consumer wool-pile carpets was shown by using mechanically shredded wool-pile carpet as a fertiliser, increasing the yield of pasture by up to 82% [10], thereby demonstrating closed loop recycling, i.e. grass-wool-carpet-grass. This type of recycling of post-consumer wool-pile carpet would not only help to alleviate the problem of waste disposal, it would increase soil fertility and reduce the use of other types of fertilisers.

Carpet have been made entirely with wool, i.e. wool pile, wool primary and secondary backing fabrics and solubilised wool latex [11], but, at present, most wool carpets contain jute and polypropylene, see **Fig. 1**. Therefore, the behaviours of jute and polypropylene in wool carpet fertiliser need to be considered. Some jute and polypropylene will end-up on top of the soil, where they will break-down by a combination of microbial and photochemical processes.

There is growing concern about the liberation of microplastic fibres during the laundering of clothing made from synthetic fibres. It has been estimated that laundering generates 0.12 kg of microplastic fibres per person per year [12], making a significant contribution to plastic pollution of rivers, lakes and oceans [13]. Microplastic fibres produced by laundering can, to various degrees, be intercepted by waste water treatment plants [14]. However, sludges from these plants are often applied to land, so that wind and rain can transport the microplastic fibres to waterways. Any photochemical degradation of the microplastic fibres would affect the risk they pose to waterways.

The work reported here investigated the changes in tensile strength and microscopic appearance of jute and polypropylene fabrics caused by exposure to light.

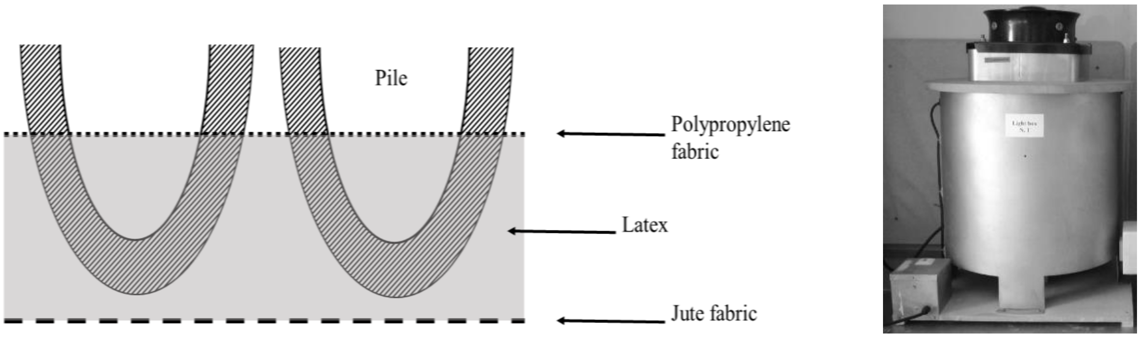

Fig. 1*: Schematic view of carpet cross-section (left) and light box (right)*

2. MATERIALS AND METHODS

The jute was a standard woven carpet backing fabric of 217 g/m^2 of unknown origin. The polypropylene was a standard woven primary carpet backing fabric of 115 g/m^2 (Poly Bac LPB 2805, Amoco, Australia). The polypropylene was manufactured for indoor use and would therefore not contain light stabilisation additives. Fabrics (70 mm × 200 mm) were exposed to a 500-Watt lamp in a light box with forced circulation of air, see **Fig. 1**. The fabrics were mounted 85 mm from the outside of the lamp (120 mm from the vertical axis of the lamp) and revolved around the lamp at one revolution per hour. The lamp was a mercury vapour, tungsten filament, internally phosphor-coated lamp (HSB-BW, Sylvania, Belgium). Fabrics were exposed to the lamp for various times up to 1,000 hours. The lamp was turned off every 48 hours for 16 hours, to approximate day and night that would be encountered outside. This type of lamp was chosen as it is commonly used to assess the photo-fading of textiles, emits light that is a reasonable approximation for sunlight (310-760 nm) and exposure of 4 weeks (672 hours) is known to be approximately equivalent to six months outdoor exposure under strong sunlight conditions (i.e. summer, latitude 23° south, in Barcaldine, Queensland, Australia) [15]. It was desirable to use an artificial light source, so that this study could be reproduced by different laboratories, and not be dependent upon local climatic conditions.

Exposed and unexposed fabrics had their tensile properties measured by the Woolmark Company Test Method 4 (Breaking Strength of Fabric). The tensile testing was performed in triplicate with a crosshead speed of 200 mm/minute, a gauge length of 200 mm and a width of 50 mm. Selected fabrics were examined by field emission scanning electron microscopy with a JSM 7000F (JEOL, Japan), after sputter coating from a gold-palladium source.

3. RESULTS AND DISCUSSION

The polypropylene was stronger than the jute initially, but the polypropylene had a greater rate of strength loss during light exposure. After some 250 hours of exposure, the two types of fabric had the same breaking strength, and as exposure continued, the polypropylene became considerably weaker than the jute. The mean breaking strengths, and extensions at break of the fabrics are shown in **Figs. 2** and **3**. After 500 hours exposure, the polypropylene fabric was too weak to be mounted in the tensile testing instrument. After 500 hours of exposure, the jute did not get any weaker with continued exposure beyond 500 hours.

The extension at break of the polypropylene followed the same trend as its breaking force. The extension at break of the jute was initially lower than that of the polypropylene, but it was largely unaffected by the light. By 250 hours of exposure, the jute had a greater extension at break than the polypropylene.

In some cases, short exposures (25 hours) slightly increased breaking strength, and extension at break, during. This could have been caused by light-induced cross-linking, such as that imparted to polypropylene by the photolysis of hydroperoxide [16]. As the light exposure was continued beyond 25 hours, radical-induced cleavage of bonds would weaken the fabrics. The losses in strength and extension at break of the jute and polypropylene were accompanied by microscopic cracking, see **Figs. 4-7**.

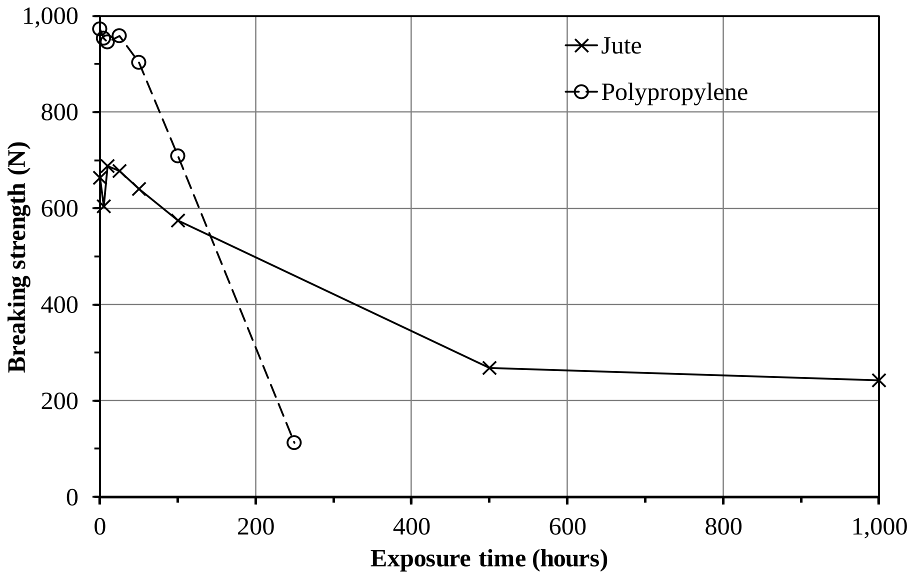

***Fig. 2**: Breaking strengths of jute and polypropylene carpet backing fabrics after exposure to a 500 W lamp. NB the polypropylene fabric was too weak to measure after 500 hours*

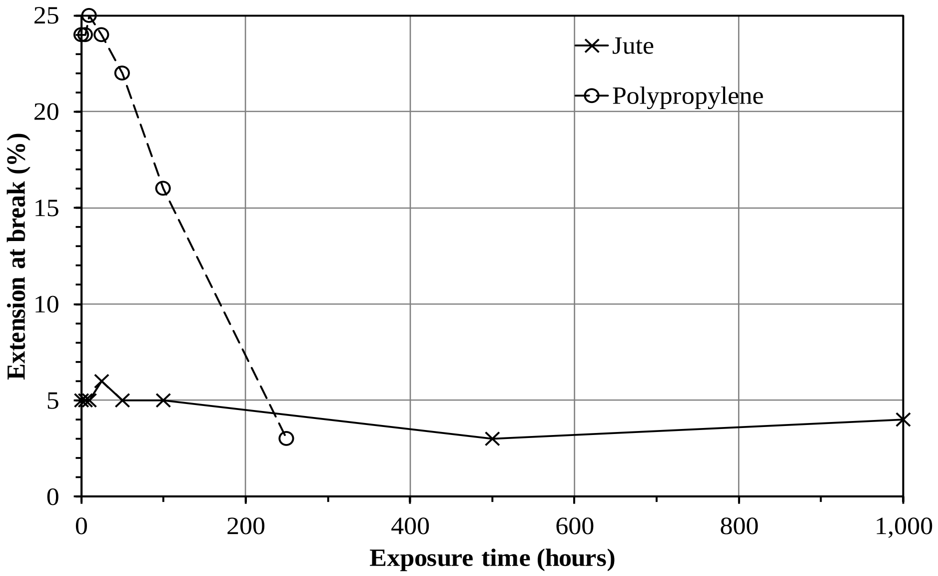

Fig. 3*: Breaking extensions of jute and polypropylene carpet backing fabrics after exposure to a 500 W lamp. NB the polypropylene fabric was too weak to measure after 500 hours*

The susceptibility of the jute and polypropylene (and other components of shredded wool-pile carpets) to degradation by photochemical and microbial processes, could be increased by conventional textile processes, such as oxidation, enzyme hydrolysis, heat, or by emerging ones such as plasma [17].

Fibres and microplastic fibres applied to land in sludges from waste water treatment plants [18], could reasonably be expected to show similar photodegradation to that observed in this study, thus reducing the risk they pose to aquatic environments.

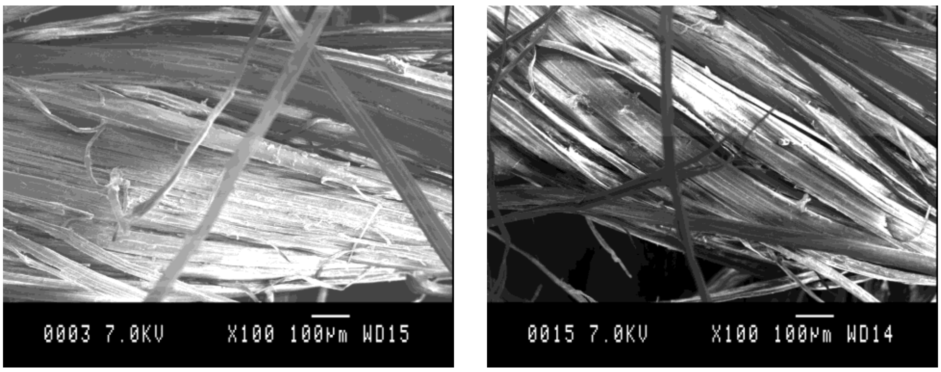

Fig. 4*: Micrographs of jute fabric, unexposed (left) and exposed for 100 hours (right)*

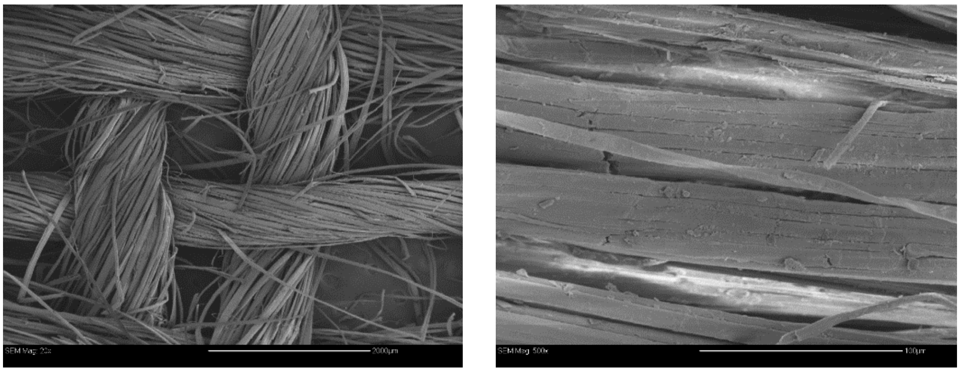

Fig. 5*: Micrographs of jute fabric exposed for 1,000 hours (scale bars 2,000 µm left, 100 µm right)*

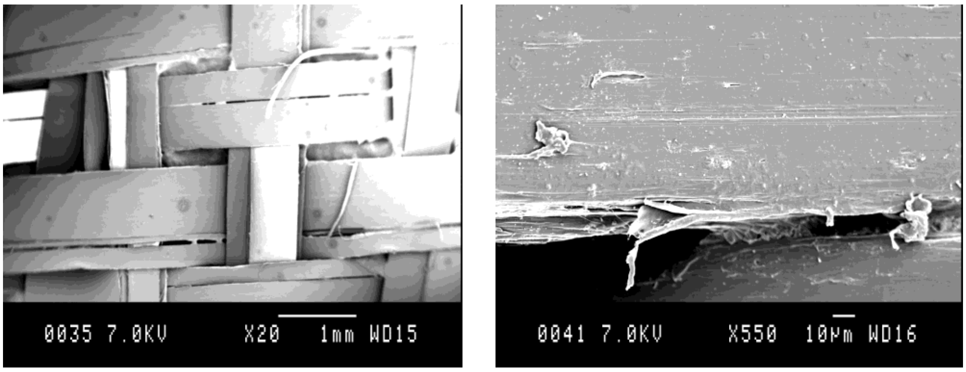

Fig. 6*: Micrographs of unexposed polypropylene fabric*

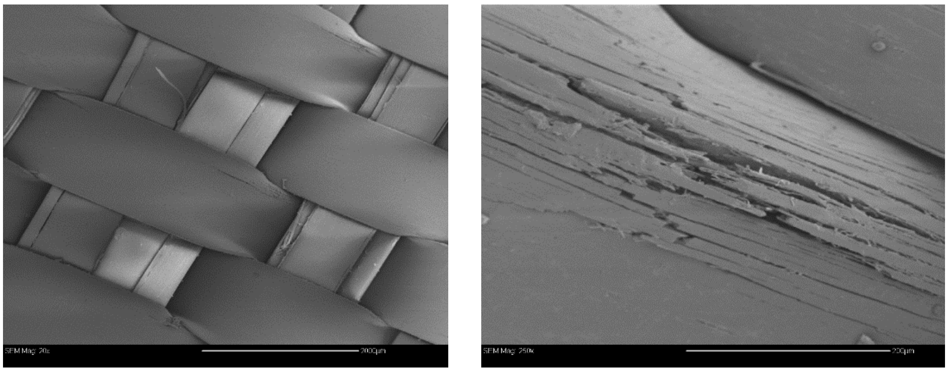

Fig. 7*: Micrographs of polypropylene fabric exposed for 250 hours (scale bars 2,000 µm left, 200 µm right)*

4. CONCLUSIONS

Jute and polypropylene carpet backing fabrics lost most of their strength when exposed to intense light, with polypropylene having the greater rate of strength loss. The action of microbes and water on fabrics outdoors could reasonably be expected to increase the rate of fabric damage compared with those reported here. These results suggest that fragments of jute and polypropylene in shredded wool-pile carpet fertiliser, on the surface of soil, would be readily degraded by sunlight. These results also suggest that microplastic fibres applied to land in sewage sludge and exposed to sunlight would be photodegraded, potentially reducing the risk they pose to aquatic environments.

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ELABORATION OF ORGANIZATIONAL CONTROL STRUCTURES BY MONITORING PRODUCTS IN THE TEXTILE GARMENT INDUSTRY: AN EXAMPLE FOR A PAIR OF TROUSER

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Abstract: *Any activity carried out in garments business to improve quality must comply with the following principles:In order to carry out the production activity in normal parameters, it must first comply with the technical documentation elaborated, as well as the technical-material and human resources necessary for the proper functioning of the production process; In order to achieve what needs to be done, preventive measures should be taken in advance if quality products are to be obtained; The documentation and technical specifications must be complied with în order to manufacture correctly; In order to execute correctly in the same way every time, there must be a way of control, that is to discover anomalies for correction.*
In the garment industry, the situation is more difficult due to the large number of features because the products are complex and the problems that may arise must be estimated. So even for different activities regarding quality some experiments were made which proved that the human error can also occur in the measurement results. If we check the quality controllers, we notice the subjective influence of judgment on some faults resulting from the imprecision of using control means and the non-assimilation of established procedures. After analyzing the quality problems along the technological flow in terms of both the manufacturing process and the quality of the products we make, we propose personalized solutions per product type in order to prevent and solve the problems. This analysis of the control plan regarding conformity of technological processes will improve the results of a textile garment enterprise both technically and economically.

Key words: *process, conformity, quality, stages, operation, critical areas.*

1. INTRODUCTION

Garment manufacturing is a complex industry for many reasons. The product line is a complex array of styles, seasons, varying life cycles, and multidimensional sizing [1]. Many sewn product firms are viewing the total quality management as the appropriate strategy to meet the double demand of competition and quality. Product manufacturing process is always complicated, and it's more vital point for the manufacturer to keep product quality. Producing a good quality product is a result of combined efforts of management, employees and workers by developing system, implementing good practices in shop floor and setting up standards. It is a fact that a consumer may not become pleased by purchasing a defective product. It is not always a prime factor for manufacturers to gain profit by delivering defective products to consumers, so that they become more conscious of improving quality standards by implementing various quality methods in the production process.

A good quality product is the constant good practice and mutual fruitful efforts of all concern people like staffs, workers, and management. In many cases of control, judgment is essential. The controllers must be able to judge such issues in order to be able to take decisions to accept or reject these products. That is why in the garment enterprises to keep a technological process under control, both final and inter-phase control of certain quality deficiencies must be intensified. This paper focuses on the fulfillment of certain objectives in establishing certain control structures for the manufacture of products by presenting some criteria. [2]

Any activity carried out in garments business to improve quality must comply with the following principles:

- In order to carry out the production activity in normal parameters, it must first comply with the technical documentation elaborated, as well as the technical-material and human resources necessary for the proper functioning of the production process.
- In order to achieve what needs to be done, preventive measures should be taken în advance if quality products are to be obtained
- The documentation and technical specifications must be complied with in order to manufacture correctly
- In order to execute correctly in the same way every time, there must be a way of control, that is to discover anomalies for correction.

2. GENERAL INFORMATION

2.1. Specification of control standards for conformity of technological products

The purpose of control over the manufacturing stream is to achieve the desired quality through the following: preventive control, tracking, inspection to eliminate as soon as possible the nonconformities and defects. Any enterprise that wishes to set up a good control system and product surveillance on the manufacturing stream must select its quality control structure through a certain organization both structurally and functionally to allow setting up certain procedures:

a) Establishing control points and examining and nominating staff on technological lines in accordance with the complexity of the products being executed, so that there is a short-term relationship to possible disturbances that may occur during the manufacturing process.
b) Control products containing information on:
- Examination type (full batch verification, statistical survey of operations, product audit, process audit).
- Specify the means and control devices used.

c) Control procedures so that general activities of quality improvement do not influence în a bad way the production but help to raise the quality standard and increase labor productivity. These procedures provide data on:
- Operations that are required to be controlled
- Establishing the limits of acceptance of semi-finished products, depending on the place where we perform the control: on the production lines or at the end
- Establishing the procedure for products with non-conformities and defects
- Choosing the data to be recorded [3]

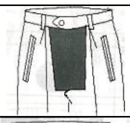
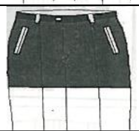
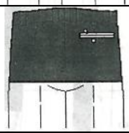
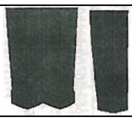
2.2.Procedure for the selection of quality examination points for operations in "critical" manufacturing areas

The following steps for selecting the critical manufacturing areas are:

a) Choosing the "critical" areas of the product that produce effects when purchasing the product by the beneficiary.

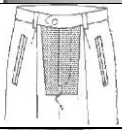
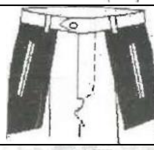
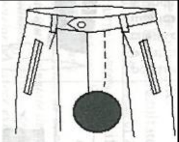
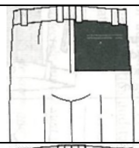
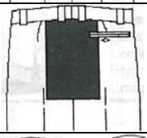
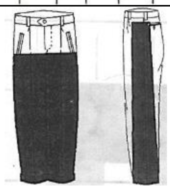
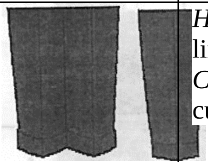
Preparing the product for launch in manufacturing with centralization operations according to already existing information in the data bank of the garment factory. Starting with the analysis of product elements, it is necessary to study distinct areas that define quality as a priority in terms of different criteria, even if at the consumer level these characteristics are rarely mentioned or even ignored. The quality level must be ensured by the manufacturer by identifying the "critical" areas of the product in the conception area, analyzing and prioritizing their qualitative level in accordance with the following aesthetic criteria, maintainability reliability, psychosensory comfort, influencing the tolerance intervals, technological documentation, technological parameters of both the equipment and the necessary devices. An example, for a pair of trousers product, critical areas (from aesthetic point of view) are seen differently in the table. 1a and b depending on the different manufacturing steps: Aesthetic implications involved in processing the product details and assembling them in a pair of trousers are found in Table 1a. [1,4]

Table 1a Audited product areas from an aesthetic point of view

Audited product area from the point of view of technological processing	**The audited product area**	Elements tracked for the area under review
Appearance of the closing system (fly)		fly line, fly spanner, decorative stitch on zipper, zipper, seating of the two sides of the fly
the aspect of front of the trousers		waistband, waistband extension, button, inner button, fly, buttonhole, hole, holes, folds, pocket on the front of the product, pocket for watch, lateral joint around the hips, stripe
aspect of back of the trousers		waistband, holes, folds, back pockets, buttons and stripe, line symmetry of the back
the aspect of the side joints (exterior and interior)		outer and inner stitching
aspect of trousers' edges		the finish line, the stitching layout
others		material faults, holes, textile scraps, tensile yarns, spots; uncut edges, lint, notations made on the product

Aesthetic implications from the point of view of the accuracy of technological processes are found in Table 1b. [1,4]

Table 1b Audited product zones from the technological processing point of view

Audited product zone from the point of view of technological processing	**The audited product zone**	**Elements tracked for the analyzed area**
waistband		the uniformity of the upper border line of the waistband; the constant width of the waistband; the accuracy of the execution of the waistband extension and the holes; correct positioning of the folds, stitches, buttons and buttonholes; symmetry of depth and positioning of the folds; the correct positioning of the sewing (hidden or visible) of the waistband back
Closing system		the uniformity of the fly line; the correctness of the key; correct application of the zipper, buttons and buttonholes; uniformity of decorative hem
Pocket on the front of the trousers		symmetrical positioning of the two cut pockets; correct positioning of counterpart on pocket bags; properly executed keys; proper pocket length; depth for pocket bags
Area of front symmetry line		the uniformity of stitching; proper stitching, without twists and strains
Pocket on the back of the trousers		corresponding positioning of the two welt pocket with constant widths; correct reinforcement of the two ends of the pockets; the correct ornamental stitch; the pocket length bag and appropriate shape
The area of the symmetry line of the back		the uniformity of stitching; appropriate aspect of stitching, without twists and strains
The outer and inner stitching area		appropriate aspect of the inner and outer stitches, even creases and strains; appropriate arrangement of decorative stitches
Edges area		*Hem end.* constant width of the reserve, uniformity of the finish line of the product, correct hidden seam *Cuff end:* correct application of the lace, constant width for the cuff, uniformity of the end, stripe
The inner areas of the trousers		the accuracy in applying the lining of the pants, the fly, waistband, the correct positioning of the emblems, the appropriate border or sewing of the reserves on the symmetryline of the back, the correctness of the waist and the uniformity of the silk band for the

		fly; on the back of the waistband
Trousers finishing		Areas, stiches, stripes

a) Definition of the critical areas of the technological process that must be kept under constant control. [5]

Following the analysis of manufacturing defects that contribute to making the product, each quality observation indicator is assigned a relative weight according to the formula.

$$F\frac{\sum_{i=1}^{n} a_i}{\sum_{i=1}^{n} n_i}\cdot 100 \qquad \textbf{(1)}$$

Where:

F - frequency of faults observation

a_i - the number of products with the same fault

n_i - the number of products rejected on that day “i”

i = 1 ÷ 5 - the number of days in which returns and faults were tracked

Following this study, we set priorities to reduce the high rejection rate, the operation or phase being a critical area of the process to be kept under priority control. Daily checkpoints were established following these procedures so as to achieve a high quality level but also eliminating as far as possible nonconformities found in the phases and manufacturing operations. Procedure - team members who verify critical operations must follow each technological line with two operations as the highest rejection frequency, and a third operation with the lowest rejection frequency. In the process are established operations where several successive parts or half-finished goods (3-4 pieces) are checked several times a day. A balance sheet can be made weekly and the operations are solved when observing the inconsistencies (in these operations, phases) within acceptable limits. [6,7]

If no reduction of these inconsistencies is observed, the “critical” operation or phase will be carried out in detail and appropriate organizational measures will be taken.

a) Creating the necessary conditions for execution and verification, especially in the technological process areas considered critical that are materialized through:
- Control patterns for certain parts that trace the shape and size;
- Information that can be represented as a graph showing the correct execution and control of the respective tasks. They may be accompanied by possible incorrect variants to ensure a partnership between operators and verifiers.

In Figure 1 is shown a sketch where we can identify the main critical areas for the pair of trousers.

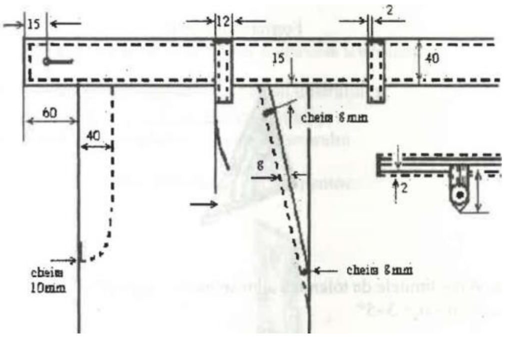


Fig.1 *The critical operation of the side pocket opening*

In order to eliminate subjectivism, there are files that contain information on the quality of operations that materialize the critical areas of the product as the main documents defining their quality. In the case of a pair of trousers, critical operations can be called slit execution, zipper application, the application of the waistband with the symmetry of the tags, the execution of the side and back pockets, etc.

2.3. Establishing specific control procedures for garment companies.

Detecting nonconformities and remedying them requires a great deal of effort on the part of the human factor and at the same time high costs even when the activity is well coordinated. In order to prevent and eliminate the deficiencies, it is necessary to properly dimension the program of quality control in the enterprises and at the same time we have to go through the following steps:

Establish an organization în charge of launching in manufacturing and tracking the technological process

a). Manage all control methods according to existing standards and appliances in the enterprise

b). Programming its own control strategy at each stage of manufacturing

c). Organization of activities, training of personnel on operations and implementation of a program for introduction into production and tracking.

d). Permanent equipment with control means and methods [7]

3. CONCLUSIONS

After analyzing the quality problems along the technological flow, both in terms of the manufacturing process and the quality of our products, we propose personalized solutions per product type in order to prevent and solve quality problems.

This analysis of the control plan of compliance with technological processes will improve the results of a textile clothing company both technically and economically.

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ANNALS OF THE UNIVERSITY OF ORADEA
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CUSTOMIZED WORK EQUIPMENT THROUGH INNOVATIVE TECHNOLOGY FOR DESIGN AND VIRTUAL SIMULATION

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Abstract: *Textile, clothing and technical products sector has an important impact on economic growth, sustainable development and employment.*
The paper presents the implementation of the innovative informational technology for design and customization of work equipment, highlighting the importance of personalizing clothing and its competitive advantages, from the idea to the prototype or product and testing it. The purpose of the research was to increase the competitiveness and quality of products obtained from the SC C&A Company Impex SRL, by the innovative informational technology for design and customization of work equipment, already validated by the National R&D Institute for Textiles and Leather - INCDTP.
By action of customization is understood individuality, customization and awareness that each wearer has different conformation and carry out specific activities. Customized work equipment involves the dimensional and conformational aspects of the body, respectively the product size as well as the quality-linked functionality criterion, aspects regarding its wearability and protection tested in accredited laboratories, the effects over the individual comfort.
The research implementation used 3D body scanning for analysis and determination of anthropometric measurements and conformation, 3D CAD technology for automatic rapid design of patterns in made to measure system, modeling and simulation of product in the virtual environment on customized mannequin highlighting the body-product correspondence. These recent technological advances lead to a restructuring of the clothing industry, increasing the capacity to efficiently and readily satisfy the requests of each customer or even to produce clothing items with increasingly more efficient services for the client.

Key words: *customization, equipment, design, virtual simulation*

1. INTRODUCTION

Textile, clothing and technical products sector has an important impact on economic growth, sustainable development and employment.

The competitive pressure of globalization is causing textile and garment manufacturers to lower production costs, increase their efficiency and to create leaner value-adding processes. To be able to cope with these changes, measures must be implemented, including the improvement of the internal organization, and the establishment of co-operations with external organizations to create a continuous supply–demand network. As a result, production logistics as well as information and communication technologies have gained importance, in order to keep job functions requiring higher qualifications within Europe [1,2].

The paper presents the implementation of the innovative informational technology for design and customization of work equipment, highlighting the importance of personalizing clothing and its competitive advantages, from the idea to the prototype or product and testing it.

The purpose of the research was to increase the competitiveness and quality of products obtained from the SC C&A Company Impex SRL, by the innovative informational technology for design and customization of work equipment, already validated by the National R&D Institute for Textiles and Leather - INCDTP.

When wearing an work equipment by users that have position, sizes and conformation which are different from the standard ones, defaults will appear between the body and the product, such as the appearance of uneven surface (pleats, folds), limiting the movement of body segments and reducing the buying demand for these products [3,4].

By action of customization is understood individuality, customization, and awareness that each wearer has different conformation and carry out specific activities [5]. The introduction and application of the innovative information technology for the design and customization of the work equipment within SC C&A Company Impex SRL represents a complex process, which includes a multitude of activities, which have as final objective the obtaining of optimal correspondence between the shape of the studied body/subject and the work equipment.

To address the objectives of the work the following steps were performed:

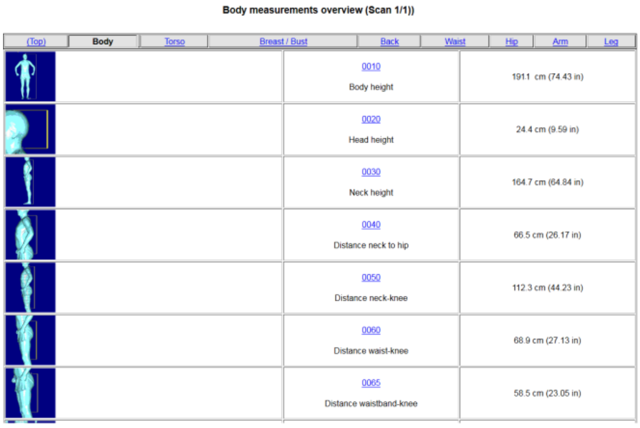
- subject selection with extreme dimensions from the database constituted by 3D scanning of adult population in the country, through the anthropometric survey conducted in 2008-2010;
- morphological analysis of the subject to identify the possibility of a body classification in the standard types, provided in the current anthropometric standard [6,7]; for the studied subject a measurement protocol has been generated, which facilitates the determination of the size of the garments and whether or not they fit into the size standards.
- analysis and selection of the model for the work equipment in the current production of the company SC C & A Company Impex SRL;
- design and development of customized pattern for the selected work equipment;
- 3D virtual simulation of body-garment system, for the studied work equipment;
- analysis of the tensions map and gathering the necessary information in patterns remodeling, in order to adapt them to the shape and body dimensions of the subject;
- completion of design that provides the best body-product correspondence.
- realization of the real prototype and its real fitting;
- evaluation of the body-product correspondence, in a static and dynamic regime and correspondence of the product with the functions it has to fulfill;

2. MORPHOLOGICAL ANALYSIS OF THE STUDIED SUBJECT

The studied subject was scanned using the body scanner 3D VITUS XXL and the measurement protocol and virtual body or parameterized virtual mannequin (Figure 1) were generated, which were the basis for designing the personalized patterns in Made-to-Measure system. The selected subject has the following main body dimensions extracted from the measurement protocol:

- **Body height (Ic) 191.1 cm;**
- **Bust circumference (Pb) 104.2 cm;**
- **Waist circumference (Pt) 85.9 cm;**

- **Hip circumference (Ps) 108.5 cm.**



Body measurements overview (Scan 1/1))

(Top) | Body | Torso | Breast / Bust | Back | Waist | Hip | Arm | Leg

	0010 Body height	191.1 cm (74.43 in)
	0020 Head height	24.4 cm (9.59 in)
	0030 Neck height	164.7 cm (64.84 in)
	0040 Distance neck to hip	66.5 cm (26.17 in)
	0050 Distance neck-knee	112.3 cm (44.23 in)
	0060 Distance waist-knee	68.9 cm (27.13 in)
	0065 Distance waistband-knee	58.5 cm (23.05 in)

Fig. 1: *Measurement protocol resulted from the 3D body scanning*

According to the data presented in Table 1 (extracted from the anthropometric standard), it can be noticed that the body height is outside the standard SR 13544 - Clothing. Men's Body Measurement and Garment Sizes. In this standard, the maximum height of the body is 190.9 cm.

