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CONTENTS

ANNALS OF THE UNIVERSITY OF ORADEA
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STUDY REGARDING THE OPTIMIZATION OF THE JERSEY' S MASS

AIRINEI Erzsebet [1], PUSTIANU Monica[2], BARBU Ionel[3], POPA Alexandru[4], BUCEVSCHI Adina[5]

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Abstract: *Correct setting of the structure parameters and their relative influences is the basis of technological adjustments which should be done when programming a new article but also during the operation as a means of preventive control for quality protection.*
The main defects that appear in the knit jersey are determined by the incorrectness of the setting of technological parameters.
Beside these parameters may also be considered as parameters of the knitting process some of the technical characteristics of knitting machines as knitting speed which can be adjusted according to the nature and fineness of the raw material and the structure of the knit.
The structure of the knit has a direct influence on the appearance, on the dimensional stability, on the rip capacity, on extensibility, weight, thickness and width of the knit. Through a judicious choice of their structure knits can satisfy a number of requirements on physico-mechanical and hygienic functional properties as well as some economic desiderata such as reducing raw material consumption by reducing the mass of the knit (but without affecting quality).
The determinations were made on a knit plated jersey made by yarns 50% cotton and 50% polyester, Nm60/1. The knit samples were made on Terrot S 256 4 track machines
To analyse the influence of the knitting parameters on the mass of the jersey was used a mathematical model that expresses the correlation between the knit mass, in g/m as dependent variable (response) and the vertical density, in courses/10mm and the number of turns, in rot/min as dependent variables.

Key words: *mass, knitting, mathematical model, structure parameters, speed, vertical density***.**

1. INTRODUCTION

For this research we used knitted fabric made by yarns Nm60/1, 50% cotton and 50% polyester [1], [2], [3]. The experimental part was conducted under a correlation program with two independent variables, central compose rotable second order program [4]. Mathematics patterning has been realised in Mathcad 8 Professional and it contains 13 experiments from which five parallel experiments has been made at independent parameters central values [5], [6].

2. EXPERIMENTAL PART

To analyse the influence of knitting parameters we chose as independent variable x – the vertical density, in courses/10mm, y - number of turns, in rot/min

The coded values of the independent variables are presented in table no.1. [4],[7],[8],[9],[10]

Table 1: *The variation limits of independent variables*

Independent variables	Coded values				
	- 1,414	**- 1**	**0**	**1**	**1,414**
x	19,5	21,2	20,5	19,62	21,5
y	19	22.42	21	19,58	23

The experimental plan is shown in table no. 2 [11]

Table2: *The experimental plan with two independent variables*

Experience' number	x	y
1.	-1	-1
2.	1	-1
3.	-1	1
4.	1	1
5.	-1.414	0
6.	1,414	0
7.	0	-1,414
8.	0	1,414
9.	0	0
10.	0	0
11.	0	0
12.	0	0
13.	0	0

Experimental matrix and measured values for the response function are presented in table no. 3.

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

Experience' number	Independent variables				Dependent variable
	x vertical density, in courses/10mm		y number of turns, in rot/min		Z=F(x,y) Mass, in g/m^2
	cod.	real	cod.	real	
1	-1	21,2	-1	22,42	248,3254
2	1	19,62	-1	22,42	270,2145
3	-1	21,2	1	19,58	249,6542
4	1	19,62	1	19,58	271,2354
5	-1,414	19,5	0	21	245,3258
6	1,414	21,5	0	21	276,0275
7	0	20,5	-1,414	19	258,2458
8	0	20,5	1,414	23	261,2154
9	0	20,5	0	21	256,2471
10	0	20,5	0	21	256,2458
11	0	20,5	0	21	256,2654
12	0	20,5	0	21	256,2357
13	0	20,5	0	21	256,2654

The regression equation that describes the evolution of the knit mass is shown in equation no.1:

$$z = 256,3147+ 10,8603\, x +0,8185\, y +2,0746\, x^2 +1,6017\, y^2 -0,0384\, xy \quad \textbf{(1)}$$

The calculated values of response function coefficients are shown in table no.4.

Table 4: ***The coefficients of the response function***

The coefficients of the response function	The calculate values of the coefficients of the response function
b_0	256,3147
b_1	10,8603
b_2	0,8185
b_{11}	2,0746
b_{22}	1,6017
b_{12}	-0.0384

The significance of the regression equation' coefficients was verified with Student test. The critical value for the test is 2,132 for a significance level $\alpha = 0,05$ and a number of degrees of freedom $\nu = n-1 = 4$ [4],[7],[8]. As a result of the verification, all coefficients of the regression equation are significant.

The adequacy of the model was verified with Fisher- Snedecor test and with the percentage deviation. [4],[7],[8]. The calculated value with Fisher- Snedecor test Fc=0,0000548 is less that the critical value Fc = 2,69, for a significance level $\alpha = 0,05$, $\nu_1 = 12$, $\nu_2 = 12$. The percentage deviations are less than 10% that shows the veracity of the model. The values for $c_{alculated}$ and for the veracity of the model are shown in table no.5

Table 5: *The veracity of the model*

No.	z measured (mass, g/m^2)	z calculated (mass, g/m^2)	Veracity A (%)
1	248,3254	248,2738	0,0207
2	270,2145	270,0714	0,0529
3	249,6542	249,988	-0,1336
4	271,2354	271,6316	-0,1460
5	245,3258	245,1064	0,0894
6	276,0275	275,8193	0,0754
7	258,2458	258,3599	-0,0441
8	261,2154	260,6748	0,2069
9	256,2471	256,3147	-0,0263
10	256,2458	256,3147	-0,0269
11	256,2654	256,3147	-0,0192
12	256,2357	256,3147	-0,0308
13	256,2654	256,3147	-0,0192

By analyzing the coefficients of the regression equation result that the two independent variables influence identically the resultative z, the mass, the most important parameter is x, the vertical density. Both vertical density increase and speed increased leads to increase mass increase.

The influence of the vertical density about the mass is 4,23% while the influence of the speed is only 0,3% We can see that the influence of the two parameters selected for experiments is low which leads to the conclusion that the mass is influenced by other factors as: yarn's count, the horizontal density of the jersey, the length of the yarn from one stitch a.s.o.

The existence of second degree terms shows that the answer surface will be well defined. The speed of change of the dependent variable is 0,8% for the vertical density and 0,6% for the speed of the knitting machine.

The interaction of the two parameters represented by the existence of b_{12} coefficient is 0,01% and shows that a concerted growth of the two parameters leads to the decrease of the resultative.

In figure no. 1 is presented the answer surfaceand in figure no.2 are presented the level curves obtained through the intersection of the response plane with parallel planes, at the following z values: 251,47; 258,811; 266,151; 273,492; 280,833; 288,174; 295,514; 302,855.

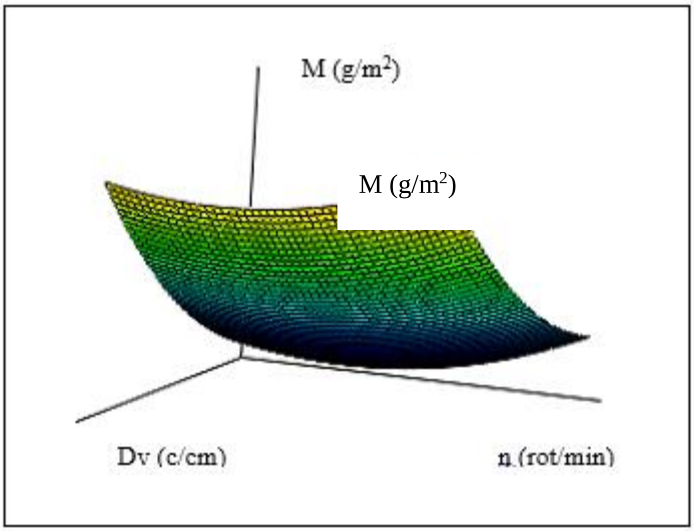

Fig.1: *The response surface*

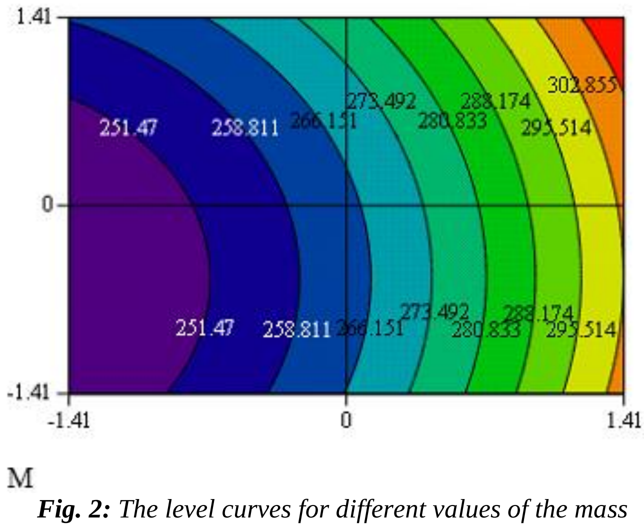

Fig. 2: *The level curves for different values of the mass*

The response surface is a conic with a with a unique center, elliptic paraboloid, and the level curves that generate the response surface, respectively the sections through the response surface for different levels of z, have elliptic shapes. The elliptical shape of the sections through the answer surface results from the calculation of the metric invariants that change the coordinates of the regression equation, resulting S $\neq$0. [4],[7],[8].

The new axis center calculated for optimal function determination is: x = -2,61 and y = -0,28. By calculating the second order partial derivatives of the regression equation results that the new axis center is a minimum point.

In figure no.3 is presented the variation z=f(x) for y=constant.

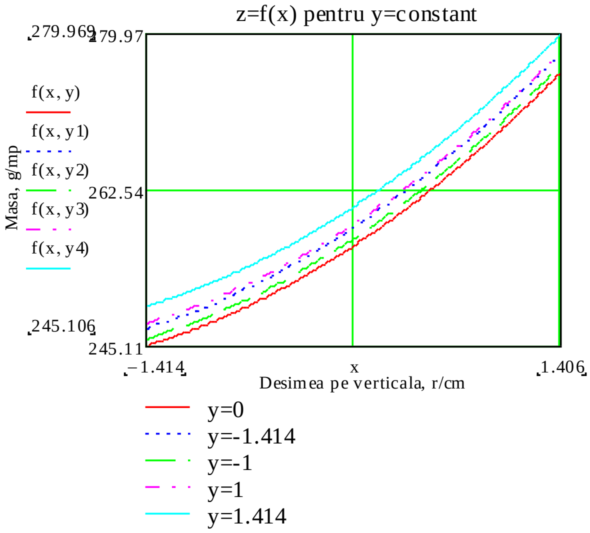

***Fig.3**: The influence of the vertical density about the mass*

3. CONCLUSIONS

For low values of vertical density, about 19,5 stitches/10mm the mass is small, 245,3258 g/m^2, because the variation of the vertical density influence directly proportional the mass size. If the vertical density grows at 20,5 stitches/10mm the mass become 256,2458 g/m^2.

At a bigger value of the vertical density, e.g. 21,5 stitches/10mm the mass become 276,0275 g/m^2. To such a vertical density there is a danger that due to the large agglomeration of stitches to appear pilling phenomenon at wearing the products. There is also the danger that in the knitting process the knit quality is affected by making the stitches forming process more difficult. The bending of the yarn under the action of the stitch forming organs will be difficult. Also, at these values the consumption of raw material is high.

After the mathematical modeling of the knitting process it is recommended to work with vertical density 19,5 stitches/10mm corresponding to -1,414 code values and a speed about 21 rot/min corresponding to 0 code value for that the mass value is 245,3258 g/m^2, very close for the optimum value that is 243,0155 g/m^2. At this value the product is easy to obtain and the raw material consumption is minimal.

REFERENCES

[1] AGIR, "*The Textile Engineer's Manual*", vol.III, Ed.AGIR, Bucharest, 2004

[2] M. Macsim, R. Butnaru and M. Penciuc, *Influence of finishing treatments on the physical-mechanical characteristics of cotton knitted fabrics,* rev. Industria textilă, vol. 61, nr. 6, pp. 297-303, 2010

[3] Subramanian Kathirvelu, *Effect of Yarn Structure on Mechanical Properties of Single Jersey Fabrics*, Annals of the Oradea University, Fascicle of Textiles, Leatherwork, 2018, pag 93

[4] R. Mihail, *Introduction to the strategy experimenting with applications in chemical technology*, Ed. Scientific and Encyclopedic, Bucharest, 1976.

[5] Schneiber, E., Lixandroiu, D., *MathCAD - Presentation and problems solved*, Ed. Technique, Bucharest, 1994

[6] Jalobeanu, C., Rasa, I., *MathCAD. Numerical and statistical problems*, Ed. Albastra, Cluj Napoca, 973-97000-3-9, 247 p., 1995.

[7] Ciocoiu, M.- „*Bazele statistico-matematice ale analizei şi controlului calităţii în industria textilă ",* Ed. Performantica, Iaşi, 2002

[8] Cojocaru, N. *Metode statistice aplicate în industria textilă*. Editura Didactică și Pedagogică București, 1986

[9] Popescu I.D., *Bazele statisticii*, Editia a III-a revizuită şi completată, Ed. Fundatiei Academice Danubius, Galati, 2000

[10] Jaba E., *Statistică*, Ed. Economică, Editia a IV-a, Bucureşti, 2007

[11] Irovan Marcela ,Tutunaru Irina , Farima Daniela , Ciocoiu Mihai, *The software application for mathematical modelling of technological process in textile industry*, Annals of the Oradea University, Fascicle of Textiles, Leatherwork, 2018, pag 55

APPLICATION OF MICROENCAPSULATED NATURAL OILS IN THE DEVELOPMENT OF FUNCTIONALIZED SUSTAINABLE CLOTHING

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Abstract: *Today more than ever, mosquito-borne diseases have a major influence on the quality of life and socio-economic development of a large part of the human population. Malaria is one such diseases. Responsible for reaching almost half of the world's population in about 100 countries, its occurrence has a tremendous impact on the human health of 214 million people, being the cause of the death of more than 438 000 people, and, also, to significant economic losses. Recent increases in drug resistance (drugs and repellents) and climate change, have led this disease to spread into new geographical areas, especially in Europe's outskirts. Aware of this situation, the authors sought to develop a new biodegradable and antimalarial technological solution, through the functionalization of PLA filaments. It is expected that, this new technological solution, might contribute to the diminishing of the impact of malaria on human health. Bearing this purpose in mind, this researcg work aim at the development of a new piece of cloth made with an entirely new family of PLA fibres, specifically designed. Those fibres were embedded with internally developed microcapsules containing a natural repellent agent – schinus molle – added during the extrusion process. Based upon this new fibre, three knit structures were produced and the repellent efficacy and washing resistance were assessed.*

Key words: *PLA; Functional textiles; Anti-malarial; Microcapsules; Natural essential oils; Sustainability.*

1. INTRODUCTION

1.1 Context

In the history of man kind, tgreat changes and transformations had their origin in the development of technology, whether through the introduction of new products, new processes, new technologies or new systems. Nowadays, it is quiet perceiveble that the evolution in the field of textile functionalization brings a constant improvement into the

Market. However, some of those new products, end up to not being completely satisfying, for their large majority do not comply with safe environmental criterion. Hence, this research seeks to contribute to the development of sustainable and functional textile materials, capable of, efficiently, protecting not only humans but, also the environment. For this purpose, biodegradable and antimalarial PLA filaments, containing silica nanocapsules with a natural essential oil were produced.

1.2 Physiopathology of Malaria: A Public Health Perspective

Growing drug and insecticide resistance, environmental change, and human migration have led to an increase in tropical epidemics, particularly malaria. Caused by the reproduction of Plasmodium parasites in human blood, malaria is transmitted through the bloodstream through the bite of the female Anopheles mosquito in rural and semi-rural subtropical climate zones (Goldman & Schafer, 2014) [1-2]. This pathology is nicknamed malarial or malaria is of Italian origin, and etymologically means "bad air," bad 'aria" (Carter & Mendis, 2002), "badly coming from the air", originating from the fumes and miasma of certain marshy regions, among other designations is one of the most serious and potentially fatal infectious diseases in the world (Cunha & Cunha, 2008).

According to the Center for Disease Control and Prevention, (2016), it is one of the most significant diseases for humanity due to its devastating impact on social and economic damage because the losses from malaria are deep, in addition to an enormous detriment to the social well-being of the population and very serious damage to health also bring aggregate, a high economic burden for the host country - its occurrence has a direct impact on human resources, not only results in lost lives and productivity, but also hampers children's normal schooling and social development due to absenteeism and permanent family harm (WHO & RBM, 2006).

1.3. Repellent activity: anti-malarial active components

For centuries, mankind has been looking for solutions to prevent insect bites, using different methods, in an attempt to avoid their painful bites and increased diseases. Insect repellents are an economic alternative for both human protection and vector control, playing an important role in combating insect bites and reducing human-vector contact. In recent years, due to the increase in resistance seen in vectors and the climate change under way, insect repellents have gained a growing and particular interest in public health in protecting against vectors. (Dickens & Bohbot, 2013).

Currently, the development of new repellent action products has grown exponentially, aiming at an adequate protection against different transmitting vectors, bringing to the final consumer different application/use possibilities applied on the skin or incorporated in textiles, thus reducing the chances of disease transmission (Katz, Miller, & Hebert, 2008; Leo, Del Regno, Gregory, & Clark, 2001). However, it is important to note that most of these formulations are not environmentally friendly and are associated with allergies, skin irritations and sometimes severe asthma reactions [3].

Lately, interest in botanical products has been shown, due to the use of synthetic products, to raise several concerns both in biological control and in the development of resistance, undesirable effects on non-target organisms, and both human and animal health and environmental concerns (Kim et al., 2003). There is now a growing interest in organic products, free of pesticides, with substances that have good efficacy and environmentally friendly (Nerio et al., 2010).

We currently have in nature a large number of plants that are known for their numerous release of chemical substances, which have served as a basis for various applications in folk medicine (Dias et al., 2012). An accurate example is the essential oils that have been evaluated/tested due to their repellent properties as a valuable natural resource (Corrêa & Salgado, 2011). They are considered the first drugs used by primitive man (Figueiredo, Pedro, & Barroso, 2007) and pesticides of minimal risk of high added value.

1.4 Natural Eessential Oil Schinus Molle

Schinus molle L. commonly called California pepper, Peruvian pepper, false pepper, mastic tree, among others, is a wild tree usually used in landscaping or afforestation of the streets and grows around 15 meters (Martins, Arantes, Candeias, Tinoco, & Cruz-Morais, 2014). There are several studies on this plant that report different biological activities of its essential oils, such as antiviral, topical antiseptic, antifungal, antioxidant, anti-inflammatory, tumor and antispasmodic, antibacterial, analgesic, healing (Bigliani et al.., 2012; Mehani & Segni, 2012), and especially with repellent and anti-malarial activity (Eryigit, Yildirim, Ekici, & Çirka, 2017; Taylor et al., 2016).

In addition to all the properties previously seen, around 60% of the essential oils of Schinus molle L. have antifungal activity and 35% have antibacterial properties (Marongiu, Porcedda, Casu, & Pierucci, 2004; Silva et al., 2010), which makes this an excellent candidate, an alternative to synthetic chemicals in pest control (Bendaoud, Romdhane, Souchard, Cazaux, & Bouajila, 2010) [4-6}.

The chemical composition of essential oil, mainly, consists of monoterpene hydrocarbons (e.g. α-pinene, Sabinene, terpinen-4-ol) and some sesquiterpenes such as (+)-spathulenol and germacrene-D) which represent a total of 94.0% of essential oil (Rocha et al., 2012).

***Fig. 1**: Schinus molle.*

1.5 Development of mosquito repellent textiles

In recent years, several studies have been carried out on the incorporation of mosquito repellents in textiles and clothing intended for outdoor activities [7]; however, these repellent textiles are based upon synthetic repellents, such as permethrin, which is extremely polluting and highly harmful to human health. Mosquito repellent textiles are usually obtained by finishing processes with the incorporation of repellent agents; however, they can also be produced by integrating repellent agents into the yarn or fiber before production.This method has some advantages over the impregnation of textiles with mosquito repellents in a final phase.

Treatments with the incorporation of repellent agents within the fiber are less polluting and their production cost is reduced as the incorporation of the repellent and the production of fibers are commonly performed in a single process (Langenhove & Paul, 2014). Padding do not guarantee such an efficient durability of the repellent on the textile surface. In addition to this fact, the chemicals used in this method may bring some environmental concerns.