Tabel l: *Limits of interdimensional intervals for body height*

Standardized value (cm)	**Interdimensional interval** (cm)
188	185-190,9

3. DESIGN AND DEVELOPMENT OF CUSTOMISED PATTERN FOR THE SELECTED WORK EQUIPMENT

In the study, the model of work equipment was analyzed and selected, which was then customized by the innovative informational technology for design. We opted for the Antistatic and flame-retardant costume, produced by the company SC C&A Company Impex SRL.

The costume is intended to be used as a reusable work equipment against cold (for temperatures > -50°C when worn with adequate winter under-clothing), which provides limited protection for the body against occasional short-term contact with open flame or sparking, convection heat, radiation and contact heat, work carried out near low heat sources (low level risk, exposure to heat and/or fire) and medium intensity superficial mechanical aggression (abrasion, hanging).

The suit is made of jacket and trouser. The jacket has a high collar and two chest pockets. In front, the jacket closes with plastic zipper and velcro tape, covered with feint. The jacket has long sleeves that are fitted with elasticated cuffs. The trousers are fitted with a button-shaped slit, adjustable waist, and the lower part of the trousers is edged and does not have a cuff.

The stained and flame-resistant costume was made of:

• outer layer: 87% antistatic and flame retardant fabric, 12% polyester and 1% carbon fiber, 260 g/m^2;

• thermal insulating layer with a mass of about 250g/m^2;

• lining: flame retardant fabric, 100% cotton antistatic, with a mass of about 170 g/m^2.

Physical-mechanical and physico-chemical characteristics of the fabric were determined in the accredited laboratories of INCDTP. The elaborated test reports were used in textile material characterization in the 3D simulation.

The design of customized patterns for the selected work equipment was based on the geometric method of pattern construction using Gemini Pattern Editor, the Made-to-Measure module. In this module, basic patterns are created for each type of clothing item, which are then modified by specific algorithms, depending on the model of the selected work equipment and the body dimensions taken from the measurement protocol provided by the 3D body scanner (Figure 2). The patterns will be used to support the development of personalized work equipment for atypical conformations and sizes outside the size standard.

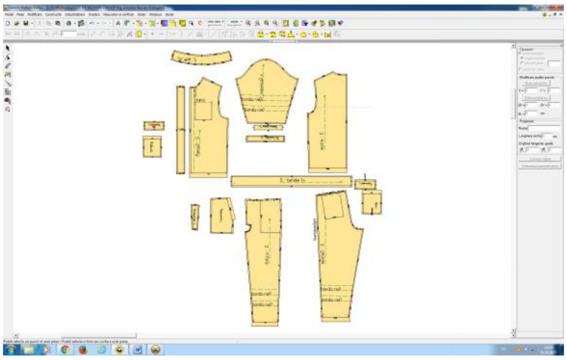


Fig. 2: *The design of customized patterns of antistatic and flame-proof costume, in Gemini Pattern Editor*

4. 3D VIRTUAL SIMULATION AND TRY-ON

Using Optitex PDS software for visualization, simulation and fitting of the prototype, the customized patterns correspondence was tested, by 2D/3D patterns modeling and simulation of the work equipment on the virtual body or the parametric mannequin.

Transforming patterns designed with the Gemini Pattern Editor into Optitex PDS from 2D to 3D, to obtain the virtual prototype of customized work equipment was done in the following sequence [8]:

• Importing the virtual body resulting from scanning or parameterizing a virtual mannequin according to the anthropometric dimensions resulting from scanning;

• shaping the surface of the patterns to obtain the 3D shape of the product with the addition of sewing lines and guide points;

• introduction of information about the materials from which the work equipment is made (fibrous composition, drape, shrinkage, mass, etc.) (Figure 3);

• virtual try-on of the product on the virtual mannequin (Figure 4);

• checking and modifying the pattern to ensure body-product correspondence.

In order to check the body-product correspondence, the software has a function that renders the degree of ease/adjustment of the product on the body, called the Tension Map (Figure 4). Thus, it can be seen that the jacket product corresponds dimensionally. Also, the trouser match fits on the waist line and is slightly wide on the hips line and at the end. The degree of ease indicated by the simulation software is justified by the jacket and trouser patterns that have a semi-rigid figure on the body. With this information, the pattern designer could return to 2D patterns by making the necessary corrections.

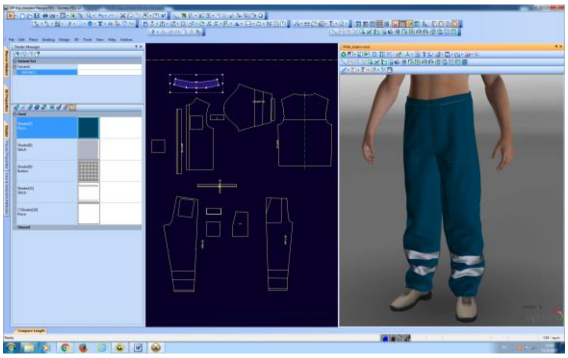


Fig. 3: *The 2D patterns of the customized work equipment, with seam lines and required characteristics of the textile material*

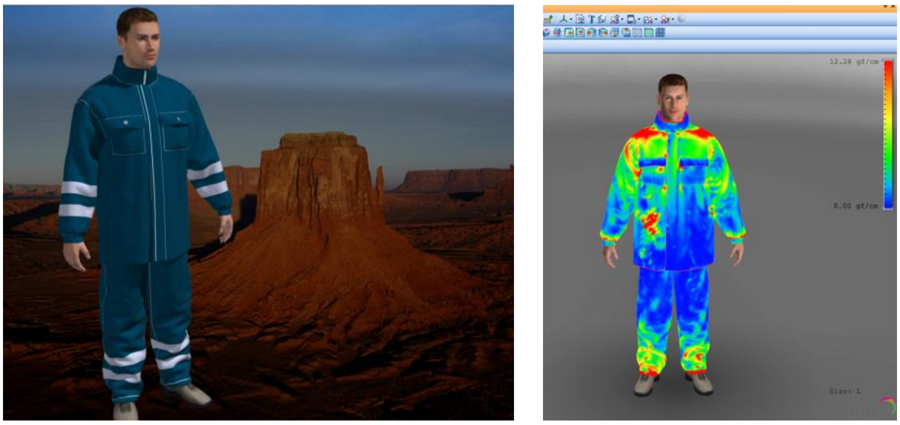


Fig. 4: *Virtual try-on and verification of the customized work equipment*

The real prototype of the customized work equipment was tested on the real body of the subject. After the test, it was found that the outfit corresponded dimensionally, without forming unsightly creases or folds and without creating discomfort in wearing.

5. CONCLUSIONS

The research implementation used 3D body scanning for analysis and determination of anthropometric measurements and conformation, 3D CAD technology for automatic rapid design of patterns in made to measure system, modeling and simulation of product in the virtual environment on customized mannequin highlighting the body-product correspondence. These recent technological advances lead to a restructuring of the clothing industry, increasing the capacity to efficiently and readily satisfy the requests of each customer or even to produce clothing items with increasingly more efficient services for the client.

The research, through its objectives, introduced the concept of personalized work equipment within the beneficiary SME, applying the latest information in the field of informational technology in the textile-clothing sector.

The innovative aspect is conferred by the expansion of the work equipment in an individual / personalized system, but using the industrial production facilities.

As a result of the analysis and evaluation of the work equipment, achieved through the application of innovative informational technology for design and simulation, it can be concluded that it presents a good body-product correspondence, both in the virtual environment and in the real body test.

The implementation of the innovative technology encouraged the SME to invest in the R&D activity by producing and launching on the market innovative products, namely the personalized work equipment and checked on the virtual mannequin, produced of textile materials tested by various physico-mechanical and physic-chemical analyses in accredited laboratories of INCDTP.

At the same time, it has tended to align with the trends on the European textiles and clothing market, by capitalizing on the existing technical and scientific competencies within the INCDTP in the productive sector and assisting the SMEs in the development, modernization and application of new technologies and advanced production methods.

ACKNOWLEDGEMENTS

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BIOTREATMENT OPTIMIZATION FOR A CELLULOSIC/LIGNOCELLULOSIC BLENDED FABRIC

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Abstract: *The paper presents a study on the optimization of the bioscouring treatment of 60 % of cotton + 40 % of flax blended material by using a commercial enzymatic product called Beisol PRO, Denimcol Wash RGN (detergent) from Bezema Company, Switzerland and sodium citrate (complexing agent) from Sigma Aldrich.*
The bioscouring treatment is imposed by the specific natural structure of the fabrics. Both cotton and flax have different organic and mineral compounds which need to be removed during the specific pretreatments applied in textile industry. In this case was chosen an alternative of the classic alkaline treatment. The alternatives propose is an eco-friendly one due to the fact that the temperature use is lower comparative with the classical one (55 °C, respect to 90 °C) and the waste waters pH is in the neutral range.
For treatment optimization, a mathematical model of the 2nd order was created by a central, rotatable second order compound program with two independent variables: enzyme concentration and treatment time. Based on the values obtained for the weight loss of the treated samples, the mathematical model obtained was analyzed from the technological and graphic point of view, and the optimum parameters for the bioscouring treatment with commercial product Beisol PRO have been set. The best results were obtained in case of 2.1% of enzymatic product and 39 min. of exposure.

Key words: *cotton/flax material, commercial enzyme, biotreatment optimization, weight loss*

1. INTRODUCTION

Cotton and flax fibers contain different percentages of morphological attendants (pectin, hemicellulose, extractable substances, waxes, etc.), which have to be removed through classical or enzymatic methods so that the material becomes hydrophilic [1]. For the enzymatic treatment, a mixture of different types of pectinases could be experienced. By using those in textile chemical finishing is increased the pectin degradation by hydrolysis and demethylation. Those reactions lead to the enlargement of the contact surface as well as to the increas of the molecular diffusion rate [2].

The intensification of the finishing processes of textile under enzyme's action leads to time chemicals reduction. The bioscoring has also implications in different related sectors. For example, the enzyme synthesis could be done using low-cost raw materials (different waste products), the chemical, energy and waster consumption is lower. The treatment is safer for the personal and has an eco-friendly charactheristic [3]. From technical poit of view during the enzymatic treatment the fibres are less damaged and the strength is higer compared with the alkaline treatment. The fibers structural changes occurred during the classical treatment influence the dyes bounding process, causing the decrease of the molecules chemical linked to the fabrics.

2. EXPERIMENTAL PART

For bioscouring treatments were used woven fabric samples of *60 % of Cotton/40 % of Flax* with width 120 ± 3 cm and weight 220 ± 10 g/m^2. The treatments conditions were: 1-3 % (o.w.f. – over weight fiber), enzymatic commercial product Beisol PRO; 2 g/L sodium citrate - complexing agent and 0.5 % Denimcol Wash RGN – surfactant in 0.1 molar sodium phosphate/disodium phosphate of pH 8 buffer solution. The treatments were done in an Elmasonic X-tra basic 2500 bath from Elma Company, Germany at 1:20 fabric to liquid ratio, temperature of 55 ^{0}C and 15 to 55 min. as treatment time [4]. Before and after bioscouring, the samples were prepared as described in [5]. The mass loss was determined by using gravimetric method and calculated using the Eq. 1: [6].

$$\% \text{ mass loss} = (W1-W2) \times 100/W1 \quad \textbf{(1)}$$

After a series of preliminary determinations to achieve a minimum number of experiments a central, rotatable second order compound program based on a matrix with 13 experiments and two independent variables was used [7]. The variation limits and the experimental plan are presented in Table 1 and Table 2.

Table 1: *The variation limits of independent variables*

Code value / Real value	-1.414	-1	0	1	+1.414
x - enzyme concentration [% o.w.f.]	1.0	1.3	2.0	2.7	3.0
y - time [minutes]	15	21	35	49	55

Table 2: *The experimental plan with two independent variables*

Exp.no.	x	y	Exp.no.	x	y	Exp.no.	x	y
1.	-1	-1	6.	1.414	0	11.	0	0
2.	1	-1	7.	0	-1.414	12.	0	0
3.	-1	1	8.	0	1.414	13.	0	0
4.	1	1	9.	0	0			
5.	-1.414	0	10.	0	0			

3. RESULTS AND DISCUSSIONS

Experimental matrix and the measured values of the response function Y are presented in Table 3.

3.1 Mathematical model interpretation obtained

In order to assess more accurately the influence of enzyme concentration and treatment time on the mass loss, a mathematical modeling of the process was made using a central compound rotatable program with two independent variables: *x* - concentration of enzyme (1-3 % o.w.f.) and *y*

– treatment time (15 - 55 minutes). As a goal-function, the mass loss (%) denoted by Y was chosen. The program has the following mathematical expression:

$$Y = b_0x_0 + b_1x_1 + b_2x_2 + b_{12}x_1x_2 + b_{11}x_1^2 + b_{22}x_2^2 \quad \textbf{(2)}$$

For the experimental data a program in MathCAD professional and Excel was used, and a regression equation was obtained [7]. The regression equation and coefficients are presented in Table 4. The regression equations obtained after eliminating insignificant coefficients are given by Eq. 3:

$$Y= F(x.y) = 1.758 + (0.106)x +(0.218)y +(-0.348)x^2 + (-0.398)y^2 + (0.000)xy \quad \textbf{(3)}$$

***Table 3**: Experimental matrix and the measured values y of the response function*

Exp. no.	Independent variables				Answers
	x		*y*		*Y*
	x (cod.)	*x* (real) Enzyme (% o.w.f.)	*y* (cod.)	*y* (real) Time, min.	*Y = f(x,y)* Mass loss, %
1.	-1	1.30	-1	21.00	0.89
2.	1	2.70	-1	21.00	0.85
3.	-1	1.30	1	49.00	0.83
4.	1	2.70	1	49.00	0.76
5.	-1.414	1.00	0	35.00	0.90
6.	1.414	3.00	0	35.00	1.58
7.	0	2.00	-1.414	15.00	0.47
8.	0	2.00	1.414	55.00	1.81
9.	0	2.00	0	35.00	2.03
10.	0	2.00	0	35.00	1.91
11.	0	2.00	0	35.00	1.44
12.	0	2.00	0	35.00	1.75
13.	0	2.00	0	35.00	1.66

The significance of the regression equation coefficients was tested using Student test. This test compares the average of a random variable with the average standard deviation. For the center of the program, where all independent variables have the value of zero, the dispersion "s" is calculated. Test values, the degree of coefficients significance and dispersion value are shown in Table 4.

***Table 4**: Regression equations coefficients, the dispersion and the verification of the regression equation coefficients significance using the Student test*

Regression equation coefficients		Calculated dispersion "S"	Verification of the coefficients significance using Student test $t_T=t_{\alpha,\nu} = t_{0,05;6} = 2.132$ (If $t_c>t_t$-term is significant)		
b0	1.758288	S= 0.401712	tc0	169.1637	Significant
b1	0.10644		tc1	16.38484	Significant
b2	0.218095		tc2	33.57245	Significant
b11	-0.34779		tc11	-46.5374	Significant
b22	-0.39781		tc22	-53.2312	Significant
b12	-0.0075		tc12	-0.57726	Insignificant

Verification of model adequacy and percentage deviations was done using the Fisher test. The values obtained are shown in Table 5. The degree of mathematical model's consistency was verified using F'c statistics. Initially, the mean square of residuals "PMrez" and the dispersion of reproducibility $S0^2$ were calculated. The Ratio Fc = PMrez/$S0^2$ was compared to the critical value $F'_c = F_{v1,\ v2,\ \alpha} = F_{5;5;0.01}$= 6.59. The Fisher-Snedecor test was used to check for the deviation of the survey data from the mean value. The calculated value Fc = 16.00524 is greater than the critical table value $F_c = F_{\alpha\ ,\ v1,\ v2} = F_{0.05;\ 12.4}$ = 5.91 indicating that deviations are due to experimental errors. The quality of the approximation of the mathematical model expressed by the standard error shows the scattering of the experimental values around the regression equation being 40.17 %. The correlation coefficients are: rx1x2 = -0.00406, rx1y = 0.1778164 and rx2z = 0.3639383. The significance of the simple correlation coefficients was verified using the Student test. The calculated values are: tc x1y = 0.602782, tc x2y = 1.3060111, tc x1x2 = -0.0134759. The calculated value t_{x1x2} = -0.0134759 is smaller than the critical table value $t_{\alpha,\ v}=t_{0.05;\ 11}$ = 2.201 for t_{x1y} and t_{x2y} which indicates that there is a correlation between the independent variables. The multiplying factors of 0.660489 shows that the influence of the two independent variables on the result is 66.04%, the rest being due to other factors. The obtained models can be geometrically viewed as hyper surfaces in the three-dimensional space of the independent variables. The extreme points of the hyper surfaces and their exact location or at least knowledge of the shape of the surface in the area adjacent to the extreme are searched. These surfaces can be cut by planes of type y = ct resulting the response contours. The interpretation of the answer and the search for the extreme are more difficult, and it is preferable to bring the surface into a more accessible form of analysis by canonical transformation. Moving to the canonical form of the regression equation, the new center of the axes has the coordinates: x = 0.152, y = 0.274 and the value of the dependent variable in the center of the response surface is: y_c = 1.796. By calculating the coefficients of the canonical form, equation 4 was obtained:

$$y = 1.796 - 0.398\ z_1^2 - 0.348\ z_2^2 \quad \textbf{(4)}$$

Table 5: *Adequacy of the calculation model*

No	Y2 meas	Y2 calc.	(Y2meas. – Y2calc.)^2	Deviation "A"	Average square of residuals "PMrez"	Dispersion of reproduce bility "$S0^2$"	Ratio Fc = PMrez/$S0^2$	Statistics Fc<F'c $F'_c = F_{v1,\ v2,\ \alpha} = F_{5;5;0.01}$= 6.59	Fisher test Fc>Ft $Ft=F_{v1,\ v2,\ \alpha} = F_{12;12;\ 0.05}$ =2.69
1.	0.89	0.6806	0,04382	23.5221	0.23043	0.0519	4.433	Fc= 4.433952 <6.59 Appropri-ate model	Fc= 2.945414 >2.69 Appropri- ate model
2.	0.85	0.9085	0.00342	-6.8862					
3.	0.83	1.1318	0.09110	-36.366					
4.	0.76	1.3297	0.32458	-74.963					
5.	0.90	0.9124	0.00015	-1.3796					
6.	1.58	1.2134	0.13437	23.2006					
7.	0.47	0.6545	0.03404	-39.258					
8.	1.81	1.2712	0.29020	29.7629					
9.	2.03	1.7582	0.07382	13.3848					
10.	1.91	1.7582	0.02301	7.9430					
11.	1.44	1.7582	0.10130	-22.103					
12.	1.75	1.7582	6.86E-05	-0.4735					
13.	1.66	1.7582	0.00966	-5.9209					

Fig. 1 presents the plot which shows the dependence of the goal-function on the two independent variables (x and y). The response surfaces of the regression equations is an elliptical paraboloid, the coefficients of the canonical equation having the same sign. The negative sign corresponds to a maximum in the center of the surface.

In **Fig. 2** are presented the contour curves for various mass loss values ranging from 0.47 to 2.03. On the response surface from **Fig. 2**, which is of the elliptical type, we can observe a stationary point of coordinates x = 0.152 and y = 0.274. These coded coordinates correspond to an enzyme concentration of 2.1% and a treatment time of 39 minutes. The value of the goal function at this point is Y = 1.796.

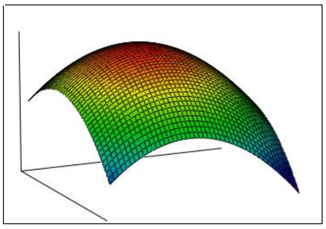

Fig.1: *The dependence of the function Y = f (x, y) on the two independent variables x and y*

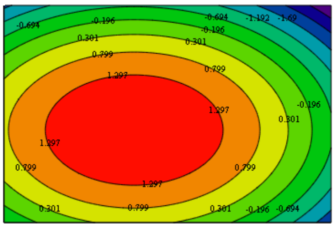

Fig. 2: *Contour curves for various values of Y = f (x, y)*

3.2 The technological interpretation of the mathematical model obtained

From the goal function expression analysis:

$$Y= F(x.y) \quad = 1.758 + (0.106)x +(0.218)y +(-0.348)x^2 + (-0.398)y^2 + (0.000)xy \qquad \textbf{(5)}$$

the following were found:

- the influence of the two independent parameters x and y on the dependent variable Y is manifested in the same way. Both the variables directly affect the resultant Y: the increase of x and y leads to the Y increase; the influence of variable x on Y is 5 % and of 12 %; the existence of the square shape for both parameters indicates that the response surface, defined by the obtained mathematical model, is well formed, reinforcing the hypothesis regarding the influence of the two parameters on the resultant; the ratio between the coefficients of the quadratic terms and the free term quantifies the variation velocity of Y by variation of x is influenced by 19 % and the variable y influences by 22 %.

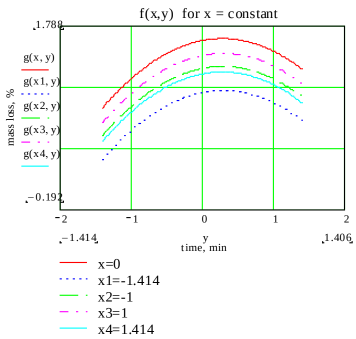

Fig. 3: *The dependence of the function Y = f (x, y) on all significant values of y, for x = const.*

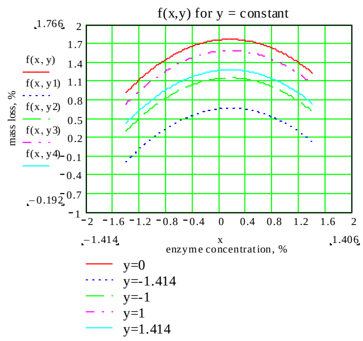

Fig.4: *The dependence of the function Y = f (x, y) on all significant values of x for y = const.*

Fig. 3 presents the dependence of the goal function by one of the two independent variables for all values of the parameters, while the second is constant. For x constant the graph of weight loss variation over time for the interval [-1.414, 0.274] (15-39 min.) indicates an increase in mass loss with maximum at 39 min. which shows a great influence of this parameter. For [0.274 +1.414] interval (39-55 minutes) by increasing time, the mass loss decreases.

Fig. 4 shows the dependence of the goal function by one of the two independent variables for all significant values of the parameters, while the second one is constant. From the graph analysis it can be seen how the enzyme concentration influences the mass loss, and how the curves have the same allure. For the [-1.414, 0.152] interval the mass loss increases with the increasing of enzyme concentration and for the [0.152 + 1.414] interval the mass loss decreases with the increasing of enzyme concentration. From a technological point of view, an experiment with small values for y variable (15-39 minutes) shows an increase in mass loss with the increasing enzyme concentration while for high values of y (39 - 55 minutes) there is a decrease in mass loss with the increasing enzyme concentration.

4. CONCLUSION

The treatment time, temperature and enzyme concentration are reduced with the improvement of the energy balance and costs obtaining textile fabrics with superior qualitative indices. The influence of enzyme concentration and treatment time on the mass loss of bioscoured material was well studied. By analyzing technologically and graphically the mathematical model, the optimal working parameters were determined: enzyme concentration - 2.1 % and treatment time - 39 minutes.

ACKNOWLEDGEMENTS

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MECHANICAL PROPERTIES OF RECYCLED COTTON NONWOVEN USING CHITOSAN AND ACRYLIC RESIN AS A BINDER

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Abstract: *Nowadays, people are concerned with the use of natural products and the environment problems that some waste and chemicals products can cause. For this reason many researchers are developing new products or manufactures which use recycled materials in order to reuse waste and studying the possibility of replacing resins or synthetic materials with natural and biodegradable materials. The textile sector is making a big effort in order to carry out changes that improve the care of the enriroment.*
The aim of this work is the use of recycled fibres to produce nonwovens. To achieve the binding of the fibers a synthetic, acrylic resin, and natural resin, chitosan, are used. Chitosan is the N-deacetylated derivative of chitin. Chitin is the most abundant natural amino polysaccharide and is estimated to be produced annually almost as much as cellulose. It has become of great interest not only as an underutilized resource, but also as a new functional material of high potential in various fields due to its antimicrobial properties.
To study the behavior of nonwovens obtained using different binders and the possibility of using chitosan as a binder to produce nonwoven fabrics, flexural rigidity and tensile tests are carried out.

Key words: *strength, reused fibers, fabric, natural polymer.*

1. INTRODUCTION

Nowadays, there is a clear concern to stop the environmental deterioration, which is reflected in the increase of proposals that through their development allow to create a conciseness and humanization with the preservation of the natural environment. This has opened the possibilities of developing products that, based on fomenting this ideology under mercantile criteria, when purchased, used and discarded, decrease the impact on the diversity of ecosystems.

The present work focuses on the development of nonwovens of recycled cotton fibers using as a binder two types of resins, a biodegradable resin, chitosan, and a synthetic one, acrylic. The influence of using different binders of different nature is analyzed by comparing the characteristics of each of the nonwovens obtained. For this, the flexural rigidity, the tensile strength and the elongation percentage are analyzed.

Chitosan is a natural polymer, whose chemical structure is composed of a poly [β- (1-4) -2-amio-2-deoxy-D-glucopyranose] bond, obtained from the chitin alkaline deacetylation, a substance extracted from crustaceans and molluscs exoskeleton. Its molecular weight depends on the conditions in which the deacetylation takes place, but it is usually greater than 100kD [1].

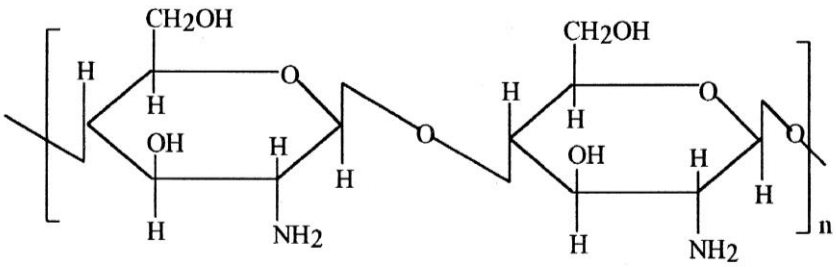

Fig. 1: *Chitosan chemical structure [2]*

Coming from a natural waste, quitosan is biodegradable and biocompatible, it also has antimicrobial properties, an aspect that has positioned it as a substance of great interest in various sectors, such as textile, because when applied it transfers this functionality being anti-allergenic and preventing infectious diseases [3].

Different applications of chitosan in fabrics are studied, for example W. Lox et al. [4] studied the improvement of the traction resistance in cotton fabrics treated with chitosan by padding system. This biopolymer is wide used as biomordant in dyeing process using natural dyes, due to textile fibers do not show any affinity to natural dyes, like Eisenia Bicyclis extraction [5]. K. Kaliyamoorthi et al. decribed a new method of union dyeing cotton and nylon fabric using chitosan nanoparticles and acid dyes, the results showed that the cotton/nylon sample treated with 0.3% of chitosan nanoparticles had higher K/S values, washing, and crocking fastness. Also observed, dyed fabric had antibacterial potential due to the antibacterial property of chitosan [6].

The objective of this study is to develop a nonwoven from recycled cotton fibers and chitosan, and on the other hand to use acrylic resin as binders, to study its influence on the behavior of the material, considering that cotton is composed of a 83% cellulose and that it is possible to increase the mechanical properties of the resulting samples [7].

2. EXPERIMENTAL

This section presents the characteristics of the textile fiber used and the resins applied as a binder, as well as the different methods and tests carried out to determine the behavior of the resulting nonwovens.

2.1 Materials

As it is mentioned previously, the fiber used for the constitution of nonwovens is 100% recycled cotton. The fibers from which the substrates were formed are shown in figure 2, it can be seen that in addition to fibers, contains a certain number of yarn.

As binders, medium molecular weight chitosan supplied by Aldrich and STK-100 acrylic resin supplied by Color-Center, S.A. were used.

Fig. 2: *100% recycled cotton fibers and yarns.*

2.2 Methods

Regenerated fibers characterization

To determine the fiber length and weight, the Duble Sorter tester (Suntex Weeb Duplex) is used, examining 75 mg. of matter, analyzing it by length interval.

Recycled cotton nonwoven

In this section the non-woven formation process is described, it is sprayied a solution of 80 g/L of both chitosan and Center STK / 100 acrylic resin, using 5 gr. of fiber as base material of each nonwoven.

The fiber web is placed in an area of 20x10cm and 40g / L of binder is sprayed and distributed by pressure along the surface of the sample. It is is subjected to drying at 100 ° C for a period of 20 minutes. Subsequently, the remaining 40 g/L of resin is sprayed on the obverse. This process applies to both binders separately.

The following image shows examples of the nonwovens obtained by each binder:

Fig. 3: *Nonwovens obtained according to the type of binder*

Nonwovens characterization

To determine the flexural stiffness of both types of binder, it is carried out a test following UNE 40-392-79 standard, which refers to the process to determine the degree of rigidity that a fabric presents.

The process to know the tensile strength of nonwovens is carried out by the Zwick / Roell Z005 dynamometer under the UNE-EN ISO 9073-18: 2008 standard, which specifies a procedure to determine the strength and the percentage of elongation to breakage of non-woven materials by the grip tensile test.

For both tests, the guidelines described in the mentioned standards were followed, except for the dimensions of the specimens (50 mm x Y mm) that had to be adapted to those of the equipment with which the non-wovens were obtained.

3. RESULTS

3.1 Regenerated fibers characterization

As a result of the regenerated cotton fibers characterization, the results are presented according to the fiber length interval in table 1.

Table 1: *Fiber length and weight per interval*

LENGTH INTERVAL OF FIBER			NUMBER OF FIBERS FOR EACH LENGTH INTERVAL	% FIBERS FOR EACH LENGTH INTERVAL
46,10	-	39,75	7	0,11
39,75	-	33,40	44	0,66
33,40	-	27,05	159	2,40
27,05	-	20,70	452	6,84
20,70	-	14,35	942	14,24
14,35	-	8,00	2.157	32,63
8,00	-	0,00	2.850	43,12
			6.610	**100,0**

The properties of the fiber are determined from the analysis of the results shown in Table 1, also integrating a disintegration test to know the amount of fiber and yarn contained in 100 mg of matter:

Table 2: *100% recycled cotton fiber length properties*

Composition	EL (mm)	Average (mm)	MODA (mm)	% Short fiber	% Yarn
100% CO	25,26	15,52	4	79	46,20%

As can be seen in table 2, the percentage of short fiber is 79% with an average length of 15,52 mm and a major dimension of 4 mm, considering that for every 100 mg of fiber, an average of 46,20% of yarn was obtained.

3.2 Nonwovens characterization

In order to evaluate and compare the composition and properties of each of the resulting nonwovens, the flexural rigidity, tensile strength and percentage of elongation are analyzed according to the specified standard.

As a result of the flexural rigidity test, the different behavior of the samples tested is notorious, since those in which the chitosan was applied have a high rigidity that it has not been possible to test, contrary to those that were made by integrating the acrylic resin, as shown in the following figure:

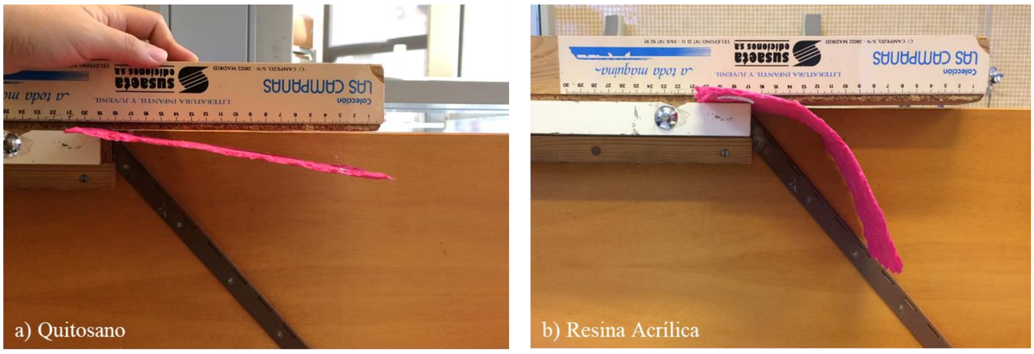

Fig. 4: *Flexural rigidity comparation by binder*

To obtain the tensile strength and percentage of elongation of each of the samples, they are subjected to the test with the dynamometer and the following results are obtained:

Table 3: *Tensile strength by binder*

	Type of binder	Tensile strength FH (N)	% Elongation εH%
100% recycled cotton	Chitosan	68,66	0,76
	Acrylic resin	13,0475	10,0575

As it is seen in Table 3, the samples to which chitosan was applied have a high tensile strength but low percentage of elongation, breaking in shear in some cases. On the other hand, those that contain acrylic resin, have low resistance but a considerable percentage of elongation.

4. CONCLUSIONS

With the present study it has been possible to develop an analysis on the influence of chitosan and acrylic resin in a nonwoven made of 100% recycled cotton. The first binder generates a biodegradable and antimicrobial nonwoven with high flexural rigidity and high mechanical strength but does not have elongation properties, while the synthetic resin provides a high index of flexion and good elongation, however, the resistance does not provide good tensile properties.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

BAGGING BEHAVIOUR OF EXTENSIBILE SHIRT FABRICS

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Abstract: *Fabric bagging is a type of three dimensional permanent deformations of garments that occurs at positions such as elbow and knee. When a prolonged compression force is exerted on a garment during wear, the three dimensional deformation may involve complex inelastic behaviour in the garment, including viscoelastic behaviour of the fibers and plastic behaviour due to frictional movements between fibers and between yarns in the fabric.*
The aim of this stduy is to engineer extensibilty values of shirt fabrics along weft direction and hence to analyze and interpret the bagging behavior of extensible shirt fabrics in terms of fabric mechanical preoperties.
In this study, finished extensible plain woven shirt fabrics with changing the core-spun extensible yarn layout along weft direction were produced. The bagging behavior of samples tested at a speed of 7 (mm/min) and initial bagging height 7(mm) in 5 successive cycles using an Instron tensile tester equipped with 4 circular clamps in 56, 61, 66 and 71 (mm) diameter. The results were then statistically analysed using ANOVA test method.
The statistical analysis results show that fabric extensibility along weft direction and sample diameter has a statistical significant effect on bagging behaviour of extensible shirt fabrics. It is indicated with the increase in fabric extensibility and sample diameter the bagging parameters are significantly decreased.

Key words: *Sample diameter, Fabric bagging, Weft extensibility. Garment deformation.*

1. INTRODUCTION

Fabric bagging is a type of three dimensional permanent deformations of garments that occurs at positions such as elbow and knee [1] and it is often being considered as an aesthetically undesirable deformation. It has been assumed that when a prolonged compression force is exerted on a garment during wear, the three dimensional deformation may involve complex inelastic behaviour in the garment, including viscoelastic behaviour of the fibers and plastic behaviour due to frictional movements between fibers and between yarns in the fabric [1,2].

The subject of bagging has been studied by many researchers both theoretically and experimentally [1-10] in which a comprehensive survey of this subject are given elsewheres [2,8,9]. Besides of the fabric aesthetic properties, the clothing comfort during usage of the apparel is also important. Woven fabrics containing elastane yarns, due to their enhanced elastic properties such as increased extensibility, elasticity, high degree of recovery, and good dimensional stability, have wide applications in which the comfort properties in wear are of the main concern. In recent years, in order to reduce permanent bagging deformation in different parts of the body; extensible and high elastic recovery fabrics have been introduced. There are little studies however on bagging behavior of extensible fabrics. In particular, Ozdil [6] investigated the bagging behavioiur of denim fabrics containing different rates of elastane along weft direction using a bagging tester based on the artificial arm with an elbow joint. The results showed that with an increase of elstane content in the fabric, permanet bagging decreases, whereas elastic bagging increases. The aim of the current study is to engineer extensibilty values of shirt fabrics along weft direction and hence to analyze the bagging behavior of extensible shirt fabrics tested with a previously developed method by the author [5,7,8].

2. MATERIAL

In this work, 4 extensible finished woven cotton shirt fabrics (plain weave design, weft density 27 cm^{-1} and warp density 47 cm^{-1}), with changing the extensible yarn layout along weft direction were prepared [10] as shown in Figure 1. Warp yarn was cotton ring-spun yarn (15 tex). Two different weft yarns namely normal cotton ring-spun yarn and elastic core-spun cotton yarn with the same linear density of 20 tex were used. Fabric thickness and weight were measured as 0.28 (mm) and 124 (g/m^2) respectively. To quantify fabric elasticity, a similar factor to FAST index [11] (E100), here named as fabric extensibility, was defined as the fabric extension at the load of 100 (N/m) in the weft direction.

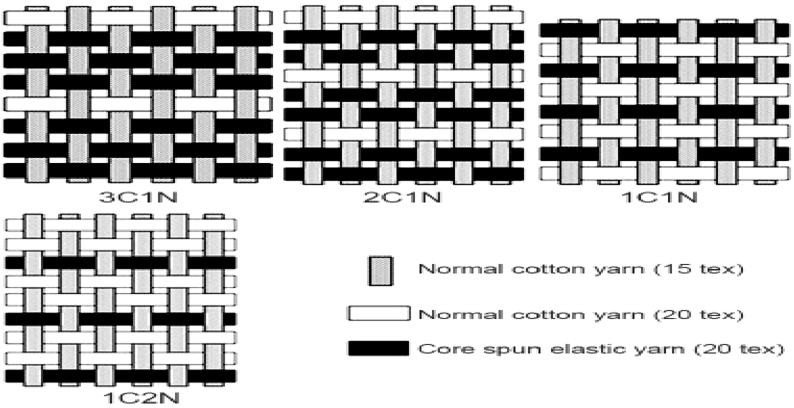

***Fig. 1**: Schematic views of woven fabric structures[10].*

3. FABRIC BAGGING TESTING

Bagging test is performed on an Instron 5566 tensile tester (Figure 2) using a previously developed method by the author [5,7,8]. A steel ball (sphere) with a diameter of 48 mm is attached to the upper jaw of tensile tester. The fabric samples with diameter of 61, 68, 71, and 78 mm respectively is placed in a corresponding circular ring with inner diameter of 56, 61, 66, and 71 mm. The crosshead speed and the bagging height were set at 7 mm/min and 7 mm values respectively. All tests were initiated under a preload of 0.1 (N) pressure force and for each fabric sample, the cyclic loading was performed 5 times and 5 tests were investigated. The maximum load and corresponding work of loads and hysteresis percentage at the first and last cycles are calculated, and then residual bagging height, bagging fatigue, bagging resistance, bagging hysteresis, and residual bagging hysteresis are calculated [3,7]. All experiments were carried out under the standard conditions. The results were statistically analysed by ANOVA test method.

Fig. 2: *A photograph of the fabric bagging tester.*

4. RESULTS AND DISCUSSION

ANOVA Statistical analysis results for bagging parameters are briefly summarized in Table 1. The statistical analysis results indicate that both fabric extensibility and sample diameter significantly influenced the fabric bagging properties.

Table 1: *ANOVA statistical analysis results for bagging parameters (P- value= 0.05).*

Parameters	Weft extensibility	Sample diameter	Weft extensibility*Sample diameter
Bagging force at the first cycle loading	0.00	0.00	0.00
Bagging force at the 5th cycle loading	0.00	0.00	0.00
Bagging resistance	0.00	0.00	0.00
Residual bagging height	0.00	0.00	0.00
Bagging hysteresis	0.00	0.00	0.00
Residual bagging hysteresis	0.00	0.00	0.00
Bagging fatigue	0.00	0.00	0.00

Typical results are depicetd in Figures 3 and 4. It is shown that with increase of fabric extensibility residual bagging height and bagging fatigue decrease. Similar trend results are obtained for other bagging parameters particularly bagging resistance and maximum bagging load. As shown in 'Figure 3', fabric with lower extensibility value, exhibits higher residual bagging height value. In fabric with higher bagging force, recovery to the initial state is lower hence residual bagging height is high. As also depicted in 'Figure 3', with increasing fabric sample diameter, the residual bagging height is significantly decreased. Sengoz [1] also indicated that increasing the circular and square frames dimension resulted to a lower residual bagging height value. It is observed that with increase of fabric extensibility, fabric tensile elastic modulus decreases which in turn leads to a lower resistance against bagging deformation. On the other hand, with increase of sample diameter and hence a lower ball to sample diameter ratio, a lower tensile membrane strain [4] and as a result a less resistance against bagging deformation is obtained which results to a significant reduction of bagging parameters.

The bagging fatigue process is related to the elastic and viscoelastic properties of fabric. As shown in 'Figure 4', with increasing fabric extensibility, stress and frictional forces between yarns decrease, hence bagging fatigue percentage decrease. Also bagging fatigue percentage significantly decreased with increasing sample diameter. This result is attributed to the lower bagging force and hence lower elastic stored energy at higher sample diameter level (lower ball to sample diameter ratio) [4].

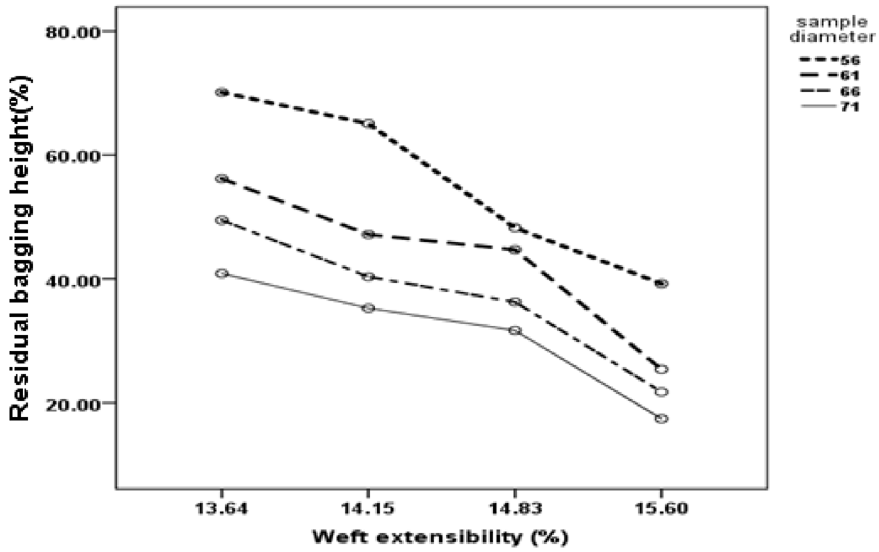

Fig. 3*: Effect of weft extensibility and sample diameter on residual bagging height.*

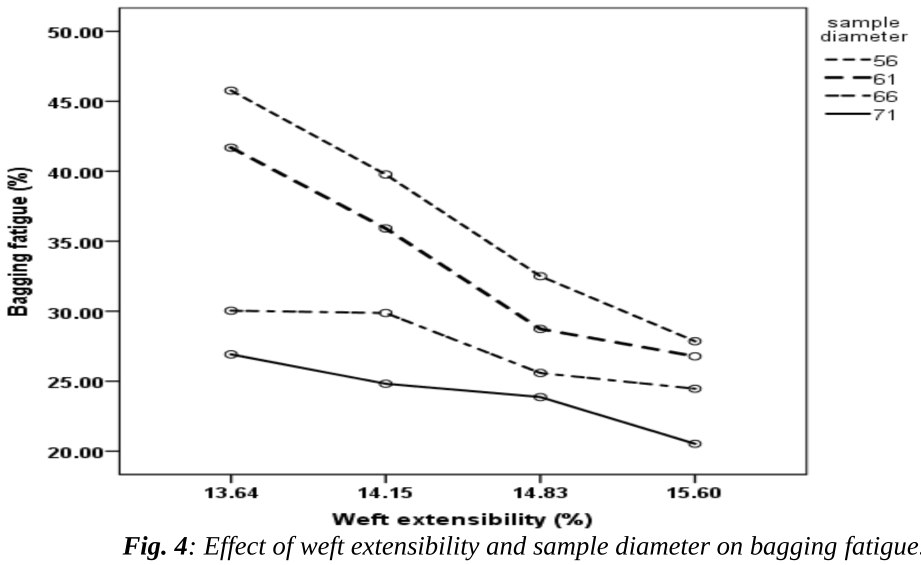

Fig. 4*: Effect of weft extensibility and sample diameter on bagging fatigue.*

5. CONCLUSIONS

The aim of this work was to investigate the effects of fabric extensibility and sample diameter on bagging behaviour of extensible shirt fabrics. Finished extensible plain woven shirt fabrics with changing the core-spun extensible yarn layout along weft direction were produced and then the bagging properties of samples were obtained at four different sample diameter of 56, 61, 66 and 71 (mm). The results were then statistically analysed using ANOVA test method.

The statistical analysis results show that fabric extensibility along weft direction and sample diameter has a statistical significant effect on bagging behaviour of extensible shirt fabrics. The results revealed that with the increase in fabric extensibility the fabric tensile strength and modulus decreased which causes the bagging parameters to be decreased. This result is mainly attributed to the higher tensile elastic recovery with increasing fabric extensibility. The results also show that with increasing sample diameter in bagging testing different bagging parameters due to the decreasing ball to sample diameter ratio significantly decreased. The obtained results of this research suggest that the in-plane fabric tensile properties play a major role in bagging behaviour of extensible woven fabrics.

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ANNALS OF THE UNIVERSITY OF ORADEA
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THE INTERCONNECTION OF THE PROGRAMS ADOBE ILLUSTRATOR ® AND ADOBE PHOTOSHOP ® AND THEIR APPLICABILITY IN THE TEXLILE INDUSTRY

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Abstract: *The use of ADOBE ILLUSTRATOR ® and ADOBE PHOTOSHOP ® programs proved to be a real help in the textile industry in the process of creating and realizing the sketches that underlie the subsequent realization of the drafted product. The ease of use and the multitude of tools, commands and functions serving the process f drawing, modeling and styling made the aforementioned programs one of the most used in the textile industry. Illustrator was used to draw the basic sketch and elements that brought the product closer to its final appearance such as making stitch-like lines at the sleeve hem and the bottom hem using the Stroke panel and achieving the stripe pattern, then stylizing the pattern was done in Photoshop by means of filters. Illustrator was used to insert the background color and insert as border the pattern already stylized in Photoshop. In order to offer more variants available in more colors, the background color and the border color corresponding to the background color were changed into Photoshop. All of these graphical programs are used to meet the needs of designers who want to implement different designs to ease their work without having to produce samples, seeing the product in its desired shape, size, and color on the computer. These programs allow the change of size, color and shape of the designs without loss of quality.*

Key words: *ADOBE ILLUSTRATOR ®, ADOBE PHOTOSHOP ®, dress sketch, stripe pattern stylization.*

1. INTRODUCTION

Adobe Illustrator® and Adobe Photoshop® are two of the most widely used programs in Computer-aided Graphics, [1], [2] Illustrator being a professional-quality graphics art vector creator and Photoshop is used for image editing.
Adobe Illustrator is an advanced vector-based program [3], [4] unlike the pixel format of Photoshop, it uses mathematical constructs to create vector graphics. In Illustrator, a line is made up of two dots connected by a computer algorithm instead of a pixel line. Because of this, Illustrator is often used to create graphics which may need to be printed or displayed in different sizes. Vector graphics will not lose their quality if scaled. One drawback of Illustrator is that it can not be easily used to modify the already created images, as the availability of filters and image editing tools is limited.

That's why using Adobe Photoshop® [5], [6] is complementary to creating graphics.

So Adobe Photoshop® is a great program to change already created images or graphics, such as photos, and is Adobe's most popular program.

2. DRAWING OF THE GRAPHIC SKETCH

Illustrator program was used to create the graphic design of the dress (Figure 1) and to achieve the stripe pattern that served to the side of the product, the stylized stripe pattern used for the bottom of the product was made in Photoshop. The model is a ladies dress without lining, the round neckline, the neckline trimming is 1 cm wide, the trimming being cut on bias it avoids curling and facilitates a suitable fitting. The neckline trimming is attached on neckline with an overlock seam. It is short sleeved dress with dropped shoulders, slightly arched on waist without a belt and it is of midi length. The suggested material is an interlock jersey its composition being 69% Viscose 26% Polyamide and 5% Elastane. The material being elastic the dress does not need a closing system like a zipper or buttons, the dress can be easily put on. The sleeve hem and the bottom hem is achieved with a double coverstitch, a stitch which is widely used in the apparel industry and is frequently used for thin jersey materials.

The lower part towards the bottom hem is made up of the printed edge of the dress. It is a sporty casual product that can also be worn as an outfit it can be easily accessorized with a short jacket or a thin A-line coat.

2.1. Drawing the sketch in Adobe Illustrator®

Execution of the sketch and the stripe pattern with Adobe Illustrator® program.

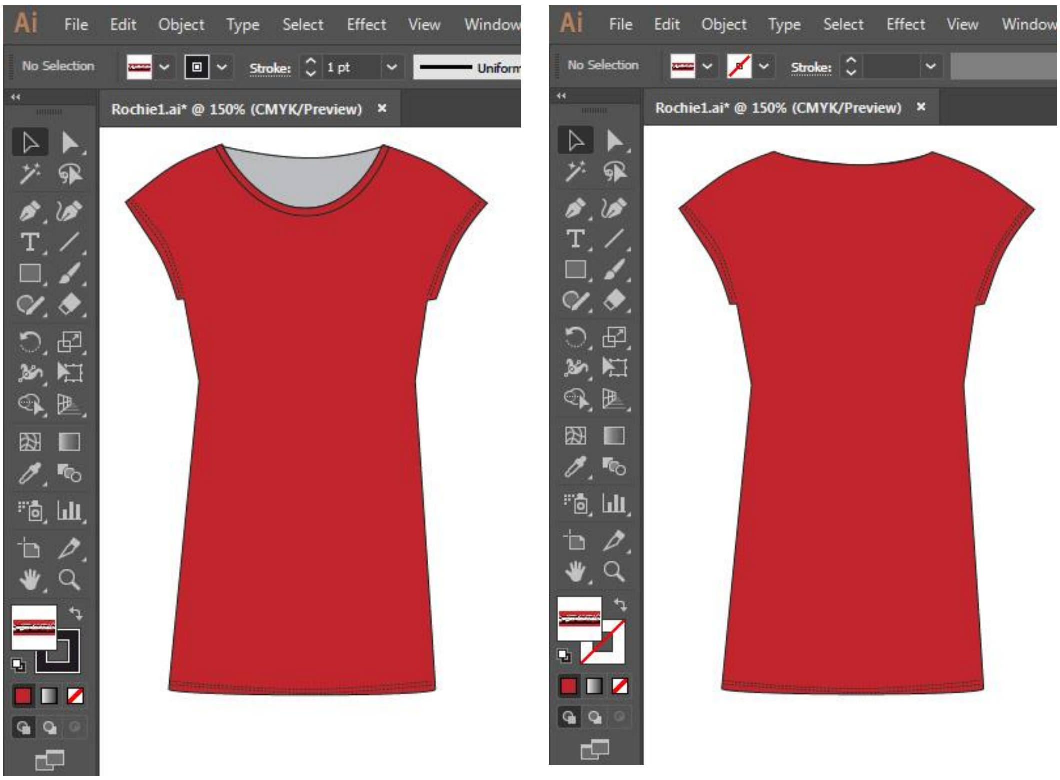

Fig. 1. *Dress sketch drawn with Adobe Illustrator® Program*

2.2. Drawing the stripe pattern which represents the bottom border

On a background using the same background color as well as for the dress, with the Rectangle tool, which is located on the left side of the program`s interface in the toolbar and by changing the color we draw the stripe pattern. (Figure 2)

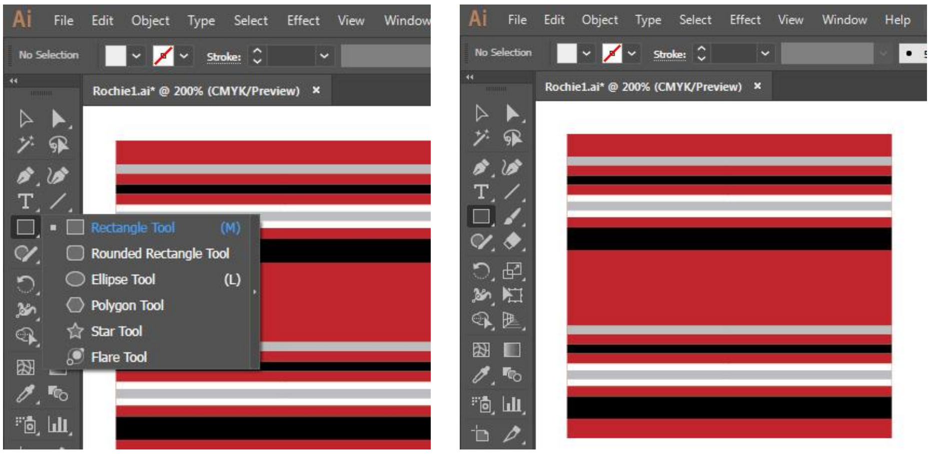

Fig. 2. Realizarea raportului de dungi în programul Adobe Illustrator®

2.3. Styling, import and insert of the stripe pattern in the Adobe Illustrator® sketch

The stylization of stripe pattern is done in Photoshop to obtain the final appearance of the border. The saved document containing the stripe pattern (Figure 3) with *.AI* extension, these documents with the Illustrator-specific extension can be accessed by Photoshop. After the document containing the stripe pattern is opened in Photoshop the first step is to use the cutting tool and restrict the document in order to have only the stripes in the workspace. Then, from the Filter menu, select the Liquify command and stylize the appearence of stripe pattern. After stylization, the document should be saved as .jpg.

In Illustrator, open the saved file as .jpg, and drag and drop it into the Swatches panel, select the bottom edge of the product for the border, and insert the previously added image.

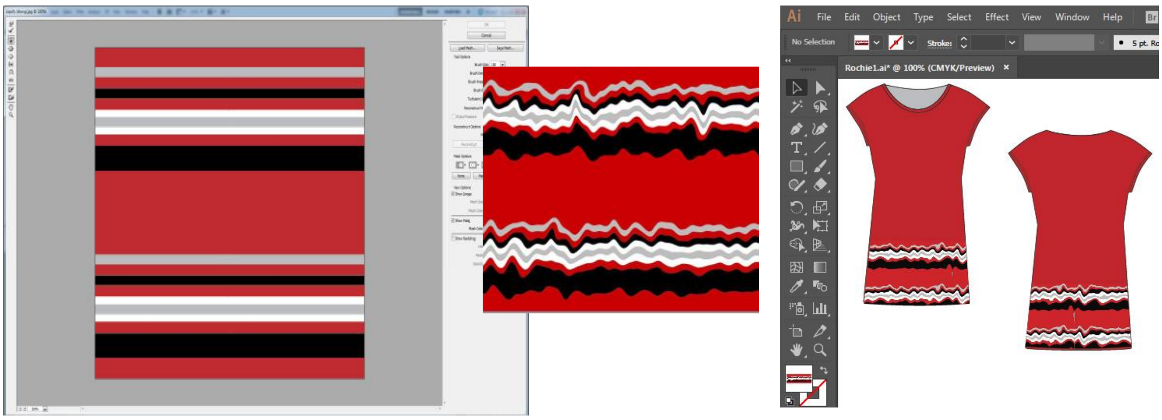

Fig. 3. *Styling the stripe pattern in Adobe Photoshop® as well as inserting the image into bottom part meant as border*

In order to be able to present several color variations, Photoshop makes it easy to do this by using the Color Range command, which is located in the Select menu and which allows with only one click to change the color of the product by replacing it with another color. Select the Color Range command, select the color that we want to replace by double-clicking, select the new color in the color panel, and the Brush tool to replace the original color (Figure 4).

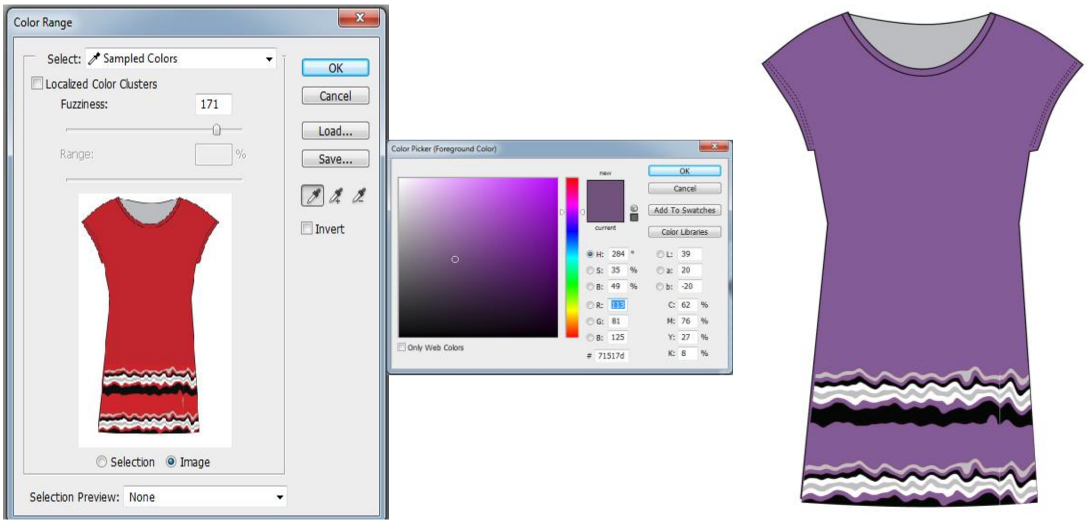

Fig. 4. *Change of the background color*

3. CONCLUSIONS

In conclusion, we want to assert that the use of the computer and the software Adobe Illustrator® and Adobe Photoshop® offers a multitude of possibilities for drawing and stylizing the products we want to achieve. All of these graphical programs are used to meet the needs of designers who want to implement different designs to ease their work without having to produce samples, seeing the product in its desired shape, size, and color on the computer. These programs allow the change of size, color and shape of the designs without loss of quality.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

INFLUENCE OF ADDITIVES ON THE CHARACTERISTICS OF NANOPARTICLES

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Abstract: *Here the influence of additives on NPs in spray formulation used for textiles treatement is assessed. After oleofobization with Tubiguard textile materials from 100% cotton were spray-treated in a specialized chamber with Ag NP and CeO_2 NP in 3 sizes ranges (<100nm, <200nm, 2-3µm) in a water – ethanol - based dispersions containing aditional additives. Electron microscopy analyzes by light field, high resolution and electron diffraction on selected area analyses highlighted the spherical and polyhedral form of the nanoparticle the homogeneitiy of the nanoparticles dispersion. Analysis of the uniformity, morphology and distribution of the nanoparticles on textile matrices were performed by using: the SEM (Scanning electron microscope) made on Quanta 200 FEY, the TEM (Transmission electron microscopy) and EDS (Energy-dispersive X-ray spectroscopy), IPC-MS Analyses (Inductively coupled plasma mass spectrometry). Analysis of the influence of the chemical auxiliaries on the shape and dimension of the nanoparticles were made for: solution of CeO_2 and Tubiguard VCN-5g/l, Solution of nanoCeO_2 and RucoDry(5 g/l) and RukoLink (1 g/l), solution of Ag NPs and Tubiguard VCN(5g/l), solution of nanoAg and RucoDry (5 g/l) and RukoLink (1 g/l).The TEM analysis reveals that dimensions and shape of the NPs did not change under the action of the chemical auxiliaries.*

Key words*:* textiles, nanoparticles, additives, microscopy

1. INTRODUCTION

In the early 2000s, a series of national and international reports highlighted the importance of nanotechnology, but also acknowledged the potential risks. These reports led to an increased interest in nanoparticles toxicology, accompanied by a change in terminology. Several preclinical and clinical studies have approached short-term inhalation and the respiratory effects of nanoparticles. For example, studies in the field noticed associations for nanoparticles and carbon with reductions of the pulmonary function in asthmatic patients, and healthy adolescents and adolescents suffering from asthma in New York showed an increase in the inflammation indices [1]. Most preclinical and clinical studies on UFPs (ultrafine particles) were conducted with diesel exhaust gases and diesel exhaust gases particles (DEP), a particularly rich source of UFPs. These studies revealed a respiratory tract inflammation in healthy individuals, including elevated levels of inflammatory cells and mediators (fig.1,2).

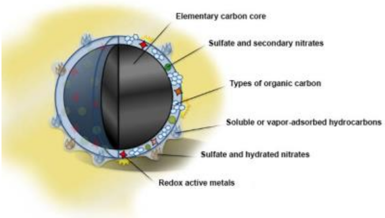


Fig. 1*: Complex Composition of UFP*

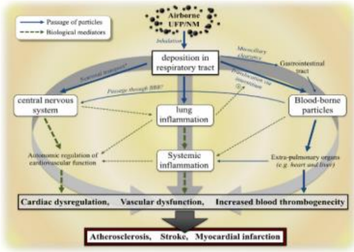


Fig. 2*: Action Mechanisms of UPF*

2. CHARACTERIZATION OF AG NPS

The Ag nanoparticles from SIGMA-ALDRICH are part of the materials category from the NM series destined only for testing in the research activity, being also included in the international testing program OECD WPMN (OECD Paris 2009-ENV-JM-MONO-2009-20 ENG Manual [3].

By the analyses [4-5] of **differential calorimetry (DSC**) the DSC thermogram was obtained which highlighted for Ag NPs, the apparition of 4 peaks corresponding to some values of the onset of: 51,54ºC, 124,97ºC, 202,26ºC and 353,63ºC determined by the degradation of the stabilization agents at the melting temperature of Ag (961,8^{0}C). The nanoAg **FT-IR-ATR analysis** of the Ag NPs highlighted the peaks corresponding to the absorbtion maxima attributed to the stabilization agents (Polyoxyethylene glycerol trioleate and Polyoxyethylene Sorbitan mono laurate), these absorbing radiation in the range of 4000-600 cm^{-1};. The TEM images in light field obtained on AG NPs (fig. 3) reveal that they are spherical and polyhedral, with a mean particle dimension of 50,55 nm ± 1.97 nm and a very uniform dispersion (fig.4). The regular sequence of the crystalline planes indicated that the nanocrystallites are uniform from a crystalline viewpoint, without having the amorphous phase and the only phase formed is the Ag.

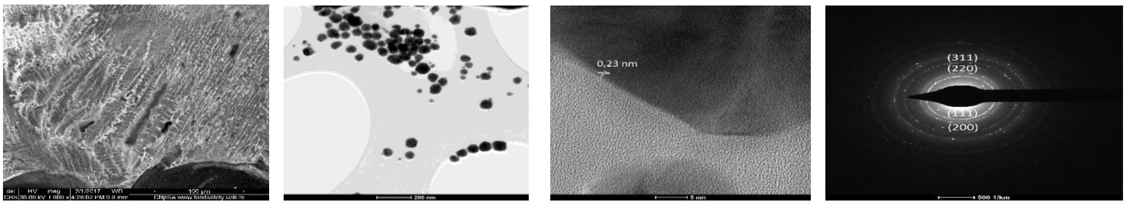


Fig. 3*: SEM Image a) TEM images in light field b) HR-TEM and SAED images -nanoAg*

The *dynamic light scattering* (DLS) characterization was performed using an electronic scanning microscope for high-resolution imaging, HR-SEM (FEI Inspect F50), which revealed the bimodal granulometric distribution of the nanoAg, identifying a 46% mass fraction of particles with an average diameter of 6.4 nm, respectively a mass fraction of 54% of particles with an average diameter of 172 nm (fig. 5).

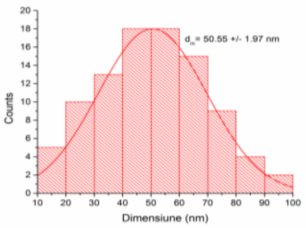


Fig. 4*: Dimension Distribution of Ag* NPs

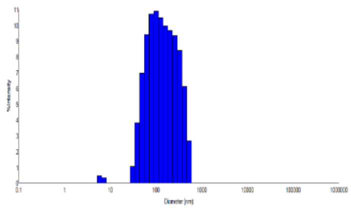


Fig. 5*: Bimodal Distribution of Ag NPs*

3. CeO_2 NPs CHARACTERIZATION

The CeO_2 nanoparticles were delivered by Sigma Aldrich under similar conditions to the Ag NPs. **The FT-IR analyzes** of the CeO_2 NPs revealed the small number of characteristic peaks specific to a high purity degree of the cerium oxide. **The SEM and TEM characterization** of the CeO_2 NPs revealed their polyhedral form. A very large variation in dimension and shape was remarked. The crystalline planes with a distance of 3.1 Å corresponding to the families of crystalline planes (311) were observed. The nanocrystallites are uniform from a crystalline viewpoint without having the amorphous phase, the only phase being that of polycrystalline cerium. The CeO_2 NPs showed a peak at the level of 357nm.

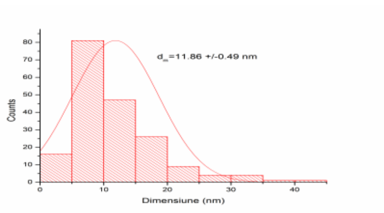


***Fig. 6**: Distribution Diagram of CeO_2 NPs*

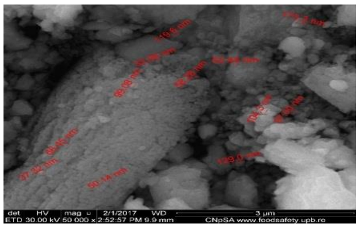


***Fig. 7**: SEM Images - CeO2 NPs*

4. FUNCTIONALIZATION EXPERIMENTATIONS

The woven fabrics made from 100% cotton were dyed and oleophobized by applying the technological flow [6]: desizing, boiling, bleaching/dyeing, oleophobization with: Rucostar EEE6 (70g/l) and acetic acid (1ml/l) with a takeover degree of 80%, drying: T=120^{0}C, condensation: 150^{0}C for 2 min.

The degree of oleophobization of the white woven fabric was at a good level, grade 5, compared to the dyed fabric, of average level – grade 2-3. The superficial wetting resistance recorded good values for both fabric variants (grade 5). For all the woven fabric variants, very good values were obtained for the parameter: color change (4-5) and color yield (4-5 and 5). The SEM images evaluation of the oleophobized woven fabrics after the washing resistance test revealed that it is *resistant* for fabrics from 100% white cotton and *partially resistant* for dyed fabrics from 100% cotton.

In order to study the uniformity, morphology and distribution of the nanoparticles on the woven fabrics surface of 100% cotton, the NPs were used in three dispersion formulas: F1 with UPW, ultra pure water, F2 with UPW and 57% ethanol and F3-1% Tween -20 + UPW and a formula for Ag NPs-F1-UPW-ultra-pure water).

5. RESULTS AND DISCUSSIONS

5.1 Analysis of the uniformity, morphology and distribution of the nanoparticles on textile matrices

5.1.1 The SEM (Scanning electron microscope) **analyses** made on Quanta 200 FEY equipment reveal the following aspects:

- the woven fabrics variants of 100% cotton oleophobized with **Rukostar EEEF 6** and treated with **CeO_2 NPs** show a very low loading degree and the CeO_2 NPs are dispersed on the surface of the fibers at large distances both in the case of using the F1 and F2 dispersion;
- the woven fabrics of 100% cotton oleophobized with **Rukostar EEEF 6** and treated with **Ag NPs** reveal that the degree of loading is relatively higher in the variant treated with F2 compared to the

F1. Ag NPs are dispersed on the surface of the fibers at large distances, exhibiting a slight tendency to agglomerate in the F2 - treated variant (57% ethanol) (fig.8);
- the variants oleophobized with **NUVA 2114** and treated with **CeO_2 NPs** show a high loading degree and the **CeO_2 NPs** are concentrated in some areas with uneven distribution and in the form of agglomerations, more accentuated in the F1 (UPW);
- the woven fabrics variants oleophobized with **NUVA 2114** and treated with **Ag NPs** show a relatively higher degree of loading than in the case of the variant oleophobized with Rukostar EEF6. The Ag NPs are distributed unevenly in the form of agglomerations.