2. MATERIALS AND METHODS

2.1 Selection of Repellent Agents

From the various options available on the market we decide to select an encapsulant that would provide the necessary thermal protection to the essential oil during, the extrusion process, and had good chemical stability, not interacting with oil or with the permethrin [8].

For this purpose, silica nanocapsules were chosen, since they have a porous honeycomb structure with hundreds of empty channels (mesoporous) that are able to absorb and/or encapsulate relatively large amounts of bioactive molecules [9]. Additionally, their morphology and specific area are also the most appropriate for our objectives (Chen et al., 2013; Giraldo et al., 2007).

2.2 Biopolymer Features

Taking into account the need to have a totally biodegradable fiber and that would be able to withstand the thermal and rheological conditions of a fusion extrusion process, Natureworks Ingeo

6201D PLA15 biopolymer was selected, marketed under the brand Ingeo™ biopolymer is a polymer that offers environmental benefits because it is made from renewable resources. The main characteristics of the above mentioned polymer are represented in table 1.

***Table 1**: Typical properties of PLA Ingeo 6201D*

PHYSICAL PROPERTIES	METRIC	COMMENTS
Specific Gravity	1,24 g/cm^3	ASTM D792
Melt Density	1,08 G/cm^3 at 230ºc	ASTM D1238
Viscosity Measurement	3,1	Relative Viscosity; CD internal Viscotek method
Melt flow	15-30 g/10 min at load 2,16 Kg and temperature 210ºC	ASTM D1238
Melting Point	160ºC-170ºC	ASTM D3418
Glass Transition Temp.	55ºC-60ºC	ASTM D3417
Shrinkage	5%-15%	ASTM D32102 Boiling Water

2.3 PLA Nanoencapsulation

The encapsulation of both chemical agents occurred individually, and was performed using the adsorption method. The adsorption process consisted in mixing the components, followed by stirring and filtering the prepared mixture. Quality control tests such as DSL, TGA, FTIR, DLS, SEM, were conducted to characterize the attained nanocapsules.

2.4. Extrusion of Functionalized PLA Multifilaments

The functionalized PLA multifilaments were obtained through a fusion extrusion operation and were performed in a melt spinning unit of Hills Inc [10]. The temperatures used in the different sections of the extruder were defined, based upon the lower limit of temperatures, at which, the used PLA could be processed. The extrusion process was thoroughly conducted so as to maximize the preservation of the used chemical additive, preventing, as much as possible, its volatilization and thermal degradation. Thus, PLA multi-filaments, with incorporated functional nanocapsules, were extruded in a 21 mm double screw extruder lab model, from Randall Technology, as seen in figure 2.

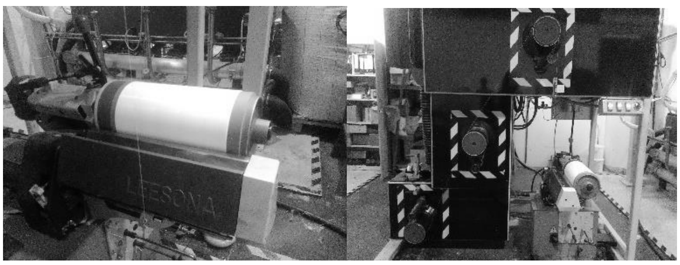

***Fig. 2:** Extrusion of Functionalized PLA Multifilaments*

Regarding multifilaments, three polypropylene pigments were added: ISPLEN® PP086Y1E, in blue (PLA+silica nano capsules + essential oil schinus molle); pink (PLA+silica nanocapsules with Permethrin) and yellow (PLA) in order to distinguish between them.

All tests have been carried out under the same conditions to ensure that any differences between the produced fibres are the result, not of process conditions, but from the used additives.

Based on the multifilaments and with a Flat V electronic bed Shima Seiki machine model SES 122FF a textile structure suitable for the manufacture of biodegradable antimalarial clothing - mesh structure - Jersey with high production capacity and economic cost was produced.

3. RESULTS

In order to verify the efficiency of the proposed technological solution, an Anopheles Spp mosquito repellency test was carried out in the laboratories of the company BTS (Biotech Testing Services) on knit samples functionalized with each of the antimalarial agents tested. The WHO Excito Repellency Test method according to WHO/CTD/WHO PES/IC/96.1 was used with male and female Anopheles Spp mosquitoes during 10 minutes of exposure through the metal box method.

The test comprises two distinct phases, in the first one the samples were rubbed 10 times with circular movements through a device that applies a force and a constant rotation speed, similar to the abrasimeter, to cause mechanical surface wear, equivalent to the use. In the second one, they were submitted to 5 wash cycles (150 minutes) at 40º and with a standard detergent, after which they were rinsed and dried in a conditioned environment. In both trials, the mosquitoes were released into the test chamber containing the mesh sample treated with the antimalarial agent and the control sample, untreated, in order to observe the behavior of the mosquitoes in terms of number of dead mosquitoes, number of mobile mosquitoes, as well as their behavior. Other tests were carried out to assess surface and mechanical properties of the produced knitted structures, such as: washing fastness, abrasion resistance, pilling resistance and tensile strength test.

4. CONCLUSIONS

This research proved the existence of antimalarial activity, for all the knit samples, with incorporated functional nanocapsules.

It was found that the developed technological solution, based upon silica nanocapsules with natural essential oil of Schinus mole, provided better antimalarial efficiency results, when compared to silica nanocapsules with Permethrin.

Overall the 100% PLA knit structure, with encapsulated natural essential oil, is the one that presents the best antimalarial behavior and combines the best characteristics for the design of biodegradable antimalarial clothing.

This research work is applying for a national patent.

REFRENCES

[1] Carter, R., & Mendis, K. N. (2002). Evolutionary and historical aspects of the burden of malaria. Clinical Microbiology Reviews, 15(4), 564–594. https://doi.org/10.1128/CMR.15.4.564–594.2002

[2] Cunha, C. B., & Cunha, B. A. (2008). Brief history of the clinical diagnosis of malaria: from Hippocrates to Osler. Journal of Vector Borne Diseases, 45(3), 194–199.

[3] Figueiredo, A. C., Pedro, L. G., & Barroso, J. G. (2007). PLANTAS AROMÁTICAS E MEDICINAIS - Óleos essenciais e voláteis. Revista Da APH, 114, 29–33. Retrieved

fromhttp://cbv.fc.ul.pt/2014_Revista_da_APH_114_20_PAM.pdf

[4] Bendaoud, H., Romdhane, M., Souchard, J. P., Cazaux, S., & Bouajila, J. (2010). Chemical Composition and Anticancer and Antioxidant Activities of Schinus Molle L. and Schinus Terebinthifolius Raddi Berries Essential Oils. Journal of Food Science, 75(6), 466–472. https://doi.org/10.1111/j.1750-3841.2010.01711.x

[5] Bigliani, M. C., Rossetti, V., Grondona, E., Presti, S. Lo, Paglini, P. M., Rivero, V., Ponce, A. A. (2012). Chemical compositions and properties of Schinus areira L. essential oil on airway inflammation and cardiovascular system of mice and rabbits. Food and Chemical Toxicology, 50(7), 2282–2288. https://doi.org/10.1016/j.fct.2012.04.025

[6] Bigliani, M. C., Rossetti, V., Grondona, E., Presti, S. Lo, Paglini, P. M., Rivero, V., Ponce, A. A. (2012). Chemical compositions and properties of Schinus areira L. essential oil on airway inflammation and cardiovascular system of mice and rabbits. Food and Chemical Toxicology, 50(7), 2282–2288. https://doi.org/10.1016/j.fct.2012.04.025

[7] Dickens, J. C., & Bohbot, J. D. (2013). Mini review: Mode of action of mosquito repellents. Pesticide Biochemistry and Physiology, 106(3), 149–155. https://doi.org/10.1016/j.pestbp.2013.02.006

[8] Chen, H., Zhen, Z., Tang, W., Todd, T., Chuang, Y. J., Wang, L., … Xie, J. (2013). Label-free luminescent mesoporous silica nanoparticles for imaging and drug delivery. Theranostics, 3(9), 650–657. https://doi.org/10.7150/thno.6668

[9] Anuar, A. A., & Yusof, N. (2016). Methods of imparting mosquito repellent agents and the assessing mosquito repellency on textile. Fashion and Textiles, 3(1), 12. https://doi.org/10.1186/s40691-016-0064-y.

[10] Langenhove, L. Van, & Paul, R. (2014). Functional Finishes for Textiles: Improving Comfort, Performance and Protection. In Insect repellent finishes for textiles (1st Editio, pp. 333–360). UK: Woodhead Publishing Ltd. https://doi.org/10.1533/9780857098450.2.579

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

STREAMLINE OF PRODUCING KNITTED PRODUCTS FOR CHILDREN

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Abstract: *In this paper are presented two variants of making knitted products, namely by classic knitting and by integral knitting - Wholegarment, a children's hat made of 100% Cashmir yarn. This yarn is chosen due to its superior qualities, which make it so comfortable to wear, offering increased comfort to the wearer. Being a product for children is the choice of material is of a high importance. This material is durable, adapts perfectly to any shape and fashion design concept. Another reason is the fineness and softness of the yarn, which can be worn directly on the skin, without the risk of irritation or eczema. Another very important feature is its thermal insulation, and hygroscopicity. The research was carried out in S.C. ASTRICO S.R.L.Piatra Neamt. The products were made on the rectilinear knitting machine SSR 12 SV finesse 7, produced by Shima Seiki from Japan. These knitting machines use the SDS-One graphics station or the APEX graphics station - the latest generation. Using the technological possibilities offered by both the machine and its graphic assisted program, it was intended to achieve the production efficiency, which can be done by finding ways of reducing the execution times as well as increasing the comfort and quality of the items produced.*

Key words: *Knitting, yarn, graphic assisted program.*

1. INTRODUCTION

Considering the impact of contemporary technical and technological progress, the technical basis of production systems undergoes a series of particularly important structural and quality transformations [1, 2]. The technical basis of such production systems will be made up of the most modern machinery and equipment [3, 4]. In knitwear, CAD/CAM applications have been developed by knitting machine producers in collaboration with software companies [5]. With consistent progress in the original technology that anticipates the market needs, Shima Seiki computerized knitting machines have become the global standard [5].

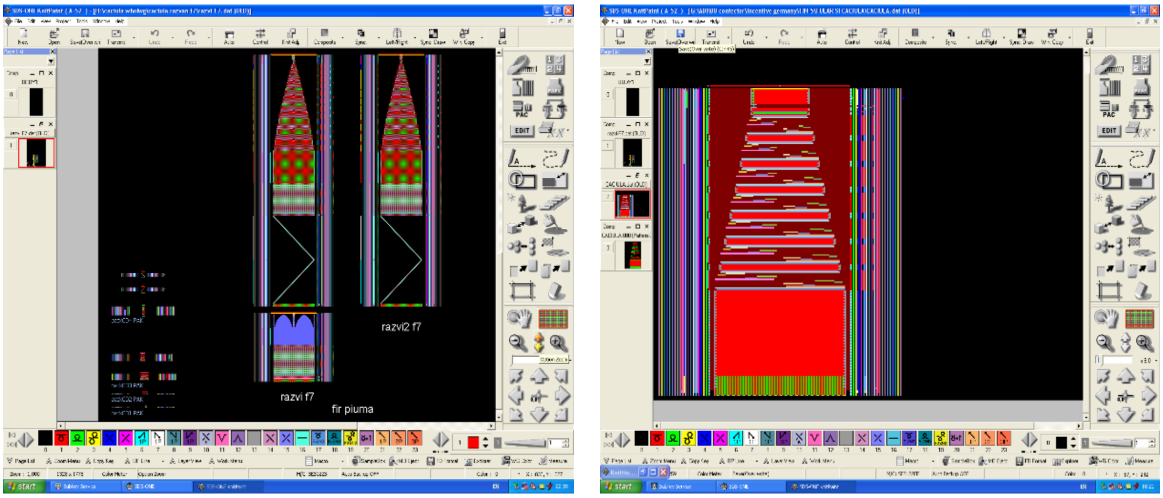
2. EXPERIMENTAL PART

The experimental part was carried out in S.C. ASTRICO S.R.L. Piatra Neamt. For the production of this item the rectilinear knitting machine SSR 12 SV finesse 7 was used, manufactured by Shima Seiki from Japan, fig.1. This machine has a command system and electronic selection with two knitting systems. The machine is fitted with a presser foot and two integrated cam systems. The DSCS device (patented by Shima Seiki) is the most important improvement in knitting technology on the rectilinear machine [5]. The device controls and adjusts the length of the weave yarn digitally, keeping it constant, with a tolerance of ± 2%. This device is essential for contour knitting and integral knitting as it allows for constantly keeping the knit dimensions [6].

Fig. 1: *Knitting machine SSR 12 SV finesse 7*

Shima Seiki, a Japanese manufacturer of knitting machines, also owns a range of machines for integral knitwear-Wholegarment products [5]. Our research has been done on a classic knitting machine using the technological possibilities offered by both the machine and its graphic assisted program. These knitting machines use the SDS-One graphics station or the APEX graphics station - the latest generation.

Figures 2a and 2b show the programs of the two knitted products, the children's hat.



a) b)

Fig. 2: *Picture of the product program a) entirely made by knitting*
b) made by using the classic knitting method

After making the products design for the items produced, the programs are processed. This means translating the code from the design program into the actual language of the knitting machines in order to produce the items, (Figure 3.).

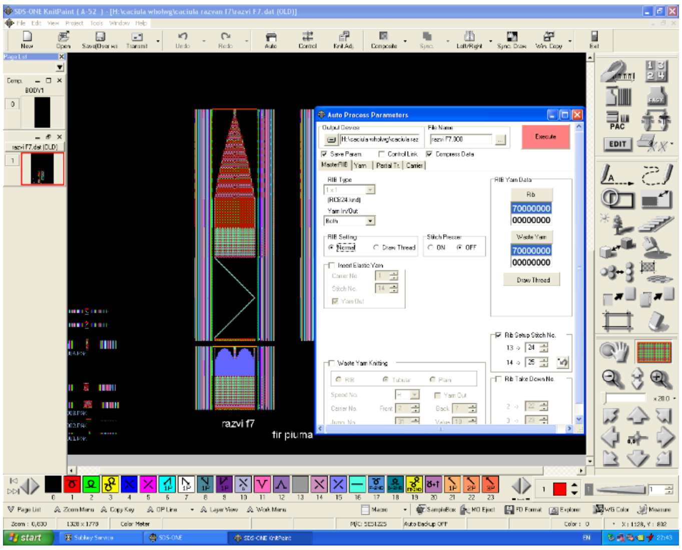
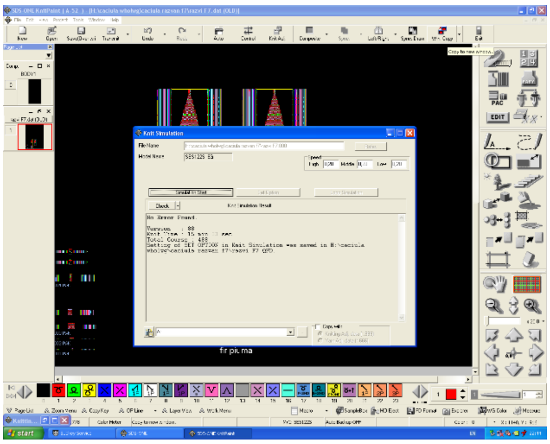
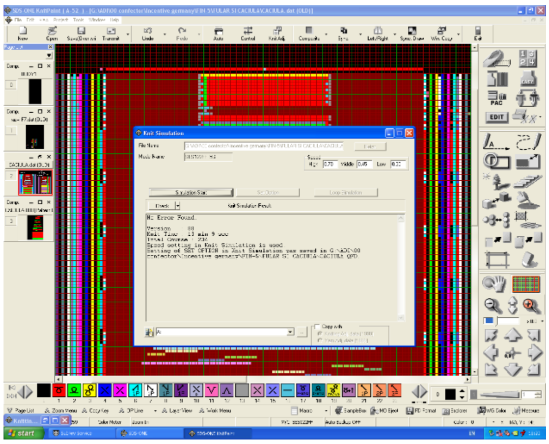


Fig. 3*: The phase of program processing of the product obtained by full knitting*

Figure 4a shows the knitting time for the product obtained by full knitting and Figure 4b shows the knitting time for the product obtained by the classic knitting method.



a)



b)

Fig. 4*: Knitting time for the product obtained by a) full knitting b) the classic knitting method*

By analyzing the knitting times, we can see that the product obtained by complete knitting is done in 15 minutes and 33 seconds, compared to the classic production where the knitting time is 13 minutes and 9 seconds. Although the knitting time in the classic version is lower, overall the product's manufacturing time will be higher due to the time it takes to manufacture the finished product.

The product obtained by classic knitting requires the following phases in the manufacturing process:

- making the chain row - with kett - for finishing the last row of knit;
- making the stitch along the length of the product - with kett - to get a finer effect;
-the finishing operation of the yarns left from knitting and manufacturing.

In the case of the knitted product all the manufacturing times do not exist, leaving only a simple finishing operation (inserting the starting and ending yarns).


a)


b)

Fig. 5: *The product obtained by a) full knitting b) the classic knitting method*

5. CONCLUSIONS

We would like to conclude that for producing certain knitted products, by using the same machine and graphic assisted program, it is possible to improve product efficiency by eliminating some manufacturing steps produced by the human factor.

With the help of the technology offered by the knitting machine and its support program, the children's hat is obtained by knitting on the rectilinear knitting machine SSR 12 SV finesse 7. Apart from eliminating the intrusion of the human factor in its production, There is also an increase in the aesthetic value, by removing the stitch on the length of the finished product, which increases the comfort while wearing it.

For a knitwear company constantly developing it is of great importance to find ways to reduce the execution time but also to increase the comfort and quality of the products made.

REFERENCES

[1] Platon, V., Sisteme avansate de producţie, Editura Tehnică,Bucureşti, 1990.

[2] Dodu, A., Îndrumător pentru îmbunătăţirea calităţii tricotajelor, Editura Tehnică, Bucureşti, 1962.

[3] Moisescu, E., Control tehnic de calitate – Tricotaje, Editura„Gh. Asachi” Iaşi, 2000.

[4] Leon, R., Dan, D., Dascalciuc, G., Tomulescu, M., Manualul tricoterului şi confecţionerului de îmbrăcăminte în industriamică, Editura Didacticăşi Pedagogică, Bucureşti, 1995.

[5] http://www.shimaseiki.co

[6] Bohm G., Şuteu, M.D., Doble, L., Albu A. - ”Improving the aesthetic aspect of a knitted product for women” Annals of the University of Oradea, fascicle of textiles, leatherwork, issn 1843-813x, oradea, volume xix, 2018, no. 1, pp. 25-30.