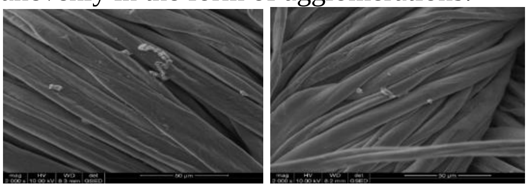


Fig. 8*: SEM Images -CeO2 NPs*

5.1.2 The TEM (Transmission electron microscopy) ***and EDS*** **(**Energy-dispersive X-ray spectroscopy) ***analyzes*** were made on the Titan Themis 200 equipment for the woven fabrics variants treated with CeO_2 NPs oleophobized with NUVA 2114 (5g/l) (fig 9).

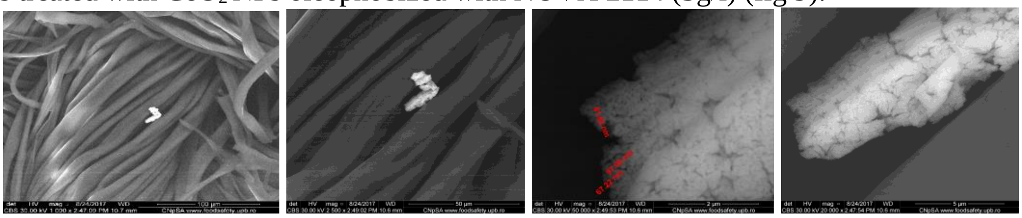
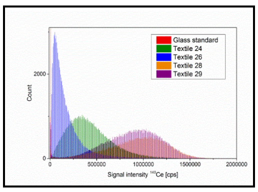


Fig. 9: *SEM-TEM Images*

- *the variant oleophobized* with NUVA 2214 and sprayed with CeO_2 NPs in dispersion with UPW (ultra-pure water) shows NPs deposited on the surface of the fabric and among the yarns. The EDS spectrum indicates the presence of the CeO_2, as an element present in the nanoparticles deposited; *in the woven fabric variant oleophobized* with *NUVA2114* and sprayed with CeO_2 NPs in dispersion of UPW and 57% ethanol, the images did not identify the CeO_2 on the surface of the fabric; for the *woven fabric variant* sprayed with CeO_2 (F3-15 Tween-20) and oleophobized with NUVA 2114 it is revealed that the arrangement of the nanoparticles is in the form of agglomerations; the nanoCeO$_2$ dimensions are of 60 and 70 nm.

5.1.3 IPC-MS Analyses (*Inductively coupled plasma mass spectrometry)*

The inductively coupled plasma mass spectrometry or ICP-MS is an analytical technique used for elemental determinations.



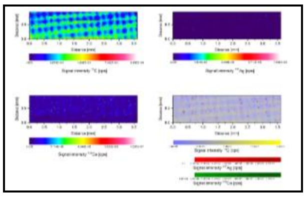


Fig. 10*: NanoCeO$_2$ Hystogra* ***Fig. 11****: LA-ICP-MS Results* ***Fig. 12****: NPs Dispersion*

The samples were fixed with resin on a glass slide and were ablated consecutively. ^{13}C, ^{107}Ag, ^{137}Ba și ^{140}Ce were detected, but Barium was used as control. ^{13}C was used to locate the fabrics. The data confirmed the first optical impression from the contour signals. For the ^{107}Ag signals we noticed that the glass standard ablation or that of the resin leads to similar distributions of decreasing intensity, which indicates a low background. The signal's distribution and intensity are different in the four variants (fig.10,11). The depth of NPs integration in the fabric was identified and that was at max. 1 μm (fig12).

5.2 Analysis of the influence of the chemical auxiliaries on the shape and dimension of the nanoparticles

In order to evaluate the influence of the chemical auxiliaries used in the oleophobization formulas of the textile materials on the form and dimension of the Ag and CeO2 NPs, the TEM electronic transmission microscopy (UPB-Bucharest) was employed for the treatment formulas with CeO2 (0,5 g/l)/ Ag (0,5 g/l NPs, Tubiguard VCN - 5 g/l respectively RucoDry (5 g/l) and RukoLink (1 g/l) used to treat 100% cotton woven fabrics.

5.2.1 Solution of CeO_2 and Tubiguard VCN-5g/l. The TEM images in light field reveal that the sample is composed of predominantly polyhedral form particles, which are arranged in the form of agglomerations of 200-300 nm. The high-resolution transmission electronic microscopy image reveals crystallographic planes with a distance of 2.70 Å corresponding to the families of crystalline planes (200). The regular succession of the crystallographic planes indicated that the nanocrystallites crystals are uniform from a crystalline viewpoint without having the non-crystalline phase. From the electron diffraction image on the selected area obtained on the cerium oxide nanopowder we can deduce that the only phase formed is the cubic cerium one.

5.2.2 Solution of nanoCeO_2 and RucoDry(5 g/l) and RukoLink (1 g/l). From the high-resolution transmission electronic microscopy image obtained on the CeO2 sample from the solution with RucoDry (5 g/l) and RukoLink (1 g/l): crystallographic planes with a distance of 3.12 Å corresponding to the families of crystalline planes were observed (1 1 1). Also, the regular succession of the crystallographic planes indicated that the nanocrystallites are uniform from a crystalline viewpoint without having the non-crystalline phase. From the electron diffraction image on the selected area obtained on the cerium oxide nanopowder presented in Figure 5 we can deduce that the only phase formed is the cubic cerium one.

5.2.3 Solution of Ag NPs and Tubiguard VCN(5g/l): the images revealed that the nanoparticles form is spherical, these being dispersed very uniformly. From the high-resolution transmission electronic microscopy image obtained on the nanoAg sample from the solution with Tubiguard VCN crystallographic planes with an interplanar distance of 2.04 Å corresponding to the families of crystalline planes (200) specific to the silver nanoparticles were observed. Also, the regular succession of the crystalline planes indicated that the nanocrystallites crystals are uniform from a crystalline viewpoint without having the non-crystalline phase. From the electron diffraction image on the selected area obtained on the Ag NPs we deduced that the only phase formed is the cubic silver one(fig.13,14,15).

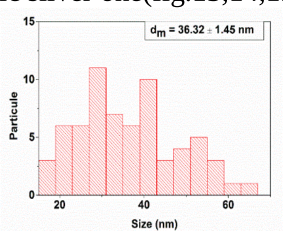


***Fig.13**: Dimensions Diagram of Ag NPs*

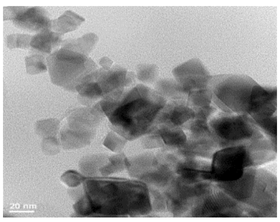


***Fig.14**: CeO_2 NPs*

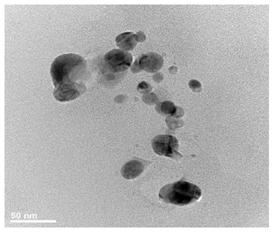


***Fig.15**: Ag NPs*

***5.2.4 Solution of nanoAg and RucoDry (5 g/l) and RukoLink (1 g/l)**:* the TEM analysis reveals that the nanoparticles form is spherical, these being in the same time very well dispersed. From the high-resolution transmission electronic microscopy image obtained on the nanoAg sample from the solution with *RucoDry(5 g/l) and RukoLink (1 g/l)* cristaline planes with an interplanar distance of 2.35 Å corresponding to the families of crystalline planes (1 1 1) specific to the nanoAg were observed. Also, the regular succession of the crystallographic planes indicated that the nanocrystallites are uniform from a crystalline viewpoint without having the non-crystalline phase. The electron diffraction image on the selected area obtained on the nano Ag highlighted that the only phase formed is the cubic silver one.

6. CONCLUSIONS

The dimension and shape analysis of the Ag and CeO_2 NPs was made by means of the SEM scanning electronic microscopy, TEM transmission and dinamic light scatering (DLS).

The influence of the chemical auxiliaries on the shape and dimension of the Ag and CeO2 NPs was determined by SEM, TEM and DLS analyzes that revealed that they maintain their shapes, dimensions and initial crystalline state.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

PIEZOELECTRIC POLYMERS IN TEXTILE INDUSTRY

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Abstract: *In the Piezoelectric behaviour refers that conversion of mechanical impact to electrical power, or electrical impact to mechanical changing. The presence of piezoelectricity has been scientifically discovered in 1880 as a result of the work of Jacques and Pierre Curie brothers. They found that some naturally occurring crystals such as quartz and Rochelle salt produced a surface charge when subject to a compressive load. Piezoelectric energy has a wide range of application areas by providing sustainable energy. One of these areas is the textile industry which has been moving towards higher value added production in recent years.*
Piezoelectric materials are divided into four groups: piezoelectric crystals (quartz, rochelle salt, tourmaline, topaz etc.), piezoelectric ceramics (lead zirconate titanate, barium titanate, etc.), piezoelectric polymers (PVDF, odd numbered nylons etc.) and piezoelectric composites. Because of different characteristics of these piezoelectric materials, each of them is preferred with regard to projected purpose. This study reviews piezoelectric polymers and highlights its properties such as elasticity, lightness, strength, etc. where the desired characteristics are needed in textile products. These features make easier to use of piezoelectric polymers in smart textile applications. They are generally used to energize from human movements or different regions of the human body. Power generation can be achieved by various textile structures such as fibre, yarn, weaving and knitting. In this review some polymers, for example polyvinylidene difluoride (PVDF), Polyamide 11 (PA11), Polypropylene (PP), are especially chosen to give more detail on their piezoelectric characteristics which are considered in the textile applications.

Key words: *Piezoelectric, polymers, PVDF, Polypropylene, Polyamide 11.*

1. INTRODUCTION

Today, the innovation has an important role in battling competition in textiles where there is need for investment in research and development areas such as developing new products, new materials with different uses [1]. Piezoelectric polymers are one of those materials which may be used in various sectors.

The harvesting of waste energy from human movement or different regions of the human body has been turned over for obtaining electrical power to low-energy consumption devices such as wireless body worn sensors and wearable consumer electronics [2].

Piezoelectric polymers have been known more than 50 years and are extremely useful in monitoring vibrations and in controlling flexible structures. On the other hand, piezoelectric materials are used to measure the extent of deflection, frequencies of vibration, and control the structure through actuation. A piezoelectric polymer can damp vibrations passively and as the need arises, the stiffness of a material can be changed with an applied electric field that enhances damping effects [3].

Polymer-based fiber sensors have been recently realized through melt spinning of the piezoelectric polymers such as poly (vinylidene fluoride (PVDF), Polypropylene and Polyamide 11. When the fibers are deformed, typically compressed or subjected to axial strain, an electric potential is generated by the piezoelectric properties [4].

The ability of piezoelectric materials to convert electrical to mechanical energy and conversely mechanical to electrical energy has been exploited in an application closely related to power generation. Many investigations done piezoelectric polymers have already gone into the design and properties of piezoelectric transformers [5].

In the below section some of the piezoelectric polymers that are used in textile studies have been specified.

2. PVDF

PVDF (polyvinylidene fluoride) which is the first explored piezoelectric polymers was detected by Kawai in 1969 [6]. Since then, these piezoelectric materials with their flexible porperties have been attracted many researchers in textile studies. In most of the applications they either used thick or thin PVDF films [7-9] and some used bulk materials [10].

The dielectric constant of PVDF is about 12, which is four times greater than most polymers [11]. The material has four crystal phases at different processing conditions. Ferroelectricity and piezoelectricity specialty is provided by the polar β phase which is one of its crystal phases is formed under mechanical stress or high electric fields [12].

Hadimani et.al. [9] studied polyvinylidene fluoride (PVDF) fibres which were extruded in continuous melting process. Poling conditions of extruded fibers were set as 4:1 extension ratio, a temperature of 80^{o}C and 13 000 V high voltage on a 0.5 mm diameter fibre. After melting and poling processes of PVDF monofilament, piezoelectric power of PVDF fibres were measured 2.2 V under an impact force of 1.02 kg from a height of 5 cm [9].

Piezoelectric bicomponent fiber consist of sheath poly (vinylidene fluoride) fiber, conductive composite with carbon black(CB) and core component polyethylene (HDPE), which was searched. The mean power from a 25 mm length of bicomponent PVDF yarn was estimated as 15 nW [13].

''3D spacer'' technology was used for manufacturing piezoelectric fabric that contain high β-phase (~80%) piezoelectric PVDF monofilaments as the spacer yarn interconnected between silver (Ag) coated PA66 multifilament yarn layers acting as the top and bottom electrodes. As a result of this work was produced power density in the range of 1.10 W µW cm-2 to 5.10 µW cm-2 at applied impact pressures of 0.02 MPa to 0.10 MPa [14].

(PVDF)/nanoclay composite nanofibers were fabricated by a “near distance-wheeling” electrospinning (NWS) method. Results of the free vibration test showed that voltage peak value of straight PVDF/nanoclay fibers was 2.76 V whereas it was 1.65 V for random PVDF/nanoclay fibers, and PVDF fibers was maximum 0.78 V [15].

3. POLYPROPYLENE

Polypropylene is one of the most widely used polymer in technical applications because it is easily available and less expensive as compared to other polymers that can be used for piezoelectric applications.

Piezoelectric isotactic polypropylene (iPP) monofilaments were producted on different draw ratios such as 1:1, 2:1, 3:1, 4:1, 5:1, 6:1, 7:1. Voltage responds were analyzed for different draw ratio and the peak voltage was found that 264 mV on 2:1 draw ratio [16].

Voltage response of varying the weight ratios (1%, 3% and 5%) of tourmaline in polypropylene polymer was examined. After monofilament meltspinning processes of PP/TM (1%, 3% and 5%) seperately, tourmaline added PP filaments were woven as 70 mm x 100mm. The recorded peak voltage values were measured 1.46 V for PP/ TM %1, 2.84 V for PP/ TT %3 and 3.92 V for PP/ TT %5 on ossiloscope [17].

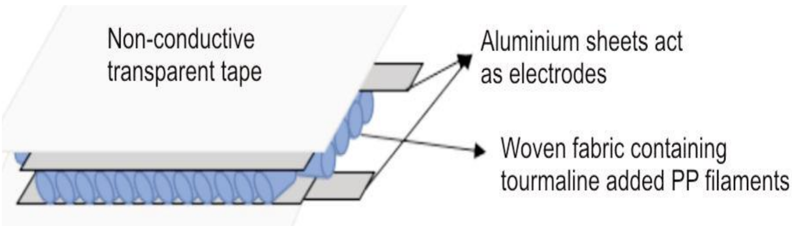

Fig.1: *PP/TM piezoelectric woven textile layer sandwiched between two aluminium sheets [17]*

The effect of addition 0%, 0.01%, 0.1% and 1% weight ratios of multiwalled carbon nanotubes (CNTs) on the piezoelectric properties of polypropylene (PP) monofilaments was investigated. CNT enhanced piezoelectric properties of the PP filament [18].

Patel and Uzun [19] reported various piezoelectric smart materials and their applications in their study. They have stated that although PVDF piezoelectric materials are relatively inexpensive, the repeatability of the material to generate consistent voltage can prove to be a challenging factor. Conversely, PP may generate least amount of energy, it showes good promise as an engineering material due to its flexibility, cost effectiveness and repeatability characteristics.

4. POLYAMID 11

In the past twenty years, the odd-numbered polyamides are well known ferroelectric polymers. Especially studies were focused on polyamide 11 (PA 11) due to its relatively low water absorption, its excellent mechanical and piezoelectrical properties. In one of those studies [20], piezoelectrical properties of PA 11 has shown better piezoelectrical properties and were thermally more stable than PVDF and to its copolymer with trifluorethylene (PVDF-TrFE). Wu et al [21] studied the effect of draw ratio on the ferroelectric and piezoelectric properties of PA11; they have observed that as the draw ratio of the films increase from 1:1 to 3,5:1, the piezoelectric strain coefficient d'_{31} measured at 25 ºC remained uchanged and roughly was 1.1 pC/N but the piezoelectric stress coefficient e'_{31} increased from 2.1 to 4.9 mC/m^2 . On the other hand, at 120 ºC, d'_{31} was increased from 3.8 to 20 pC/N and e'_{31} from 0.5 to 27 mC/m^2 .

PA 11 is a high-performance semicrystalline polymer, which was found the triclinic α-form, the monoclinic β-form and three hexagonal or pseudo-hexagonal forms (γ, δ, and δ' -forms) with different crystal lattices [22]. On the other hand, at room temperature the odd-numbered nylons have shown lower piezoelectric constants than PVDF [11].

In one study, PA 11 piezoelectric mono-filament was successfully extruded via a continuous process on melt spinning apparatus. Result of applied 1.02 kg force from 10 cm height to PA 11 monofilaments was a peak voltage about 3.24 V [23].

Some researchers [24] discovered crystal morphology of PA11/clay blends of nanocomposites; they used polarized light microscopy (PLM), small angle scattering (SALS) and differential scanning calorimetry (DSC) for that and PA 11 can crystallize into well-formed spherulites. Both isothermal and non-isothermal crystallization methods showed an increased crystallization rate with the addition of clay.

Datta et al [25], used PA 11 nanowire arrays to observe their vibrational energy harvesting applications; they have reported their fabrication and properties of vertically aligned and self-poled piezoelectric PA 11 nanowires with a melting temperature of around 200 ^{o}C. They have indicated that the produced nanogenerator exhibited an excellent fatigue performance and high temperature stability which this low cost piezoelectric polymer offers nanowire-based energy harvesting at temperatures well above the room temperatures.

5. CONCLUSIONS

This review indicates that it is possible to design textile-based piezoelectric structures using PVDF, PP and Polyamid 11 polymers. At the table given below we have compared the physical and piezoelectric properties of PVDF, PP and Polyamid 11.

Table 1: *Comparison of some physical and piezoelectric properties of some polymeric materials*

Polymer	**Density (g/cm^3)**	**Tensile modulus of elasticity (MPa)**	**Tensile strength (MPa)**	**Tg (^{o}C)**	**Tm (^{o}C)**	**Max use Temp (^{o}C)**	**d_{31} (pC/N)**
PVDF	1.78	2200	60	-35	175	80	20-28
PP	0.91	1000	37	-10	161	80	128$\pm$ 1
PA 11	1.06	340	48	68	195	185	14

In the near future, we believe that further studies will take place on varies types polymeric yarns, woven and knitted fabrics or nonwovens with a different type of conductive electrodes may be ideal to optimize the piezoelectric output for smart textile applications. With these high quality piezoelectric materials, it may also be possible to develope high performance energy-harvesting textile structures for future applications in multi diciplinar sectors such as for environmental aspects or for human health.

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ANNALS OF THE UNIVERSITY OF ORADEA
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THE INFLUENCE OF FATLIOURING PROCESS ON GARMENT LEATHER DRAPEABILITY

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Abstract: *Fatliquoring process is of importance due to the impact on the comfort and mechanical properties of the leathers. In this process, leathers are lubricated to minimize the fibre friction, to ensure the comfort properties like softness, drapeability and flexibility, to provide the required mechanical and touch properties. And the comfort of a leather product is explained as the satisfaction of a person in the wear material. Thus the fatliqouring process, the types and the proportion of fatliqours used in the process become the main focus in terms of drape behaoivors and physical characteristics of the leathers. For this purpose, the effect of fatliqouring process on the drapeability behaiovurs of the garment leathers was aimed to investigate. In the study, fifteen wet-blue leathers and the mixture of synthetic, sulphited and sulphonated fatliqouring agents were used for the garment leather production. The leathers were treated with the fatliqouring agents in five different proportions such as 4, 6, 8, 10 and 12%. Subsequent to mechanical operations, crust leathers were evaluated in accordance with the standards of TS ISO 3801 - Determination of mass per unit length and mass per unit area, TS EN ISO 2589 - Determination of thickness, TS 9693 - The Assessment of Drape of Fabrics, TS 1409 - Stiffness Determination of Woven Textiles and ASTM D1388 - Standard test method for stiffness of fabrics. As a result of the study, it was revealed that the increase in the amount of fatliqours led the enhanced drapeability characteristics of the garment leathers.*

Key words: *Fatliqouring, leather, softness, drapeability, bending rigidity, stiffness*

1. INTRODUCTION

Leathers are produced by a series of chemical and mechanical operations and fatliquoring is one of the important processes due to the influence on the physical characteristics of the leather products [1,2]. The products used in fatliqouring applications provide the comfort and mechanical properties that helps to convert the crust leathers into high-performance leather goods [3,4]. By fatliqouring applications, minimization of the fibre friction, ensurance of wear comfort properties as well as mechanical and touch properties will be performed [5,6].

Leathers used for garment leathers need to be fulfilled the required comfort and physical properties such as softness, drape, water vapor permeability and so on [2,7]. Drape is known as the deformation of a fabric produced by its own weight and is of importance for garment aesthetics [2,8] and the stiffness is the parameter to assess the bending rigidity and handling of the material [9].

Although there are some studies in literatures about fabric drapeability and stiffness, according to our knowledge, there is not any study describing the effect of fatliqouring applications on the drabeability characteristics of garment leathers.

For this purpose, to determine the effect of the fatliqouring process on the drapeability behaivours of the garment leathers in terms of drapeability, bending rigidity and stiffness properties were aimed to determine. Therefore, fifteen metis type wet-blue leathers were used for the fatliqouring process. The mixture of synthetic, sulphited and sulphonated lubricating agents were used in the proportions of 4, 6, 8, 10 and 12% for triplicate experiments to determine and compare the drapeability characteristics of the garment leathers.

2. MATERIAL AND METHOD

2.1 Material

In the study, fifteen wet-blue leathers were used for the fatliquoring process. The metis type chromium tanned leathers were obtained from Akaylar Leather Company (Izmir, Turkey). Three different types of fatliqour agent (mixture of synthetic, sulphited and sulphonated fatliqours) commonly used for the garment leather production were selected for the fatliqouring applications.

2.2 Methods

Metis type wet blue leathers were washed and retanned with 4% chromium syntan. After the neutralization process at pH 5.5, the leathers were subjected to retanning and fatliqouring process. First, the leathers were treated with resin and phenolic based syntan in the proportion of 3%. Later, the leathers were fatliqouried with the mixture of synthetic, sulphited and sulphonated fatliqour agents in the amount of 4, 6, 8, 10 and 12% based on the leather weight. After washing, drying and mechanical operations, the drapeability behaivours of the garment leathers were determined by the measurement of thickness, grammage, drape-ability, bending rigidity and stiffness properties of the leather samples.

Sampling of the crust leathers was performed according to TS EN ISO 2418 standard [10] and the samples were conditioned in accordance with TS EN ISO 2419, at 23±2°C and 50%±5 relative humidity [11].

The thickness and grammage of the samples were measured according to TS EN ISO 2589 and TS ISO 3801 standards respectively [12,13].

Drape coefficient was determined using drape tester according to TS 9693 [14]. The drape coefficient was expressed as a percentage. A circular leather specimen of 30cm diameter was placed between two horizontal discs (18cm), and the unsupported annulus of leather was allowed to hang down. The photos of the draped specimens were taken by a camera and the pixels of the photos were counted. The drape coefficient was calculated with the formula Eq. (1) as given below:

$$\textit{Drape coefficient (DC \%)} = [(M - S) / (L - S)] \times 100 \quad \textbf{(1)}$$

M: Material Pixels Count, S: Small Diameter Pixels Count, L: Large Diameter Pixels Count

Stiffness test was performed using digital pneumatic stiffness tester according to ASTM D1388 [15]. The bending stiffness of the garment leathers were tested by the standart of TS 1409 [16]. Bending stiffness, G was calculated according to the following equation:

$$G = 0.1.M.C^{3} \text{ (mg.cm)} \quad \textbf{(2)}$$

where: M - fabric weight (g/m^2)

C - bending length mean value in warp and weft direction (cm)

$$G = \sqrt{G_{warp}.G_{weft}} \quad \textbf{(3)}$$

All the experiments were performed in triplicates and the results were given as mean values.

3. RESULTS AND DISCUSSION

3.1. Mass per unit area and thickness values of the garment leathers

Mass per unit area and thickness values of the garment leathers fatliqoured in different proportions such as 4, 6, 8, 10 and 12% are given in Table 1. The thickness values of the garment leathers were found similar due to the shaving process as generally the requested final thickness values of the garment leathers were 1mm.

The mass per unit area values of the leathers showed a direct proportion to the increased fatliqour amounts. Comparable grammage values were obtained from the leathers fatliqoured with the amount of 6% and 8% and the effect of the fatliqouring proportion on the mass per unit area values of the crust garment leathers were found significant.

Table 1: *Mass per unit area and thickness values of the garment leathers fatliqoured in different amounts*

	4%	6%	8%	10%	12%
Thickness (mm)	0.95±0.07	1.03±0.12	0.99±0.05	1.10±0.04	1.01±0.10
Grammage (g/m^2)	453.59±34.91	523.68±34.37	530.19±10.54	554.69±9.82	612.44±46.64

3.2. Drapeability behaivours of the garment leathers

The drapeability characteristics of the garment leathers in terms of drapeability coefficient, stiffness and bending rigidity are shown in Table 2. It is revealed that the fatliqouring process performed in five different proportions was found effective on the drapeability behaivours of the garment leathers. Drape coefficients, stiffness and bending rigidity values of the leathers were decreased in accordance with the increased amount of fatliqouring agents. The higher amounts of fatliqours led to an increase on the softness and drapeability properties of the leathers. Considering the drapeability coefficient, the amounts of 10 and 12% of fatliqours resulted similar values, although a slight difference were observed from their stiffness and bending rigidity values of the leathers. This is attributed to their increased softness properties of the leathers but from the environmental and economic point of view, there seems to be no need to use the mixture of fatliqouring agents above 10%.

Table 2: *The drapeability characteristics of the garment leathers fatliqoured in different amounts*

Ratio	Drapeability coefficient	Stiffness (N)	Bending Rigidity (mg.cm)
4%	50.62	22.6	8059.35
6%	48.89	21.3	8087.46
8%	43.54	16.5	7935.68
10%	40.26	15.7	7813.97
12%	40.16	13.5	7427.94

4. CONCLUSIONS

In the study, the effect of the fatliqouring process on the drabeability behaviours of the garment leathers were aimed to determine. For this purpose, metis type wet blue leathers were treated with five different amounts of fatliqour mixture consisting of synthetic, sulphited and sulphonated lubricating agents' mixture in the proportions of 4, 6, 8, 10 and 12%. The change occurred due to the increasing amount of lubricating agents were presented as mass per unit area, thickness, drapeability, bending rigidity and stiffness values and the following conclusions have been drawn;

1. The grammage values of the garment leathers were found in direct proportion with the usage amount of fatliqouring agents.
2. Drapeability coefficient, stiffness and bending rigidity values were decreased by the increase of the fatliqours amount.
3. Thus, the increase in the amount of fatliqours led to an increase in the softness and drapeability properties of the garment leathers. Consequently, it was revealed that fatliqouring process had an impact role on the drapeability behaivours of the garment leathers.

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THE INFLUENCE OF RECIPE FORMULATION AND ELECTRIC FIELD FREQUENCY UPON DIELECTRIC LOSS IN PLASTIFIED PVC FILMS

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Abstract: *Plastified polyvinyl chloride (PVC) films are largely used in the clothing and footwear industries. The composition of the PVC-based blend and the curing stage determine the main characteristics of the final films. Lately, radio frequency fields (RF fields) have gained popularity as heat generators in different processing stages of polymer films, like the PVC ones. The dielectric behaviour of PVC films can be controlled by the recipe formulation of plastisol blends. This paper presents the influence of the chemical nature and concentration of some auxiliaries, added in the plastisol blend, upon dielectric loss, tg δ in plastified PVC films obtained in high frequency electric field. The chemicals used as additives in the recipe formulation were: polydimethylsiloxane (PDMS) polymethylhydrosiloxane (PHDMS), nonylphenol ethoxylate emulsifier NF10 (NE) and collagen hydrolizate (CH). Additives concentration was in the range 4-6 parts. The RF field was provided by a high capacitive generator with 380 V supply voltage, and 13.56 MHz working frequency. Increased concentration of auxiliaries determined the increase of tg δ irrespective the nature of the chemical auxiliary. The dielectric loss of PVC films, due to the presence of chemical additives, increased in the following order: PDMS< NE< CH< PHDMS. The dielectric loss angle increased in the RF field up to a maximum value that corresponds to a critical frequency. The addition of additives to the plastisol PVC blend, as mono, binary, ternary or quaternary mixture, has a beneficial effect upon the dielectric behaviour of final films, making them suitable for use in the footwear manufacturing.*

Key words: *leather substitutes, polymer films, plasticizers, radio frequency field, dielectric relaxation*

1. INTRODUCTION

PVC is increasingly used as a substitute for leather, because it is cheaper and offers great flexibility to fashion designers, without raising the environmental or ethical issues sometimes associated with genuine leather.

For plastified PVC films, specialty literature mentions many research works on dielectric properties in which the dependence between dielectric permittivity ε'_r or loss factor and frequency is presented, but no reference to multicomponent formulations was found [1-4]. Some of the common factors that influence the dielectric strength of a material are: temperature, humidity, material thickness frequency of applied voltage. It is known that an increase in the frequency will result in increased dielectric strength or breakdown voltage [3, 4].

When an insulating material is subjected to alternating voltage, some of the electrical energy is absorbed by the insulating material and this energy is dissipated as heat. This amount of energy absorbed by the material is called dielectric loss [5-8].

In the case of a perfect dielectric material, current leads the voltage by 90 degrees but this is not the case with practically available dielectric materials. In practical case it is less than 90 degrees, say it an angle Θ. The (90-Θ) difference is called dielectric loss angle, tg δ and is a very important property of insulating materials. The addition of different additives to the PVC-based mixture can significantly change their dielectric properties. As above mentioned, the best dielectric properties are exhibited by binary, ternary, and/or quaternary blends, from which plastified PVC films were obtained through a methodology described in [6-10]. In respect to monocompound products, dielectric properties were studied in order to find any possible synergetic or anergetic effects in binary, ternary or quaternary blends.

It is the aim of this paper to investigate the influence of chemical auxiliaries/additives and the RF field frequency upon the dielectric behaviour of plastified PVC films intended for leather substitutes with uses in the footwear industry, for the manufacture of shoe uppers.

2. MATERIALS AND EQUIPMENT

The components of the basic recipe are: Polyvinyl chloride, PVC (Sigma Aldrich), with the following chemical and physical characteristics: molecular weight M= 4000 g/mol, viscosity index Kwert = 65– 67, density 0.48–0.56 (powder PVC emulsion type); Dioctylphthalate, DOP (Limited England), with a viscosity of 74-76 cP and M = 390 g/mol; thermal stabilizer of Cd–Zn type KZII (România); blowing agent Genitron AC_4, BA (Limited England). The chemical auxiliaries used in the recipe formulation were: polydimethylsiloxane, PDMS (Sigma Aldrich) with M=17537 g/mol; polymethylhydrosiloxane, PHDMS (Sigma Aldrich) with M=16180 g/mol; nonylphenol ethoxylate emulsifier emulsifier NF10, NE (România); collagen hydrolizate, CH with M=30000 g/mol and pH_{iz}=10.8 (România). The auxiliary agents were added as mono, binary, ternary or quaternary mixtures. The following laboratory equipment was used: Werner Mathis type LTE-S-B apparus for film forming; laboratory Roll Mill Type W 110 E for mixture preparation; gelling vaccum oven type Horyzont (Germany).

The high frequency electric field for treatment of PVC plasticized films was provided by a high frequency capacitive generator with 380 V supply voltage, and 13.56 MHz working frequency. Temperature was controlled by a non-contact infrared (IR) thermal sensor. The dielectric loss angle was measured with a Q-meter type LCR-Q (Model HP4284), with variable capacity, in the range 50 KHz-14.8 MHz [11-13].

3. EXPERIMENTAL

Mixtures for the preparation of plasticized PVC films were obtained accordingly with the following recipe: PVC (polyvinyl chloride) -100 parts, DOP (dioctylphtalate)- 60 parts, thermal stabilizer (KZ II)- 3 parts, blowing agent(BA) (Genitron AC_4) – 2 parts, auxiliary agents (CH-collagen hydrolizate, polydimethylsiloxane (PDMS), polydimethylhydroxisiloxane (PHDMS), Nonionic emulgator type NF10 (NE): 4 - 6 parts.

Plastisol mixtures were prepared from the above-mentioned constituents on the mixing roll mill and degassed for 15 min. in a vacuum oven at 30°C.

Films of 0.5 mm thickness were formed on a teflon antiadherent plate in the Werner Mahis apparatus, and pregellified for 20 s at 120°C in RF field, at 13.56 MHz working frequency. The subsequent blowing/expanding operation was performed at 190 °C at the same working frequency.

Treatment time ranged between 30 and 120 seconds. Rectangular (20×100 mm) and circular (60 mm diameter) test specimens were cut from the PVC films. Experimental determinations were made on representative PVC films (containing mono, binary, ternary and quaternary mixture of chemical additives) in order to determine the dependence of tg δ on the frequency of the RF field. The variable frequency was achieved on the Q-meter, and tg δ was measured by the resonance method on a capacitive oscillating circuit [12-16].