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ASPECTS REGARDING THE ECO-AWARENESS OF THE ROLE OF AGROTEXTILE SYSTEMS IN THE SUSTAINABLE DEVELOPMENT OF ROMANIA

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Abstract: *As the basic branch of our national economy, agriculture is said to be an area of particularly complex and complicated activity. Food, clothing and shelter are the three basic needs of the human being. Agriculture, branch of the basis of our national economy, has complex activity.The complexity is determined by the role of agriculture in the economic - social development and of them technical, economic and social particularities. The management of the production process is differentiated in relation to the production area where the agricultural process materializes and requires a double approach, namely: - to reduce greenhouse gas emissions / GHGs; - adaptation to the anticipated effects of climate change. The textile research are a key role in this field, and the strategic direction of the activity are interactive eco-design of textile element which can be used as systems involved in agriculture, forestry, horticulture, fishing, gardening, animal husbandry, aquaculture, agro-engineering or as individual protective equipment.Use fibre/yarns with performance characteristics, flexible technology. Classic /unconventional processing of textile structures, the principles of simultaneous engineering for multifunction agrotextilele can ensure properties required for agro textiles, such as: performance ratio, ease of transport, space saving storage, long service life, resistance to solar radiation, resistance to ultraviolet radiation, biodegradability, high potential to retain water.Technical textiles and in particular agrotextilele, are instruments in order to transpose in practice the concepts and strategies for sustainable development by conciliation economic and social progress.*

Key words: *agrotextiles, sustainable development, eco-awareness*

1. INTRODUCTION

Technical textiles are high performance, special textile materials and they are becoming very popular all over the world due to several functional requirement, user friendliness; eco friendliness; health & safety; cost effectiveness; durability; high strength; light weight; versatility; customization; logistical convenience etc. Technical textile is also known as, functional textiles, performance textiles, engineering textiles, invisible textiles and high-tech textiles. Technical textiles are increasingly being used in various industries such as agro textile, clothing textile, construction textile, geo-textile, eco textile, home textile, industrial textile, medical textile, packaging textile, protective textile, sport textile and transport textile. Technical textiles sector is a pillar of textile export outside of EU -28 with a 38% share in 2016.[1] The top 5 exporters of technical textiles(Germany, Italy, France, United Kingdom and Belgium) represented almost 60% of total exports to the world from Member States. Moreover, the Member States for which technical textiles represented the highest share of their textile exports (excluding clothing) were Croatia, Finland, Denmark, Sweden, Czech Republic and Hungary. EU countries are the main export destination markets for technical textiles, in particular for companies originating in Slovakia, the Czech Republic, Croatia, Bulgaria, Belgium, Hungary, Denmark, the Netherlands, Romania, Portugal and Poland (with Intra-EU shares above 71%).(figure 1)

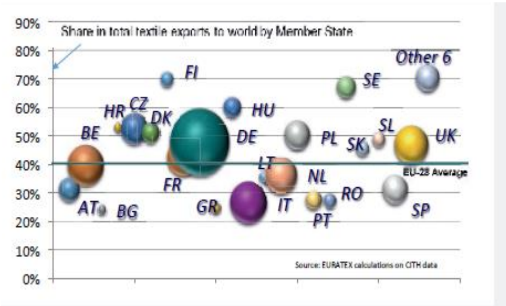

Fig.1: *Technical textile share of world exports Legend for Bubbles: size of TT exports to world - Member States size – clothing excluded [Sursa: Activity of year 2016, Annual Report, Euratex]*

2. CONSIDERATIONS ON THE AGROTEXTILES ROLE

Agrotech interdisciplinary field possess various desirable properties such as protection from pest, light or hail, lightweight, bio-degradability, resistance to microorganisms, and high potential to retain water. According to a new market report published by Credence Research, the global agro textile market is expected to reach over US$ 14,363.2 Mn by 2025, expanding at a CAGR of 5.5% from 2017 to 2025 [2] The demand for agrotextile products depends on the awareness and acceptance of these products by farming community and also on the technical and performance properties of these products. [3] Depending on the final application, the composition, production method and properties change.[4] As the world population continues to grow geometrically, great pressure is being placed on arable land, water, energy, and biological resources to provide an adequate supply of food while maintaining the integrity of our ecosystem.[5]

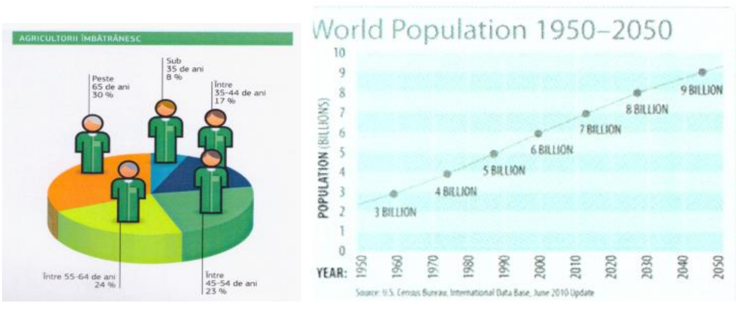

Fig.2: *World population generally and in agriculture*
Sursa:[EUROSTAT 2010; http://www.iijsr.org/data/frontImages/gallery/Vol._3_No._1/1._1-8.pdf]

Factors influencing agricultural activities are [6]: Sunshine – direct and indirect; Water; Climatic circumstances including wind, hail, humidity; External factors like birds, insects, wild plant; Post-harvest handling of produce – storage and packaging. Agrotech products are a partial solution to this problem as they increase yield and cater to major issues such as soil pollution, water conservation, and climatic change. Grand View Research has segmented the global agro textiles market **(**volume, kg, tons; revenue, USD Million; 2014 – 2025) on the basis of product, application, and region (table 1):

Table 1: Segmented the global agro textiles market

Product Outlook	Application Outlook	Regional Outlook
Shade-nets Mulch-mats Anti-hail, anti- bird nets Fishing nets etc.	Agriculture Horticulture & Floriculture Aquaculture	North America: U.S., Canada, Mexico Europe: Germany, France, Spain, Italy Asia Pacific: China, Japan, India, Indonesia Central & South America: Middle East & Africa

3. TYPES OF AGROTEXTILES

There are many agrotextiles product used in various agricultural sectors. (table 2), (figure 3)

Table 2: *Classification of agro-textiles product with the fabric type (Agrawal, July, 2013) (Dr V Subramaniam, April 2009) (Gopalakrishnan)*

	Crop production and packing	***Horticulture & Floriculture***	***Forestry***	***Animal Husbandry***	***Fishing & Aquaculture***
Woven	Sunscreen, Packing sack, Insect meshes, Cold/frost control, Ground cover.	Sunscreen, Root ball net	Soil protection	Tape net, Mats for animals	Anti fouling nets
Non woven	Mulch mat	Mulch mat, mixed bed for mushroom	Weed control fabric	Reducing mud, Filter for milking	Anti fouling nets
Knitted	Plant net, Bird protection, Shade cloth,Wind shield, Anti hailstone nets, Support nets, Monofil nets.	For plant, Bird, insects, light shade, Windshield, Anti hailstone, Harves-tings,		Udder protection , mosquito protection, tape nets	Fishing nets, Aquaculture nets, Anti fouling nets
Plastic Sheets	Ground cover, Cherry cover	Ground, Green-house covers, Rain protection			UVradiation
Braided & Twisted				Baler twine, belt	Fishing line

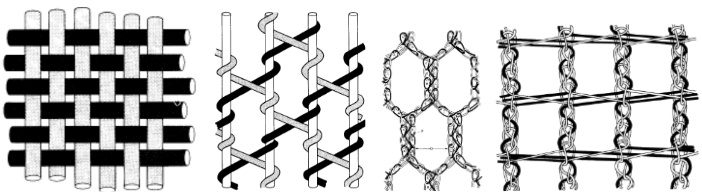

Fig. 3: *Images with textile fabrics meant for agrotextiles*

4. AGROTEXTILES - PRODUCT DIVERSITY

Application of textile materials in agriculture is growing fast. In table 3 there are presented types of agrotextiles with different functions/ requirements.

Table 3:Function of different agro-textile product [7,8]:

Product	Scope	Product Picture
Protective screen against solar radiation	Controls the distribution of solar radiation. The degree of shading between (35-95)%	
Mulch mat	Enhances the intensive character through early production, high quality.	
Harvesting nets	Facilitates harvesting in hygienic and more sustainable conditions.	
Udder protection nets and support nets	These protect against udder damage in the pasture and in crowded barns. It is also ideal to protect the udder against steps injuries.	 
Porous tube for localized irrigation	Connects the entire surface cultivated by irrigation pipes, controls the watering process of the target surface uniformly	
Insect meshes	Keeps pollinating insects inside the mesh. Protect to harmful insects.	
Nets for root protection	Biodegradable material that protects the roots of crops from possible damage caused during transport and storage.	
Antifouling nets	Physical barrier for bacteria, diatoms and microalgae that could be planted on fishing nets;	
Bird protection net	It protects seeds, crops and fruit from birds but allow movement of bees.	
Aquaculture net	To cultivate different types of fish in the same pond. Cltivation of predatory fish with normal fish, cultivation of different fish size in one pond or lake.	

5. AGROTEXTILES – TEXTILE POTENTIAL

In figure 4 it is shown the basic characteristics of agrotextiles correlated to their destination as well as the functional and design parameters.

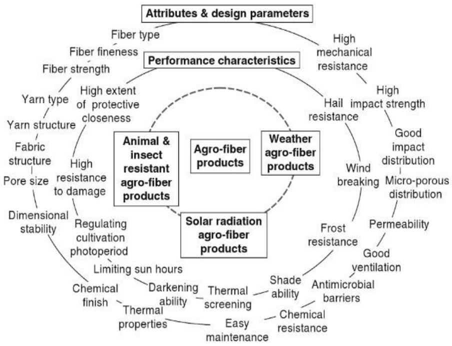

Fig. 4: *The basic characteristics of agrotextiles and their functional&design parameters; Sursa: Mogahzy Y, Engineering Textiles: Integrating the Design and Manufacture of Textile Products, Elsevier, 2008.*

Agrotextile systems are generally architectural elements that can be placed at negative and positive level share, in relation to the soil (zero rate). Both absolute and real values are direct expressions regarding the type, complexity, and the requirements of an agrotextile system. At present, by developing technical textiles, it is possible to use all textile structures (woven fabrics, warp knitted fabrics, knits, nonwovens). It is observed that the textile structure, woven type, component part of an agrotextile system, is recommended for those architectural elements that have explicit mechanical durability requirements. At the level of the textile structure, this requirement affords an optimal response, adequate to mechanical deformation demands, in dynamic conditions. For commonly used agrotextile systems, textile structures made from warp knits are the most recommended and found on profile market. Warp knitted fabrics are very linked to woven fabrics. The differences are related to the the possibility to obtain elasticity, in longitudinal direction, having in view that in a woven structure, the elasticity is esspecialy on transversal direction (weft direction). Both have dimensional stability, of different amplitudes, but superior to other textile structures.

6. AGROTEXTILES - PERFORMANCE & SUSTAINABILITY

Depending on requirements, raw materials for agrotextile are textile fibers, natural-artificially - synthetic types or hightenacity- high density – high elasticity types or virgin / first processing – recycled- waste recovered – (bio) degradable types. The textile fibers meant for agrotextile structures are: polyester, polyamde, polyethylene with high/ low density, polypropylene, linen, flax, different compostion of fiber type in waste recoverd textile structures. Agrotextiles as support should be mainly high tenacity (performant fibers). Agrotextiles as fitering net for different lights should have specific colours. Agtotextiles for filtering different hazardous agents should have mecnaical potential in time. Agrotextiles from crop to crop should be durable and/ or sustainable.

In Romania, research in the field of technical textiles is a standard for INCDTP. The experience of over 20 years in this field, including agrotexillor, is a certainty. The presence of agrotextile products is at first on the road in Romania, with the observation that most of the products come from outside. During the beginning of technical textiles 1990-2005, the research and the results of the specialists from INCDTP were promoted and implemented at various R&D Resorts in agriculture, and the raw materials and processing technologies were 100% Romanian. Nowadays, through research projects, a reconsideration of technical textiles in agriculture, in line with policies, strategies, research directions at international level, to which INCDTP is aligned, is desirable. Current multidisciplinary research allows for a complex, convergent, viable research with real personalization attributes and / or real-time response. All these are the elements that will allow for a real, useful technological transfer, assumed by multidisciplinary, by thinking of agrotextile systems. The transition from technical textile entities to technical textile systems in agriculture is the solution that INCDTP specialists, along with a multidisciplinary consortium, are currently implementing in a complex research project.

7. CONCLUSIONS

Textiles as elements and structures used in agriculture have some advantages, namely: increase crop production, avoid the soil from drying out, decrease the requirement of fertilizers, pesticides and water, they make product quality better, increase the early maturing of crops and non-seasonal plants, protects from climatic changes and its effect. Climate alteration, ecological degradation, increasing competition for land and water, high energy charge, and uncertainties about future acceptance rates for new technologies all present enormous challenges and danger that make predictions complicated. Today, agriculture has realized the need of tomorrow and opting for various technologies to get higher overall yield, quality and tasty agro-products. Textiles, in different forms are exclusively used for many agricultural end uses and the most important requirements of textiles for agricultural applications are weather resistance, resistance to microorganism, stable construction and lightweight. In Romania, research in the field of technical textiles is a standard of INCDTP. The experience of over 20 years in this field, including agrotexillor, is a certainty. The weak point is represented by a mix of mistakes such as lack of education for technical textiles in non-textile fields including agriculture, destruction of textile industry after 2000 and policy and strategy support among textile patronages and clusters of lohn, to the detriment of the redevelopment of a real textile industry, including the accreditation of false ideas that the textile industry means clothing.

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REFERENCES

[1].Eu technical textiles &menswear exports up in 2016, Posted by Editorial Team ,Jul 31 ,2017,Global [Online].Available:http://www.apparelviews.com/eu-technical-textiles-menswear-exports-2016/

[2]. Agro Textile Market By Product Type (Shade Net, Mulch Mat, Ground Cover, Crop Cover, Insect Net, Pond Liners), By Application (Crop Production, Animal Husbandry, Horticulture & Floriculture) - Growth, Future Prospects And Competitive Analysis, 2017 - 2025[Online]. Available: https://www.credenceresearch.com/report/agro-textile-market

[3]. Agro Textiles Market Analysis, 2018 – 2025, [Online]. Available:https://www.grandviewresearch.com/industry-analysis/agro-textiles-market

[4]. M. Ferrándiz, L. Capablanca, D. García, Ma. Á. Bonet, Application of Antimicrobial Microcapsules on Agrotextiles, Journal of Agricultural Chemistry and Environment, 2017, 6, 62-82.

[5]. David, Pimentel, X. Huang, A. Cordova, and M. Pimentel (1996). Impact of Population Growth on Food Supplies and Environment, Presented at AAAS Annual Meeting, Baltimore, MD, 9 February 1996, [Online]. Available: http://dieoff.org/page57.htm

[6]. K., Bhavani, N. Mallikarjun, N.M. Sunilkumar, Agro textiles - Their applications in agriculture and scope for utilizing natural fibers in agro tech sector, International Journal of Applied Home Science, Volume 4 (7&8), July & August (2017) : 653-662

[7]. Md. J. Chowdhury, S. Nasrin, Significance of Agrotextiles and Future Prospects in Bangladesh, European Scientific journal, july 2017 edition Vol.13.No.21 ISSN: 1857-7881, [Online].Available:https://www.researchgate.net/publication/319059456_Significance_of_Agro-Textiles_and_Future_Prospects_in_Bangladesh

[8]. E Dirgar, O ORAL, M.C.Erdogan, Properties of agrotextiles and their use, Textile Science and Economy VI, Proceedings, 2014, [Online]. Available:http://www.tfzr.uns.ac.rs/tnp2015/files/Zbornik%202014.pdf

MICROENCAPSULATION OF BIO-DEGRADABLE PCM USING COCONUT OIL AND ETHYL CELULOSE

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Abstract: *Over the few past decades, preparation of uniform microparticles has received a great interest in the textile area to add new functionalities to the textile fabric. Amongst them, thermal insulation textile and more specially microencapsulation of phase change materials (PCMs) have attracted more and more attention in recent years. In an latent heat thermal energy storage system, energy is stored during the melting, and recovered during the freezing, of phase change material (PCM). It plays an important role in solving energy imbalance, by improving thermal efficiency and protecting the environment. The aim of this study is obtaining bio-degradable PCM which shell is Ethly cellulose and active agent is coconut oil by using solvent evaporation as a microencansulation method. In order to microencapsulation with solvent evaporation method: we have prepared 4 different combinations of emulsions by changing the amount of ethyl cellulose and coconut oil. We examined the samples obtained by scanning electron microscope (SEM) to see how the ratio of materials used as active agent and shell play a role in microcapsule formation. SEM analysis showed that we obtained significative results when we use ethyl cellulose and coconut oil in a ratio of 1: 1, we obtain the spherical microcapsules.*

Key words: *Microencapsulation; Phase Change Material; Functional Textiles; Coconut oil; SEM.*

1. INTRODUCTION

Over the few past decades, preparation of uniform microparticles has received a great interest in the textile area to add new functionalities to the textile fabric. Amongst them, thermal insulation textile and more specially microencapsulation of phase change materials (PCMs) have attracted more and more attention in recent years[1]. Beside textile, latent heat thermal energy storage systems have been applied in many fields, such as environmental building materials, solar energy systems, central air conditioning systems and industrial waste heat recovery, due to their high energy storage density and small temperature variation from storage to retrieval. In an latent heat thermal energy storage system, energy is stored during the melting, and recovered during the freezing, of phase change material (PCM). It plays an important role in solving energy imbalance, by improving thermal efficiency and protecting the environment [2]. PCMs can be categorized into two major groups: inorganic compounds and organic compounds. Also, organic PCMs are classified paraffinic PCMs and non-paraffinic. Compared to paraffinic PCMs, non-paraffinic PCMs are significantly less flammable[2]. For this reason and also ecological reasons, we decided to use non-paraffinic PCMs, namely bio-based PCMs which contained various fatty acids.

Bio-originated PCMs such as soybean oils, coconut oils, palm oils, and beef tallow [2] have high latent heat of fusion, good thermal stability, and no toxicity, similarly to paraffin, and are also suitable for microencapsulation. However, most paraffins are flammable, while bio-originated PCMs have considerably higher ignition resistance. Since bio-based PCMs are fully hydrogenated, they are not sensitive to oxidation [3]. Their melting point can be adjusted in a wide temperature range, from −23 °C up to 78 °C, hence they can be suited to various application fields in various climatic condition. They possess low vapor pressure, self-nucleating behavior, safety, and commercial availability at low cost [4].

Microcapsules production can be achieved by means of physical or chemical techniques. One of them was based on solvent extraction/evaporation allowing the preparation of a wide range of microspherical and microcapsular products [5]. Cellulose derivatives and more specially cellulose acetate buty-rate are ideally suitable for the preparation of microparticles by solvent evaporation[1]. Solvent extraction/evaporation neither requires elevated temperatures nor phase separation-inducing agents. Controlled particle sizes in the nano to micrometer range can be achieved, but careful selection of encapsulation conditions and materials is needed to yield high encapsulation efficiencies and a low residual solvent content [6].

2. EXPERIMENTAL

The preparation of the microcapsules was carried out by using following materials and method:

Coconut oil used as active agent of Mcs, ETYL CELLULOSE (Viscosity of a 5%solution in toluene: ethanol (4:1) at 25C Approx. 45cps. Ethoxy content 49.0%) used as shell of microcapsules and ethyl acetate used as solvent. 200mg/100mg liquid coconut oil, 200ml/400ml ethyl cellulose, 10mg ethyl acetate, 20ml 1% polyvinyl alcohol in total 4 different combination of solution have been used which are shown in the table 1. Each solution combinations was emulsified at 900 rpm with a homogenizer at room temperature during 150 minutes. A drom of sample has taken during mixing in each 15 minutes till 150th minute.

Table 1*: Formulations of coconut microcapsules.*

REFERENCE	POLYMER	SOLVENT	OIL	WATER	CONDUTIONS		
	ETHYL CELULOSE (mg)	**ETHYL ACETATE (mg)**	**COCONUT (mg)**	**1% PVA**	**TIME**	**T**	***rpm**
CO-EC 01	200	10	200	20 mL	150’	ROOM	900
CO-EC 02	400	10	200	20 mL	150’	ROOM	900
CO-EC 03	200	10	100	20 mL	150’	ROOM	900
CO-EC 04	400	10	100	20 mL	150’	ROOM	900

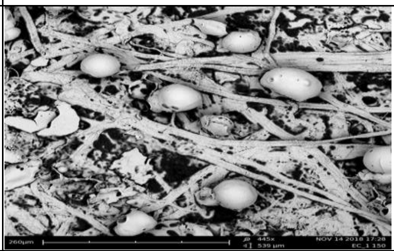
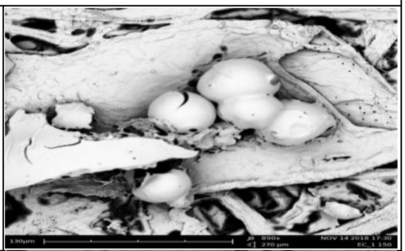
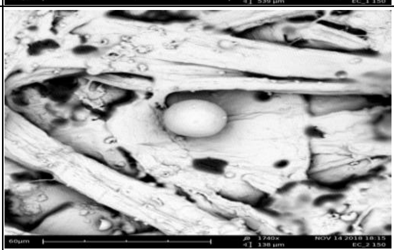
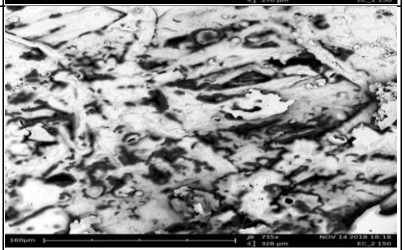
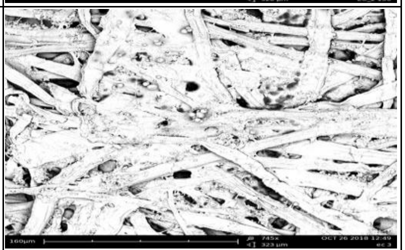
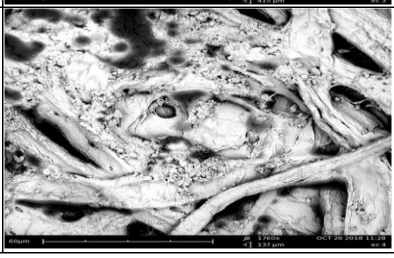
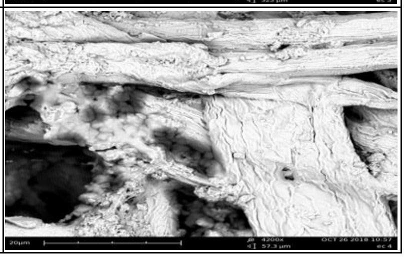
In order to characterize the microcapsules samples the Scanning electronic microscope (SEM), FEI model Phenom (Fei, Oregon, USA).