4. RESULTS AND DISSCUSIONS

Experimental data presented in fig. 1-7 show that polarisation of studied chemical auxiliaries/additives is function of external field frequency and dielectric nature of the compound, (BA is theblowing agent and additives in mixture are generally denoted by AM). Thus, the $0.5\cdot10^5 \div 7\cdot10^5$ Hz frequency range leads to a partial orientation of the voluminous, high molecular weight structural elements of the compound, indicating some polarization and oscillatory displacement. The internal (rotational) friction is prevailing. At the same time, a maximum orientation of low volume structural elements (free radicals reactive groups, chain ends) is noticed, which are subjected to rapid oscillatory motion in the $7\cdot10^5 \div 1.48\cdot 10^7$ Hz frequency range.

In these situations, two domains can be distinguished:

- in the first case, the "dipole-elastic" loss domain, in which a maximum value, α of the dielectric constant, ε' is observed, due to the polarisation in alternative electric field of COO^-, $-NH_2$, -OH groups present in auxiliaries such as: polyhydroxdimethylsiloxane (PHDMS), collagen hydrolizate (CH), or non-ionic emulsifier (NE).

- in the second case, the "dipole-radical" loss, in the high frequency domain; the maximum, β of the dielectric constant, ε', caused by the displacement of nonpolar radicals, can be noticed.

So these phenomena are due to dielectric relaxation of both polar and non-polar mobile radicals.

The evolution of the measured dielectric loss vs. compounds nature and concentration present a behaviour that is characteristic to polar polymers, like PVC, CH, PDMS and PHDMS.

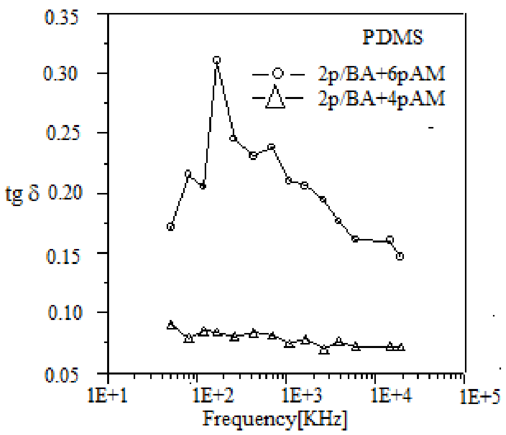

Fig.1. *The dependence of tg δ on the RF field frequency, for the PDMS-containing mixture*

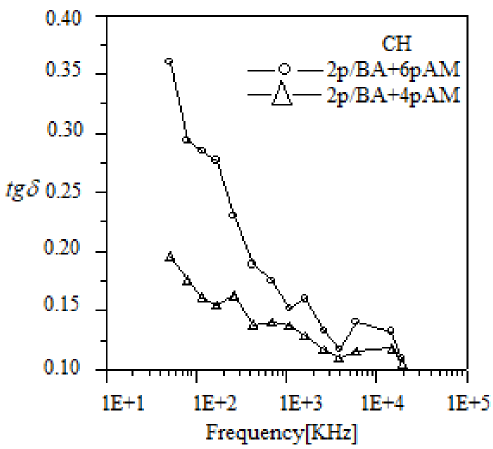

Fig.2. *The dependence of tg δ on the RF field frequency, for the CH-containing mixture*

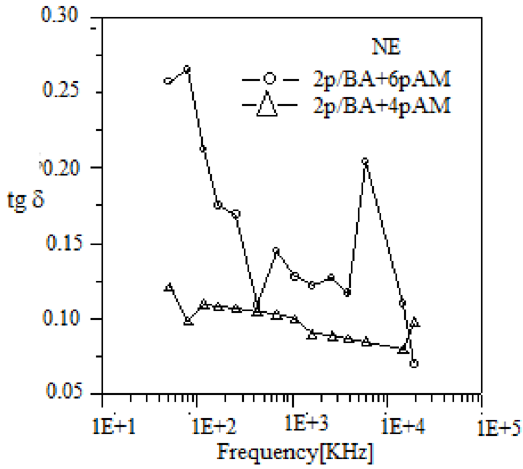

Fig. 3. *The dependence of tg δ on the RF field frequency, for the NE-containing mixture*

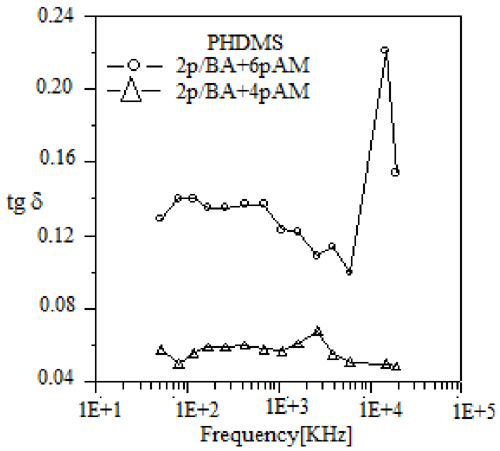

Fig. 4. *The dependence of tg δ on the RF field frequency, for the PHDMS-containing mixture*

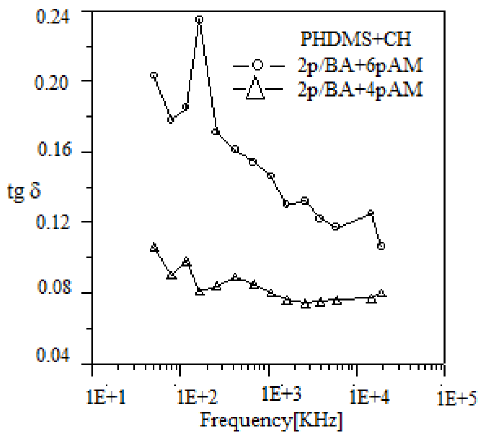

Fig. 5. *The dependence of tg δ on the RF field frequency, for the (PDMHS+CH)-containing mixture*

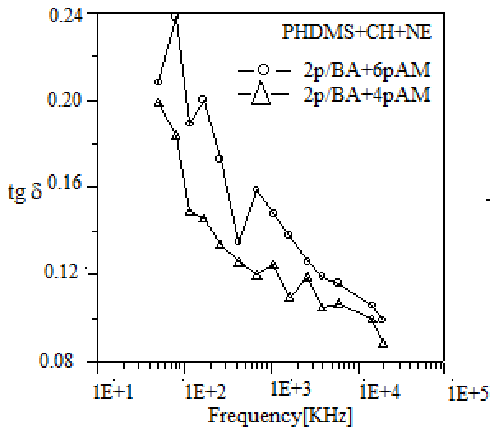

Fig. 6. *The dependence of tg δ on the RF field frequency, for the (PDMHS+CH+NE)-containing mixture*

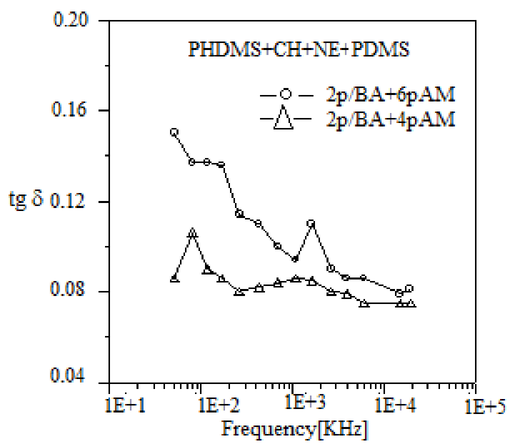

Fig. 7. *The dependence of tg δ on the RF field frequency, for the (PHDMS+CH+NE+PDMS-containing mixture*

The analysis of experimental data presenting the variation of loss factor *vs.* frequency (shown in figures 1-7) allows the following findings:

- The blends containing 4 parts auxiliaries show lower loss factor values in comparison with blends containing 6 parts of chemical auxiliaries;
- Both type α and β relaxation were observed;
- It is apparent that the relaxation time is defined as the time in which the polymeric compounds from the studied blend will re-establish a new equilibrium state, or make new displacements.

It must be noticed that for a certain value of the external field frequency, termed as critical frequency, a high energy absorption occurs, due to resonance between the self- frequency of the polar group and external field frequency. The critical frequency is pointed out by the higher peak on the frequency – tg δ diagrams.

For all studied blend, low frequency values lead to high dielectric loss angles, which decrease when frequency is increased. The oscillations of dielectric measures are due to conduction processes that take place due to the existence of free charge carriers (side group such as OH, CH_2, NH_2, Cl, etc), which at the beginning of the process are in phase with the external current and lead to the increase of dielectric loss. At the same time, the "dipole-elastic" domain is prevailing at frequency lower than 10^5Hz, and the type α relaxation occur. The first characteristic peak is observed in this low frequency range.

In the high frequency range (more than 10^6Hz), "dipole-radical" loss occur, which are characteristic to the β maximum of dielectric constant, ε' (β type dielectric relaxation). The "dipole-radical" loss is more obvious in blends containing nonionic emulsifier and polysiloxane auxiliary, respectively. Multi-component blends show many characteristic peaks, determined both by the chemical nature of components and the interaction between them. At high frequency, peaks characteristic to "dipole radical" loss (β type) are alleviated in ternary and quaternary blends in comparison with individual components, thus indicating some anergetic effects.

The fact that ternary and/or binary blends present best behaviour in high frequency electric field can't be explained only by means of dielectric properties. All factors involved in the manufacturing process of the porous sheet structures must be taken in account.

5. CONCLUSIONS

Study of the behaviour of plastified PVC films exposed to external high frequency field under laboratory experimental conditions led to the following conclusions:

1. The addition of different chemical auxiliaries in the plastisol PVC blends determines changes in dielectric loss of resulting films. Thus, the increase of auxiliaries concentration determines the increase of the dielectric loss up to a maximum value irrespective the nature of the chemical auxiliary, indicating a satisfactory behaviour in high frequency electric field; consequently, high values of dielectric loss will be favorable to structures obtained;

2. The dielectric loss of PVC films, imparted by the presence of chemical additives, increased in the following order: PDMS< NE< CH< PHDMS;

3. The dielectric loss is in direct dependence with the additive concentration. In all cases, blends containing 4 parts auxiliaries presented lower loss factor values in comparison with those containing 6 parts auxiliaries;

4. Variation of dielectric loss vs. external field frequency in the studied films indicate a specific behaviour, determined by the nature and concentration of components. At a certain value of the external field frequency named "critical frequency" an increased absorption energy is noticed

due to the resonance between the self-frequency of polar groups and the external field frequency, as proved by more pronounced peaks.

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TENSILE STRENGHT OF COMPOSITE MATERIALS DURING THE LASTING PROCESS

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Abstract: *The manufacture of footwear suppose tensile loads during the lasting process of uppers. The paper presents the results of the study for the materials' behavior under tensile stress. To this intent, the breaking strength and elongation at break have been analyzed when the tensile load of 10N/mm^2 is applied to flexible materials and leather. The behavior under the tensile stress of 10N/mm^2, tested in order to determine the materials deformability during the lasting process, has been observed using tensile testing machine SATRA (STM 466) and its software providing quick and simple-to-understand load-distance graphics. The elongation corresponding to a tensile stress of 10N/mm^2, concluded from the graphics, is useful for characterizing the mechanical properties of materials as the lasting process involves stresses of about 7-8 N/mm^2. It was found that the selected materials for the present study can be used for sport footwear manufacture combined with leather and spacer fabrics. In the case of composite materials, the elongation at break is smaller than for the simple materials, tested individually. Among leathers, the biggest values of the maximum tensile force at breaking were obtained for nubuck leather, followed by box calf leather.*

Key words: *tensile, breaking, strength, elongation, leather, spacer fabric*

1. INTRODUCTION

In the lasting process of sports footwear, the shoe uppers are tensioned so that their shape is maintained after removal of the last from the finished product and particularly during wear [1, 2, 3]. The lasting process implies a tensile load applied to materials that is mostly achieved by creating a residual elongation in the structure of the material [4]. In order to obtain a spatial form as stable as possible in behavior, it is necessary that a greater part of the total elongation is transformed into plastic elongation [5, 6].

Flexible materials behavior, in the case of manufacture and wear of the sport footwear is established following a series of mechanical characteristics such as:

~ *elongation at imposed tensile load (1 daN/mm^2)*, ε_i, highlights the leather and leather substitutes' capacity to change shape in the lasting process, in the case of machines that work with loads close to this value;

~ *elongation at break*, respectively the elongation when the breaking takes place;

Starting from these aspects, the paper presents the results of tests at breaking of some flexible materials: leather and textile composites used for footwear uppers [7].

2. EXPERIMENTAL PART

The behaviour of the flexible materials has been observed with the help of testing machine SATRA (STM 466) with 466F attachment, and SATRA software, providing quick results and statistical analysis**,** figure 1.

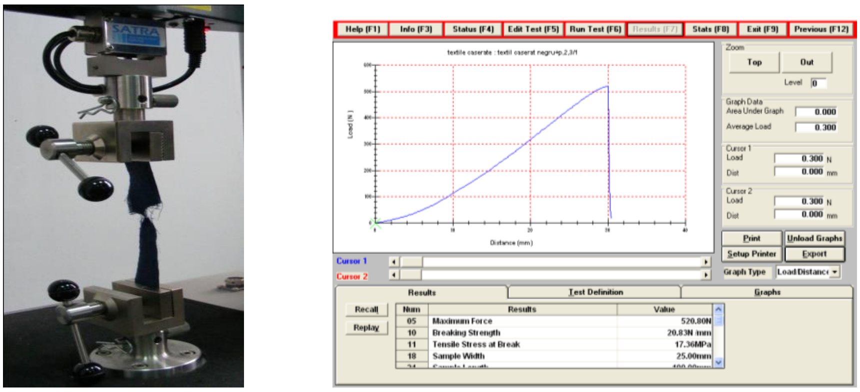
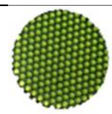


***Fig.1** Tensile testing and load distance graph at breaking*

The tests have been done with materials usually used for manufacturing sport footwear uppers, both leather and composite textiles like warp-knitted spacer fabrics, table 1.

The spacer fabrics are three dimensional kintted fabrics consisting of two separate knitted layers which are joined together by spacer yarns. The spacer fabrics tested in this paper have a monofilament spacer layer.

***Table 1.** Materials used for testing*

Nr.	Code	Material	δ /mm/	Photo sample	Nr.	Code	Material	δ /mm/	Photo sample
1.	P1	Box calf leather	1.3		4.	TS1	Spacer fabric 1	3.2	
2.	P2	Nubuck leather	1.4		5.	TS2	Spacer fabric 2	3.0	
3.	P3	Nappa leather	0.9		6.	TS3	Spacer fabric 3	2.3	

The specimens have been cut at dimensions specified in SR EN ISO 3376/2003: total length l=190mm; length betwwen clamps l_0=100, width b=20mm. After conditioning (as provided in the ISO2419 standard) the specimens were tensioned at Satra dynamometer until breaking at a speed of 100±5 mm/minute. The software of the dynamometer allowed registering of load-distance graphs as the tensile testing was performed.

3. RESULTS AND DISCUSSIONS

After testing the materials till breaking off, the software of the dynamometer SATRA STM 466 has registered for each specimen the load-distance graphic, as well as the peak force (N) –the highest value registered throughout the testing, the force at breaking (N) – registered when the specimen breaks, the breaking strength in N/mm^2, tensile elongation (%) – elongation of the sample under tensile stress, the elongation at break (%) and the longitudinal elastic modulus, in N/mm^2.

The specimens shape and dimensions were cut as provided by the SR EN ISO 2418/2003. Before testing, the specimens were conditioned under standard conditions (SR EN ISO 2419/2006) of 20±2°C and 65±2% humidity for 24 hours.

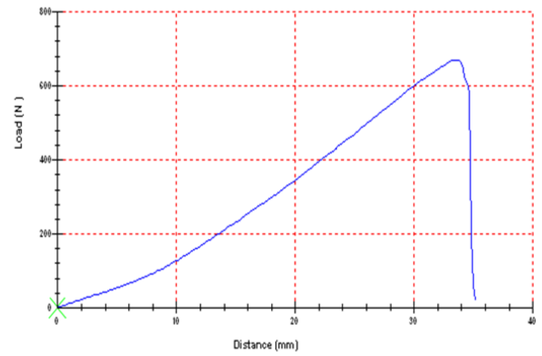
As an example, there are presented the medium values for breaking strength and elongation at break for nubuck and spacer fabric, table 2.

Table 2. *Simple materials and combined(composite) materials*

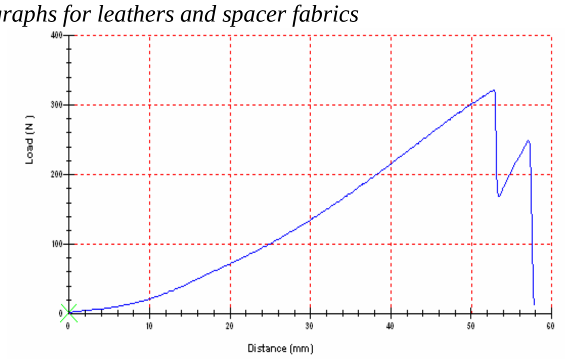
Nr. crt.	Specimen type	Code	F_{max} [N]	F_{rup} [N]	Force at breaking the first layer [N/mm]	R_{rup} [N/mm^2]	Rmax [N/mm^2]	ε [%]	E [N/mm^2]
1.	Nubuck	A3»	558.367	475.167	27.562	21.598	25.380	33.050	94.625
2.	Spacer fabric	D6	412.267	253.46	5.51	8.962	86.850	17.801	412.267
3.	Nubuck + Spacer fabric	A3D6	678.900	678.900	33.953	9.174	9.174	75.492	23.44

All graphs registered for the materials tested at *SATRA (STM 466), with STM 466F attachment*, are illustrated in table 3.

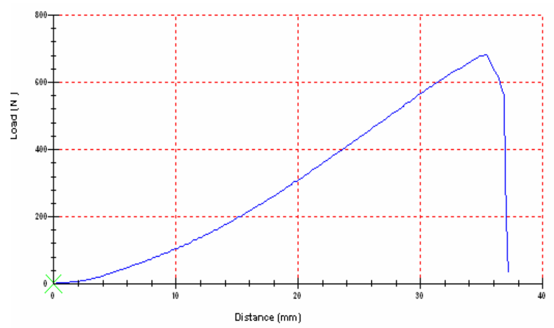
Table 3. *Load – distance graphs for leathers and spacer fabrics*

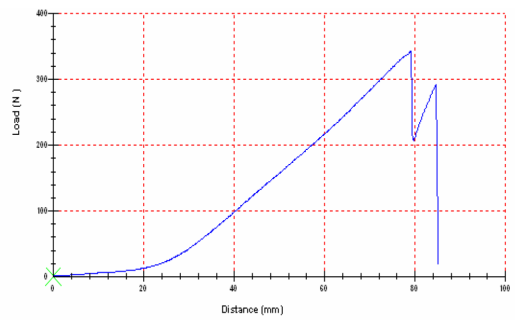


P1

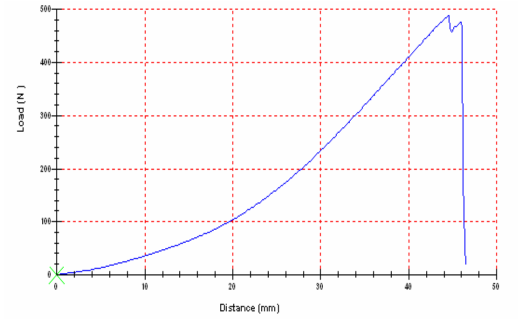


TS1

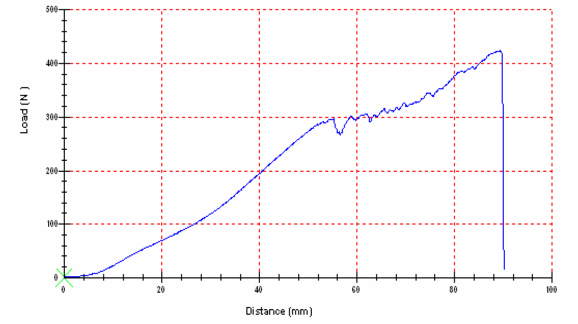




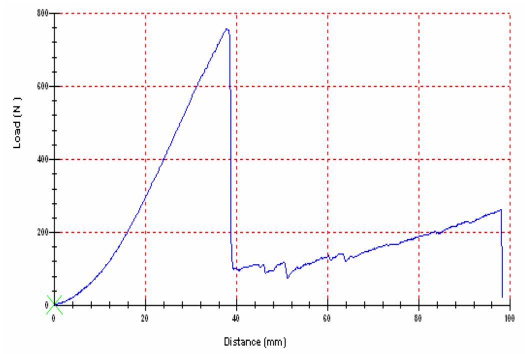
P2



TS2

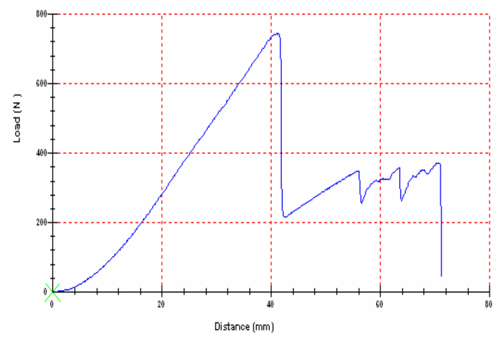


P3



P3TS2

TS3



P2TS3

The load-distance graphs that allow obtaining the elongation at an imposed value of 10N/mm^2, resulted a value of 17.2% for the box calf leather P1. In the case of an imposed tensile load of 10 N/mm^2, the elongation is 18,5% for nubuck , and 26.5% for the nappa leathers.

In the case of the tested leathers, the obtained values for the elongation corresponding to a load of 10N/mm^2 are situated in the limits provided by the actual standars, respectively between 18-28%. As seen in the graphs, the maximum values of the peak force were obtained for nubuck (P2), followed by the box calf leather (P1). Concerning the breaking strength the spacer fabrics have smaller values than for the leathers, figure 2.

The breaking strength corresponding to the first cracking point of the fabric is smaller than the maximum strength obtained during the entire tensile testing. The spacer fabric TS3 resists only at a value of 7N/mm^2. Spacer fabrics TS1 and TS2 present a smaller strength during the lasting process. Thus, in order to resist throughtout the lasting process of the uppers, these materials must be reinforced in the areas of maximum tensioning.

The elongation at break is comprised between 40-78% for spacer fabrics and 32-42% for leathers used in the manufacture of footwear uppers, figure 3.

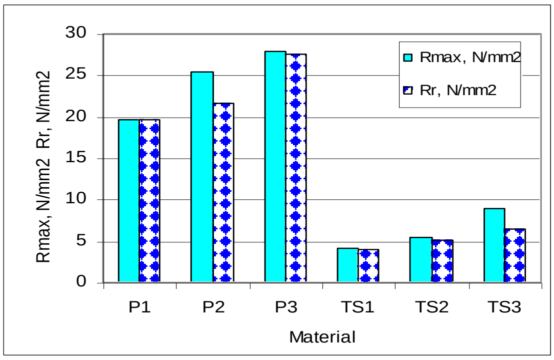


Fig.2. *The breaking strength for leathers and spacer fabrics*

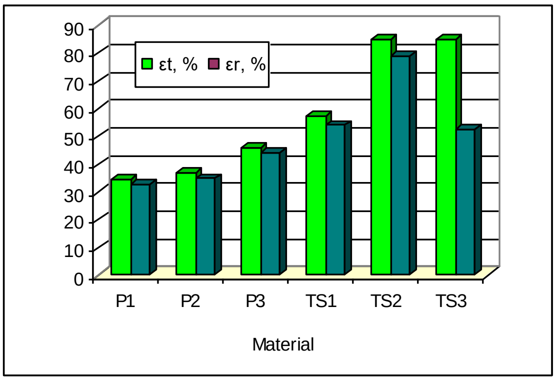
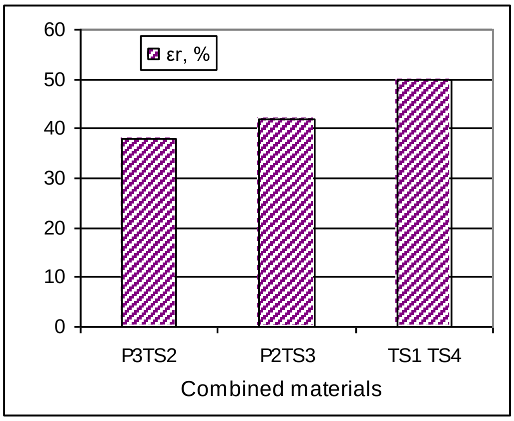
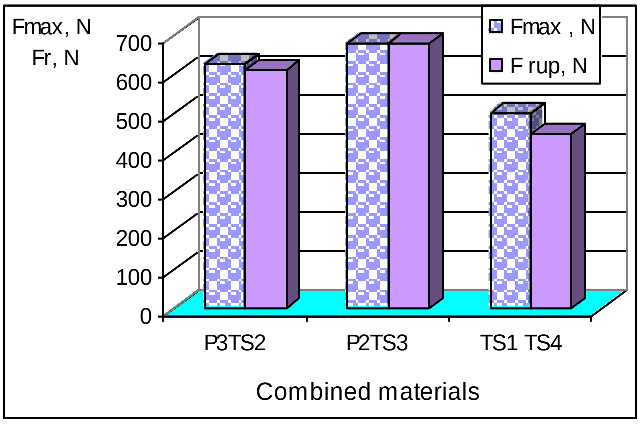


Fig.3 *Elongation at break*

These fabrics break at forces far bellow those corresponding to an imposed load of 10N/mm^2.

In the case of composite materials, the elongation at break is smaller for the structures of materials than for the simple materials, figure 4a. Instead, small differences between the peak force and the force at breaking are noted, figure 4b.





b)

Fig.4. *Elongation at break (b) and force at breaking (a) for the combined materials*

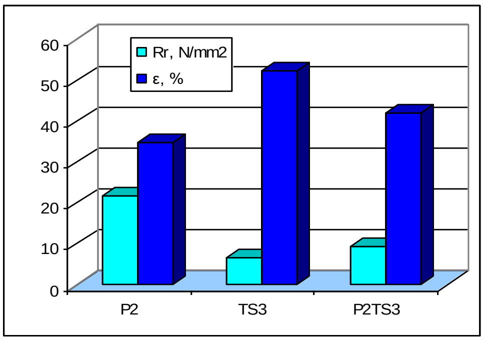


Fig.5. *Elongation at break and breaking strength for simple and combined materials*

From the tested composite materials, P2TS3 (nubuck with spacer fabric) presents the highest value of the force at breaking, the strength being of 9,2 N/mm^2. Thus this structure of combined materials will resist during the lasting process.

Elongation at break and breaking strength for the structure of materials P2TS3 are illustrated in figure 5, comparatively with values registered for the component materails (leather and spacer fabric), tested individually.

4. CONCLUSIONS

In the case of tested materials several results emerge:

- ✓ The load-distance graphs from the Satra dynamometer offer useful information as fot the breaking of materials.
- ✓ Among the tested leathers, the biggest values of the maximum tensile force were obtained for P2 leather (nubuck), followed by P1 leather (box calf), respectively values of breaking strength between 20 şi 28N/mm^2.
- ✓ The spacer fabrics present a strength of the first breaking smaller than the maximum tensile strength, respectively values between 3.80 and 11N/mm^2.
- ✓ The spacer fabric TS3 resists only at a load of 7N/mm^2. Spacer fabrics TS1, TS2 present a small tensile strength during the lasting process, so these fabrics cannot be used individually , a reinforcement with leather must be done in the forepart, heel or sideways.
- ✓ As for the composite materials, P2 TS3 (nubuck spacer fabric) presents the highest value of breaking strength, respectively 9,2N/mm^2. So, this combination of materials will resist in the lasting process of uppers. The structure of materials P3TS2 will resist at a tensile load of 7N/mm^2.
- ✓ The maximum elongation at break, for the combination of materials (leather and spacer fabric), present bigger values than the elongation corresponding to the break of the inferior layer of the material.
- ✓ The load – distance graphs registered at Satra dynamometer determine the elongation at an imposed tensile load of 10N/mm^2, in order to highlight the deformation capacity during lasting process (knowing that the tensile loads at uppers lasting are of 7-8 N/mm^2).
- ✓ In the case of the tested leathers, the values of elongation obtained under a tensile stress of 10 N/mm^2 are within the limits set by the standards, ie between 18-28%.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

REMOVAL OF DYES (DIRECT RED 80 AND LEVAFIX BRILLANT BLUE) BY USING VINE STEM WASTE AS A BIOSORBENT

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Abstract: *Synthetic dyes, which are commonly used in textile, paper, leather and plastic industries, pose a significant risk to the environment. This means that the wastewater from industrial sources mixes with groundwater, surfacewater or rivers, affecting aquatic life, water quality and food chain in negatively. Vine stem is an agricultural side product and has no economic value. Every year hundreds thousands of tons vine stem come out as a waste by trimming or pruning and destroyed by burning. In the present study, grinded vine stem was investigated as a biosorbent for the removal of dyes from the aqueous solution. To identify the functional groups of the biosorbent, attenuated total reflectance spectra (ATR-IR) were used. The zeta potential of vine stem was measured as a function of pH for investigating the surface charge. It was found negativity for all the pH. The batch biosorption method (BBM) was used for the study. The analysis of the pH functioning, biosorbent amount, and contact time of the biosorption process have been made. The Langmuir model was found to fit well with the experimental data for the biosorbent. The maximum adsorption capacities were found as 53.5 and 45.5 for Direct Red 80 and Levafix Brillant Blue, respectively. The optimization study revealed that the grinded vine stem can be an effective and economically feasible biosorbent for the removal of dye.*

Keywords*: Biosorption, vine stem, dye Direct Red 80, Levafix Brillant Blue*

1. INTRODUCTION

Synthetic dyes, which are commonly used in textile, paper, leather and plastic industries, pose a significant risk to the environment. This means that the wastewater from industrial sources mixes with groundwater, surfacewater or rivers, affecting aquatic life, water quality and food chain in negatively [1]. Varied methods such as chemical precipitation and filtration, chemical reduction and oxidation, electrochemical purification, ion exchange, reverse osmosis are used for the removal of dyes. Adsorption techniques are preferred today because of the advantages of the adsorption process which are more economical, simple design and independence from high concentration.The toxic chemicals can be removed without degrading the quality of the water and without releasing any reduced toxic substances. Most effective adsorbent is active carbon, but it is quite expensive [2]. For this reason, the researches were focused on alternative low-cost adsorbents to active carbon and explored the substances which is cheap and obtained easier [3]. Bentonite, clay, fly ash, chitosan, chitin etc. substances were used as an alternative to the active carbon. In addition, lignocellulosic biomass is also used as biosorbent because of the negative surface charge of the outer surfaces [4]. It is thought that the use of the wastes will make an economical contribution to the environment. Vine-stem waste was used as an adsorbent in the present study. In Turkey, an area of 560.000 hectares produces approximately 3.500.000 tons of grapes per year and generates approximately 300,000 tonnes of vine stem wastes emerge annually after pruning, which is destroyed by incineration or various methods.

The purpose of the study is to investigate the removal capacity of the vine stem on theaqueous solution containing Direct Red 80 and Levafix Brillant Blue dyes. The analysis of the pH functioning, biosorbent amount, and contact time of the biosorption process have been made.

2. MATERIALS AND METHODS

2.1 Materials

The vine-stem wastes were collected from the vineyards in the Manisa/Turkey region and separated into small pieces, then washed with pure water until the color of the washing water was clear. Then, it was dried under the daylight and re-milled having a 0.25 mm particle sized sieve. After milling step, the grinded substance was oven dried at 110 ºC till constant weight was obtained for the study.

2.2 Dyes

Structures of the dyes are given in the Figures.

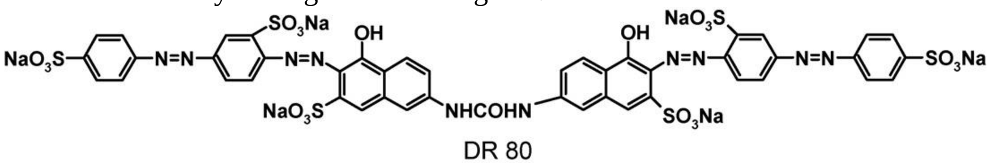

Fig. 1: *Direct Red 80*

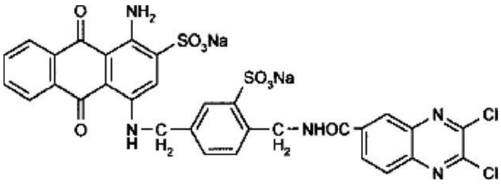

Fig. 2: *Levafix Brilliant Blue E-B*

2.3 Adsorbent characterization

The electrophoresis method was used to determine the zeta potential of the vine stem by using a Zeta-Meter. The zeta potential of the particles was measured as a function of pH between 2 and 10. Attenuated total reflectance infrared (ATR/IR) spectra of biosorbents and activated carbon were taken by using a spectrophotometer (Spectrum 100, Perkin-Elmer)

2.4 Methods

The adsorption experiments were carried out for specific time intervals with 100 mL of known dye concentration. A certain amount of the biosorbent and known concentration of dye solution were shaked with the orbital shaker (150 rpm) at 25 ± 2 °C. Prior to mixing, the pH of the solution was adjusted using with pH-meter with glass electrode. At the end of the each experiment, the biosorbent was carefully removed by filtration with the aid of filter paper and the absorbance of dye in the filtrate was measured by UV spectrophotometer. All experiments were repeated 3 times and mean results were given.

3. RESULTS AND DISCUSSION

3.1 Surface properties

3.1.1 FT-IR spectra

The Fig. 3 shows the FT-IR analysis of vine-stem. The bands;1023–1030 cm^{-1} corresponding to C-O deformation vibrations in cellulose, 3000 and 3600 cm^{-1} attributed to the associated OH- functional group of phenols, alcohols, and carboxylic acids. 2923 cm^{-1} and 1734 cm^{-1} can be assigned to the C-H bonds of aliphatic acids and C-O stretching band of aromatic ethers, esters, respectively and phenols appearing at 1232 and 1234 cm^{-1}.

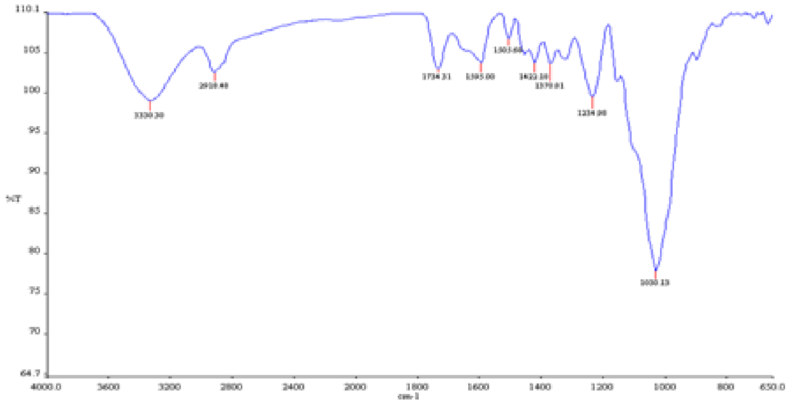

Fig. 3: *FT-IR spectra of vine-stem waste.*

The bands at 1705 and 1575 cm^{-1} can be attributed to the C-O stretching in ketones and esters, respectively. The wide band between 1500 and 900 cm^{-1} may be attributed to ether groups and the band at 878 and 753 cm^{-1} show the aromaticity [5].

3.1.2 Zeta Potential

The surface charge of adsorbents was investigated by measuring zeta potential. The zeta-potentials of vine-stem in a pH range of 2–10 were measured. Fig. 4 shows the variation of zeta potential (z) of adsorbents as a function of pH. The surface of biosorbent exhibited an increasing negativity as the pH of the solution increased slightly from 2 to 10 and indicated negative charge values that should be favorable to the attraction between active sites and positive charges of dyes, resulting in an electrostatic interaction [5].

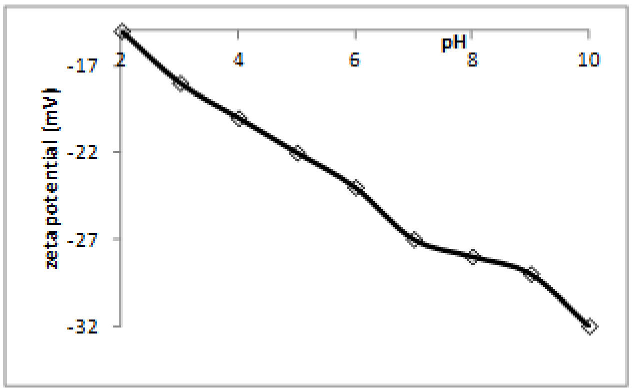

Fig. 4: *The effect of pH on the zeta potential of vine-stem.*

3.2. Direct Red 80

3.2.1 The Effect of Contact Time

50 ppm Direct Red 80 (pH 2) and 0.1 g biosorbent were mixed with orbital shaker for 2, 4, 6 and 24 hours. There was no significant effect on the adsorption capacity after 4 hours, so the contact time was chosen as 4 hours.

3.2.2 The Effect of pH

50 ppm Direct Red at different pHs and 0.1 gram of biosorbent were stirred in the shaker for 4 hours. No removal was observed at pH >2 so pH was selected as 2. This is compatible with the work of Ardejani et al. (2008) using a different adsorbent with same dye [6,7]. The biosorbent is lignocellulosic and consists of negative groups on its surface. Since the dye has a negative charge, it is not observed to be removed at higher pH due to the repulsion between the dye and the adsorbent due to increased OH^- groups at high pH [5].

3.2.3 The Effect of Biosorbent Amount

50 ppm Direct Red 80 and different amounts of biosorbent (0.05, 0.1, 0.2, 0.5) were mixed for 4 hours in a shaker. As it can be seen from the Fig. 5, the highest removal of dye was obtained by using 0.05 gram biosorbent.

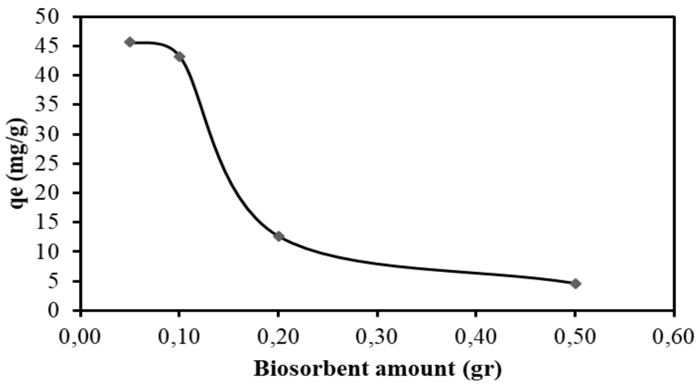

Fig. 5: *The effect of biosorbent amount on the adsorption capacity of Direct Red 80 Dye*

3.2.4 The Adsorption Isotherm

Adsorption isotherms were obtained by mixing 100 mL dye (pH 2) ranging from 30-130 ppm in concentration at optimum conditions. Langmuir and Freundlich isotherms which are commonly used for adsorption have been tested and the adsorption is coincided with the Langmuir ishoterm. The maximum adsorption capacity was found to be 53.48 mg/g and the Langmuir constant (K_L) was calculated as 0.000855 L / g. The maximum adsorption capacity was found to be 28.50 mg /g by the researchers working on the same dyes [6]. In another study, the maximum adsorption capacity was calculated as 21.052 mg /g using the orange shell for the same dye. In another study using soy bran, the maximum adsorption capacity for the same dye was calculated to be 178.57 mg /g [6]. Langmuir isotherms suggests that adsorption was a single layer. Potential binding sites are thought to be phenols, alcohols, and carboxylic acids in the biosorbent.

3.3. Levafix Brillant Blue

3.3.1 The Effect of Contact Time

100 ppm Levafix Blue Brillant (pH 2) and 0.1 g biosorbent were mixed with orbital shaker for 2, 4, 6 and 24 hours. There was no significant effect of the contact time on the adsorption capacity. So, the contact time was chosen as 2 hours.

3.3.2 The Effect of pH

50 ppm Levafix Blue Brillant at different pHs and 0.1 gram of biosorbent were stirred in the shaker for 2 hours (Fig.6). The best removal observed at pH 2 and decreased as pH increase, so pH was selected as 2. It is not observed to be removed at higher pH due to the repulsion between the dye and the adsorbent due to increased OH^- groups at high pH [5].

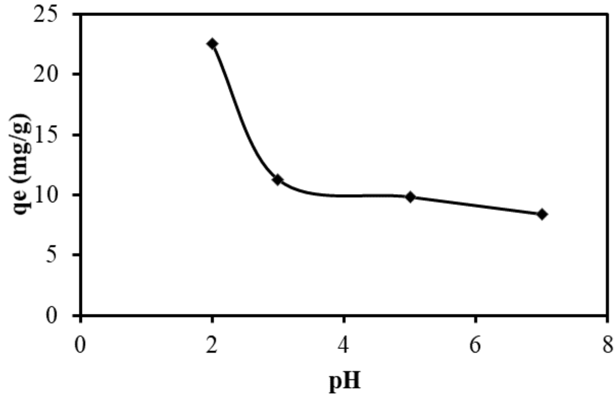

Fig. 6: *The effect of pH on the adsorption capacity of Levafix Blue Brillant Dye*

3.3.3 The Effect of Biosorbent Amount

50 ppm Levafix Blue Brillant (pH 2) and different amounts of biosorbent (0.05, 0.075, 0.1, 0.5) were mixed for 2 hours in a shaker. The highest removal was at 0.05 grams.

3.3.4 The Adsorption Isotherm

Adsorption isotherms were obtained by mixing 100 mL dye ranging from 20-110 ppm in concentration at optimum conditions. Langmuir and Freundlich isotherms have been tested and the adsorption is coincided with the Langmuir ishoterm. The maximum adsorption capacity is found to be 43.48 mg /g and the Langmuir constant (K_L) is calculated as 0.003128 L/g. In the study of Erkut et al. (2012) using Aspergillus oryzae to investigate the removal of Levafix Blue Brillant dye, the maximum adsorption capacity was found to be 61 mg/g [8]. Yavuz and Aydın (2005) calculated the maximum adsorption capacity of 26.22 and 48 mg/g, respectively, using activated carbon, kaolinite and montmorillonite from coconut shell for the same dye [9]. In another study using the fibers of the banana tree, the maximum adsorption capacity for the same dye was calculated to be 4.42 mg/g [10].

4. CONCLUSIONS

In this study, vine stem was investigated as a biosorbent for the removal of textile dyes (Levafix Blue Brillant and Direct Red 80) from aqueous solution. The biosorption data conformed best with the Langmuir model for Direct Red 80 and Levafix Brillllant Blue. The maximum adsorption capacities were found as 53.5 and 45.5 for Direct Red 80 and Levafix Brillllant Blue, respectively. The results showed that vine stem can be used as low-cost biosorbent in treating colored dye effluents.

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ALTERNATIVE LEATHER MANUFACTURING PROCESS - 1. PRE-TANNING WITH A REACTIVE OLIGOMERIC RESIN

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Abstract:*This paper presents a non-conventional tanning technology, which uses a benzenesulfonate melamine-formaldehyde resin (BSMF) as pre-tanning agent. BSMF tanning alone can produce white leather, which generates chrome-free leather wastes. A BSMF pre-tanning step can be applied prior to a tanning step with lower chrome offer - 1 % Cr_2O_3, as compared with the conventional chrome tanning technology, which uses around 2 % Cr_2O_3. Thus, low chrome-content leather can be obtained, having the organoleptic properties and physico-mechanical behavior similar to those obtained through conventional processing, mainly as it regards the hydrothermal stability. The cross-section of leather pre-tanned with the BSMF resin is less compact as the cross-section of the conventionally chrome tanned leather, which proves that BSMF tannage alone cannot provide leather with the performances acquired by the chrome tannage. Physical deposition of the BSMF product in the interfibrillar voids and envelopment of collagen fibers, significantly contribute to the fibrilar matrix consolidation, which is the essential condition for splitting and shaving in the tanyard, before chrome tanning and vegetable retanning steps. A BSMF pre-tanning, followed by a chrome tanning with an offer of 1 % Cr_2O_3 and mimosa extract retanning results in leather having the compositional and structural characteristics required by the upper leather type standards.*

Key words*: tanned leather, melamine-formaldehyde resins, wet-blue, wet-white, clean technology*

1. INTRODUCTION

During recent years, there is an increasing concern on the replacement of chrome as tanning agent, due to more stringent restrictions regarding the environmental pollution with chrome-containing wastes coming from tanneries. Efforts to find alternative solutions have been focused on complete replacement of chrome with other tanning agents (basic salts of metals such as Al, Zr, Ti, vegetable tannins,synthetic organics), partial chrome replacement, alternative technologies based on low-offer or high chrome exhaustion [1-5].

Synthetic tannins, also termed as syntans, are reactive chemicals whose action is based on chemical reactions with the collagen functional groups. Sulfonated condensation products of aromatic compounds with low-molecular weight aldehydes are a class of syntans commonly used as retanning agents, but little investigation has been done on their use as pre-tanning agents [6,7].

Chemically modified condensed triazine, known as sulfonated melamine-formaldehyde resins (SMF) showed satisfactory pre-tanning or even tanning effects [8,9], but has at the same time several shortcomings, such as low storage stability, low solubility in the processing float, high hydrophilicity imparted to leather, high prices. Studies on the use of benzenesulfonated melamine-formaldehyde (BSMF) resin as pre-tanning agent showed that its tanning effect is based on its uniform diffusion in the leather cross-section, and on its ability to envelope the collagen fibers and to fill the interfibrillar voids within the collagen fibrous matrix. Tanning practice showed that, as compared with other SMFs, BSMF is able to raise the shrinking temperature of the processed leather, allowing a lower offer of basic chromium salt in the tanning operation [10].

This paper is dealing with a novel tanning technology of cattle hides, which consists of a pre-tanning step with the benzenesulfonated melamine-formaldehyde resin, a low-offer chrome tanning stage and a final vegetable retanning, in order to obtain low chrome-content finished leather that meets the quality requirements for upper leather.

2. EXPERIMENTAL

The effectiveness of the BSMF resin as pre-tanning agent was tested within a novel process for the obtaining of upper leather from light and medium weight cattle hides. The framework technological process, which uses the BSMF product as pre-tanning agents in conjuction with a low-offer chrome tanning stage is given in Fig. 1. The conventional operations in the tanyard are also presented. The chromium offer is given as chromium oxide, Cr_2O_3 per 100 kg pre-tanned leather; the BSMF offer is given as liquid product, with 26% dry matter, per 100 kg delimed pelt.

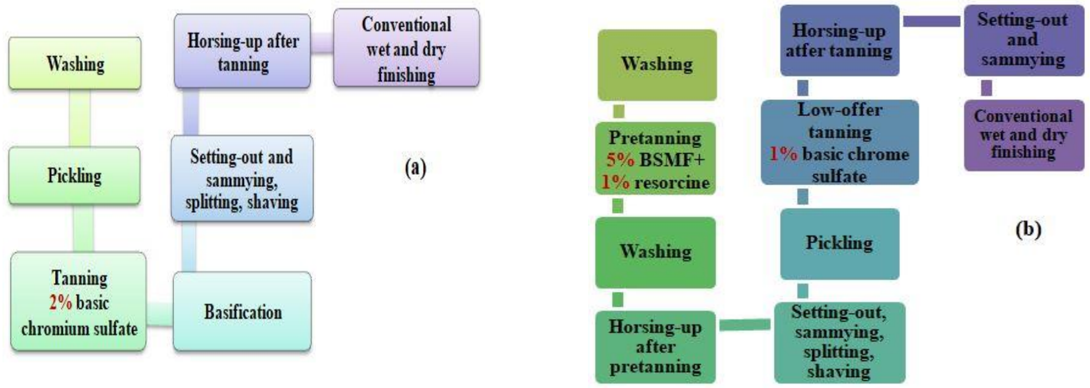


Fig. 1. *Tanning process: (a) Conventional chrome tanning; (b) low-offer chrome tanning using a BSMF*

3. RESULTS AND DISCUSSIONS

3.1. Physico-mechanical and chemical characterization of the processed leather

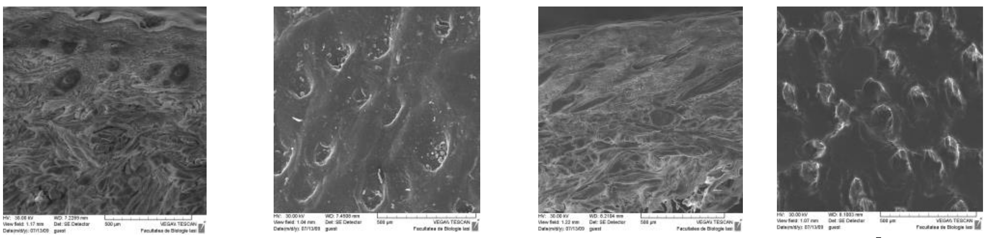
Physical and chemical tests of pretanned leather samples were performed in accordance with SR EN ISO 2418:2003, SR EN ISO 2419:2006 and SR EN ISO 4044:2002. From the test results, given in Table 1, it is obvious that the pretanning stage has a positive effect on the physico-mechanical behaviour of in-process leather. Improvement of firmness and compactness facilitates the execution of the mechanical operations such as splitting and shaving in the tanyard. Performing these operations before chrome tanning has the advantage of generating chrome-free collagenous wastes. Subsequent chrome tanning and vegetable retanning provides leather with characteristics similar to conventionally tanned leather, mainly as it regards the hydrothermal stability. The only noticeable discrepancy is related to the extractible matter content, which is much lower than that imposed by standards. Subsequent fatliquoring with carefully chosen fatliquoring products can make up for this shortcoming.

3.2. SEM Electron Microscopy

The performances of the novel tanning technology can be assessed by means of SEM images of leather surface and cross-section, in different processing stages. Comparative SEM images of finished leather obtained by the conventional chrome tanning process and by the novel technology, which includes an organic pre-tanning stage, are given in Figure 2. The cross-section of leather pre-tanned with the BSMF resin (Fig. 2 (c)) is less compact than the cross-section of the conventionally chrome tanned leather (Fig. 2 (a)), which proves that BSMF tannage alone cannot provide leather with the performances acquired by the chrome tannage. Physical deposition of the BSMF product in the interfibrillar voids, which is obvious in Fig. 2 (c), significantly contributes to the fibrilar matrix consolidation, which is the essential condition for splitting and shaving in the tanyard, before chrome tanning and vegetable retanning steps.

Table 1: *Characteristics properties of leather processed by the low-offer chrome technology*

No.	**Characteristic / Property**	**UM**	**Assessment/Numerical value**		**Method of determination**	**Current values**
			on wet-basis	on dry-basis		
1.	Water content, **U**	%	13,37	--	STAS 8574 / 1992	10 ÷ 15
2.	Total nitrogen (TKN), **N**	%	14,58	16,83	SR EN ISO 5397: 1996	--
3.	Dermal matter, **SD**	%	82,06	94,72	SR EN ISO5397:1996	--
4.	Mineral substances **SM**	%	1,87	2,15	SR EN ISO 4047:2002	min. 3,5 %
5.	Chromium oxide (Cr_2O_3), T	%	1,47	1,67	STAS 8602 - 90	max. 2,5 %
6.	Extractable fat matter, **SG**	%	2,70	3,11	SR EN ISO 4048:2002	max. 8 %
7.	Total dry matter	%	86,63	99,99	STAS 723 / 15 - 76	--
Mass balance (U+SD +SM+SG)			**99,76**	--	Calculation	--
Mass balance on a dry-basis (SD+SM+SG)				99,98	Calculation	--
8.	Grain appearance	--	not uptight	--	Organoleptically	--
9.	Feel	--	soft, warm	--	Organoleptically	--
10.	Firmness	--	semi rigid	--	Organoleptically	--
11.	Folding	--	large folds	--	Organoleptically	--
12.	Shrinkage temperature, **T**$_C$	° C	97 ± 0,5	--	SR EN ISO3380 : 2003	100 ± 0,5 ºC
13.	Shrinkage coefficient , **I**$_C$	%	3 ± 0,3	--	SR 5053 :1998	max. 5 %
14.	Tensile strength, σ_R	N / mm ^{2}	39,8 ± 1,1	--	SR EN ISO 3376: 2003	min. 22
15.	Elongation at break, ε_R	%	41 ± 3	--	SR EN ISO3376 : 2003	max. 80
16.	Tear strength, $\sigma_{R\ tear}$	N / mm	46 ± 1,4	--	SR 5045 : 1999	min. 30
17.	Water vapor permeability	mg H_2O/24h	--	459		500 - 541



a b c d

Fig. 2: *SEM images of in-process leather*: a) *Cross-section of chrome-tanned leather; (b) Surface of chrome-tanned leather; (c) Cross-section of leather tanned with BSMF and chrome; (d) Surface of leather tanned with BSMF and chrome*

The cross-section images of the conventionally chrome-tanned leather (Fig. 2 2(a)) and of the leather processed according with the novel technology (BSMF pre-tannage + low-offer chrome tannage + vegetable retannage), given in Fig. 2 (c), are similar. Surface SEM image of the leather processed according with the novel technology (Fig. 2 (d)) is clearly different from the other two: pores are closed, the grain is tighter, and surface roughness is higher. This effects must be assigned to the vegetable tanning agent, which has an astringent action and modifies the cross-section distribution of the BSMF resin.

4. CONCLUSIONS

The proposed tanning process allows entire or partial replacement of chrome as tanning agent and provides the execution of splitting and shaving operations on the BSMF-pretanned leather, which avoids the generation of chrome-containing solid wastes. The BSMF tanning alone results in wet-white leather. The BSMF pretanning followed by a low-offer chrome tanning (1% chrome as chrome oxide) and a vegetable tanning step results in leather types that fully meet the requirements for upper leather. This is ascertained by the chemical and physicomechanical properties of finished leather and by the SEM images.

A tanning process that includes a BSMF resin pre-tanning and a low-offer chrome tanning provides leather with structural and compositional stability that meet the requirement for finished leather types.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

VIABLE ENVIRONMENTAL TECHNOLOGIES INTEGRATED WITH CLEANER PRODUCTION - SUSTAINABLE OPTIONS FOR GLOBAL LEATHER SECTOR

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Abstract: *World Leather tanneries process 16 to 17million tones of hides & skins per year and generate 600million m*^{3} *of wastewater. Nearly 60% of the World Leather production is carried out in Asian region and the tanneries discharge more than 350 million m*^{3} *of wastewater per annum. Environmental challenges due to the depletion of quality water resources, disposal of chrome containing sludge, increase in salinity, etc. have resulted in the development of sustainable cleaner production in tanneries and upgradation of treatment technologies such as advance oxidation for reduced sludge generation. Viable cleaner production and treatment technologies had been engineered in many individual and Common Effluent Treatment Plants (CETPs) in India, China, Turkey and other leather producing countries.*
Some of the recent developments in environmental protection technologies are (i) Improved chrome recovery system (ii) Advanced process control and cleaner production (iii) Special biological treatment system with mild chemical usage for reduced sludge generation (iv) Advanced tertiary treatment systems, etc. for the application of single or multiple stage Reverse Osmosis (RO) system for recovery of water. Recent applied R&D on the sustainable development in cleaner leather production, environmental protection techniques with focus on saving of energy, chemical usage, occupational health and safety, water-recovery for reuse, development of social forestry using treated effluent, salt recovery, marine disposal of saline reject with proper bio-control system, etc. are dealt in this noval technical paper.

Keywords: *Improved Chrome Recovery system, Effluent Treatment, Sludge generation, Biological treatment, Water Recovery.*

1. INTRODUCTION

Annual leather process in Asian Countries is estimated at 8 to 10 million tons of hides and skins which is more than 50% of the world leather production of about 16 million tons per year. The tanneries in Asian countries including India, China, Vietnam, etc. discharge more than 350 million m^3 of wastewater per annum [1]. In India there are 20 Common Effluent Treatment Plants (CETPs) mainly located in Tamilnadu, Uttarpradesh, Kolkata and Punjab.

Conventional physiochemical and biological treatment systems are designed and implemented only to reduce Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids (SS), Heavy metals etc. and not TDS and salinity which are mainly contributed by chlorides, hardness and sulphates[2]. Due to inherent quality of wastewater from tanning industry, the treatment plants are unable to meet the prescribed standards in terms of TDS, chlorides in salinity in the treated effluent. The TDS limit is being enforced in India and other parts of the World depending upon the final mode of disposal. In addition to the removal of TDS in the treated effluent, it is necessary to recover water for reuse to meet the challenge of water shortage. In some of the states such as Tamilnadu in India, the pollution control authorities insist on water recovery integrated with Zero Liquid Discharge (ZLD) system[3]. However, the achievement of Zero Liquid Discharge concept has got many technical challenges in terms of management of saline streams from membrane system, disposal issues of contaminated salt from multiple stage evaporator, high operation and maintenance cost, etc.

Recent directions from the National Green Tribunal (NGT) and Environmental Protection authorities, paved way for adoption of Sustainable Technologies[4] Integrated with Cleaner Production, Centralized Chrome Recovery System and TDS management without the use of Multiple Stage Evaporator (MEE).

2. CLEANER PRODUCTION AND SEGREGATION OF STREAMS FOR CONTROL OF CHROMIUM AND SALINITY

Due to inherent quality of industrial wastewater such as textile dyeing units, tanneries etc., the conventional treatment plants are unable to meet the prescribed TDS level of 2100 mg/l in the treated effluent. In addition to TDS management the control of volatile solids in hazardous category sludge is also becoming a necessity. For control of salinity, chromium, sludge and viable management of TDS with recovery of quality water from wastewater, the required treatment steps are (i) Cleaner production and other viable process control in tanneries (ii) Segregation of streams such as spent chrome liquor for recovery and reuse (iii) Upgradation of biological treatment systems with better efficiency in BOD and COD removal, (iv) Minimum usage of chemicals in the treatment process and reduction in sludge generation (v) Tertiary treatment and integration of treated tannery effluent with treated domestic sewage wherever feasible for TDS management [5].

Some of the land locked locations such as in Uttar Pradesh and Tamilnadu in South India where the availability of domestic sewage is limited for dilution with treated domestic sewage the noval idea of segregation of soak liquor, separate treatment and recovery of quality salt for reuse have been developed and are being adopted in many tannery clusters. The segregated soak liquor is taken to the CETPs through separate pipe line and after primary and secondary treatment units, membrane system is adopted for recovery of water and quality of saline stream for reuse in pickling. The balance treated saline stream is evaporated and quality salt (98% purity) is recovered for reuse without any difficulty. In addition to recovery and reuse of quality water by the industry, the additional benefits are savings in chemical usage in the tanning process and reduction in pollution load in the effluent.

The segregated chrome stream is taken for Centralized Chrome Recovery System (CCRS) for recovery of chromium in the form of chromium cake. The process flow diagram of the improved chrome recovery system is given below:

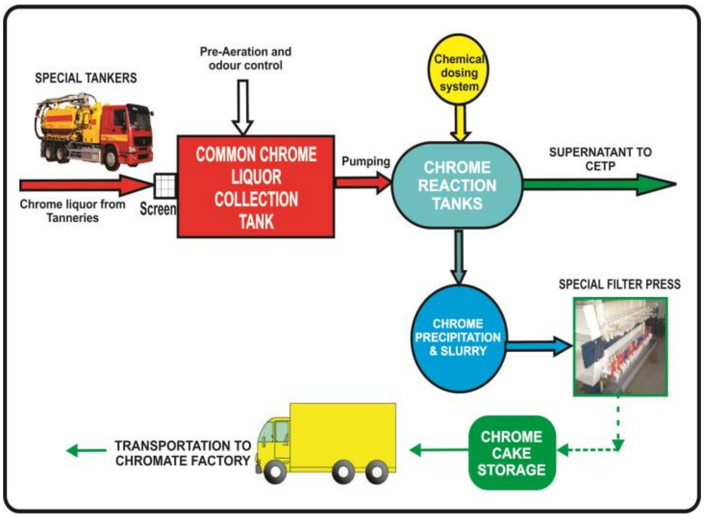

Fig.1: *Improved Chrome Recovery System and Recovery in the form of Chrome Cake*

3. SUSTAINABLE INTEGRATED TREATMENT FOR TDS MANAGEMENT AND FINAL DISPOSAL

Due to the segregation of soak liquor and chrome stream for separate treatment and reuse, the TDS level in the main combined stream taken to the CETP is reduced by 50% and it has become viable to adopt fully biological treatment system and scope for mixing the treated effluent with treated domestic sewage for overall TDS management and disposal by meeting all the discharge parameters without the necessity of multiple stage evaporator[6].

The technological system developed in accordance with the National Green Tribunal (NGT) and Pollution Control authorities is shown in the following process flow diagram.

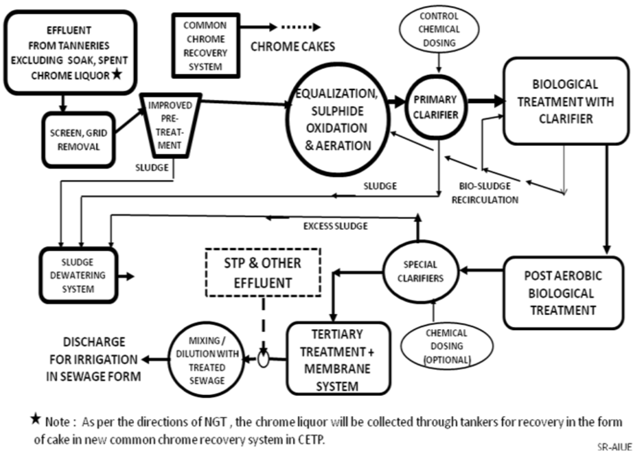

Fig.2 : *Upgradation of CETP – Integrated with Cleaner Production and Mixing with treated domestic sewage for TDS management*

4. CONVERSION OF PHYSIOCHEMICAL TREATMENT IN TO TOTAL BIOLOGICAL TREATMENT

In conventional physiochemical treatment the effluent is collected in equalization cum mixing system, pumped to the primary clarifier, mixed with high dosing of chemicals such as lime alum, etc. The conventional system adopted in most of the CETPs in India could not reduce the sulphide level in the physiochemical treatment and the sludge accumulation in the equalization tank is one of the major problems. The COD reduction to the prescribed level (i.e. 250mg/l) in the final treated effluent could not be met by some of the CETPs adopting conventional physiochemical and biological treatment. The performances of the aerobic biological treatment system with limited detention time are not satisfactory and unable to produce required quality effluent.

With a view to oxidize the sulphide present in the effluent, control the sludge settling in the equalization tank and to minimize the chemical usage the equalization system has been upgraded with increased detention time, increased depth and usage of new type of aspirators integrated with compressor. The residual excess biosludge from secondary clarifier is pumped to the equalization tank which is helpful in biological oxidation process and to reduce the chemical dosage in the first stage clarifier [7]. The upgradation of equalization cum mixing system in to aerobic biological oxidation using residual / excess biosludge and adopted in one of the CETPs in India is shown below:

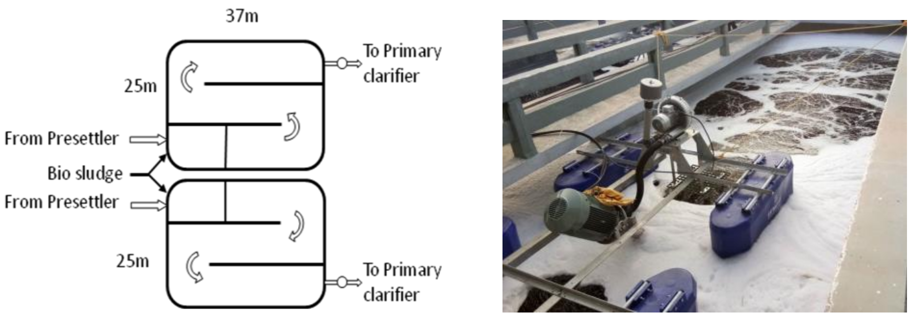

Fig. 3: *Upgraded biological treatment system using Jet Aspirator*

The primary clarifier units are also upgraded by providing elevated clarifiers with minimum required chemical dosing. This improved system is performing better in terms of sludge settling, withdrawal and dewatering. The elevated primary clarifier implemented in one of the CETPs is shown below:

Fig.4 : *Elevated Primary Clarifier*

The improved aeration system with jet aspirator has been successfully adopted in one of the CETPs in Tamilnadu and planned to be adopted in more CETPs in Uttarpradesh and other locations. The viable alternatives to ZLD are being developed and implemented in many CETPs. It is also estimated that nearly 80% capacity of the wastewater from Indian Leather Sector will be treated by adopting cleaner technologies, segregation of streams and separate treatment, integration with treated domestic sewage, etc[8]. In this circumstance, the long term sustainability of the CETPs which are forced to adopt ZLD by incorporating systems such as Multiple Stage Evaporator (MEE) need be reviewed for adoption of sustainable treatment options.

5. CONCLUSION

The conventional physiochemical treatment systems are being upgraded and converted in to total biological treatment system to reduce sludge generation and to achieve the pollution control discharge parameters such as COD and clarity in the treated effluent. Many organizations in countries such as India, China, etc. extend technical and financial support for upgradation of CETPs with Improved Cleaner Production Process, Centralized Chrome Recovery and Reuse systems, Integrated treatment with treated domestic sewage for sustainable TDS management, etc. These technological developments and upgradation of CETPs are being carried out by many CETPs in Tamilnadu and Uttarpradesh with financial outlay of more than 150 million US dollars.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

NEW MICRO AND NANO-STRUCTURED EMULSIONS BASED ON COLLAGEN AND KERATIN HYDROLYSATES

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Abstract: *The aim of the paper is to create new micro and nano-structured emulsions based on multifunctional surfactants (bolaform and gemini) with potential applications in designing foliar fertilizers based on collagen and keratin additives. Collagen and keratin additives were extracted from leather industry by-products using chemical and chemical-enzymatic hydrolyses. Bolaamphiphiles and gemini are new classes of amphiphilic surfactants with large potential of applications due to the high ability to deliver active substances. The preparation of nano and micro emulsions was based on optimisation of main parameters system composition, emulsifiers, shearing speed and temperature in a two-stage process.The used lipophilic non-ionic emulsifier is a long-chain fatty acid ester - isopropyl oleate, the hydrophilic emulsifier is a diester of sucrose and a vegetable oil in order to obtain a multiple water-oil-water emulsion due to the ability of surfactants to orient and make honeycomb formations, at nano and micro scale. The saturation of an aqueous solution of collagen and keratin hydrolysates with microelements was done up to 40% by using 2% of diester of sucrose. Due to properties such as biodegradability, nontoxicity, adherence to surfaces, surfactants based on sugar may be successfully used as fertilizers in agriculture. In our research we have elaborated a new method for including microelements and collagen or keratin hydrolysates in stable emulsions with the final purpose of application as a new class of foliar fertilizer.*

Key words: *surfactant, bolaform and gemini, smart emulsion, collagen, keratin hydrolysate*

1. INTRODUCTION

The aim is to create new micro and nano-structured emulsions based on surfactants (bolaform and gemini) with potential applications in biomaterial design based on leather and wool by-products. Industrial surfactants are divided into four categories based on the presence or absence of electrical charge in solutions: anionic surfactants have a negative ion in the polar group and the cationic ones have positive, nonionic and ampholytic ions. Surfactants having in the same molecule non-polar structural elements (or weakly polar, such as alkyl chains), and strongly polar structural elements (functional groups ionized or not) are adsorbed at interfaces in oriented monomolecular layers. Bolaamphiphiles and Gemini are new classes of amphiphilic surfactants with large potential of applications due to the high ability to deliver active substances [1]. Changes in interactions of surfactants at separation surfaces between phases result in changes in physicochemical properties of heterogenous systems such as: change in superficial tension, change of adhesion energy between phases, of shape and size of volume occupied by a certain phase, etc. These changes underlie a great number of phenomena with significant industrial applications: wetting, emulsification, foaming, detergent, etc.