To obtain biodegradable PCM, solvent evaporation method was used in microencapsulation. Microsphere preparation by solvent extraction/evaporation basically consists of four major steps: (i) dissolution or dispersion of the bioactive compound often in an organic solvent containing the matrix forming material; (ii) emulsification of this organic phase in a second continuous (frequently aqueous) phase immiscible with the first one; (iii) extraction of the solvent from the dispersed phase by the continuous phase, which is optionally accompanied by solvent evaporation, either one transforming the droplets into solid microspheres; (iv) harvesting and drying of the microspheres [6].

3. RESULTS

A drope of sample of each formulation was analyzed by SEM to see if microcapsules were obtained or not. In below table 2 each 4 samples SEM images have been shown.

***Table. 2**: SEM images of microcapsules.*

REFERENCE	SEM IMAGES	
CO-EC 01		
CO-EC 02		
CO-EC 03		
CO-EC 04		

According to SEM images, we obtained the best result in the sample CO-EC 01 which we used 200mg Ethyl cellulose and 200 mg coconut oil. In CO-EC 02 we increased Ethyl cellulose amount, which is 400mg, although we obtained some microcapsules as it is shown in the image on left, in the image on right the photo is taken increasing the magnification and it seems that ethyl cellulose rate is high due to the excess of polymer. In CO-EC 03 we decreased coconut oil amount which is 100mg and it seems that this quantity is not enough to obtain microcapsules. In CO-EC 04 it was increased ethyl cellulose amount using 100mg and decreased coconut oil amount as 100mg and in SEM images we can see clearly that the ethyl cellulose amount is too high and we have not got enough coconut oil to establish regular microcapsules.

4. CONCLUSIONS

In order to microencapsulation with solvent evaporation method: we have prepared 4 different combinations of emulsions by changing the amount of ethyl cellulose and coconut oil. We examined the samples obtained by SEM to see how the ratio of materials used for active agent and shell play a role in microcapsule formation.

SEM analysis shown that we have obtained significative results that when we use ethyl cellulose and coconut oil in a ratio of 1: 1, we obtain spherical microcapsules.

REFERENCES

[1] Fabien Salaün, Eric Devauxa, Serge Bourbigot, Pascal Rumeau, *"Influence of the solvent on the microencapsulation of an hydrated salt"* Carbohydrate Polymers, vol. 79(4), 2010, pp. 964-974.

[2] Su-Gwang Jeong Okyoung Chung Seulgi Yu Sughwan Kim Sumin Kim, *"Improvement of the thermal properties of Bio-based PCM using exfoliated graphite nanoplatelets"*. Solar Energy Materials and Solar Cells, vol. 117, 2013, pp. 87-92.

[3] Bence Németha,b, Ágnes S. Németha, *"Fully bio-originated latent heat storing calcium alginate microcapsules with T high coconut oil loading"* Solar Energy 170, 2018, pp. 314–322.

[4] Yujin Kang, Su-Gwang Jeong, SeunghwanWi, SuminKim, *"Energy efficient Bio-based PCM with silica fume composites to apply in concrete for energy saving in buildings"* Solar Energy Materials and Solar Cells, vol.143, 2015, pp. 430-434.

[5] R. Arshady. *"Microspheres and microcapsules, a survey of manufacturin* techniques: *Part III: Solvent evaporation"* Polymer Engineering and Science, 30 (15), 1990, pp. 915-924.

[6] Sergio Freitas Hans, P. Merkle Bruno Gander, *"Microencapsulation by solvent extraction/evaporation: reviewing the state of the art of microsphere preparation process technology"* Journal of Controlled Release, 102 (2), 2005, pp. 313-332.

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

MATHEMATICAL MODELING OF THE VAPOUR PERMEABILITY OF TEXTILE MATERIALS

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Abstract: *The current research is based on experimental values regarding the vapor permeability of knitted knitted fabrics made of different yarns. The objective of the research is to define the transfer of moisture by variables which establish the existence of a functional interdependence. For this purpose mathematical modeling of the respective transfer is required, finding the type of function that expressesthe best the correlation between the variables and the dynamic evolution of the vapor transfer as a whole. The paper aims to highlight the correlation between the structure parameters of the double layer knits and their vapor permeability. The mathematical modeling of vapor permeability through these knits consists of two stages: obtaining the mathematical model and testing it. The mathematical model used in the experimental data processing, allowed the quantitative expression of the thermophysiological comfort characteristic, depending on the structure parameters of the analyzed knits. Based on the mathematical model, graphical representations were obtained by linear and spatial interpolation, adapted to concrete situations. These allow information to be obtained regarding the modification of the vapor permeability capacity according to the structural parameters involved in its mathematical model. The mathematical model obtained may be the starting point for further research, in which to obtain knits with new features and destinations.*

Key words: *vapour permeability, knits, structure parameters, regression equation, correlation coefficients*

1.INTRODUCTION

The mathematical function can be linear or nonlinear and is defined by the regression analysis, which must necessarily be completed with the correlation analysis, that obtains the quantitative expression of the strict dependence of one variable on the other, dependence given by the value of the correlation coefficient [1]. The quality of the regression equations depends on the experimental data on the one hand, and on the other hand on the used method to obtain the coefficients of these equations.

One of the most representativ statistical mathematical models is the regression model, which is generally used in cases when the solution of the theoretical problem encounters difficulties because of the complexity the functional interdependencies in term of theoretical analyses or mathematical formulation.

This paper aims to highlight the correlation between the structure parameters of six variants of double layer knit V_1, V_2, V_3, V_4, V_5, V_6 (cotton threads on the back and polypropylene threads on the front) and their the vapour permeability C_{vap} [%].The mathematical modeling of vapour permeability consists two stages: obtaining of the mathematical model and testing it.

2.OBTAINING THE MATHEMATICAL MODEL

The initial data required to develop regression models for the research results are:
- independent variables denoted by X_i (structure parameters of layered knits: surface density on the back of the knits $X_1 = D_{ss}$ [N_{os} / rap], horizontal densities ratio $X_2 = D_{of} / D_{os}$, verticality densities ratio $X_3 = D_{vf} / D_{Vs}$; thickness $X_4 = g_t$ [mm], surface area mass $X_5 = M$ [g / m^2], number of patented loops $X_6 = N_{op}$ / rap, porosity $X_7 = P_z$ [%] %]) (table 2);
-dependent variable: vapour permeability capacity C_{vap}. [%] denoted by y (table 1).

Table 1:*The values of vapour permeability capacity C_{vap} [%]*

The thermo-physiological characteristic y	Knit variant V_i					
	V_1	V_2	V_3	V_4	V_5	V_6
$y=C_{vap\ Vi}$[%]	36,2	42,1	40.1	33,1	40,11	36,5

Table 2 :*The structures parameters values*

Structure parameters of knit variants xi	Knit variant V_i					
	V_1	V_2	V_3	V_4	V_5	V_6
$x_1=D_{ss\ Vi}$[Nos/rap]	5680	4880	5246	5796	5247	5325
$x_2=D_{of}/D_{os\ Vi}$	0,971	0,967	0,950	0,968	0,934	0,957
$x_3=D_{vf}/D_{vs\ Vi}$	1,025	1,037	1,023	1,021	1,026	1,034
$x_4=g_{t\ Vi}$[mm]	1,39	1,24	1,20	1,11	1,42	1,54
$x_5=M_{Vi}$[g/m^2]	245	242	235	236	253	277
$x_6=N_{op}/rap_{Vi}$	2	2	4	8	94	42
$x_7=P_{zVi}$ [%]	79,72	78,85	80,72	76,21	81,50	82,07
$x_8=P_{PP\ Vi}$[%]	53,14	57,97	55,79	52,46	51,76	50,37

In the correlation analysis we determined the simple correlation coefficients noted with ryxi. Their values are shown in table 3, which also that in the mathematical models were included only the structure parameters with the simple correlation coeffcient *ryxi* > 0.5 un significant at Student test for the other cases [2].

Table 3: *The values of the simple correlation coefficients*

The type of correlation yi=f(xi)	The value of the simple correlation coefficient ryxi	The significance of the correlation
$C_{vap\ Vi}=f(D_{ss\ Vi})$	-0,92705270472449	Significant
$C_{vap\ Vi}=f(D_{of}/D_{os\ Vi})$	-0,43378908369164	Insignificant
$C_{vap\ Vi}=f(D_{vf}/D_{vs\ Vi})$	0,49961603576932	Insignificant
$C_{vap\ Vi}=f(g_{t\ Vi})$	0,07686474297386	Insignificant
$C_{vap\ Vi}=f(M_{Vi})$	-0,07946529996672	Insignificant
$C_{vap\ Vi}=f(N_{op}/rap_{Vi})$	0,18041475920435	Insignificant
$C_{vap\ Vi}=f(P_{zVi})$	0,45093868277429	Insignificant
$C_{vap\ Vi}=f(P_{PP\ Vi})$	0,64266343492296	Significant

It is assumed that if $t_c > t_T$ ($t_T = t_{0,05}$; n = n-2) there is a link between the two variables; Otherwise, the correlation link is missing. The multiple regression equation was established by testing the signifiance of the simple correlation coefficient only for yhose structure parameters proved to be signifiant (table 4).

The multiple correlation coefficient R, of which value expresses the total correlation between the independent variables and the dependent variable, used the values of the simple correlation coefficients. In case of perfect adjustment the value of the multiple correlation coefficient R=1 (table 4).

Multiple determination coefficient R^2 (table 4) expresses that part of the variation of the moisture permeability characteristic, which can be attributed to the group of knot structure parameters that enter the mathematical model. The value $(1-R^2)$ indicates the part that can be attributed to the experimental error, the deviation from the assumed linearity and the dispersion of the experimental data.

One of the most difficult problems to be solved by obtaining those structural parameters that significantly influence the vapor permeability characteristic C_{vap} [%] is their interpretation. The most commonly used method is multiple regression analysis, which aims to establish a regression equation that exists between the comfort feature and multiple structural parameters.

In order to check the significance of the multiple correlation coefficient, the Fischer criterion was used; if $F_c > F_T$ ($F_T = F_{0,05}$; $\nu_1 = k$; $\nu_2 = n_{k-1}$) is assumed the existence of a correlation between the dependent variable Y (vapour permeability) and the independent variables $X_1, X_2, \ldots X_k$ (the structure parameters, k = 8) with a 95% probability. The concrete form of the multiple regression equation found for vapor permeability capacity y = C_{vap} [%] is $y = C_{vap} = b_0 + b_1 D_{ss} + b_2 P_{PP} + b_3 P^2_{PP}$ and is presented in fig.1.

In table 4 are shown the limits of the confidence intervals for the real values of the of the regression equation coefficients by using the Student distribution for a 95% statistical certainty.

Table 4: *The limits limitele intervalelor of the confidence intervals R, R^2*

The concrete form of the regression equation	The value of the equation coefficients of regression	The interval limits of confidence for regression coefficients	R	R^2
y=Cvap.=b_0+b_1Dss+b2PPP+b3P²PP	b_0= - 711.3549 b_1= 30.4155 b_3= - 0.2814	-1674.32÷251.61 -0.0208÷0.05495 -6.671÷67.750 -0.626÷0.0638	0.991	0.982

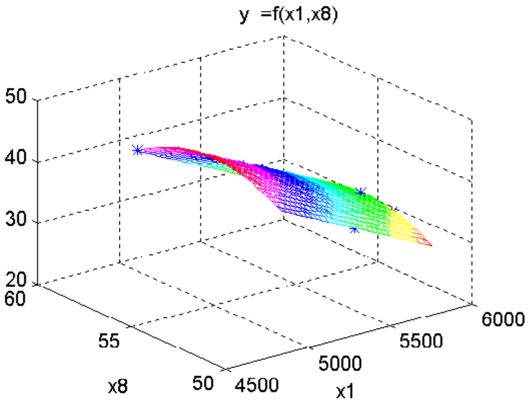

Fig.1: *$y=C_{vap.} = b_0+b_1Dss+b_2P_{PP}+b_3P^2_{PP}$*

3.THE STATISTICAL TESTING OF THE MATHEMATICAL MODEL

The extent of which the mathematical model reflects the actual situation from which it started can be verified by calculating the residues attached to the regression, residues calculated as deviations from the values observed for y_{oi} and the estimated y_{ei} of the vapor permeability capacity C_{vap} [%] (equation 1) [3]:

$$r_i = y_{0i} - y_{ei} = (y_{0i} - \bar{y}) - (y_{ei} - \bar{y}) \quad \textbf{(1)}$$

The residual values obtained, their maximum values for the vapour permeability capacity C_{vap}, as well as the confidence intervals for the residual values are presented in table 5 and fig. 2. The significance threshold considered is $\alpha = 0{,}05$.

Table 5: *Tthe confidence intervals for residues and the maximum residue value over the observed value $C_{vap.Vi}$*

Knit variant	The value of the residue $r_{Cvap.Vi}$	The maximum residue value compared to the observed value [%]	The limits of confidence intervals for residues
V_1	-0,4077	1,946	-2,2820÷1,4664
V_2	0,6910		-0,56581÷9480
V_3	-0,1173		-1,8634÷1,6288
V_4	-0,4863		-2,4552÷1,4824
V_5	0,1386		-2,0042÷2,2814
V_6	0,1817		-0,7731÷1,1366

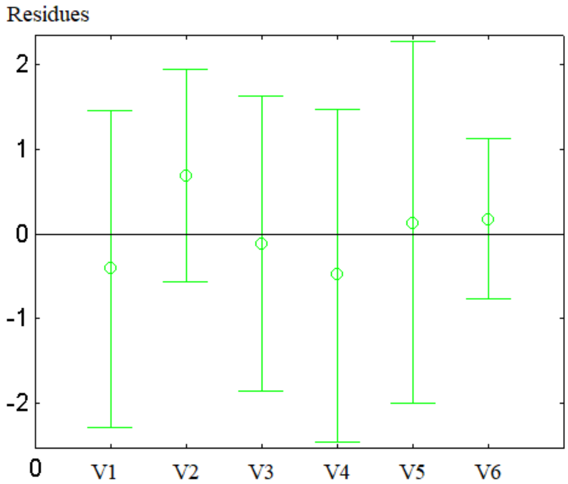

Fig. 2: *Graphic representation of the C_{vap} on knitting variants*

Small residues reflect a better adjustment of experimental data, but setting a criterion indicating how small the residue should be for regression, in order to be accepted, is a difficult issue. The acceptance of a regression cannot be admetted by using only the residue's size. For this purpose, it was calculated the multiplication correlation coefficient R whose value expresses the total correlation between the group of independent variables and the dependent variable and the value of the coefficient of multiple determination R2 (table 4).

On the based of the residue calculation equation [5], it was possible to express the dispersion analysis presented in table 6.

A first clue on the mathematical model adequacy is obtained by analyzing the squares sums for the regression S_{Preg} and the residues S_{Prez} [3] (equation 2,3).

$$S_{Preg} = \sum_{i=1}^{n} (y_{ei} - y_{mediu})^2 \tag{2}$$

$$S_{Prez} = \sum_{i=1}^{n} (y_{oi} - y_{ei})^2 \tag{3}$$

The smaller the S_{Prez}. comparing to S_{Preg} is, the better the mathematical model adjusting.In this case it can be stated that the variation in the survey data is in the range of the estimated data, so the estimated data "represents" the data determined experimentally.The data in table 6 of the dispersion analysis indicates that the mathematical model adjustment is acceptable. A matter of great practical importance is the prediction of the estimated value y_0 for an x_0 that was not taken into account when adjusting the mathematical model. This situation occurs when the mathematical model is used to study the real phenomenon outside the values considered in modeling. As an indicator of the quality of regression, the most common test was the Fisher F.

***Table 6**: Dispersion analysis of multiple regression equations*

Source of variation	Degrees of freedom	Squares sum	Average squares	F	F_T
Cvap.=b0+b1Dss+b2PPP+b3P¸PP	3	54,2236	18,074		
rmax.=1,946[%]	2	0,9464	0,4732	95	19,2
Total	5	55,1700	-		

In the literature [4] there it is a recommended to use a regression equation for prediction purposes if the F statistic is more than 4 times higher than the table value „F_T”. The probability of invalidation of the regression capacity of the permeability capacity at vapor C_{vap} [%] is 0.02562.

4. INTERPRETATION OF MATHEMATICAL MODELS

In the mathematical model describing the vaporization capacity of water C_{vap} ($y = C_{vap} = b_0 + b_1D_{ss} + b_2P_{PP} + b_3P_{2PP}$ or $y = C_{vap} = b_0 + b_1x_1 + b_2x_8 + b_3x^2_8$ or $y = C_{vap} = -711.35, 49 - 0.01315x_1 + 30.4155x8 - 0.2814x^2_8$), the structure parameters have the following experimentally determined values: x1: [4880; 5246; 5247; 5325; 5680; 5796]; x_8: [50.37; 51. 76; 52.46, 53.14; 55.79; 57.97] [5].

If the percentage of polypropylene x_8 = 51.5% is constant, y = f (x_1) (fig.3), can be calculated.

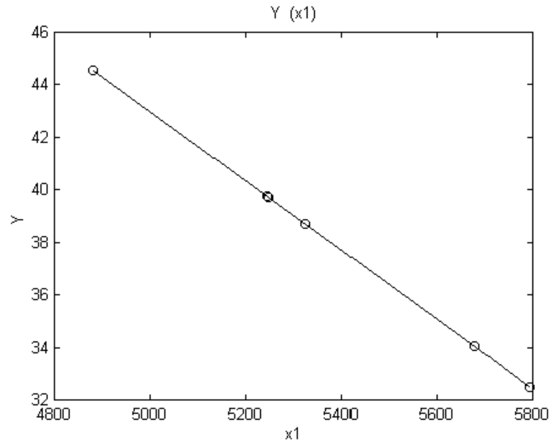

Fig. 3: *y=f(x₁); x₈- constant*

When we want to obtain a cotton and polypropylene layered knit fabric with a surface area on the back Dss = x1 = 5059 [Nos / rap] we can determine the vaporization capacity C_{vap} . = y = f (x_8) by using the linear interpolation [6].

5.CONCLUSIONS

The use of mathematical model in the processing of the experimantal data for the vapour permeability capacity cvap allowed to express the quantity of the thermo-physiological comfort characterisic by using the structure parameters of the analyzed knits.

The obtained mathematical model can be a starting point for further research in which:

- other types of raw materials or the same as in the present paper, that with different density lenth can be used in order to obtain the knitted fabrics;
- it can modify the structure parameters by modifyng the technolocal parameters;
- different finishing treatments can be applied to knitted fabrics, etc.

Based on the mathematical model of graphical representation obtained by linear and spatial interpolation, adapted to concrete situations, it is possible to obtain information regarding the modification of the comfort characteristic C_{vap} [%], depending on the structural parameters involved in its mathematical model.

By expanding the research, it is possible to use the experimental programming for predicting the studied phenomena.