2. GENERAL INFORMATION

2.1. Obtaining nano-structured emulsions

2.1.1. General characteristics

In this study the nonionic lipophilic emulsifier is a long-chain fatty acid ester - isopropyl oleate, the hydrophilic emulsifier - sucrose diester, and thyme oil. The aim is saturation of an aqueous solution of microelements or collagen/keratin hydrolysate (<40%) in an aqueous solution of sucrose diester (2%) in order to obtain a new foliar fertiziler.

The hydrophilic properties of non-ionic surfactants are provided by hydroxyl groups (-OH), ether linkages (-O-), amide groups (-CONH-), etc. Such groups are found in sugar, polyethers and similar combinations. Nonionic surfactants have a series of important characteristics different from anionic and cationic surfactants. This is due to the lack of electrostatic rejection found in ionic surfactants at the phase separation limit and in the micellar interior, which facilitates the adsorption of non-ionic surfactants on the interphase surfaces and their aggregation in the mycelia. Sugar esters and ethers with tenside properties are known as surfactants based on carbohydrates. Surfactants used in this study are sucrose esters - R alkyl radicals C_8-C_{18} as it is presented in Figure 1.

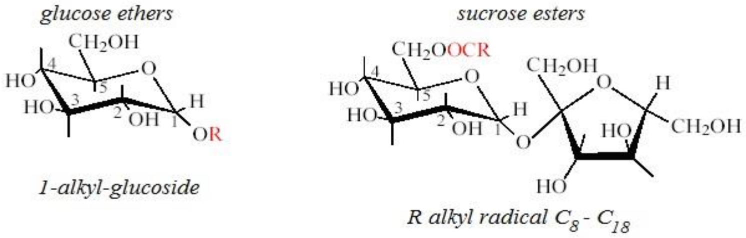

Fig. 1*: Representation of sucrose ethers and esters*

The most important features of these surfactants are: lack of toxicity, high biodegradability, low wetting potential and compatibility with other surfactants. The sucrose diester used in this study is obtained using an excess of methyl ester (sucrose: methyl ester = 1:2 molar ratio) and a small amount of dimethylformamide (12.5:1 relative to sucrose). The formation of diesters is also favored by the presence of small amounts of water. An excess of catalyst is undesirable because in the presence of K_2CO_3 saponification of the methyl ester occurs. Recovery of unreacted sucrose is carried out as follows: the reaction product, after removal of the dimethylformamide, is dissolved in an aqueous NaCl solution (5%) in a proportion of 3-4 parts solution to one part of raw ester, heated to 80-90°C, and maintained at this temperature until the sucrose ester has been decanted completely. After cooling, the ester is separated by filtration or centrifugation. From the aqueous solution, sucrose is recovered by evaporating the water.

2.1.2. Technological process

The two-step emulsification process (Figure 2) is used in this paper, where the result is a multiple nanostructured emulsion due to the properties of surfactants used to orient and form honeycomb formations at the nano and micro levels. Multiple emulsions are complex systems, also called ‘emulsions of emulsions’, in which the dispersed phase droplets contain a continuous phase with other dispersed droplets. The main types of multiple emulsions are water-oil-water and oil-water-oil. Two types of emulsifiers are used: a hydrophobic I one, isopropyl oleate (for W/O emulsion) and a hydrophilic II one - diester of sucrose based on sugar (for O/W emulsion). In the first step, water, vegetable oil (3%), lipophilic-isopropyl oleate surfactant (2%) are added and homogenized by stirring at 60°C to obtain a water-oil emulsion. In step II a solution of microelements saturated up to 40% (or collagen/keratin hydrolysate [2-4]) and a sugar-based surfactant - hydrophilic-diester (2%) are added to the water-oil emulsion, and homogenized by stirring at 60°C, obtaining a multiple water-oil-water emulsion (W/O/W).

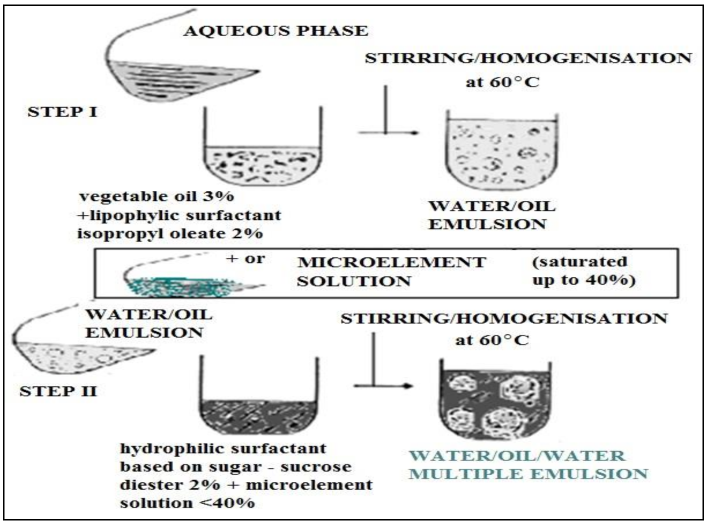

Fig. 2: *Two-step technological proces of obtaining nano- and micro- structured emulsions*

The thermal introduction of phase inversion for oil-water concentrated emulsions is preceded by obtaining a W/O/W emulsion. When an aqueous solution of a hydrophilic emulsifier is introduced into an oil containing a lipophilic surfactant, the W/O/W emulsion is obtained due to the inversion of the phases by modifying the HLB of the surfactant mixture. The phase inversion of multiple emulsions occurs when the dispersed droplets are tightly packed, nano and microstructured into the fluid in which they are suspended. The technological process is analogous to obtaining emulsions by replacing microelements with collagen hydrolysate or a 1:1 hydrolysed collagen-keratin blend. In order to obtain new structured nano and microemulsions an important part is to select the characteristics of the working parameters: system composition, emulsifiers, shear rate, tension, stirring speed, temperature. Long-chain fatty acid esters, including isopropyl oleate, vegetable oils, have been used to vary the physico-chemical properties of multiple emulsions as well as to attempt to control the transfer rate of the solute through the oil phase. Apart from the oil concentration used and the chemical nature, the behavior of the system is also influenced by the physico-chemical characteristics of the oil used, such as density and viscosity. Nonionic emulsifiers are preferred due to their low toxicity and because they hardly interact with other components. It has been demonstrated in literature [1] that it is preferred to use nonionic surfactants to obtain W/O/W emulsions with good yields. To obtain multiple W/O/W emulsions, at least two emulsifiers are introduced into the system, a lyophilic one, in the primary emulsion, and the hydrophilic one to form the secondary emulsion. Generally, multiple emulsions with a single emulsifier cannot be obtained. In a W/O/W emulsion, the optimal HLB value of the primary surfactant ranges from 2 to 7, while for the secondary surfactant it is 6 to 16. To stabilize a multiple system, the second emulsifier that disperses the primary emulsion in a continuous phase is generally less than 1/5 of the primary emulsifier and the HLB value of the emulsifier mixture is less than 10. If the value is high, there is a risk of reversing the phases and forming a single emulsion. If the second emulsifier is in high concentration, a portion of the primary surfactant may be incorporated into the micelle of the secondary one, thereby reducing the concentration of the primary surfactant that stabilized the W/O system. This would lead to the breakage of the oil layer with the loss of internal aqueous droplets. The temperature at which the phase inversion occurs depends on the concentration of the emulsifier mixture and on the HLB values. The higher the temperature, the more stable the O/W emulsion at ambient temperature. Temperature is one of the parameters that must be precisely controlled during the preparation of both the primary and the multiple emulsions. The minimum preparation temperatures are 60°C for the primary emulsion and 10°C for the multiple one. The stirring rate must be at least 800 rpm for the first emulsification and 200 rpm for the multiple emulsion. If the rates were lower, the system would show the tendency to coalesce and/or cream. Multiple emulsions are fragile systems, so the choice of emulsification methods is of particular importance in the success of obtaining the dispersed system with the desired properties. The two characteristic parameters for each multiple system are shear rate and tension. The yield of multiple drop formation decreases rapidly as the homogenization time increases. Structured and stable micro and nanoemulsions are formed, able to incorporate microelements or collagen/keratin hydrolysates with a 40% saturation, and the properties derive from the surfactants used, as well as the conditions and working parameters. In our research we have elaborated a new method for including micoelements and collagen or keratin hydrolysates in stable emulsions with the final purpose of application as a new class of foliar fertilizer.

2.2. Characteristics of nano-strucures emulsions

The three types of emulsions with: microelements (MC), collagen hydrolysates (HC) and collagen/keratin hydrolysate mixture (HK) were characterized by dynamic light scattering and optical microscopy. Dynamic light scattering test showed that all three types of emulsions are nano and microstructured. The size, percentage of the particles and Zeta potential were determined (indicating their stability). Figure 3 shows that MC emulsions have sizes ranging between 42 nm, 225 nm and 5269 nm without stirring (3a) and of 87.7 nm and 449 nm nm after 10 minutes mechanical stirring (3b). Nano size emulsion particle concentration increased from 6.5% to 22% after stirring. Zeta potential is -20.7 mV (3c) without stirring and -21.7 mV after stirring.

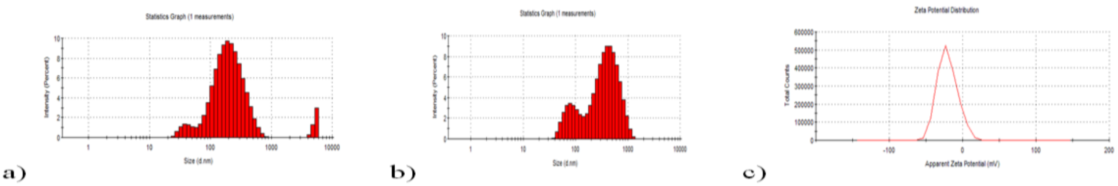

Fig. 3*: Particle size of MC emulsion: a) without stirring; b) after 10 min stirring; c) Zeta potential*

The analyses of HK sample with a collagen/keratin hydrolysate mixture in a 1:1 ratio, particle size and zeta potential, with stirring only, at different times, the experimental results are given in figure 4.

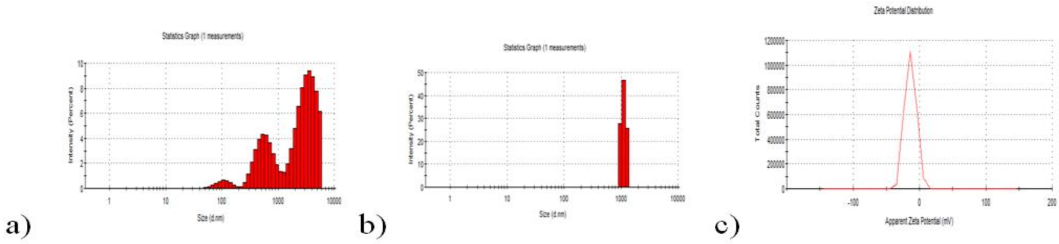

Fig. 4*: Particle size of emulsion HK : a) without stirring; b) after stirring; c) Zeta potential*

Figure 4 shows that HK emulsions have particle sizes ranging between 109.7 nm, 621.8 nm nm and 3371 nm without stirring (4a) and after 10 minutes stirring, the emulsion size is of 1109 nm (4b) with almost same values of -13.5 mV and respectively, -14.2 mV for Zeta potential (4c). For the third sample, HC, with collagen hydrolysate, experimental results are given in figure 5 and show that the emulsion particles are of 44.8 nm and 776.3 nm without stirring (5a) and of 1314 nm (5b) after 10 minutes stirring. Zeta potential is -2.74 mV (5c) without stirring and -4.52 mV, 5 minutes after stirring, showing a tendency to aglomeration. The influence of high molecular weights of collagen and keratin were revealed through higher particle size of emulsions after stirring and lower value for Zeta potential.

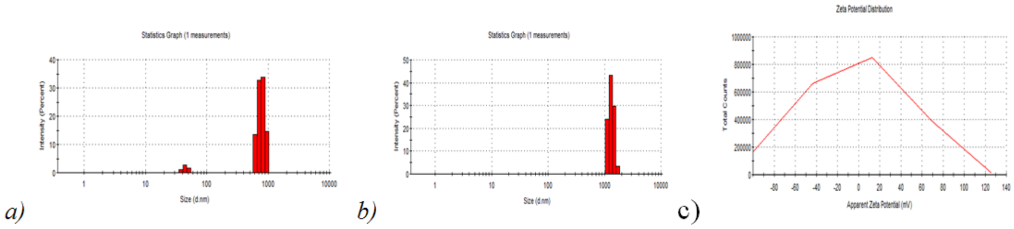

Fig. 5*: Particle size of emulsion HC: a) without stirring; b) after stirring* ; c) *Zeta potential*

Optical microscopy images (Figure 6) show that emulsions with collagen/keratin hydrolysate (HK) and emulsions with microelements (MC) are structured in honeycomb formations and only the collagen hydrolysate (HC) emulsions are oriented and agglomerated in a chain. The results are in agreement with literature data [5] related to the formation of honeycomb and chain structures in multiple water-oil-water emulsions.

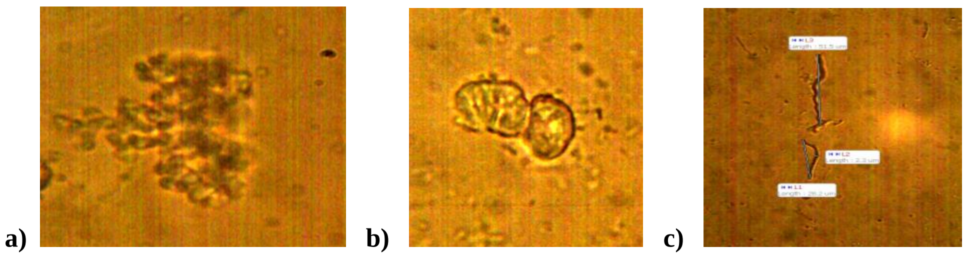

Fig. 6*: Optical microscopy images (1000x) of emulsions structures:a) honeycomb of HK emulsion; b) honeycomb of MC of ;c) chain structure of HC emulsion*

The three samples were also microbiologically analysed, to determine behaviour to fungal attack of *Fusarium spp*, *Penicilium spp*, *Aspergillus flavus*, and carrying out analysis three days from inoculations, with images presented in figure 7.

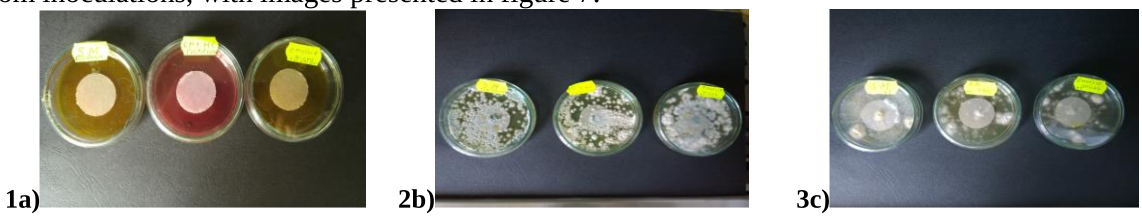

Fig. 7*: Microscopy images of 1) HC; 2) HK;3) MC emulsion upon attack of: a) Fusarium spp; b) Penicilium spp; c) Aspergillus Flavus*

The best results were obtained for *Fusarium spp*, a specific saprotrophic and pathogenic fungus for its colonization of cereal grains and legumes. Due to properties such as biodegradability, nontoxicity, adherence to surfaces [6], surfactants based on sugar may be successfully used for designing new foliar fertilizers for agriculture. The new multiple emulsions are original due to the succesful inclusion of collagen and keratin hydrolysate with high potential for plant and seed biostimulation and nutrition. The research are in progress regarding the experimental of the new multiple emulsions in biostimulation and nutrition of cereal plants.

3. CONCLUSIONS

- The most effective method of obtaining multiple emulsions is the two-step emulsification process; inversion of multiple emulsion phases occurs when the dispersed droplets are packed tightly into the fluid in which they are suspended.
- The obtained multiple emulsions showed structures of honeycomb and chain with size particles of 42 nm to 5269 nm and Zeta potential from -2.74 mV to -21.7 mV and good resistance to *Fusarium spp* which recommend them for agriculture use.

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INVESTIGATING PROCESS WATER PROPERTIES FROM DIFFERENT LEATHER INDUSTRY ZONES OF TURKEY

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Abstract: *All the physical and chemical processes in leather production from soaking till dyeing-fatliquoring stages take place in water as medium. Water is also used as carrier for the chemicals in subsequent finishing processes. In leather production many kinds of chemicals are being used in processes. These chemicals are penetrated and chemically bounded to leather collagen in water medium. Therefore, the nature and quality of the process water used in leather industry is crucial. The pH, calcium and magnesium salts, other inorganic salts and organic matters usually affects the chemical reactions, especially in bating, pickling, tanning, dyeing and fatliquoring stages. Thus, determination of the properties of process water used in industry and reveal their affect in leather production is very important. In the present study process water samples were taken from leather industrial zones located in Izmir, Istanbul, Usak, Gerede, Corlu and Bursa regions in Turkiye. Subsequently, the water parameters such as; pH, conductivity, total hardness, permanent hardness, temporary hardness, chloride, nitrate levels as well as the inorganic constituents i.e. natrium, potassium, magnesium, lead, manganese, iron, aluminum, chromium, zinc, copper and nickel were determinated. In this way the properties of the process water used in different leather industrial zones were documented and their possible effects on the regional leather production processes and leather quality have been discussed.*

Key words: *Leather industry, leather production, process water, water quality, water hardness, ICP-OES.*

1. INTRODUCTION

Water is one of the major inputs of leather industry [1]. Almost all chemical reactions in leather production take place in water as medium. All the chemicals used in processes have to penetrate into the three-dimensional skin/hide matrix. Therefore, a transporting medium is required to carry the chemicals into the skin/hide matrix [2-5]. In conventional leather manufacturing, water is used as the transporting medium to carry the chemicals into the matrix and also as a medium for the reaction between the chemicals and the functional groups present in skin matrix [6]. Therefore, water plays an important role in leather manufacturing.

The quality and properties of water have effect on the final leather products. Therefore, the process water is expected to fulfill some requirements. The water used in the production has to be periodically controlled in terms of qualitative, organoleptic and quantitative methods. In this manner, the color, pH, hardness, turbidity, organic and inorganic constituents of the water have to be determined [7]. The general requirements for process water to be used in leather production are summarized in Table 1 [8].

Table 1. *General requirements for water used in leather manufacturing [8]*

Parameter	Required level	Parameter	Required level
Appearance	Clear, no suspended solids	Nitrate	30 mg/L
Temperature	≤ 20°C	Nitrite	n.d
pH	7.0 ± 0.5	Ammonia	n.d
Bacteria	< 200 count in 1m^3	Fe	< 0.1 mg/L
Total hardness	Max 15 °A	Mn	< 0.05 mg/L
Temporary hardness	Max 12 °A	Pb	< 0 mg/L
Salts (Chloride and sulfate)	Max. 100 mg/L	Phosphate	n.d
Sulfate ion	20 mg/L	Free carbon acid	n.d
Chloride ion	30 mg/L	$KMnO_4$ consumption	2-5 mg/L

Whilst the role of water in leather production is so crucial, the quality parameters of process water are usually not investigated. Hence, the penetration efficiency and the reaction ability of the chemicals through the skin/hides are highly affected by the quality and constituents of process water. The number of studies investigated the properties of process water and their effect on leather quality is very limited. Among them the most comprehensive one was reported by Devikavathi and Muralidharan [9]. They showed the effect of different hardness and chloride content of water on some leather quality parameters. In their results they revealed that chloride content up to 20.000 ppm and high hardness values could be tolerated in soaking stage while the chromium uptake was significantly affected in tanning stage. They also observed increased chromium content in wastewater effluents. In another study Devikavathi et al. [10] examined the effect of water with different hardness level on the dyeing properties of leathers. In their study they showed that the hardness level of water affected the shades of leather color. In a similar study Hauber ve Germann [11] the effect of water hardness level on dyeing properties of leathers was also shown. They studied different types of dyestuff and compared the color properties of leathers. In their results they also pointed out the significant influence of water hardness on color shades of leathers. Some other researchers also mentioned about the importance of water properties in leather production and their possible effects on leather quality [12,13,14].

The characteristics of the water differ due to the region where industry is located. Thus, there might be quite differences of water quality between different regions. Although there is a few individual companies, most of the leather companies are located in certain organized industrial zones in Turkey such as Istanbul-Tuzla, Izmir-Menemen, Usak, Manisa, Bolu-Gerede, Tekirdag-Corlu, Bursa. In the present study process water samples were taken from these industrial zones and their parameters such as pH, hardness, conductivity, chloride, nitrate content were investigated. Many inorganic constituents including trace elements like Na, K, Ca, Mg, Pb, Mn, Fe, Al, Cr, Zn, Cu, and Ni were also determined by using ICP-OES. Therefore, many important quality parameters of the process waters from different leather industrial zones were shown comparatively and their possible effects on leather quality were discussed.

2. MATERIAL AND METHODS

2.1 Material

In this study, ten water samples obtained from six different leather industrial zones in Turkey were used as material of the study. The sources of water samples are given in Table 2. The samples were coded as Wx for water sample number(x), following two letters for first two letters of city, S for source water, G for ground water and C for city water.

Table 2. *The codes and sources of the water samples*

Code	Water Source
W1GES	Spring Water - Gerede Leather Specialized Organized Industrial Zone, Bolu
W2GEG	Ground Water - Gerede Leather Specialized Organized Industrial Zone, Bolu
W3BOG	Ground Water - Bursa Specialized Leather Industrial Zone, Bursa
W4BOC	City Water - Bursa Specialized Leather Industrial Zone, Bursa
W5ISC	City Water - Istanbul Leather Organized Industrial Zone, Istanbul
W6USC	City Water - Usak Leather (Mixed) Organized Industrial Zone, Usak
W7COG	Ground Water - Corlu Leather Specialized and Mixed Organized Industrial Zone, Tekirdag
W8COG	Ground Water - Corlu Leather Specialized and Mixed Organized Industrial Zone, Tekirdag
W9COG	Ground Water - Corlu Leather Specialized and Mixed Organized Industrial Zone, Tekirdag
W10IZC	City Water - Izmir Free Zone, Izmir

2.2 METHOD

Conductivity and salinity of water used in the leather production process were determined by using YSI brand 30 model Conductivity meter (USA). The pH values were measured with Metrohm brand 827 model pH Meter (Switzerland). Determination of chloride (Cl^-) content of the water was done according to potentiometric titration method by Metrohm brand 848 titrino plus model Potantiometer (Switzerland). Determination of hardness in water by titration was made according to ASTM D1126-17 test method [15]. The nitrate (NO_3^-) content in process water was examined according to spectrophotometric method in 220 nm by Shimadzu brand 1601 model UV Spectrophotometer (Japan). Trace and basic elements in were detected by using PerkinElmer brand Optima 2100 DV model ICP-OES instrument (USA) equipped with WinLab32 software for ICP according to EPA method 6010D [16].

3. RESULTS AND DISCUSSIONS

When conductivity and salinity values of process waters taken from different regions were investigated, it was seen that especially W2GEG and W10IZC samples had fairly high salinity and thus conductivity values. A high content of electrolytes in the float can affect the solubility of most dyes, with direct consequences on levelness, penetration and fastness and use of unstable fatliquors can lead to precipitation of fat emulsion [17]. All process water samples' pH values fit well to recommended 7.0±0.5 pH for leather production (Table 3).

Table 3. Conductivity, pH, chloride, nitrate, nitrate nitrogen contents data of process waters

Water Sample	Conductivity (µS) (25°C)	Salinity (gL^{-1})	pH	Chloride (Cl^-)	Nitrate Nitrogen (NO_3^-N)	Nitrate (NO_3^-)
W1GES	372	0,2	7,3±0,1	10±1	2,7±0,3	11,7±1,2
W2GEG	3572	2	6,7±0,1	910±39	5,1±0,4	22,7±1,6
W3BOG	813	0,4	7,4±0,1	117,6±2,1	2,0±0,4	8,8±1,8
W4BOC	849	0,8	7,4±0,1	50,9±0,7	17,4±0,9	76,9±4,2
W5ISC	1295	0,6	6,8±0,1	191,8±3	18,1±1,1	80,2±4,9
W6USC	732	0,4	7,0±0,1	28,7±0,3	16,9±1,0	74,6±4,9
W7COG	559	0,5	6,9±0,1	138,5±2,3	9,7±0,9	42,7±4,3
W8COG	1551	0,7	6,5±0,1	208,8±3	15,0±1,2	67,3±5,2
W9COG	683	0,3	6,8±0,1	109,8±3	1,5±0,3	6,8±1,4
W10IZC	2378	1,2	6,8±0,1	498±19	16,1±1,2	71,0±4,9

Evaluating chloride (Cl^-) content results of the process waters (Table 3); it was detected that except W1GES and W6USC samples, rest of the water samples had chloride contents higher than recommended value (30 mg L^{-1}) for leather process water cloride content. Within them particularly W2GEG and W10IZC water samples had fairly high chloride contents. Chlorides, sulphates from permanent hardness constituents can cause a retardation of reaction or precipitations only in higher concentrations. They may also lead to the destruction of cement pipes or cement vessels by corrosion[17].

Examining the Table 4 in which hardness values of process waters are given, it is seen that W10IZC, W2GEG and W8COG samples were in very hard waters group, W1GES was in medium hard waters and rest of the samples were in hard waters group. When conductivity and salinity values were recalled, as expected they were in accordance with the hardness values. Use of waters with high carbonate hardness, the poorly soluble calsium carbonate; can lead to precipitations, color changes, retarded reactions and staining in many processes of leather production such as soaking, liming, rinsing and washing floats, bating, manufacture of vegetable tanning agents, during vegetable tanning, dyeing and fatliquoring. It also causes dangerous scale formation in steam boilers [17, 18].

Process water used in tanneries has direct and indirect effect on dyeing and fatliquoring processes. For example use of very soft waters result with flat leathers. High temporary hardness has negative effect on fatliquoring and dyeing processes, and causes cloudy lime stains. Dyestuffs are also very sensitive to calcium in water; it may lead to precipitations of dyes [13]. In fatliquoring process especially fatliquors with low stability, hard water prevents and breaks emulsions. This also can lead to precipitation of fat emulison. Especially when natural fats which were stored for long time are used, hard water causes calcium soaps [7].

Considering water hardness recomended for leather processing (slightly hard 14,5-21,5 FS°) [8]; except W1GES water sample, all other water samples are not suitable for directly use and a necessity for softening or purifying before using in processes is appeared.

Table 4. *Hardness data of process waters*

Water Sample	Total Hardness (°fH)	Permanent Hardness (°fH)	Temporary Hardness (°fH)
W1GES	18,8±0,2	6,0±0,2	12,8
W2GEG	49,6±0,3	10,9±0,2	38,7
W3BOG	24,2±0,3	10,6±0,2	13,6
W4BOC	31,4±0,3	6,6±0,2	24,8
W5ISC	23,0±0,3	12,3±0,2	10,7
W6USC	23,2±0,2	20,0±0,2	13,2
W7COG	30,4±0,3	23,4±0,3	7,0
W8COG	44,4±0,4	23,8±0,3	20,6
W9COG	22,6±0,3	7,8±0,1	14,8
W10IZC	53,7±0,5	23,0±0,3	30,7

From the investigation of heavy metal contents of the water samples (Table 5); in none of them noticable amounts of lead (Pb), aluminium (Al), copper (Cu) and nickel (Ni) ions could be detected. Only in W8COG sample approximately 7 ppm zinc (Zn) was found. Iron (Fe) content for leather process water is recommended to be <0.1mgL^{-1}. From the investigation of the iron (Fe) content results of the samples; it was seen that in the mean time W1GES and W2GEG samples were having fairly high iron content, W8COG and W7COG samples' iron contents were over the recomended value. Recommended value for manganese (Mn) content for leather processing water is<0.05 mgL^{-1}. Considering the manganese content results of water samples it was seen that W5ISC, W1GES and W2GEG samples were containing respectively 10 and 2 times of recomended value. Free metal salts such as chromium, aluminum, zirconium or lime components may react with unstable fats, natural oils or content of natural fats; and can cause soap formation in fatliquoring process. Iron content in the case of vegetable or some synthetic tanning or retanning processes result in grey or blue staining over the entire surface of the leather or in patches. This also results bluish-grey blunt dyeing [17]. Furthermore metal contents in water can lead to unsolubility problems in leather dyeing and colour shifts in metal complex dyes.

From the evaluation of alkali and alkaline earth metal contents of water samples such as natrium (Na), potassium (K) and magnesium (Mg); it was found out that W1GES, W1GEG and W10IZC samples were very rich from these ions. W5ISC and W10IZC water samples followed them with high natrium (Na) and potassium (K) contents. Also, W8COG sample was containing remarkably high amount of calcium. Calcium and magnesium salts react with vegetable tanning agents or also synthetic phenolic tanning agents to produce insoluble precipitation compounds. Lead to stains in leather which cannot be dyed, and also to crackiness of the grain in these parts [17].

Table 5. *Inorganic constituents of water samples*

Water Sample	Na	K	Ca	Mg	Pb	Mn	Fe	Al	Cr	Zn	Cu	Ni
W1GES	279.4	18.04	278.4	75.45	n.d.	0.101	2.774	n.d.	0.077	n.d.	0.013	n.d.
W2GEG	273.4	15.36	248.7	68.84	n.d.	0.151	2.312	n.d.	0.025	n.d.	0.011	n.d.
W3BOG	58.46	5.181	34.20	26.57	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.015	n.d.
W4BOC	45.66	5.290	48.66	38.25	n.d.	n.d.	n.d.	n.d.	n.d.	0.52	0.017	n.d.
W5ISC	141.5	15.05	59.98	10.37	n.d.	0.471	0.09	n.d.	0.002	0.04	0.015	0.037
W6USC	12.55	4.518	49.39	33.88	n.d.	n.d.	n.d.	n.d.	0.003	n.d.	0.018	n.d.
W7COG	54.74	3.864	74.98	17.09	n.d.	n.d.	0.1	n.d.	n.d.	0.298	0.019	n.d.
W8COG	68.4	4.991	118.7	25.85	n.d.	0.05	0.242	n.d.	n.d.	6.993	0.014	n.d.
W9COG	27.58	3.694	55.49	13.82	n.d.	0.033	0.492	n.d.	n.d.	0.162	0.016	n.d.
W10IZC	215.9	19.71	164.8	31.97	n.d.	n.d.	0.006	n.d.	0.083	n.d.	0.013	n.d.

4. CONCLUSIONS

Water, one of the main inputs of leather processing, may have more or less impact on chemicals and processes used. Therefore, process waters should have certain criteria not to cause any problems in processes and to assure quality of final products. In this study properties of water samples from different industrial zones were examined and findings were discussed with possible problems based on literature. It was concluded that none of the water samples was appropriate for direct use in leather processes. Use of these process waters can lead to precipitations, color changes, retarded reactions and staining in many processes of leather production such as soaking, liming, rinsing and washing floats, bating, tanning, dyeing and fatliquoring. Therefore, waters available in Gerede, Bursa, Istanbul, Corlu, Usak and Izmir leather industrial zones should be softened and purified before using in leather processing to avoid problems and obtain quality.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

APPAREL MANUFACTURING AND MASS CUSTOMIZATION EXPERIENCE

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Abstract: *This paper examines the manufacturing experience of clothing configuration within the mass customization approach. It is within this context that 'mass individualism' is examined; a phenomenon which in a climate of globalization can provide novel and environmentally sustainable consumer opportunities for major fashion manufacturers. It has become increasingly difficult for companies to offer interesting products and respond to the specific needs and desires of clients who have become much more savvy and aware of traditional methods of marketing. Thus, the industry must add real value to previously standardized products, in the form of customer specific services to better respond to consumer demand for authenticity and individuality. We find there some problem is related to the manufacturing aspects with measurements, adaptation of patterns and flexibility in methods and experience on the part of the manufacturers to properly use the configuration systems. It is in this respect that mass customization is examined, and several key implementation strategies are developed for manufacturers. From the start, mass customization needs to directly involve customers in the designing and manufacturing phases. Furthermore, this approach must provide opportunities to generate savings by reducing stocks and allowing for better integration of all actors in the supply chain. Mass customization offers possibilities to reach, or even surpass, customers' expectations. Therefore, it needs to provide a knowledge base of consumers' needs and preferences and thus create opportunities for market segmentation and market targeting. Fashion Apparel Industry and smart mass customization approach with digitization makes the supply chain more efficient, agile, and customer-focused.*

Key words: *Fashion Industry, Mass Customization Program, Sticky Information, Fitting Clothing, Configurator.*

1. INTRODUCTION

The fashion and apparel industry faces the urgent need to rethink and strengthen strategy and identify alternative levers for sustainable growth. Past research has demonstrated the importance of understanding the mass customization approach within the context of trade globalization, which has led to ever more ferocious competition in the apparel industry. Moreover, as apparel products now seem to have an even shorter life cycle, a phenomenon which is exacerbated by the introduction and implementation of new business models, businesses' commercial strategies face mounting tension. Nevertheless, fashion retailers and manufacturers are confronting growing pressures on their margins and stocks. Over the past few years, increasing vertical integration and the relentless rise of online sales have created fundamental structural and mechanical shifts in the fashion and apparel industry. This situation forces fashion and apparel industry players to revise their organizational strategies in order to survive in this highly competitive market. Organizations must reinvent themselves and find new ways to satisfy their customers. In order to grow and to maintain the current level of employment and possibly increase it, clothing producers will need to develop new manufacturing strategies by orienting local production toward a flexible, quick-response system that allows for the fulfillment of various types of orders (small quantities, short deadlines, skilled labor, etc.). Thus, it will become essential for businesses to implement new strategies that correspond to the reality of current markets, in order to keep up with the rhythm of short cycle production. With this approach, manufacturing businesses need to focus on flexibility, adaptability, agility, and traceability. Managers in this industry need to take a close look at the current evolving market and, in some cases, quickly change or adapt their business models. To succeed at this, a company cannot rely solely on its popularity. Above all it must tap into the unique strength of its offering, because there's no room for error.