REFERENCES

[1]Duma L., *Algoritm si schema logica de programare a calculatorului pentru testarea statistica a ipotezelor de corelare*, Revista Industria usoara, 1976

[2]Panaite Gh., *Control statistic si fiabilitate*, Ed. Didactica si Pedagogica, Bucuresti, 1982

[3]Cojocaru N., *Metode statistice aplicate in industria textila*, Ed. Tehnica Bucuresti, 1986

[4] Scov A. V., *Teoria suschi*, Moscova, 1968

[5] Farima D., *Contributii privind studiul functiilor produselor vestimentare din tricot, in conexiune cu parametrii de structura si conditiile de stare ale organismului*, Teza de doctorat, 1998

[6] MATLAB Programming

ANNALS OF THE UNIVERSITY OF ORADEA
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EFFICIENCY ASSESSMENT OF THE DIFFERENT SCOURING CONDITIONS OF COTTON MATERIALS BY RUTHENIUM RED DYEING

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***Abstract**: Natural fibres are subjected to scouring treatment in order to remove different impurities like waxes, organic acids, pigments and pectins. Pectines are found in the plant cell walls. From the chemical point of view are polysaccharides. The modern trends in different industrial sectors are based on the utilisation of eco friendly treatments to remove them. In our case, the classical alkaline procedure was substituted by an enzymatic one. On 100 % of cotton samples were applied different bioscouring treatments with a pectinases mixture in different conditions. All the bioscouring treatments were developed in presence of ultrasound (45 KHz). The reaction bath contained a commercial pectinolytic product, a complexing agent and a washing agent. There were used diffent enzyme concentratios and the treatment time was variable. To determine the samples behavior toward the enzymes action, the residual pectin was quantified. Ruthenium red dye was chosen since it is considered to be a specific one for binding pectin presented in the fibres. The measurements were done spectrophotometrically with a Datacolor 500 spectrophotometer and the colour strength ratio [K/S] was obtained by measuring the reflectance at 530 nm. The results obtain in case of each treatment were compared with the one determined for the untreated sample, which was considered to have the highest amount of pectin.*

***Key words:** cotton fabric, pectins, ruthenium red, dyeing, pectinase, ultrasound*

1. INTRODUCTION

As pectin are named a group of compounds closely related from the chemical point of view. They are polysaccharides ensuring primarily the plants cell walls mechanical resistance. The pectin has an anionic structure, which is considered to contribute also to ionic transportation, to influence the walls porosity and its permeability to enzyme [1]. Studies made on the pectine structure showed a complex matrix made of different monosaccharides and types of linkages. The main residue present is considered to be the galacturonic acid which has partially esterified acidic groups. It is considered that between the carboxylic unesterified groups of two pectic chains are formed calcium bridges [1]. As shown in the literature, the pectin carboxylic groups show two different hydrolysis models. One type of the acidic group is affected by the pectinesterase produced by higher plants, and the other one by microbial enzymes or alkali treatments [2].

In our case, we used a mixture of microbial pectinases to hydrolyse and eliminate the methil groups from the pectin chain present in the cotton fibres. As control method, to determine the efficiency of the bioscouring process the colour strength ratio [K/S] was determined. The samples were treated with ruthenium red dye. It is known that it has the property to particular link the pectin's carboxylic groups internally located. Calcium forms bridges between pectin's different acidic groups linked in the chains. During the treatment, the calcium pectate become red colored due to the fact that the intermolecular reactive clusters are notححsotericaly affected by the calcium ion [2]. A less colored sample will indicate a higher efficiency of the bioscouring treatment. The ruthenium red method is frequently used now to determine the quantity of residual pectin from natural fibers or fabrics after application of different specific treatments.

The intention to use an eco friendly pretreatment is based on the wold trend to protect the environment by using natural, biodegradable, non aggressive industrial procedure. In many researches are proposed viable solutions to use recycled natural material. Also, some of the synthesis reagents used could be successfully replaced by natural ones. For example, recycled nonwoven cotton treated with a natural amino polisccharide (chitosan) have been obtain good results regarding the antimicrobial properties, the biodegradability of the product an also of the mechanical strength and flexural rigidness index [3]. The chitosan positive influence on reducing the cotton stiffness has been proven not only to the fiber but also to the fabric [4].

The results presented in the literature underline the utility of using the ultrasound in the bioscouring treatments. It was shown that a frequency varying between 40-270 kHz has less influence on enzyme activity [5]. Also the two new approaches for cotton pretreatment, enzymes and ultrasound, could successfully represent an eco alternative to the aggressive alkaline treatment, by decreasing the industrial wastewater quantity and the effluents non degradable chemical charge. The positive influence of the bioscouring treatment developed in an ultrasound media has been observed not only for the cotton fabrics but also in case of the cotton slivers [6].

Recent research underlines the efficiency of the bioscoring treatment on cotton fibers and the possibility of natural dyes recovery using pectinases. This creates the opportunity to decrease pollutants concentration to acceptable level [7].

2. EXPERIMANTAL PART

2.1 Materials

For determinations were used 100 % cotton fabric characterised by: width (150 ± 3 cm), weight (200 ± 10 g/m^2), and warp of 100 % cotton yarn with Nm 25/2 and weft of 100 % cotton yarn with Nm 25/1.

The enzymatic product Beisol PRO was a mixture of pectinase purchase from CHT Bezema Company. Denimcol Wash RGN used as surfactant, was supplied by the same company. Sulfolen 148 (S-148, alkyl polyglicol ether) was provides by Rotta Company. The ruthenium red dye, sodium citrate, sodium hydroxide, sodium carbonate, sodium bisulfite, sodium silicate were purchased from Sigma-Aldrich.

2.2 Methods

2.2.1 Cotton pretreatment before bioscouring

Initialy, the cotton samples were washed with hot water at 100 °C in an AATCC standardized Lander-Ömeter, model M228-AA from SDL Atlas Company-USA. After that, were dried, conditioned and weighing according to the specific international standards.

2.2.2 The bioscouring procedure

The bioscouring procedure was made in ultrasound (45 KHz) bath in the presence of commercial pectinolytic product Beisol PRO. The enzyme concentrations varied between 1-3 % (o.w.f – concentration over fiber), 2 g/L sodium citrate and 0.5 % Denimcol Wash RGN. The reaction was developed at 55 ^{o}C. The exposure time has variable ranging from 15-55 min. and the liquor to fabric ratio was 1:20.

For the alkaline treatment, the exposure time was 1 h at 100 ^{0}C, and a treatment bath consisting of: 10 g/L sodium hydroxide, 5 g/L sodium carbonate, 1 g/L sodium bisulfite, 2 g/L sodium silicate and 2 g/L of wetting agent Sulfolen 148 (S-148, alkyl polyglicol ether) was used.

After applying the above treatments, the cotton samples were washed with hot (70°C) and cold water and dried at room temperature.

2.2.3 The dyeing treatment with Ruthenium red

The dyeing bath was made of: 0.2 g/L ruthenium red dye, 1.0 g/L ammonium chloride, 2.5 ml/L ammonium hydroxide solution (28 %) and 1.0 g/L Denimcol Wash RGN. The nonionic surfactant was used to obtain the dye's uniformly adhesion to the cotton surface [8].

2.2.4 The spectrophotometric analisys

The cotton samples were analyzed using the Datacolor 500 spectrophotometrer. It was measured the colour strength [K/S] of the bioscoured samples after dyeing with ruthenium red. The reflectance (R %) was measured at 530 nm and K/S values were calculated by according to equations (1) and (2):

$$K/S = [\{(1-R)^{2} / 2R\}] \quad \textbf{(1)}$$

$$\text{Color Strength} = [(K/S)_{\text{Batch}} / (K/S)_{\text{Standard}}] \times 100 \quad \textbf{(2)}$$

where: R-reflectance measured at 530 nm;
K/S_{Batch} -color strength of the dyed treated sample;
K/S_{Standard}-color strength of the standard.

The pectin amount for enzymatic treated cotton samples was determined comparing it with the control one. The control one had the highest pectin amount (untreated sample). The sample from the alkaline treatment was considered to have the least amount of pectin.

3. RESULTS AND DISCUSSIONS

An effective pretreatment of the material is given by the removing of natural attendants, including pectin. The color strength [K/S] value is a number related to the amount of the dyestuff present in a substrate. For bioscoured cotton samples, it was determined after dyeing with ruthenium red, which in the presence of calcium ions from pectin forms salts giving a color reaction. The [K/S] values were directly calculated by the DataColor Tools software from the reflectance measured at the wavelength of 530 nm. From these data, the percentage of residual pectin could be calculated.

Table 1 and Table 2 show the [K/S] values and the percentage of residual pectin for all types of experimental conditions for the cotton fabric samples.

Table 1: *The color strength [K/S] of the ruthenium red dyed cotton samples treated in different conditions*

Sample	Enzyme [%]	Treatment time [s]	Color strength [K/S] Rhutenium red
1	1.30	21.00	0.4975
2	2.70	21.00	0.4415
3	1.30	49.00	0.4508
4	2.70	49.00	0.3759
5	1.00	35.00	0.2678
6	3.00	35.00	0.2452
7	2.00	15.00	0.6741
8	2.00	55.00	0.3951
9	2.00	35.00	0.3320
10	2.00	35.00	0.3302
11	2.00	35.00	0.3310
12	2.00	35.00	0.3386
13	2.00	35.00	0.3596
Alkaline			0.0012
Control			2.6973

Table 2: *The percentage of residual pectin for cotton samples treated in different conditions*

Sample	Enzyme [%]	Treatment time [s]	Residual pectin [%]
1	1.30	21.00	18.44
2	2.70	21.00	16.37
3	1.30	49.00	16.71
4	2.70	49.00	13.94
5	1.00	35.00	9.93
6	3.00	35.00	9.09
7	2.00	15.00	24.99
8	2.00	55.00	14.65
9	2.00	35.00	12.31
10	2.00	35.00	12.24
11	2.00	35.00	12.27
12	2.00	35.00	12.55
13	2.00	35.00	13.33
Alkaline			0.04
Control			100.00

As a direct result of dyeing with ruthenium red, for the enzymatic treated samples, lower values of the intensity of dyeing [K/S] were obtained compared to the control sample because of the pectin elimination. Considering that the untreated cotton sample (control) has the higher quantity of pectin it showed the biggest color strength of 2.6973 due to the complexation between pectin and ruthenium red dye. The values obtained for enzymatically treated cotton samples decreased by a percentage between 75 % - 33 % compared to the control. For alkaline treatment a ~ 99 % decreasing was obtained. The alkali-treated sample is considered to have 100 % pectin removed; therefore it has the lowest [K/S] value of 0.0012.

All enzymatic treatments shows small amounts of residual pectin, these ranging between 9.09 % for sample 6 (3 % o.w.f. enzyme concentration and 35 minutes as enzyme action time) and 24.99 % for sample 7 (2 % o.w.f. enzyme concentration and 15 minutes as enzyme action time).

The smallest amount of residual pectin is present in the sample treated with 3 % o.w.f. enzyme for 35 minutes, followed by sample 5 (9.93 % o residual pectin) which was treated with 1 % o.w.f. enzyme concentration for 35 minutes.

A higher quantity of residual pectin is presented by samples 1 (1.3 % o.w.f. enzyme concentration and 21 minutes as enzyme action time) and 7 (2 % o.w.f. enzyme concentration and 15 minutes as enzyme action time) with a percentage of 18.44 % and 24.99 %, respectively. A reproducibility of the data can be seen in case of the samples from 9 to 13 (2 % o.w.f. enzyme concentration and 35 minutes as enzyme action time).

The variation of the residual pectin quantity from the treated cotton samples depends on the treatment conditions, which is influenced by both the concentration of the enzyme used and the time of its action.

4. CONCLUSIONS

By using this method of determining the residual pectin content, an assessment of the efficiency of different scouring treatment conditions can be carried out. From the acquired data of [K/S] values and the residual pectin quantities, it can be concluded that the most effective treatment in the case of enzymatically treated one was obtained for the sample treated with 3 % o.w.f. enzyme concentration and 35 minutes as enzyme action time.

A low [K/S] values was registered for all bioscouring conditions, indicating a decrease in the pectin content from the treatead samples. Since ruthenium red is a pectin-specific dye, by measuring the color intensity [K/S] of bioscoured samples after dyeing, its value may be an indicator for pectin removal from the fabric substrate.

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REFERENCES

[1] A. G. J. Voragen, G.-J. Coenen, R.´ P. Verhoef, H. A. Schols, "*Pectin, a versatile polysaccharide present in plant cell walls*", Struct Chem., vol. 20, pp. 263-275, 2009.

[2] W.-C. Hou, W.-H. Chang, C.-M. Jiang, "*Qualitative distinction of carboxyl group distributions in pectins with ruthenium red*", Bot. Bull. Acad. Sin., vol. 40, pp. 115-119, 1999.

[3] N. Saldaña, I. Montava, E. Bou-Belda, P. Diaz-García, A. Santamaria, "*Mechanical properties of recycled cotton nonwoven using chitosan and acrylic resin as a binder*", Annals of the University of Oradea Fascicle of textiles, leatherwork, vol. XIX, No. 1, ISSN 1843-813X, pp. 89-94, 2018.

[4] J. Campos, P. Díaz-García, I. Montava, M. Bonet-Aracil, E. Bou-Belda, "S*tiffness modification of cotton in chitosan treatment*", Annals of the University of Oradea Fascicle of textiles, leatherwork, vol. XVIII, No. 1, ISSN 1843-813X, pp. 17-20, 2017.

[5] M. Easson, B. Condon, A. Villalpando, S. Chang, "*The application of ultrasound and enzymes in textile processing of greige cotton*", Ultrasonics, vol. 84, pp. 223-233, 2018.

[6] A.Erdem, M. I. Bahtiyari, ”*Ultrasonic-bioscouring and ozone based bleaching of cotton slivers and coloration of them with natural dye sources*”, J. Clean. Prod., vol. 188, pp. 670-677, 2018.

[7] M. Shanmugavel,S. Vasantharaj, A. Yazhmozhi, P. Bhavsar, P. Aswin , C. Felshia, U. Mani, B. Ranganathan, A. Gnanamani, ”*A study on pectinases from Aspergillus tamarii: Toward greener approach for cotton bioscouring and phytopigments processing*”, Biocatal. Agric. Biotechnol., vol. 15, pp. 295-303, 2018

[8] W.-C. Hou, W.-H. Chang, C.-M. Jiang, ”*Qualitative distinction of carboxyl group distributions in pectins with ruthenium red*”, Botanical Bulletin of Academia Sinica, vol. 40, pp. 115-119, 1999.

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

STUDY OF THE CREASE REACTION OF THE WORSTED FABRIC TYPES

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Abstract: *In this paper, it was analyzed the crease behavior of the assortments of fabrics made of worsted yarns type for manufacture of clothing. Crease recovery behaviour is an important property of fabrics for apparel applications. The creasing of woven materials made from combed yarns type wool used for ready-clothes is an undesired deformation effect with temporary or permanent character, which is caused by a composed strain of bending and compression during utilization, processing or maintenance. It is manifested by the appearance of wrinkles, folds or stripes on the surface of wovens materials, thus diminishing their qualitative appearance and also their practical value. By the experimental determinations were revealed the factors which influence the returning capacity from wrinkling/bending of fabric assortments (fibrous composition, component fiber properties, structure parameters of fabrics, mechanical properties of warp and weft yarns and fabric finishing treatments). The measurement is applied to standardized fabric samples and 180 ° bent, pressed in the direction of one of the component yarn systems with mass-dependent bending loads on the surface unit for a specified time. After removing the bending load, the specimen relaxes freely within a specified time interval, then the angle of return is measured. Creasing of a fabric during wear is not change in appearance that is generally desired. The ability of a fabric to resist creasing is in the first instance dependent on the type of fiber used in its construction.*

Key words: *crease behavior, crease recovery angle, woven fabric, curvature, bending of fabric*

1. INTRODUCTION

Creasing is a bending deformation of the fabric and causes an undesirable appearance on the fabric's surface. Physical properties especially bending properties of fibers, fabric construction and finishing processes are three main parameters which affect the crease recovery of fabrics [1, 2, 3]. Fabrics are often subject to repeated creasing and bending deformations, such as elbow movements, and the resilience of crease recovery is an important property that affects fabric's serviceability [4, 5]. Apart from these parameters: twist coefficient, fabric weft and warp yarn densities, fabric thickness are also important parameters related to crease recovery property [6, 7]. Creasing is the result of irreversible changes created through the reciprocal sliding of structural fiber components when exposed to a bending strain. Therefore the woven materials used for garments manufacturing are classified in the following categories:

-reduced creasing, articles type wool;
-average creasing, articles made of synthetic yarns;
-pronounced creasing, articles made of cellulosic yarns that can be improved through

superior finishing [8, 9]. Creasing is specific to oriented structures with high crystallinity (cellulosic fibers) [10]. The sliding appears because of hydrogen bond breaking which can, however, reform easy in other positions conferring a permanent character to creasing [10, 11].

Crease recovery behaviour is an important property of fabrics for apparel applications [11, 12]. A theoretical model is developed in which the fabric is represented by an elastic element and a frictional element. The frictional restraint is assumed to be proportional to the square root of the curvature of the fabric during deformation [13, 14]. An energy method is applied to the study of crease recovery behaviour of the fabric. Equations of crease recovery work and crease recovery force as a function of curvature are derived. Two basic parameters are needed to characterise the fabric in the crease recovery model: the bending rigidity and bending hysteresis of the fabric; both are readily measured in a pure bending test [14, 16]. Good agreement is observed between experimental data and theoretical predictions for wool/polyester blended and worsted fabrics. Cotton fabrics take fewer cycles to reach steady than wool fabrics [16, 17, 18]. The high elasticity of polyester fibers affects the resilience remarkably [19, 20].

2. MATERIALS AND METHODS

The study was conducted on woven materials made of combed wool type yarns used for manufacturing outwear clothing, on 12 articles structured as follows. The variation limits of the composition and structural characteristics for the tested woven materials are indicated in table 1.

Table1: *Indicators for assessing the behavior of the Group A fabrics at the request of crease*

Code Art.	Bonding	Yarn count Nm		Recovery angle from creasing, α		Recovery coefficient from creasing λ	
		warp	weft	warp	weft	warp	weft
A1	D2/1	64/2	64/2	149	147	17.2	18.3
A2	D2/1	64/2	64/2	150.1	149.2	16.6	17.1
A3	plain	64/2	64/2	134.6	131.8	25.2	26.8
A4	R 3/1	60/2	60/2	161.2	159	10.4	11.7
A5	D 1/1 2/1 1/5	60/2	60/2	156	153.2	13.3	14.9
A6	plain	60/2	60/2	135.2	130.4	24.9	27.6
A7	D2/2	60/2	60/2	160.5	158.3	10.8	12.1
A8	D4/1	60/2	60/2	165	163.8	8.3	9.0
A9	check	52/2	52/2	144.4	141.6	19.8	21.3
A10	D2/1	52/2	52/2	148.7	146.5	17.4	18.6
A11	plain	52/2	52/2	134.9	132.5	25.1	26.4
A12	D 1/1 1/5	52/2	52/2	161.4	160.7	10.3	10.7

The experimental trials have been performed on a series of woven materials made of 45% wool+55%pes. Factors like fibrous composition, properties of constituent fibers, structural woven parameters, mechanical properties of warp and weft yarns and finishing treatments that influenced the recovery capacity from creasing/folding were investigated such as to assess their importance.

In order to reveal the influence of bonding on the surface characteristics of wovens we have expressed it through the mean flotation F_{warp} for warp yarns and mean flotation F_{weft} for weft yarns. The intersection between a warp yarn and weft yarn is called bonding point, thus the bonding contains all bonding points having a warp or weft effect along a longitudinal or transversal direction.

One or more bonding points having the same effect and forming one bonding segment can exist in longitudinal or transversal direction. The bonding segments with the same effect are called flotation (F). They can be warp flotation (F_{warp}) when the warp yarn passes over the weft yarn and weft flotation (F_{weft}) when the weft yarns passes over the warp yarn. The flotation size, similar to the bonding segment, have the minimum value F=1. The following relations exist between the ration (R), number of passes (t) and mean flotation (F):

$$F_{warp} = \frac{R_{weft}}{t_{warp}}; \; F_{weft} = \frac{R_{warp}}{t_{weft}} \quad \textbf{(1)}$$

The measurements are done on woven samples having standard dimensions. These are folded at 180^o and pressed along the direction of one of the constituent fiber systems by applying over a defined time interval folding forces which are dependent on the unit surface mass. After the removal of the folding forces, the sample is left to relax freely. The recovery angle is measured in the end of a determined time interval.

The following indicators are for estimating the capacity of textile materials to maintain their initial shape and dimensions during the wearing time:

- the recovery angle after folding (α)- the angle between the sample sides folded according to the SR EN 22313:1997 after the removal of the folding force;
- recovery coefficient λ (%) calculated according to relation (2):

$$\lambda = \frac{\alpha_1}{180^o}100 \quad \textbf{(2)}$$

where the recovery coefficient λ can be determined:

-at t_1=1 minute after detension when either λ_1 (%) or the instantaneous recovery coefficient is determined;

-at t_2=10 minutes after detension when either λ_2 (%) or the slow recovery coefficient is determined. The latter is defined by relation (3):

$$\lambda_2 = \frac{\alpha_2 - \alpha_1}{180^o}100 \quad \textbf{(3)}$$

The total coefficient of recovery after folding is calculated according to relation (4):

$$\lambda = \lambda_1 + \lambda_2 \quad \textbf{(4)}$$

The bending property is one of the most significant properties in fabric handling evaluation, affecting fabric drape, crease resistance, garment formability, and other performances.

3. EXPERIMENTAL PART

The bending properties of a fabric are dependent on the mechanical properties of fibres, the structure of yarns, as well as the weave and finishing of the fabric. The recovery capacity from creasing depends on the fibrous composition and on the level of deformations. Additionally, also technological processing through mechanical, physical or chemical processes can influence positively or negatively the evolution of the indicator. Several operations have been performed for each item from the woven materials considered in the study:

-evaluation of the recovery angle after folding (α) and of the recovery coefficient λ (%) along the direction of the two yarn systems, i.e. warp and weft. The experimental values are given in Table 1;
-Fig.1 and Fig. 2 are illustrating the plots of functions α(t) and λ(t) by considering the woven materials grouped based on their flotation size.

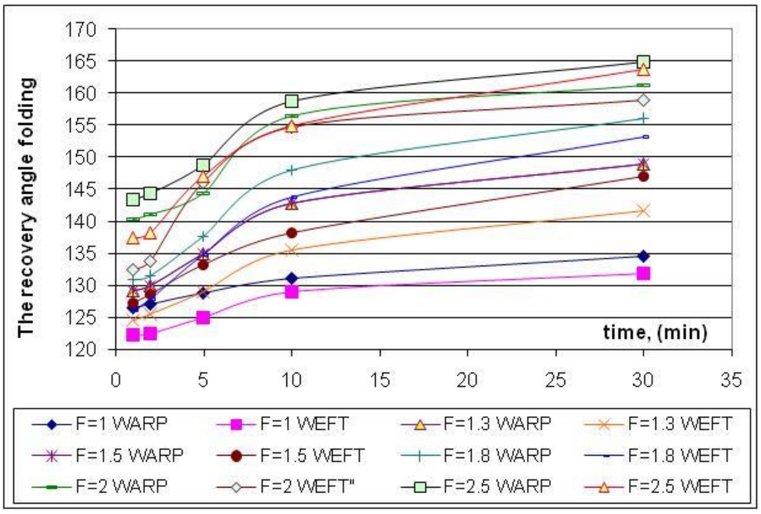

Fig.1. *Variation of return angle after bending, for the Group A studied fabric assortments*

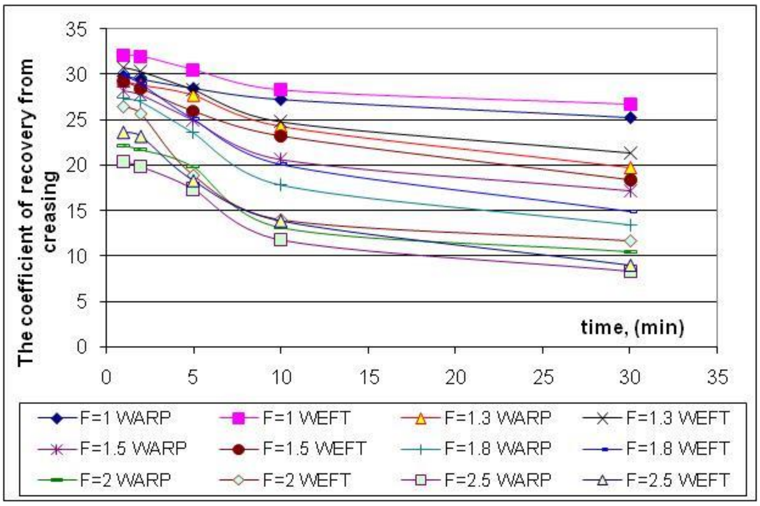

Fig.2. *The variation coefficient of recovery from creasing for the Group A fabrics*

Following useful observations for the design of woven materials can be drawn based on the analysis of the values in Table 1 and on their graphical representation:

- the fabric assortments in this group have the lowest value of the return angle after bending, the values are higher in the direction of the warp threads than in the direction of the weft yarns, all the fabrics in this group are balanced to fines and unbalanced to the width, and in this group, it is noted that, for example, as flotation increases, the angle of return after bending decreases: Art. A8, α_{weft} =164.2° and α_{warp} =165.4° with (Nm_{warp}=Nm_{weft}=60/2, P_{warp}>P_{weft}), linen D $\frac{4}{1}$/ so the average float F=2.5 and Art. A3 α_{warp} =134.2° and α_{weft} =130.5°, with $Nm_{warp}=Nm_{weft}$=64/2, $P_{warp}>P_{weft}$, canvas linen, so the average float F=1.

Also creasing cause damages on fabric, because abrasion occurred along the crease. Creasing recovery is the ability of a fabric to recover from folding deformations and return to original appearance as much as possible. This ability also improves the aesthetic view and easy-care properties of the fabrics and also affects the performance of end product. The performance of fabrics under most service conditions depends largely on their bending behaviour.

4. CONCLUSIONS

An energy method is applied to the study of crease recovery behaviour of the fabric. Equations of crease recovery work and crease recovery force as a function of curvature are derived. Two basic parameters are needed to characterise the fabric in the crease recovery model: the bending rigidity and bending hysteresis of the fabric; both are readily measured in a pure bending test. Good agreement is observed between experimental data and theoretical predictions for wool/polyester blended and worsted fabrics.

The creasing of wovens is a complex process of deformation under the action of mechanical stretching, bending and compression strains. The behavior to creasing is determined by the deformability of the constituent fibers with respect to the creasing conditions. The response at a certain strain level (strain speed, time, alternation of application direction, compression or stretching level) is evaluated depending whether the creasing is under or over the elasticity limit of the mentioned strain. The strain level through creasing determines the total deformation which in turn is determining the ratio between the elastic components of recovery and the remanent deformation value. Based on the data presented above one can observe that under the standard conditions the recovery angle is higher along the weft yarns direction, which could be because of the following reasons: warp yarns fatigue during the weaving process, density difference of the two yarn systems, different respons of the two yarn systems, during the finishing process.

The plaine bonding presents a low recovery capacity from creasing, thus the flotation increase for both of warp yarns and weft yarns is favorable for reducing the creasing. The effect is compensated because the density in the two yarn systems is different.

REFERENCES

[1] B. Arık, *"Latest Developments on Crease Resistance Processes for Cellulosic Fabrics"*, Pamukkale University Journal of Engineering Sciences, vol. 21, no. 7, 2015, pp. 296-305.

[2] L. Hristian, M.M. Ostafe, L.R. Manea,L.L. Apostol, "*Experimental Researches on the Durability Indicators and the Physiological Comfort of Fabrics using the Principal Component Analysis (PCA) Method*", International Conference on Innovative Research (ICIR Euroinvent), Book Series: IOP Conference Series-Materials Science and Engineering, Vol.209, No.012104, Iasi, 2017.

[3] N. Özdil, "*The Physical Quality Control Methods of Fabrics*", Izmir: Ege University Textile and Apparel Research-Application Center, 2003, pp.105- 107.

[4] T. Hussain, M. Tanveer, A. Zulfiqar, Z. Arshad and A. Nazır, *"Comparison of Artificial Neural Network and Adaptive NeuroFuzzy İnference System for Predicting the Wrinkle Recovery of Woven Fabrics"*, Journal of Textile Institute, vol. 106, no. 9, 2015, pp. 934-938.

[5] L. Hristian, *"A study regarding the tensile behaviour of woollen woven fabrics"*, Buletinul Institutului Politehnic Iasi, Publicat de Universitatea Tehnică „Gheorghe Asachi" din Iaşi, Tomul LVII(LXI), Fasc. 2, 2011, pp. 21-27.

[6] F. Shi and Y. Wang, *"Modelling Crease Recovery Behaviour of Woven Fabrics",* The Journal of The Textile Institute, vol.100, no. 3, 2009, pp. 218-222.

[7] L. Hristian, M.M. Ostafe, L.R Manea, A.L. Leon, *"The study about the use of the natural fibres in composite materials"*, Modtech International Conference-Modern Technologies in Engenering IV, pts 1-7, Book Series: IOP Conference Series-Materials Science and Engineering, Vol. 145, No. 032004, 2016

[8] B. K. Behera and P. K. Hari, *"Woven Textile Structure",* 1st ed., The Textile Institute, Woodhead Publishing Limited, Cambridge, 2010, pp.197–204.

[9] M.S. Neculăiasa, L. Hristian, *"Metrologie Textilă"* Vol. I, pp.326, Ed. Performantica, Iaşi, 2004

[10] M. Hashem, P. Hauser and B. Smith, *"Wrinkle Recovery for Cellulosic Fabric by Means of Ionic Crosslinking",* Textile Research J., 73(9), 2003, pp.762–766.

[11] L. Hristian, D.L. Bordeianu, M.M. Ostafe, G. Bohm-Revesz, *"Creasing behavior of some woven materials made from combed yarns type"*, International Scientific Conference – Innovative solutions for sustainable development of textile industry, Annals of the University of Oradea, Fascicle of Textiles-Leatherwork, XVIII (2), 2017, pp. 47-52.

[12] J. Hu, F. Shi and T. Yu, *"Wrinkle recovery angle of woven fabrics"*, Textile Asia, Vol. 30, No. 4, 1999, pp. 68–70.

[13] L. Wang, J. Liu, R. Pan and W. Gao, *"Dynamic measurement of fabric wrinkle recovery angle by video sequence processing",* Textile Research Journal, 84, 2014, pp. 694-703.

[14] D.L. Bordeianu, I. Arnăutu, L. Hristian, *"Fibre textile. Aplicaţii"*, pp.200, Ed. Performantica, Iaşi, 2016.

[15] J.L. Hu, W.M. Lo, M.T. Lo, *"Bending Hysteresis of Plain Woven Fabrics in Various Directions"*, Textile Research Journal, Vol. 70, No. 3, 2000, pp. 237-242

[16] D. Truncytė, M.V. Gutauskas, A. Baltušnikas, *"The Peculiarities of Clothing Fabrics During Exploitational Behaviour",* Mat. Science (Medžiagotyra), Vol. 14, No. 3, 2008, pp. 263-267.

[17] L. Hristian, A.V. Sandu, L.R. Manea, E.A. Tulbure, K. Earar, *"Analysis of the Principal Components on the Durability and Comfort Indices of the Fabrics Made of Core-coating Filament Yarns"*, Revista de chimie, Vol. 66, no. 3, 2015, pp. 342-347.

[18] O. Tokmak, O.B. Berkalp, J. Gersak, *"Investigation of the Mechanics and Performance of Woven Fabrics Using Objective Evaluation Techniques"*, Part I: The Relationship Between FAST, KES-F and Cuisick's Drape-Meter Parameters Fibres&Textiles in Eastern Europe, Vol. 18, No. 2, 2010, pp. 55-59.

[19] F. Shi, *"Study on crease recovery properties of woven fabrics",* Wool Textile Journal, 4, 2001, pp.16–19.

[20] K. Ancutiene, E. Strazdiene, A. Nesterova, *"The Relationship between Fabrics Bending Rigidity Parameters Defined by KES-F and FAST Equipment",* Materials Science (Medžiagotyra), Vol. 16, No. 4, 2010, pp. 346-352.

ANNALS OF THE UNIVERSITY OF ORADEA
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CHROMATOGRAPHIC CHARACTERIZATION OF BEMACID ROT DYE COMPOUNDS FOLLOWING *CERIOPORUS SQUAMOSUS* BIOREMEDIATION

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Abstract: *Fungi mediated bioremediation of industrial wastewaters containing azo-dyes has been gaining increased attention in the last years. One of the downsizes of bioremediation of azo-dyes is the possibility of resulting degradation aromatic amines, following breakage of azo-bond by microbial azoreductase. In the present study, HPLC technique was used for the analysis of Bemacid Rot (Bezema) azo-dye compounds, resulting from treatment of synthetic-dyed wastewater with Cerioporus squamosus fungal strain. C. squamosus is a basidiomycete bracket fungus, that has gained little attention towards bioremediation methods of industrial wastewaters. Chromatographic analyses were performed on three experimental sets: solutions of pure dyes dissolved in distilled water at concentration of 200 mg/L; solution of sample resulting from the biodegradation of dyes (containing nutrients from the culture media: salts, fungal cells, dye, biodegradation products of different polarities) and on a solution of the dye dissolved in the nutritive media. Analyses were conducted at five wavelengths (226nm, 243nm, 304nm, 500nm and 550nm). Major differences could be highlighted, in terms of elution profiles, retention times, number of peaks, and proportion of components. This allowed the highlighting of dye degradation compounds with lower retention times, which can indicate the degradation of the azo-dye into highly polar compounds.*

Key words: *Moving bed biofilm reactor, fungi, wastewater, azo-dyes*

1. INTRODUCTION

Water in the textile industry is characterized by large fluctuations in physical-chemical parameters [1] such as chemical oxygen demand (COD), biochemical oxygen demand (BOD), pH, conductivity, turbidity, color and salinity, their composition depending on both the content in organic compounds and the type of dyes used in the finishing processes [2].

The toxic effect of azo-dyes can be the result of their direct action or amine derivatives resulting from azoic biotransformation [3-4]. The color of the textile effluents is notable at a concentration of about 1 mg/L, their average concentration in the textile effluents being about 300 mg/L, with a loss of dyes in the dyeing processes, ranging from 2-60% [5]. The presence of industrial dyes in water effluents reduces the pathway of solar rays, with difficulty in lower volumes, with effect on photosynthetic activities of the aquatic flora, decreasing of dissolved oxygen concentration, with negative effects on aquatic flora and fauna [6].

Biological treatment methods of industrial wastewater are often presented as less costly alternative methods, compared to conventional physical-chemical ones. Technological processes of biodegradation by fungi are starting to be used in degradation of pollutants by adsorption on viable or inactive biomass, use of microbial biomass as biosorbents, microbial bioremediation systems, all of which have been successfully applied in industrial effluent treatment technologies [7][8].

2. MATERIALS AND METHODS

2.1 HPLC analysis

High Performance Liquid Chromatography analysis was carried out on an Agilent Series 1100 spectrophotometer, with quaternary pump and MWD detector (with multiple wavelengths). The process parameters were as follows: Phenomenex-Kinetex C18 100µ 2.6µm column, thermostated at 250ºC; 70% CH_3OH/30% HOH, vol / vol, mobile phase; 10µl injection volume; 0.7 ml/min flow rate; 2 minutes of post-time (wash time after each analysis); 260 bar maximum pressure during column analysis. Dye solutions and samples were filtered on filter paper and subsequently on 20µm porosity filters, after which they were analyzed on the spectrophotometer. The wavelengths at which dye separation was carried out was selected starting from previous UV-VIS analysis, for Bemacid Rot dye, with absorption maximum at 500nm, and two secondary peaks at 243nm and 304nm.

2.2 Azo-dye and strain

The chromatographic analysis was carried out on Bemacid Rot azo-dye (Fig. 1), from BEZEMA AG Company (N-TF (CAS EINECS: 276-115-7), $C_{24}H_{20}ClN_4NaO_6S_2$, M = 583.0 g/M). Dye degradation was induced by enzymatic activity of *Cerioporus squamosus* fungal strain, grown in liquid nutritive broth (Czapek-Dox: 30g/L sucrose, 3g/L sodium nitrate, 0.5g/L magnesium sulfate, 0.5g/L potassium chloride, 1.0g/L potassium phosphate dibasic, 0.01g/L ferrous sulfate, pH 7.3 at 25oC) incorporating the azo-dye for supplying nutrients (data not shown in this paper). Selected microbial strain, *Cerioporus squamosus*, is a basidiomycete bracket fungus, belonging to the Basidiomycota phylum (Agaricomycetes class), with saprobic activity on decaying hardwood logs and stumps.

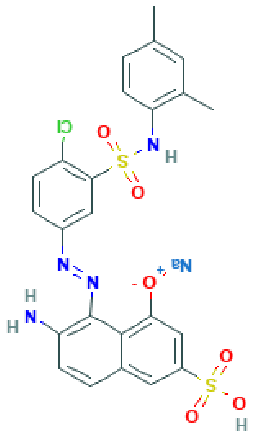

***Fig. 1**: Bemacid Rot chemical structure*

3. RESULTS AND DISCUSSIONS

For separating and identifying the components of the mixture resulting from the degradation of the dyes, High Performance Liquid Chromatography (HPLC) was used due to high accuracy, high separation efficiency and relatively simple sample preparation.

In Fig. 2 are shown the chromatograms of Bemacid ROT dye at 200 mg/L, at 226nm, 243nm, 304nm, 500nm and 550nm wavelengths.

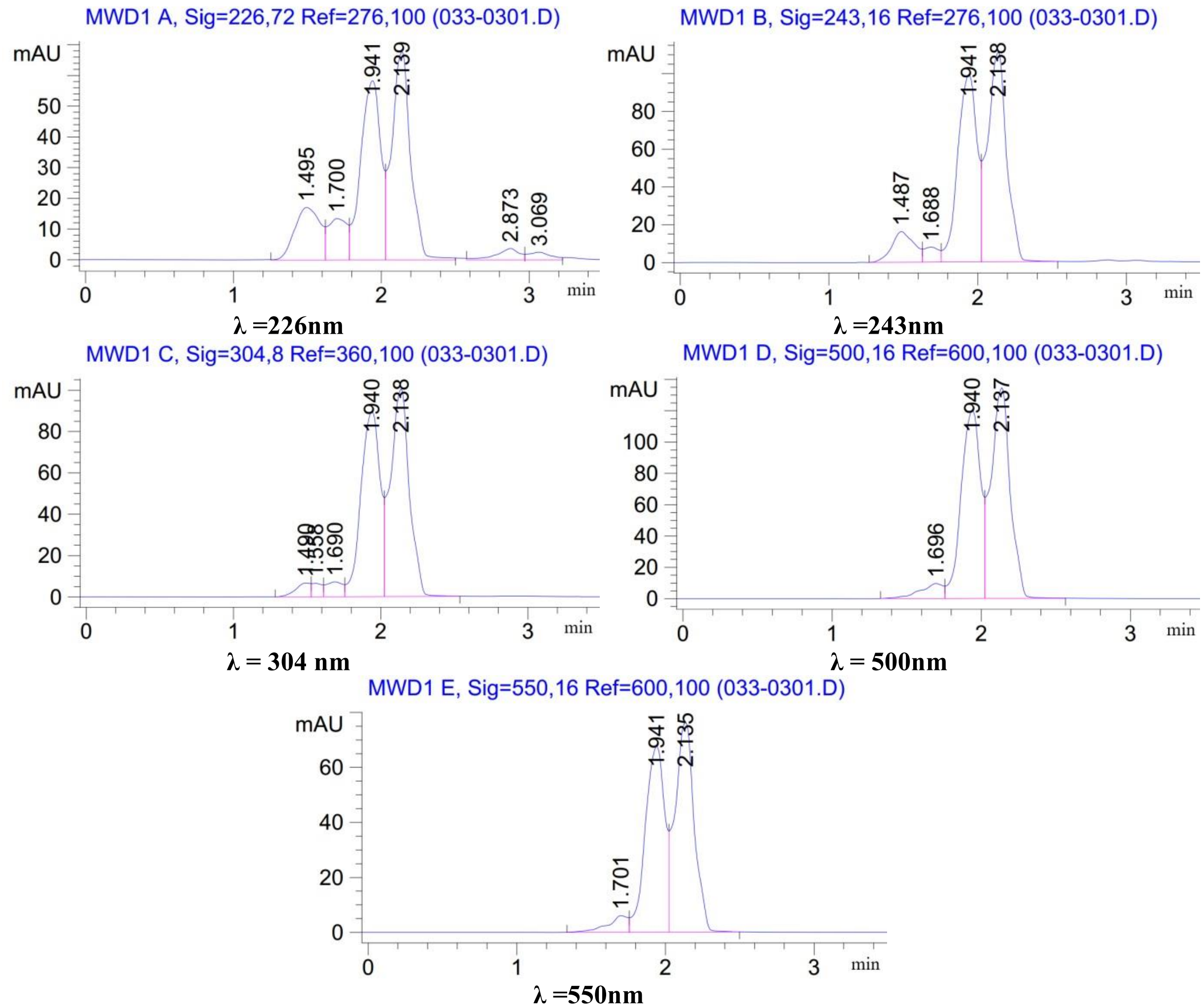

***Fig. 2**: HPLC-MWD chromatogram at 200mg/L Bemacid Rot dye*

Results show that Bemacid Rot dye has a different number of components. Thus, at λ=226nm there are 5 components, at λ=243nm, 4 components, at λ=304nm, 5 components, at λ=500 and at λ=550nm there are 3 components. Taking into account the peak integration area, it can be observed that at all wavelengths there are two major peaks at a retention time of approximately 1,941 and 2,135-2,138 minutes, representing 45% and 50% of the total integration area.