2. THE GOAL OF MASS CUSTOMIZATION

Reviewing the writings on this subject tells us that paradoxically, at a time where the global keyword in most industries is standardization, the focus in the apparel industry is on ‘‘uniqueness.’’ Today's consumers are increasingly demanding and will no longer settle for the mass offerings proposed by major retailers. They want what they buy to have a personal quality. A mass customizer must first identify the idiosyncratic needs of its customers, specifically those product attributes along which customer needs to diverge the most [1]. The increased use of mobile devices due to convenience of the Internet is likely to influence consumer shopping behaviors, such as time spent in searching various channels and other ways in which they can use digital devices [2]. Add to this the strong influence the Internet and digital technology have on consumer habits and choices. They are no longer satisfied with standardized products that force them to make compromises. The Internet influences customers’ buying habits by creating needs that have to be satisfied instantaneously. At an increasing rate, people are losing interest in mass produced items and are seeking a little piece of the manufacturer's DNA, that which makes the item authentic. They're looking for the experience, but not at any price. The goal of mass customization is to efficiently provide customers with what they want, when they want it, at an affordable price. According to Pine [3] the success of mass customization rests mainly on a successful integration of the value chain.

2.1 One of the issues

In the apparel industry, these expectations not only imply having to constantly provide consumers with new options in terms of styles and colors, but also to allow them to find an affordable well-fitting product item and make it available to them almost as rapidly as if it were a standard-sized product. In order to meet these expectations, apparel companies must now propose custom-made products. Brands that offer personalized products (mass customization) are taking over both traditional and online stores. According to McKinney et al. [4] this is made possible by identifying the key points of body measurement necessary to produce well-adjusted, well-fitting garments. However, being able to take these measurements effectively and efficiently is crucial. Although efficient and affordable technologies are available to provide a body scan, few businesses are able to meet the requirements of custom-made products for the following reasons: lack of reliability of the measures provided by the body scan, problems related to the transmission of a large quantity of data to potential manufacturers, and interface issues between the data generated by the body scan software and that used by pattern making, cutting and assembly. Many apparel businesses are currently researching technological ways to produce, adjust, sell, and deliver, in a systematic and automatized fashion, personalized and made-to-measure products. Thus, for example, manufacturers will have to change their positioning from simple manufacturer to positioning solutions and service providers. This example demonstrates the profound changes that traditional clusters will have to make. It is precisely on this point that digital interventions will allow implementation of an agile organization. Nevertheless, mass customization somehow remains misunderstood or is rarely used by actors in the clothing industry mainly because of the widely variable measurements, the problems in adapting patterns, and the need for flexibility in manufacturing delays and methods. Many authors have produced research on mass customization; however, few of them have sought to identify the problems related to sizing and to so-called hidden data coming from the customers (ease allowance, fullness, etc.). On the other hand, the strengths of 3D body scanning are the speed and the low cost (nowadays), while its main weaknesses are in the measurement inconsistencies due to movement and the lack of accuracy when compared with manual measurements [5].

4. MASS CUSTOMIZATION EXPERIENCE

In recent years, we have been working with manufacturers on product configuration. Our objective was to develop a configurator for clothing mass customization embedded in apparel industry, using computerized digital information systems, that could be used to analyze and decode measurement data coming from peripheral devices in order to identify the necessary information to produce a well-fitting garment. Hence, it was necessary to identify the fundamental variables and data that are necessary to produce custom-made clothing. Parsimony in fundamental variables (length, circumference, density, textile matter) allowed us to significantly diminish the amount of data to analyze and send out in order to create an “smart” pattern during the experiment.

2.2 Smart configuration for clothing product design

In this context, configuration is an essential aspect of mass customization because it creates the possibilities to guide customers as they are making choices. Recently, a number of mass customizers have connected their sales configurators with social software applications and this is not surprising, as social software enables an interactive and socially rich shopping experience, which makes shopping with a mass customization toolkit more similar to retail shopping [6]. Here (Figure 1), configuration processes play a crucial role in managing this task by providing customers with support and navigation in co-designing their individual product or service.

***Fig. 1**: Mass customization configurator for clothing*

According to Kwon et al. [7], online self-customization (OSC) enables customers to design a product tailored to their preferences and needs via the online platform. The successful OSC experience goes beyond simply increasing a consumer's choice in preferred fit; it provides an opportunity to develop a meaningful relationship with customers by allowing them to embed their sense of self into the customized products and thus identify themselves with the products.

However, a lack of expertise eventually requires investments in terms of time and effort; moreover, it forces employees to keep up to date with frequent technical changes and improvements. At the same time, many industrial companies will need to develop digital skills sets around creative digital strategy design, technology, architecture, and user experience design. As a result, the smart configuration of a product to meet a customer's requirements can become a complex task, which gets more demanding as the number of components and options increases. When the configuration requires numerous variations, the possibility of making errors also rises, which can result in production delays. Mass customization creates various technical challenges that need to be overcome before mass customized garments can be produced.

4. DISCUSSION AND FINDINGS

The first problem is related to the apparel manufacturing aspects with measurements, adaptation of patterns and flexibility in methods and manufacturing deadlines. The second is the lack of knowledge and experience on the part of the manufacturers to properly use the configuration systems. It has become increasingly important to understand how to create an approach for configurator implementation for the clothing personalization and mass customization program. For producers to make the most of this approach, they need to understand what can be done in terms of clothing personalization and mass customization capabilities.

We discuss custom clothing in conjunction with the effects stemming from the evolution of mass production practices. This led us to explore from different angles the problems related to the automation of standard sizes and integration of "fits" done in traditional ways as well as computerized ways with respect to product adaptation. In terms of research, we also analyze the mass customization concept and propose technological and transparent operational approaches aimed at initiating useful discussions to better understand these issues and the new culture that has been created.

Our tests with a configurator confirm the validity of our variables and the future potential for rapid prototyping via mass individual production and assurance of well-fitting garments via online request. This method can be applied for professional, commercial, technical, and mass consumer apparel. Through this work, it is also seen that it would be beneficial to label ready-to-wear clothing with silhouette-type information that best displays the style. This would no doubt allow the customer to filter more quickly through non-desired styles or models. This simple approach provides new perspectives with respect to new and interesting concepts such as "fitthinking" theory for this industry, which could serve well in future tasks. These elements include product sustainability, sustainable supply-chain management, design practice, business innovation, operational effectiveness, and consumer engagement – the strongest indicator of customers' feelings about your brand.

This project offers numerous innovative possibilities and could provide a major opportunity for those implicated in the fashion apparel industry and contributes an analysis of how the design process can support the development of new and competitive business models for a sustainable fashion industry. Typically within the field of sustainable apparel, the strength has been on technological adaptations within the mass customization supply chain. Although these efforts can significantly reduce environmental impacts, the outsourced manufacturers are more in control, thus limiting the influence of a fashion brand.

One of the innovative trends approach is fashion apparel industrie 4.0 called a ''smart apparel factory'' is the current trend of automation and data exchange in apparel manufacturing technologies. The combination of several major innovations in digital technology it includes the Internet of things, cloud computing, and cyber-physical systems communicate and cooperate with each other in real time used by participants of the value chain driving a new shift of change across the economy, with major implications for fashion market – including RFID, sophisticated sensors, digital printing and fabrication, 3D product development and more. This trend is more with the digital transformation merging with Industry 4.0. Manufacturers need to transform their processes and products to become more digital. This becomes more attractive for manufacturing as part of a mass customization program.

After discussion and meeting with experts from the sector, we are able to define the priority of five key success factors for fashion apparel industry : (1) customer excellence focus (the voice of the customer) and brand performance profile, (2) seamlessness in the omnichannel user experience integration, (3) renewed focus on physical retail, (4) operational excellence and innovation, and (5) process integration and traceability. To remain strong and competitive, a company has to demonstrate its capacity to adapt in terms of creativity, production, quality, timing, and price.

These findings should encourage the actors that make up this industry to readjust. In an age where innovation and technological developments play an increasingly crucial role in counteracting the effects of lower wages found in other countries, the objective of this research is to demonstrate the importance of implementing mass customization and rapid manufacturing systems adapted to the needs of all players in the clothing industry. If the vision of Industry is to be realized, most business processes must become more digitized. A critical element will be the evolution of traditional supply chains toward a connected, smart, and highly efficient and agile supply chain ecosystem.

5. CONCLUSIONS

Fashion apparel industry businesses must be proactive, adopt, and adapt to new mindsets and management tools and digital culture to take full advantage of information technologies. To successfully implement mass customization, it is of the utmost importance that they emphasize analysis, decision making, performance evaluation, and added value. Indeed, flexibility is a must as the market increasingly expects it. Mass customization offers much potential for extending brand awareness, acquiring new markets and generating profits.

However, as stated, in order to do so, manufacturers must adjust their business practices and clearly define the limits of their operational strategy so that they do not radically alter a structure that took years to build. Mass customization must not be seen as a strictly short-term marketing strategy. When introducing new products or practices, a brand must be in synergy with its new offers, even if the company initially loses money.

Manufacturer must commit to sustainable development with demonstrated leadership, vision, challenges, directions, areas of intervention, and objectives as “clear as possible,” in order to be an example to follow. If actors in the fashion and clothing industry accept this change of direction, this project could evolve into an extremely competitive business model, which could also represent a viable option for companies in different sectors.

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CONSUMER VALUE IN APPAREL ONLINE MARKETING WITH REPERTORY GRID ANALYSIS

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Abstract: *Online marketing has been increasing year by year and with the great advantages either for suppliers or consumers and e-business become more popular for any scale companies. Altough it was seen adequate to set up a webiste was enough for e-commerce, it definetly needs much more than this for growth and survive. Consumer value has been in the center of many research for online and offline marketing chanelles and showed as a key factor of success in marketing. In this study, consumer value was investigated via repertory grid analysis. In traditional data collection, researchers make interview or questionnaire with participants. However, these data collections make researches restricted, because participant answer only ready questions in quaestionaire or many unrelated data can be collected in interviews. In reprtory grid analysis, participants uncover their thoughts and feelings without any guidance from researcher. In the study, participants were asked to tell 5 different online retailers that they have shopped before and answers were noted as elements. In the second step, the differences between selected 3 out of 5 e-retailers were asked and answers were noted as constructs. Elements and constructs were used to build repertory grid. In the last part, analytic hierarchy process was employed to find out which constructs were defined by participants as a value in their online shopping experience.*

Key words: *apparel online marketing, repertory grid analysis, analytic hierarchy process, consumer value*

1. INTRODUCTION

E-commerce has distrupted the traditional brick and mortar retail business model and is changing both supply and demand dynamics. The conflation of time and space afforded by online retailing has given retailers an unparalleled operational flexibility in terms of supply management, product internalization, making distant geographic markets and highly accessible supply resources. The selling of products has become truly global. On the demand side, the convenience of online shopping, now supported by easier cross-border transfers of goods, has made e-commerce an attractive alternative to physical shopping. E-commerce's rapid growth is predicted to severely impact traditional retailing, which continues to lose customers to their online counterparts. However, in online marketing which become necessity rather than choice, growth and survive needs require much more effort than start up. Lee and Overby [1] claimed that despite dramatic increase in number of visitors who come a retailer website, only small amount of those visitors actually make purchase.

Dictionary meaning of the value is 'value is the regard something is held to deserve, the importance, worth or usefulness of something' [2]. This is perhaps the most common concept about the meaning of the value. Nonetheless, the terms of value appear in different context. The American Marketing Association [3] has revised its definition of marketing to cover the concept of customer value and subsequently there have been important discussions in the literature over the centrality of customer value. Kotler and Armstrong [4] defines marketing as a transaction between two parties in which each side gives up something of value in return for something of greater value.

Value plays a crucial role at the heart of all marketing activity and therefore it needs clear attention for consumer marketing researcher [5]. Many researchers have worked on consumer value and they brought out that customer value is perceived by customers rather than provided by seller [4,6,7]. Besides, another significant point was placed for online retailing that online customers choose retailer who offer the best value, value defined by customers [7]. Therefore, the examination of customer value determination has become a focal point in the marketing literature.

In this study, it was aimed to find out that what are the factors that consumers relate as value in their experience of online apparel purchasing. In a study, which aim to undercover consumers' perception toward apparel e-retailers, it is important to take into consideration of consumer view without any guidance. For this purpose, "Repertory Grid Method" was used as a data collection tool. Repertory grid is based on the 'Theory of Personal Constructs' and is a method of collecting and analysing data about how individuals view and shape their worlds employing construct psychology.

2. METHOD

This study has been conducted among 25 frequent online shoppers who are also at certain level of education. Research group contain male and female participants between the ages of 22 to 40. Each participant was asked to give the name of five online apparel retailers that they have shopped before. The answers were set as elements in grid structure. Afterwards, researcher asked participant the questions for each of the three online suppliers selected using the triple combination of five retailers. During this process researcher never asked any open-ended questions as in the interview or never offer any answer-options as in the questionnaires. The only questions were repeatedly asked 'which of the element is different as opposed to other two' and 'in which way this element is different?'. Thus, influence of interviewer on interviewee was minimized. Besides, answers of each triads were noted as constructs in the grid structure.

a. Repertory Grid Analysis

"Repertory Grid" technique includes two concepts, 'elements' and 'constructs'. The elements are the objects of people mind to which they relate their concepts and values. The constructs differentiate how people identify the elements in their individual world [8].

The process of repertory grid technique resembles as semi-structure interview which are asked two of the elements are similar as opposed a third. The characteristic that respondents use to differentiate between the elements is the construct. Participants are then asked to rate elements on scale and which element they prefer. This process repeated through a number of iterations involving different combinations of triads until the participant finds no more construct options [8].

Steps to complete repertory grid [8]:

1. Choose the topic for grid: Specific topic should be chosen for repertory grid.
2. Select elements: Products or services may be chosen as element.
3. Group elements in threes to undercover construct: The interviewer chooses three elements randomly and ask to interviewee for 'what do two of these elements similar as opposed to third?'
4. Create the grid framework: A simple grid will be created with the elements at the top and the poles of the constructs will be placed both side of the grid.
5. Interpret the grid: Columns are compared in order to search for similarity and contrasts in the elements, the interviewer can see how the respondents would profile a particular element. By comparing rows, the researcher is able to indicate related and unrelated constructs.

6. Aggregate the individual grids. Repertory grid technique is used to evaluate the constructs of groups in marketing research and organizational behaviour.

This study involves an evaluation of the constructs that respondents expressed in order to evaluate customer perceived value. Repertory grid analysis allows a highly individualized approach to each respondent and lets to take into consideration the mental, emotional and personality characteristics of interviewee's [9]. Other widely used methods (questionnaire and interviews) are usually criticized problems related to the issues of validity and reliability. A questionnaire which use questions with predetermined attributes are usually criticized for limiting respondent's choice and not give chance for open discussion [10]. An interview can partly deal with this issue and gives the respondents more opportunity to express their personal thoughts, but an interview cannot resolve the issue of interviewer's bias and inability to access the underlying reality.

2.1.1Analytic Hierachy Process

The Analytic Hierarchy Process (AHP), developed by Saaty [11], is a technique to rank a finite number of alternatives based on a finite number of criteria [12]. The process requires the decision maker to provide judgments about the relative importance of each of the criteria and then to specify a preference for each decision alternative on each criterion. The output of the AHP is a prioritized ranking indicating the overall preference for each of the decision alternatives [13].

Obtained constructs used in AHP table and below steps were followed;

1. Calculate the column sums
2. Normalize the columns: Divide each value of the column into column sum.
3. Calculate the row sums
4. Normalize the column of row sums and establish the priorities: Take the sum of the column of row sums and normalize the values by dividing each value into the sum. Thus, the priority of each preference is established.

3. RESULTS AND DISCUSSIONS

In the study, consumer value –value defined by consumers was investigated and for data collection repertory grid was used. During data collection process, all participants were asked to tell 5 different apparel online retailers that they have recently used. After the identification of retailers, 3 different retailers were chosed and asked participants to identify difference of one as oppesed to other two. This step was repeated to cover all possibilities of selected 3 retailers.

Participants identified totally 13 different online apparel retailers which are also elements in repertory grid and 27 different constructs were obtained (Table 1). As it seen from Table 1, each of the constructs has different number of repetitions. However, reperitions does not prove that consumer relate them as value. Even, in some cases, less repetitive constructs may be more important than others. Therefore, AHP was employed on collected data to uncover the constructs that consumers relate as value.

Table 1:*Collected constructs*

Constructs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**total**	**(%)**
fast cargo	*	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	**23**	**9,31**
luxury products	*	*	*	*	*		*	*	*	*	*	*	*		*	*		*	*	*			*		*	**19**	**7,69**
range of products	*			*			*	*	*			*	*	*	*		*	*	*	*	*	*	*	*	*	**18**	**7,29**

phsycal store	*	*	*	*	*	*	*	*	*	*	*	*	*	*			*	*			*	*				**18**	**7,29**
private discount and gift	*	*	*	*		*		*	*	*	*		*			*	*	*	*	*		*			*	**17**	**6,88**
free return and change		*	*			*	*	*	*		*	*	*			*	*		*	*	*	*		*	*	**17**	**6,88**
similar product with similar price		*	*	*	*	*	*			*	*	*				*				*		*	*			**13**	**5,26**
live customer service				*	*		*	*		*					*		*			*	*	*	*	*		**12**	**4,86**
sale own brand					*		*			*		*	*				*	*	*		*	*		*	*	**12**	**4,86**
monthly payment (never-never)	*	*				*			*		*			*		*	*			*				*	*	**11**	**4,45**
good navigation website	*		*			*				*				*		*	*	*					*	*		**10**	**4,05**
3D secure payment	*					*					*	*	*	*	*	*	*	*								**10**	**4,05**
return in phsycal store				*	*					*		*		*	*			*	*			*	*			**10**	**4,05**
free cargo			*					*			*		*					*	*	*			*		*	**9**	**3,64**
availability of wide range products		*	*	*	*		*							*		*							*			**8**	**3,24**
qualitf of customer service		*	*			*			*						*					*						**6**	**2,43**
different seller						*			*		*					*					*		*			**6**	**2,43**
private designed products				*				*	*												*	*				**5**	**2,02**
recycled product use										*					*						*			*	*	**5**	**2,02**
importance of customer satisfaction							*	*							*						*					**4**	**1,62**
detailed descriptive product												*	*	*	*											**4**	**1,62**
payment at the door																*			*					*		**3**	**1,21**
direct		*												*												**2**	**0,81**

contact with seller																										
mobile application										*													*		**2**	**0,81**
easy product return	*																								**1**	**0,4**
enough stock																								*	**1**	**0,4**
weekly based new products					*																				**1**	**0,4**

After employing AHP, importance levels of constructs showed differences from frequency of each constructs. Result of AHP illustrated that similar products with similar price (12,20%), private discount and gift (8,74%) and security (%7,04) were three constructs with the highest importance levels. However, in a methodology that consumer perceptions are taken into consideration without any influence of researcher, different consturcts can show similarities. These similarities divide importance level and can misguide study. In order to eliminate these similarities, constructs were grouped by AHP team. New groups of constructs are given in Table 2. After new groups were created, "campaigns" have the gratest importance level (31,09%) followed by "shipping and return" (23,8%). Impotance level of "customer service and satisfaction" (21,12%) is also close to "shipping and return" and third the highest importance level. Surprisingly, "security" (%7,06) was found out as one of the least important factor.

Table 2. *Groups of collected constructs*

Groups	Constructs	Importance Level (%)	Total Importance Level (%)
Campaigns	similar product with similar price	12,20	31,09
	private discount and gift	8,74	
	free return and change	4,04	
	monthly payment (never-never)	1,12	
	payment at the door	0,85	
	weekly based new products	3,22	
	recycled product use	0,93	
Shipping and Return	fast cargo	6,06	23,8
	free cargo	3,17	
	return in phsycal store	4,55	
	phsycal store	5,36	
	easy product return	4,67	
Customer Satisfaction and Services	quality of customer service	6,44	21,12
	importance of customer satisfaction	5,83	
	live customer service	3,69	
	direct contact with seller	1,53	
	detailed descriptive product	3,63	
Availability and Range of Product	easy product return	6,20	15,35
	availability of wide range products	2,80	

	range of products	1,97	
	luxury products	1,22	
	private designed products	0,58	
	mobile application	0,52	
	good navigation website	2,04	
Security	3D secure payment	7,06	7,06
Different Sellers	Different seller	0,90	1,59
	sale own brand	0,69	

4. CONCLUSIONS

In this study, it was aimed to determine the factors that online consumers relate as value in their apparel online shopping experience. In order to minimize the influence of researcher during data collection, repertory grid technique was used. For better assessment, AHP was employed to prioriate the importance levels of collected data independently of the number of repetitions. Research findings showed that most important constracts can be grouped under utilitarian values and are also more prominent in consumers' online shopping experience [7].

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JOB SATISFACTION OF TEXTILE INDUSTRY EMPLOYEES IN REPUBLIC OF SERBIA

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Abstract: *Successful companies, including textile companies dealing with certain problems, are conditioned by an optimal combination of material and nonmaterial factor directed towards employee motivation. Employee motivation is very important for the success of a company and its work processes. The quality concept of a business life encompasses aspects which influence employees being satisfied with the job, compensation system, working environment, respecting employee rights and needs. The satisfaction of employees with a job is based on social, economic and working conditions. The issue of earnings is one of the most important issues for the relation between employers and employees, which at the same time has a strong influence on social and economic development and social relations in society. The goal of this research, which was done within textile organizations in the Republic of Serbia, is to assess whether the benefits provided by employers in the textile organizations, such as overtime work, material and nonmaterial compensations and benefits and working conditions, influence the level of employee satisfaction. In the paper employee satisfaction with job content and working conditions was considered, whereby it was noted that the opinion was shared among the respondents regarding the satisfaction with working conditions, the attitude of the direct superior in everyday communication, the mutual relation of the employees in the realization of tasks, the system of social welfare and development of teamwork when performing work tasks in the organization.*

Key words: *textile industry, employee satisfaction, work conditions, material and nonmaterial benefits*

1. INTRODUCTION

Employee satisfaction, based on literature, showed that employee satisfaction and motivation is one of the basic interests of the modern management, because they have a significant importance and influence on the development and survival of contemporary organizations in an ever-growing and competitive market. In order to achieve the general satisfaction with work, employees must also receive feedback on the quality of their work and the results achieved and certainly have to have adequate material and nonmaterial reward. Therefore, employees can be satisfied when they consider that the work they do makes sense, that they are useful for the organization, that they are adequately paid and rewarded, and when they believe that they can apply their knowledge and improve it. In order to explicitly show the relation between the working conditions and the employee satisfaction, and to determine the correlation between the level of employee satisfaction and the care of the organization for the employees in the textile industry, the study was carried out among the employees in the textile organizations. It is well known that predominantly female workforce is employed in the textile industry, but most of them do not receive adequate salaries and other benefits. Also, the insecurity is high, and the job prospects are undetermined. In the studies conducted in the leather and footwear industry, it has been shown that the most important motivators for work are motivation and nonmaterial motivation, i.e. providing material conditions for life [1,2]

2. IMPORTANCE OF EMPLOYEE SATISFACTION FOR THE COMPANY'S SUCCESS

Job satisfaction can also be defined as a pleasant emotional state of the employee in relation to his/her business tasks, supervisor, situation at work and organizations as a whole [3]. Job satisfaction is actually the satisfaction of an individual with his/her job. Job satisfaction can be reduced by the influence of various factors such as: organization policy, control, administration, pay and quality of life. The conclusion of various studies is that job satisfaction represents the difference between what people expect from work and what they actually have [4]. Since there is a common belief that a satisfied worker is a productive worker, and that the organization's success is impossible with the dissatisfied employees, job satisfaction is one of the most explored topics in the field of human behavior in organizations.

Commitment to the organization refers to how employees value the goals of their organization, the value of identification, acceptance, and loyalty to the organization itself [5]. Achieving set goals and good organization results have a great impact on interpersonal relationships in the organization, as well as on creating favorable organizational climate and employee satisfaction who see the results of the organization as theirs and perceive them as personal development.

The relation between employee satisfaction and the organizational performance is very complex and influenced by job characteristics, employee behavior, personal value system and other demographic and organizational factors [6]. Acuna and associates [7] relate employee satisfaction and personal traits, processes in the collective and the quality of products / services. As key elements of employee satisfaction, Rutherford and associates [8] emphasize satisfaction with the superiors, job description, business policy and job support, improvement opportunities and career advancement, material conditions, interpersonal relationships, and finally, with customer satisfaction. Bebba and his associates [9] explicitly emphasize the influence of material conditions on motivation and employee satisfaction. The organizational structure and perceptions of employees are very influential factors on employee satisfaction [10]. Since motivation factors differently influence the satisfaction of each employee, it is necessary for the management of each organization to determine the priorities, to develop them and to encourage activities which can affect the satisfaction and well-being of all.

One of the important elements of employee satisfaction, but also organizational performance is teamwork that we analyzed in this study. Teamwork is characterized by individual and joint responsibility of its members at the same time, as well as commitment to the common goal. It can be said that teamwork is a key component of productivity, efficiency, job satisfaction and results [11].

Employee motivation is one of the key preconditions for business success. Therefore, it is necessary to continuously study and improve this system. Moral motives can also be called collective motives in relation to teamwork, and material to personal motives [12]. Therefore, motivation is the process of initiating and directing efforts and activities for the purpose of personal and organizational goals.

Since the concern for the employee is one of the most important aspects of the socially responsible companies, the employee motivation, their satisfaction, professional improvement and development represent both personal and organizational success. One of the factors which greatly influence employee satisfaction, which will be discussed further on, is the safety and health of employees at work, which is closely related to the working environment.

3. METHODOLOGY

The structured questionnaire was used. We used the theoretical analysis method which will enable theoretical understanding of different methodological approaches in studying the problem of employee satisfaction in the textile industry. Also, we applied the descriptive research method, which is in accordance with the defined problem we are studying. The total study involves 241 respondents, that is, workers employed in the textile industry sector. The study was conducted in the textile organizations in the Republic of Serbia, which have been trying for years to establish competitiveness on the domestic and international market [13].

4. RESULTS AND DISCUSSION

Answers to the questions from Part I - Demographic issues are presented in Table 1.

Table 1. *Demography*

Characteristic		Number of respondents (N)	Percent (%)
Gender	Male Female	56 185	23,24 76,76
Age	Less than 20 years 20 to 30 years 30 to 50 years 50 to 65 years	0 33 208 0	0,00 13,69 86,31 0,00
Education level	Elementary school Nonqualified workers Qualified workers BA MA	3 12 94 106 26	1.24 4.98 39,00 43.98 10.79
Work post	Blue collar Production management Other (technical staff, administration, etc.	197 29 15	81.74 12.03 6.22

The second group of questions relate to material and nonmaterial incentives. Respondents marked their level of satisfaction with the factors and activities of the organization related to material and non-material incentives on the scale from 1 to 5 satisfied. To the first question, *To what extent are you satisfied with the amount of total maternal benefits for your work*, 74.28% of respondents answered that they are not satisfied with the total material income, while only a small number of respondents, 7.05%, said that they were very dissatisfied and satisfied (Table 2). Based on employee responses, we can see that the largest number of respondents said they were dissatisfied with the material rewards they received for the work and the achieved results. The consequence of such dissatisfaction can be great economic changes in our country and the material status of workers which is not at an enviable level in the past few years.

Since nonmaterial incentives have a great significance on employee satisfaction, apart from material incentives, and they were asked "To what extent are you satisfied with the nonmaterial incentives you receive for the results achieved? The answer is 77.12%, and only slightly more than 8% said that they were satisfied and very satisfied with nonmaterial incentives and recognitions related to the achieved results of work in organizations (Table 3).

In relation to the answers, we can say that nonmaterial incentives can be of great importance for the employees and that they represent important elements of satisfaction and essential elements of a good organizational climate. The study shows that the management of these organizations does not offer appropriate nonmaterial incentives to their employees or rewards for the achieved work results, which basically affects the employee satisfaction, their engagement, and this can have an impact on the success of the organization itself. If we emphasize that rewarding, adequate system of earnings, compensation, benefits, and recognition affect the motivation, fluctuation and satisfaction of employees, then we must mention that human resources management has to responsibly study and develop all these elements in order to achieve organizational goals.

Table 2. *Employee satisfaction with their total material compensation*

Level of satisfaction	**Number of respondents (N)**	**Percent (%)**
Extremely dissatisfied	17	7,05
Dissatisfied	179	74,28
Indifferent	28	11,62
Satisfied	17	7,05
Extremely satisfied	0	0
Total	241	100

Table 3. *Employee satisfaction with nonmaterial incentives*

Level of satisfaction	**Number of respondents (N)**	**Percent (%)**
Extremely dissatisfied	20	8,30
Dissatisfied	186	77,12
Indifferent	15	6,28
Satisfied	10	4,15
Extremely satisfied	10	4,15
Total	241	100

The third group of questions is related to the satisfaction of employees with the content of the work they perform and the working conditions. We asked the following questions: First question - "*To what extent are you satisfied with working conditions in your workplace*?" It can be concluded that there are very few dissatisfied and very dissatisfied employees, and that 52.7% of respondents answered that they are satisfied, also 7.05% are very satisfied with the working conditions (Table 4). It can be concluded that most of the employees are satisfied with working conditions, which can be the result of the well-developed management system and the applied responsible behavior towards employees. The level of employee satisfaction with working conditions derives also from the employee satisfaction level with organizational care about the employees, which was confirmed in the second part of the study.

To the questions "To what extent are you satisfied with the attitude of your immediate superior in daily communication with employees?" 52.70% of respondents answered that they were satisfied, and 7.05% were very satisfied with the attitude of the immediate manager in the daily communication with the employees and mutual communication among employees when realizing work tasks (Table 5). This part of the employee satisfaction survey is considered very important because communication in organizations has a significant impact on the transfer of the organizational vision and goals to employees, as well as the better understanding of business reality and long-term success of the organization. Accuracy and timeliness of information is one of the conditions for good work of employees. It is very important that there is a two-way communication in the organization. The level of satisfaction of employees in the realization of mutual communication, considered in this survey, indicates the significance of this factor and its importance for achieving the favorable organizational climate.

Table 4. *Employee satisfaction with working conditions*

Level of satisfaction	Number of respondents (N)	Percent (%)
Extremely dissatisfied	7	2,91
Dissatisfied	24	9,96
Indifferent	66	27,38
Satisfied	127	52,7
Extremely satisfied	17	7,05
Total	241	100

Table 5. *Employee satisfaction with the direct superior's communication with employees on daily bases and the attitude among workers when performing daily tasks*

Level of satisfaction	Number of respondents (N)	Percent (%)
Extremely dissatisfied	3	1,24
Dissatisfied	17	7,05
Indifferent	77	31,95
Satisfied	127	52,70
Extremely satisfied	17	7,05
Total	241	100

When analyzing the answers to the question "*To what extent are you satisfied with the social welfare system in your organization*?", We can point out that more than half of the respondents are insufficiently satisfied with the social welfare system in the organization in which they are employed 108 respondents, or 53.11%, 5 or 2.07% respondents are extremely dissatisfied, 76 or 31.53% are dissatisfied, and 32 or 13.29% are satisfied.

The question of satisfaction with the development of teamwork in the realization of tasks is another issue that was discussed. The following results were obtained: 126 or 52.28% of respondents were equally satisfied and dissatisfied, and 38 or 15.77% of respondents were satisfied with the teamwork in the realization of their tasks in the organization in which they were employed. The conducted survey showed that there is no well organized teamwork in the organizations that participated in this study, even though its existence is very important for business success and development. The team has a common approach to resolving problems and members are complementing each other in solving them, new ideas are being developed, and each member of the team has responsibility in carrying out work tasks, but also the team is responsible to each member. Therefore, it is extremely important that human resources management in textile organizations, in which technological processes are complex and interconnected, develop the spirit of teamwork among employees in order to solve their work tasks more efficiently.

6. CONCLUSION

The research carried out in textile industry organizations was aiming at assessing whether the benefits provided by the employer, overtime, material and nonmaterial incentives and benefits, and the working conditions influence on their level of satisfaction. The aim of this paper is to evaluate the satisfaction of employees in terms of working environment, to assess their satisfaction with material and nonmaterial incentives, and to determine the extent to which different motivational factors affect the satisfaction of employees. The study shows that all investigated factors and activities of the organization are important for achieving general employee satisfaction. Considering the social status of workers in the textile industry, it can be said that material and nonmaterial incentives are of the prime importance, and most of the respondents are dissatisfied with them. The issue of earnings is one of the most important issues of relations between employers and employees, which at the same time has a strong influence on social and economic development and social relations in society. The positive impact on behavior and the increase in motivation for the work makes the wage a useful investment for employers, which is conditioned by the appropriate design of the salary system in accordance with motivational theories.

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