Furthermore, after bioremediation method (data not shown), the obtained solutions were chromatographically analyzed at 226nm, 243nm, 304nm, 500nm and 550nm wavelengths (Fig. 3).

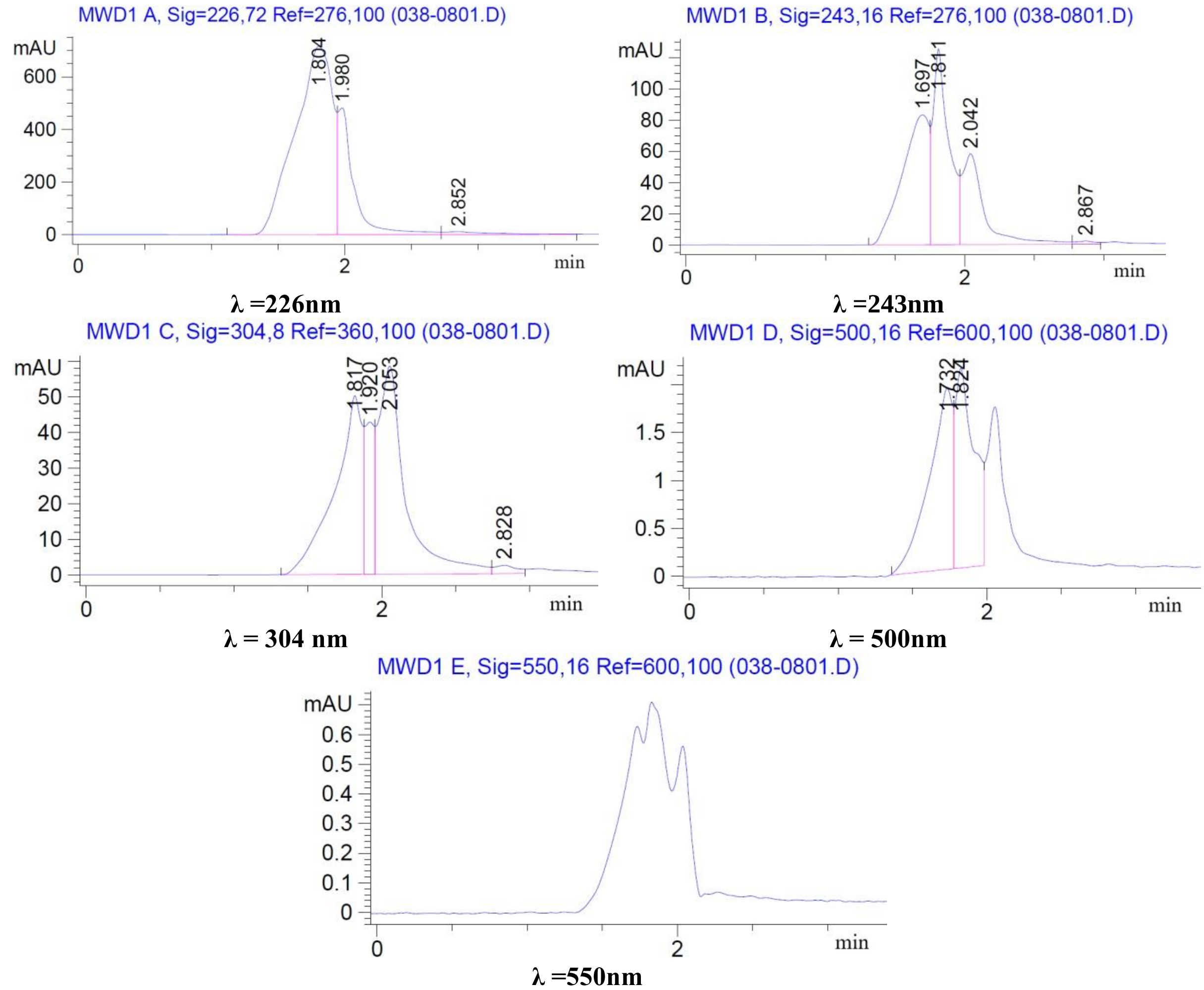

***Fig. 3**: HPLC-MWD chromatogram of sample R5 (Polyporus squamosus)*

Analysis shows major differences in elution profile, retention times, number of peaks, and proportion of components, when compared to the chromatograms of initial dye solution. It is noted the formation of dye degradation compounds with lower retention times, which cand lead to the hypothesis of dye degradation into highly polar compounds.

Furthermore, for assessment of influence of nutritive media composition on the analysis, and in order to remove the resulting compounds from the reaction media (enzymes, proteins, amino acids, sucrose, sodium nitrate, di-potassium sulfate, potassium chloride, ferrous sulphate, magnesium sulphate), chromatography analysis (at 226nm, 243nm and 304nm, 500nm and 550nm) was performed under similar conditions to those of Bemacid Rot and samples subjected to biodegradation (Fig 4 and Tab. 1).

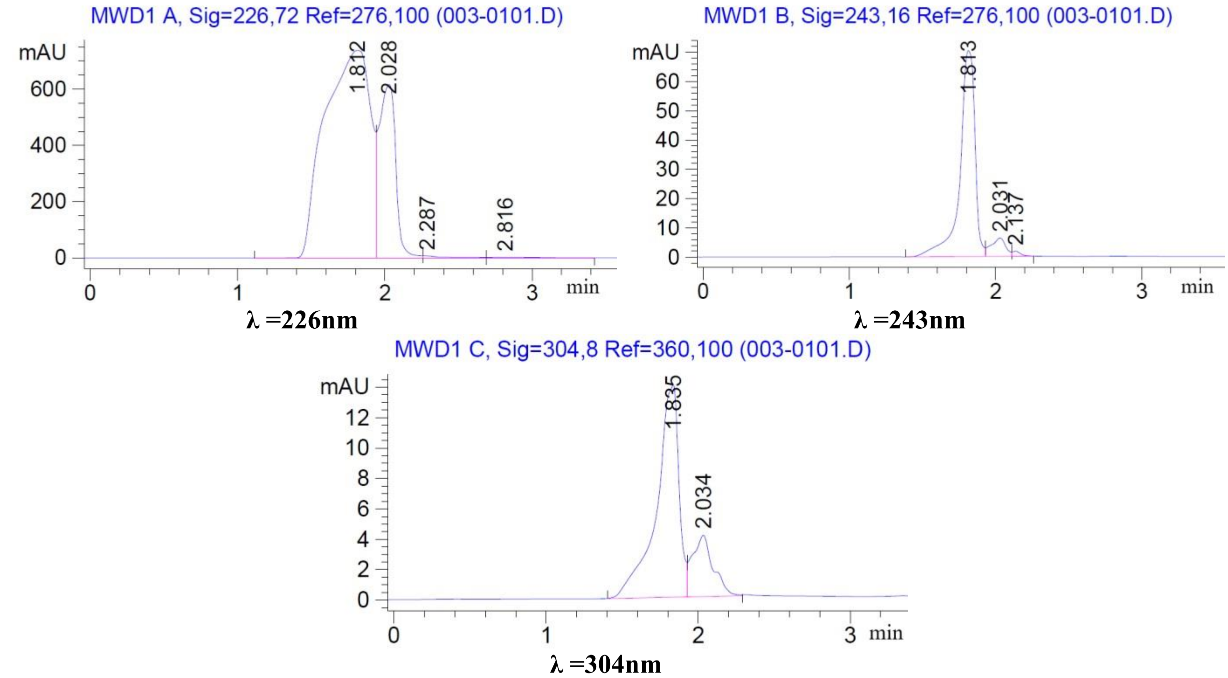

Fig. 4*: HPLC-MWD chromatogram of Bemacid Rot and culture media*

Table 1*: Culture media HPLC-MWD chromatogram characteristics*

Pic	λ=226nm		λ=243nm		λ=304nm	
	Ret. (min)	**Area (%)**	**Ret. (min)**	**Area (%)**	**Ret. (min)**	**Area (%)**
1	1.812	75.99	1.813	90.89	1.835	78.89
2	2.028	23.27	2.031	7.87	2.034	21.11
3	2.287	0.40	2.137	1.24	-	-
4	2.816	0.33	-	-	-	-

Obtained data shows that the culture media has 4 peaks at 226nm, 3 peaks at 243nm, 2 peaks at 304nm (no data was obtained at 500 and 550nm. Comparing the results with those of analysis carried out on *C. squamosus* samples, it was observed that the peaks eluted at 1,812 minutes are also found on the chromatograms of the sample, (in similar proportions at λ=226 nm) at approximately the same elution times and % area, indicating that these peaks are from the culture medium. These peaks are also found at 243nm and 304nm, but in considerably smaller proportions.

4. CONCLUSIONS

High Performance Liquid Chromatography (HPLC) analysis allowed the separation and identification of the compounds resulting from the biodegradation of Bemacid Rot dye by *Cerioporus squamosus* fungal strain. The decrease or even disappearance of the compounds eluted from the pure dye solution could be observed, highlighting the biodegradative action of the strain or isomeric transformation of the dye. The determinations were performed at five wavelengths for each sample, so partial degradation of the dye may be evidenced, in some samples, with the formation of sub-compounds, with absorption especially in the UV region. Analysis of the proportion of peaks and elution times, generally lower, reinforced the hypothesis of dye degradation, with the formation of more polar compounds, which determined their elution faster on the column and the degradation of the functional groups and the aromatic nuclei of the original dye.

Chromatographic analysis of the culture medium did not reveal the identification of their compounds with the chromatographic profiles of the dyes but revealed extremely low absorption rates of the dyes in the culture medium with very low integration of the signals and elution times.

ACKNOWLEDGEMENTS

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REFERENCES

[1] Arun P.A.S., Bhaskara R.K.V., 2010. Physico chemical characterization of textile effluent and screening for dye decolorizing bacteria, Global Journal of Biotechnology and Biochemistry 2010; 5(2) 80-86;

[2] Dos Santos A.B., Cervantes F.J., van Lier J.B., 2007. Review paper on current technologies for decolourisation of textile wastewaters: Perspectives for anaerobic biotechnology, Bio-resource Technology, 98 (12) 2369-2385;

[3] Bornick H., 2001. Simulation of biological degradation of aromatic amines in river bed sediments, Water Research; 35 (3) 619-624;

[4] Rajaguru P., Fairbairn L.J., Ashby J., Willington M.A., Turner S., Woolford L.A., Chinnasamy N., Rafferty J.A., 1999. Genotoxicity studies on the azo dye Direct Red 2 using the in vivo mouse bone marrow micronucleus test, Mutation Research; 444(1) 175-180;

[5] vHessel C., Allegre C., Maisseu M. Charbit F., Moulin P., 2007. “Guidelines and legislation for dye house effluents, a review”, Journal of Environmental Management, 83, 171-180;

[6] Nilsson I., Moller A., Mattiasson B., Rubindamayugi M.S.T., Welander U., 2006. “Decolorization of synthetic and real textile wastewater by the use of white-Rot fungi”, Enzyme and Microbial Technology, 38, 94-100;

[7] Espinosa-Ortiz E.J., Rene E.R., van Hullebusch E.D., Lens P.N.L., 2015. Removal of selenite from wastewater in a Phanerochaete chrysosporium pellet based fungal bioreactor. International Biodeterioration & Biodegradation, Volume 102, August 2015, Pages 361–369, CESE-2014 – Challenges in Environmental Science and Engineering Series Conference;

[8] DJORDJEVIC Dragan, UROSEVIC Snezana, DJORDJEVIC Suzana. Emission reduction of colored waste water after contact with a natural sorbent with a special focus on the thermodynamics of adsorption. Annals of the Oradea University, Fascicle of Textiles, Leatherwork, 2018.

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

USAGE OF HORSE HAIR AS A TEXTILE FIBER AND EVALUATION OF COLOR PROPERTIES

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Abstract: *The usage of horse hair as a textile material can be traced to the old ages. Although many animal hair fibers have lost their importance due to the introduction of synthetic fibers into our lives, special fibers such as horsehair have been able to survive in some unique applications. Horse hair fiber exhibits durability, stiffness, antibacterial, antifungal antiallergic and thermal comfort properties. Horse hair fibers have been used in a wide range of products from surgical sutures to brushes, musical instruments, upholstery fabrics and accessories. It is a promising animal hair fiber especially for technical textiles and special designed products thanks to its prominent textile propertie. The recent studies which are about to usage of horse hair fibers for car seat covers and reinforcement materials for composites prove this claim. Since the application areas of the fibers are mostly visible surfaces, the color of the hair becomes an important parameter. Therefore, the color properties of two different horse hair types (as tail and mane) from two different Arabian horses were examined in this study. Moreover, the structure, properties and the usage areas of horsehair fibers were reviewed in detail and future uses of the horse hair fibers were also discussed.*

Key words: *horse hair, anti-allergic, thermal comfort, durable, textile, fiber*

1. INTRODUCTION

The usage of animal fibers in the textile industry does not have a large market in general fiber consumption. Wool is the first fiber kind that comes to mind when it is called the most commonly used animal protein fiber. Silk fibers follow the wool fibers. Special fur fibers such as angora, cashmere and camelhair also have a limited area within animal fiber category [1]. Protein fibers, including wool and silk, generally address a specific and niche market.

The usage of horse hair as a textile material can be traced to the old ages. Before the synthetic fibers have entered into our lives, the main sources of textile materials were the only natural fiber sources. Cotton, linen, wool and silk fibers are the oldest fiber sources in the textile history. In the past, horse hair fibers were the type of fiber that was used extensively in different times and in different regions of the world, especially when animal husbandry was important. The fibers obtained from horses' tails and manes were used for production of many different products such as a special usage of single fiber, woven or felt surfaces. Horse hair fibers have been used in a wide range of products from surgical sutures to brushes, musical instruments, upholstery fabrics and accessories owing to its durable, anti-allergic and stiff character [2-5].

In this study, the structure, properties and the usage areas of horse hair fibers were evaluated in special textile fibers category and these characteristics were reviewed in detail from the past to the recent times. In addition, the color properties of two different horse hair types (as tail and mane) from two different Arabian horses supplied from Karacabey-Bursa, which is the one of the most important horse breeding region in Turkey, were examined. Morever, the future usage areas of horsehair fibers in textile industry were also discussed.

2. HORSE HAIR FIBER

2.1 Basics of horse hair fibers

Horse is an herbivorous mammal, including the *Equidae* family. Horses, whose life spans are around 20-30 years, are among the most talented animals that have served people throughout history [6]. Horses are domesticated animals, although there are also wild species. These animals, which are presumed to have served people for 5500 years, have different races such as Arabian horse, Morgan horse, and pony, etc. Horse hair is obtained from the tail or mane of the horse. The presence of horsehair sutures and fabrics woven from horsehair fibers in archaeological studies shows that the use of horsehair fibers is quite old [2, 7]. Although many animal hair fibers have lost their importance with the introduction of synthetic fibers into our lives, special fibers such as horsehair have been able to survive in some unique applications. In the recent years, with the spread of the concept of sustainability, natural fibers have become more preferable again and new areas of use have been created for many special textile fibers such as horsehair. Nowadays, the main exporters of horsehair fibers, which mostly appeal to a niche textile market, are Argentina, Canada, Mongolia, China and Australia [6, 8].

2.2. Horse hair fiber structure

Even though horse hair fibers can be obtained from the tail or mane of the horse, tail hair is more commonly used for textile applications because the tail hairs are lush and longer. The length of the horse tail fibers can be around 60-80 cm and the fineness are generally between 80-400 micron whereas the length and the fineness of the horse mane fibers 25-45 cm and 50-200 micron, respectively [6]. The average diameter of the horse hair fibers varies between 75 and 280 microns. Horsehair fibers can be in many different colors such as brown, red, white, grey, black. The tail and the mane of the horse may be different from the horse's own color, and the tail or mane may also contain a different color of hair. Horse hair structure is exhibited in Fig. 1.

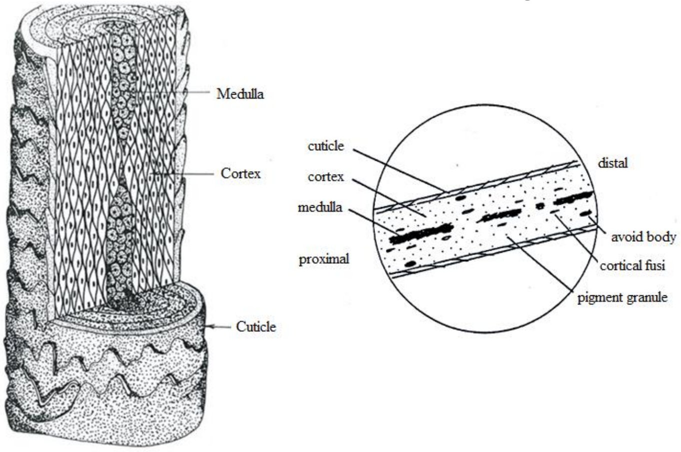

Fig. 1: *Horse hair fiber structure [9, 10]*

2.3 Horse hair fiber properties

Horse hair fibers are mostly stiff, flexible and smooth fibers. They are also well ventilated and washable fibers and resistant to wear [6, 8]. Horse hair fibers and cotton fibers can be blended for some specific lining and tailoring textile applications [11]. The good ventilation of horsehair fibers promotes the use of these fibers as a filling fiber. In addition, the stiffness of the fibers allows the use of lining and interlining for tailored garments and millinery. The texture of the horse hair can be differed by the breed, diet and climate [3, 6]. Horse hair fibers provides good air circulation thanks to its special fiber structure when it is especially used as a filling material [6]. Therefore, they have become a popular filling material for mattress filling. Horse hair fibers provide transferring of heat and moisture dissipated from the human body during sleep due to its long and very open core (medulla) fiber structure [8]. Horse hair fibers can be dyed/colored easily by using conventional dyes suitable for protein fibers in spite of absorbing water slowly. Although it is not easy, horse hair fibers also can be felted [8].

2.4 End-uses of horse hair fibers

Horse hair fibers can be used in many different areas thanks to their advantageous fiber properties. Main usage types of horse hair fiber are summurized in Table 1. In addition to these general uses, they were used for wall coverings and winter clothes thanks to its good insulation property. It is possible to find horse hair fibers inside lime plasters in the historical buildings [12]. Horse hair fiber is a kind of fiber which has the potential to be used in many different industries and, especially in technical textiles field thanks to its strength, durability and thermal comfort properties. Nowadays, the recent studies which are about to usage of horse hair fibers for car seat covers and reinforcement materials for composites prove this claim [6, 8, 13-15].

Table 1: *The End-use applications of horse hair fibers[3-8]*

Fiber Properties	→	Usage	Fiber Properties	→	Usage
Antibacterial Anti-fungal	→	Sutures	Stiffness Durability	→	Industrial and domestic brushes
Durability Lustre	→	Woven fabric	Stiffness Durability	→	Crinoline
Good air circulation Moisture transfer effect Thermal comfort Antibacterial Anti-fungal Anti-mite	→	Filling material for mattress, sofas, etc.	Durability Lustre	→	Handbags, cases and bags
Stiffness Durability	→	Interlining for clothes	Durability Lustre Washability	→	Upholstery and interiors
Stiffness Durability	→	Musical instruments (violin and other stringed instrument bows)	Durability Lustre	→	Accessorizes (bracelets, necklaces, earrings and barrettes)

3. MATERIAL AND METHOD

3.1. Material

The utilized horse hair fibers were supplied from Karacabey-Bursa which is the one of the most important horse breeding region in Turkey. The utilized hair was from the two pured-bred Arabian horses are shown in Fig.2. Fiber sapmles were taken from manes and tails.

3.2. Method

The horse hair fibers were rinsed with 50 ºC water before evaluation. The color properties of the horse hair fibers were measured by using DataColor SpectraFlash 600 (DataColor SpectraFlash 600, Datacolor International, USA) spectrophotometer (D65 day light, 10° standard observer). The CIE *L**, *a**, *b** and *C** color coordinates [16] were measured and the K/S (color strength) values were calculated for each horse hair sample. Moreover, the reflectance curves were also obtained.

Region **Horse A** **Horse B**

Fig. 2*: Photos of utilized Arabian horses and supplied region map of the horses in Turkey*

4. RESULTS AND DISCUSSIONS

Colorimetric measurements of horse hair fibers were given in Fig. 3 and Table 2. It can be clearly seen from the measurements that tail and mane hairs of both Arabian horses differ from each other (Fig. 3). The colorimetric properties exhibited well fit with the appearance of the mane ant tail fibers of the utilized horses (Figs. 2 and 3). In general, tail fibers are slightly darker than mane fibers for both horses A and B. It is clearly visible from reflectance curves and colorimetric values that Horse B fibers exhibited darker appearance with higher color strength (K/S), higher chroma (*C**) and lower lightness (*L**) levels than Horse A fibers (Fig. 3). Horse A tail fiber is clearly brighter than Horse B tail with higher lightness and higher chroma values. Both horse A fibers exhibited significantly redder appearance with higher *a** values than both horse B fibers (Fig. 3 and Table 2).

Table 2: *CIE-Lab measurements of horse hair fibers*

	*L**	*a**	*b**	*C**	*h*°
Horse A-mane	68,3	-0,23	6,16	6,16	92,1
Horse A-tail	67,0	0,93	13,7	13,7	86,1
Horse B-mane	38,2	9,37	16,4	18,9	60,3
Horse B-tail	31,0	6,07	8,70	10,6	55,1

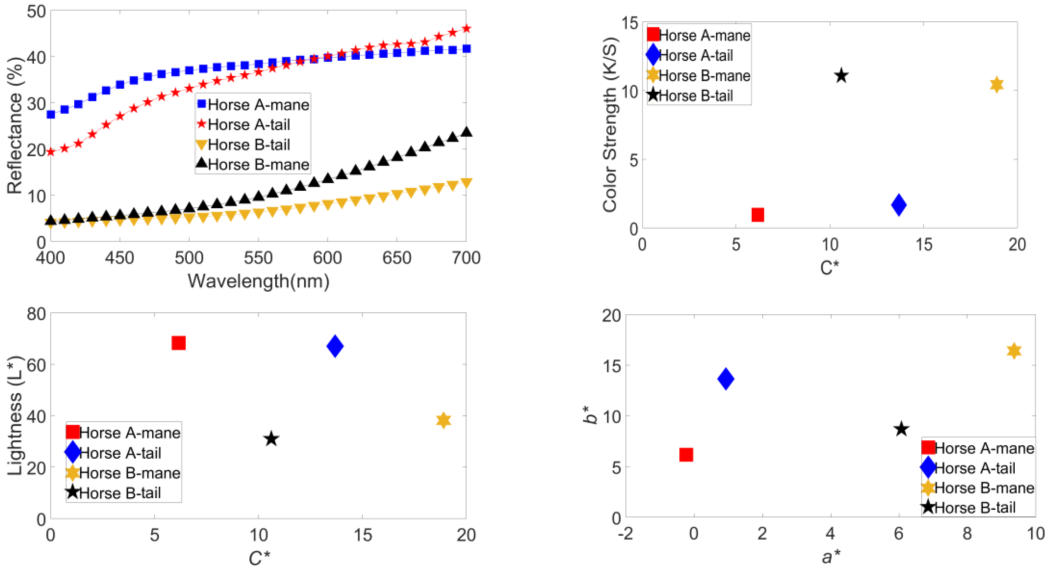

Fig.3: *Colorimetric properties of Arabian horse hair fibers (manes and tails)*

5. CONCLUSIONS

Horse hair fiber is a promising animal hair fiber with its special fiber properties such as durability, stiffness, antibacterial, antifungal anti allergic and thermal comfort. Since the application areas of the fibers are mostly visible surfaces, the color becomes an important parameter. However, the colors of horsehair fibers may vary between the fibers obtained from the tail and mane. The use of fiber reinforced composite materials is increasing day by day. Considering the increasing demand for natural fiber reinforced composite structures, it is thought that horse hair fibers may be among the textile fibers of the future. In this study, color properties of tail and mane samples taken from two different Arabian horses were investigated. As a result, it was observed that the color properties of horse hairs slightly vary between the tail and the mane. Consequently, possible color differences should be considered in cases where the tail and mane fibers were used together.

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REFERENCES

[1] G. Süpüren Mengüç, N. Özdil. "*Özel Hayvansal Lifler*". Electronic Journal Of Vehicle Technologies/Tasit Teknolojileri Elektronik Dergisi. 2014;8(2).

[2] I. Isik, O. Ozyaral. "*May antibacterial suture material be efficient in preventing surgical site infections? An overview of literature*". Turkish Journal of Surgery. 2011;27:123.

[3] B. Bolormaa, J. Y. Drean, D. Enkhtuya. "*A study of the diameter distribution and tensile property of horse tail hair*". Journal of Natural Fibers. 2008;4(4):1-11.

[4] C. Kutlu, N. Meydan. "*Geleceğin Modasında Radikal Materyal Arayışları*". Akdeniz Sanat Dergisi 4(7).

[5] S. R. Yedke, S. Y. Raut, C. Jangde. "*Experimental evaluation of horse hair as a nonabsorbable monofilament suture*". Journal of Ayurveda and integrative medicine. 2013;4(4):206.

[6] A. Lakshmanan, S. Jose, S. Chakraborty. "*Luxury Hair Fibers for Fashion Industry*". In: Muthu SS, Gardetti MA, (Eds.) Sustainable Fibres for Fashion Industry. Singapore: Springer; 2016. p. 1-38.

[7] T. Atıcı, E. Atıcı, N. Şahin. "*The historical development of surgical suture materials from past to present*". Ulusal Cerrahi Dergisi. 2010;26(4):233-42.

[8] "*Use of horse hair in textile industries*", https://www.chemarc.com/content/article/use-of-horse-hair-in-textile-industries/588891bf67856525c8448f0d?in=chemarc%2Fmagazine%2Fcol%2F2016%2F04, Accessed: March, 2019

[9] "*Horse Hair Under a Microscope: A descriptive report*", https://colorgenetics.info/equine/horse-hair-under-microscope-descriptive-report, Accessed: March, 2019

[10] M. Dejmal, L. Lisá, M. F. Nývltová, A. Bajer, L. Petr, P. Kočár, et al. "*Medieval horse stable; the results of multi proxy interdisciplinary research*". PloS one. 2014;9(3):e89273.

[11] Author. "*Garment Comprising Multiple Layers*". 2014.US 2014/013.7309 A1

[12] C. J. Kennedy, W. A. Revie, L. Troalen, M. Wade, T. J. Wess. "*Studies of hair for use in lime plaster: Implications for conservation and new work*". Polymer degradation and stability. 2013;98(4):894-8.

[13] S. Javid Azimi. "*Structural Behavior of Hair Fiber Reinforced Concrete Beams*". IOSR Journal of Engineering. 2017;07(01):39-48.

[14] H. Naik, N. A. Naikoo, S. A. Dar, M. Showket, S. A. Muhamm. "*Use of horse hair as fiber reinforcement in concrete*". International Journal of Advanced Research. 2015;3(6).

[15] A. Singh, V. Devaraj. "*The Tribological and Mechanical Behaviour of Horsehair Strengthened Composite*". International Journal for Scientific Research & Development. 2017;5(9).

[16] B. Raluca. "*A Review of Color Measurements in the Textile Industry*". Annals of the University of Oradea Fascicle of Textiles. 2016;17(1):19-24.

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

MAGNETIC ELECTROSPUN COMPOSITE FIBERS

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Abstract: *This work is focusing on electrospinning polyethylene oxide (PEO) with incorporated barium ferrite nano-particles (BaFe) and the characterization of the magnetic properties of the obtained composites fibers. The barium ferrite powders used belong to a group of ferrites with hexagonal crystal structure. PEO has low toxicity, is water soluble, and is available in a variety of molecular weights of which 600.000 g/mol was used in this study. Following successful electrospinning of magnetic composite fibers, we have selected two samples, denoted as S1 and S2, for further investigation. The process parameters corresponding to the production of S1 and S2 differ only by the needle tip-to-collector distance which is larger for S2 (70 mm as compared to 50 mm). SEM images and fiber diameter distributions reveal that, as previously shown for pure PEO electrospun fibers, the average fiber diameter is decreasing with decreasing tip-collector distance. In addition, the distribution of the fiber diameters for the S1 sample is wider than the one for S2. This is indicative of a less controlled electrospinning process in the case of the S1 sample. Magnetic measurements on composite fibers reveal an expected ferrimagnetic behavior and no major differences between the magnetic properties of S1 and S2.*

Key words: *electrospinning, polyethylene oxide, barium ferrite nano-particles, composite fibers, magnetic properties*

1. INTRODUCTION

Current society increasingly requires innovative materials and associated technologies to answer its demands. In this context, nanotechnologies foster the creation, through structural control at nano level, of nano-structured materials with exceptional performance and innovative new functions. Nano-structured organic materials and biomaterials are finding diverse industrial applications while expanding as a major field of material research. Semiconductor related materials are both socially and economically important as information communication and energy transformation materials.

Composite materials made of various organic and inorganic materials hold a huge potential for intelligent structures.

In order for nano-structured materials to develop entirely new functions, it is important to design and control the technologies which allow their production. Among the many promising ones, electrospinning is actively pursued both at research and at industrial level for its capability of producing nano-sized polymer fibers which can be easily functionalized with various nano-particles for added properties. In this paper, we are focusing on conferring magnetic properties to polymeric fibers obtained through electrospinning. Magnetic fibers are manufactured by introducing ferrimagnetic nano-particle powders into the polymer solution prior to electrospinning. The resulting polymer fibers are composite fibers, as the polymer (the matrix) together with the magnetic powder filler make a discontinuous phase. These composites have many potential applications in microelectronics as nano-electronic micro-mechanical systems (MEMS) and bio-micro-mechanical systems (BioMEMS).

Prior work on electrospun magnetic nano-fibers has mainly involved electrospinning combined with the sol-gel method [1-4]. Various authors have also reported on the electrospinning of polymer and nano-particles mixtures. However, in this case, the affinity between the inorganic and the organic materials may complicate fiber synthesis. However, the large range of potential applications such as electromagnetic interference (EMI) shielding, electrically conducting materials, super-capacitors and filters has motivated research in this direction. For example, $BaFe_{12}O_{19}$ nano-particles incorporated in poly (vinyl alcohol) were electrospun with the purpose of producing filters for the effective separation of Fe_3O_4 nanoparticles and removal of arsenic from waste water [4]. Cobalt ferrite/polyacrylonitrile and cobalt ferrite/carbon nano-fibers were electrospun and characterized by Chen *et al.* [5].

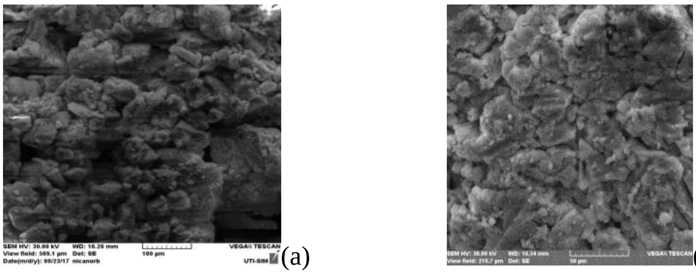
We are focusing in this work on: (a) electrospinning polyethylene oxide (PEO) with incorporated barium ferrite (BaFe) nano-particles and (b) characterization of the magnetic properties of the obtained composite fibers. The barium ferrite powders used belong to a group of ferrites with hexagonal crystal structure. PEO has low toxicity, is water soluble and available in a variety of molecular weights of which the 600.000 g/mol is used in this study. The wide variety of molecular weights available for PEO confer significant versatility to its usage but the real benefit is its water solubility which provides a more sustainable less hazardous route to nano-fiber production [6]. BaFe on the other hand, is attracting significant scientific and technological interest because of its relatively high Curie temperature, high coercive force and high magnetic anisotropy field, as well as its excellent chemical stability and corrosion resistivity [7]. Thus, composite electrospun fibers obtained from PEO and BaFe can exhibit important properties for a wide field of applications.

2. EXPERIMENTAL

2.1. Materials

Polyethylene oxide (PEO) from Sigma-Aldrich with a molecular mass of 600.000 g/mol was used to prepare PEO solutions. Deionized water and ethanol (> 99%, PanReac &AppliChem IWT Reagents) were used as solvent without any further purification and sodium chloride as additive to improve the electric conductivity of the polymer solution. Magnetic nano-barium ferrite particles with a diameter of less than 100 nm were supplied by Sigma-Aldrich. Some of the properties of the BaFe nano-particles include saturation magnetization 5.2801 emu/g, remanent magnetization 2.2174 emu/g and coercivity 4141.4 G. All solutions and samples were stored at room temperature.

The SEM images of the nano-barium ferrite particles obtained at different magnifications with a SEM-EDX VEGA II LSH TESCAN are shown in Fig. 1. They reveal particle agglomeration due to magnetic nature of the hard magnetic materials.



(a) (b)

Fig. 1: *SEM images of barium ferrite nano-particles (a) 500x magnification (b) 1000x magnification.*

A VSM Vibrating Sample Magnetometer (VSM model 7410 Lake-Shore) was used for measuring the hysteresis loops of barium ferrite nano-particles (see Fig. 2). The hysteresis loops indicate a behavior specific to hard magnetic materials with a high coercive field value.

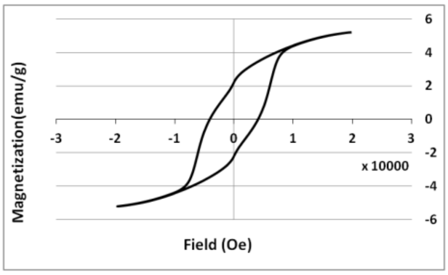


Fig. 2: *Magnetic loops of magnetizing barium ferrite nano-particles.*

2.2. Solution preparation

The solvent used to prepare the polymer solution is a mixture of ethanol and water in a weight ratio of approximately 4:1. The PEO powder (600.000 g/mol, 5.5 wt %) was dissolved in this solvent mixture by stirring vigorously using a magnetic stirring rod. An amount of 0.8 wt% of NaCl was added to the mixture to improve the conductive properties of the polymer solution.

An amount of 1.0 wt% barium ferrite nano-particles was dispersed in the PEO solution and subjected to ultrasonication at room temperature to obtain a homogeneous suspension. The obtained ferrite particle polymer suspension was used for electrospinning with different process parameters.

2.3. Electrospinning process

A 3 ml syringe with a needle inner diameter of 0.4 mm was used for feeding the polymer suspension. The syringe was fixed horizontally on the syringe pump (Model: KDS 100, KD Scientific) and the solution was electrospun by using a standard high voltage power supply (Matsusada HER 20R3) on a rotating drum. An external magnetic field produced by two permanent NdFeB magnets placed next to the electrospun area was applied in order to orient the nano-particles within the polymeric fibers. Several tests with different process parameters were performed and the once presented in Table 1 were selected for further investigation due to their improved fiber properties, *i.e.* absence of beads and smaller fiber diameters.

Table 1: *Process parameters for the selected samples S1 and S2.*

Sample	**Flow rate (ml/h)**	**Voltage (kV)**	**Tip-collector distance (mm)**	**Tip speed (mm/s)**	**Temperature (^{0}C)**	**Humidity (%)**	**Deposition time (s)**
S1	1	20	70	50	26	35	120
S2	1	20	50	50	26	35	120

2.4. Characterization

The electrospun fibrous mats were deposited on aluminum foil. A small piece of the foil was cut to obtain a suitable sample for imagistic investigation. The sample was placed in a SEM VEGA II LSH TESCAN and imaged with different magnification for dimensional characterization. For each image, at least 50 different points were randomly chosen to measure the average diameter of the fibers. A Lake Shore 7300 Vibrating Sample Magnetometer operating up to a maximum field of 30kG was used to obtain data for saturation magnetization, magnetic remanence and coercivity. This data was used to generate the hysteresis loops of the magnetic composite fibers.

3. RESULTS AND DISCUSSION

Fig. 3 shows, for each of the selected samples, SEM images at 500x, 2000x and 5000x magnification. The 500x magnified SEM images reveal a non-uniform structure of the fiber network which contains twisted fibers and also fiber agglomerations. The 2000x magnification is revealing, at closer inspection, some of the magnetic nano-particles which become clearly visible at higher magnifications. However, it is hard to draw a comparative conclusion between the two samples just by visual inspection. This is better evidenced through the investigation of the fiber diameter distribution.

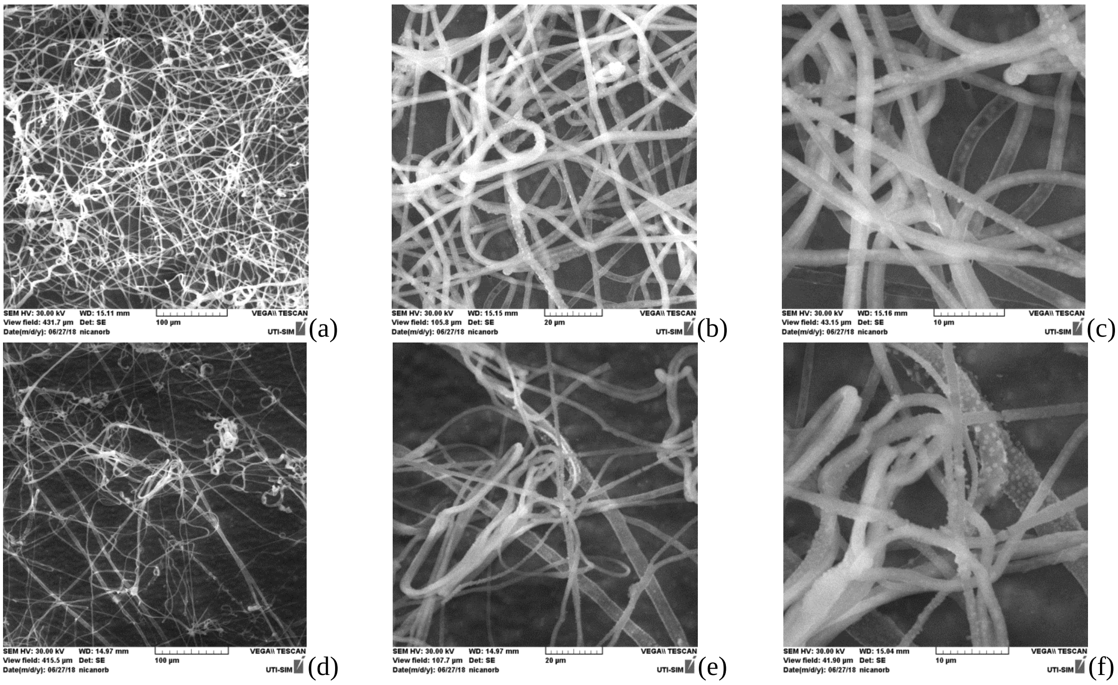
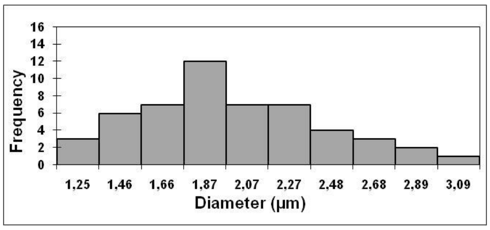
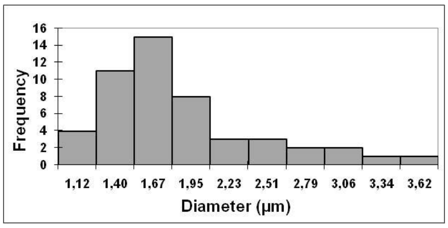


Fig. 3: *SEM images of sample S1 at 500x (a), 2000x (b), 5000x (c) magnification and of sample S2 at 500x (d), 2000x (e), 5000x (f) magnification.*

A series of 50 measurements were performed on the 2000x magnification SEM images of the samples in order to determine the diameter distribution presented in Fig. 4. The average fiber diameters for S1 and S2 are 1.89 µm and 1.75 µm, respectively. The peak of the distribution is at 1.87 µm and 1.67 µm for S1 while the diameter varies between 1.05 and 3.09 µm. For S2, the peak of the distribution is at 1.67 µm but the variation limits are larger, *i.e.* 0.84 to 4.64 µm. These values are in line with previous studies, including our own [8], which are revealing that the average electrospun fiber diameter is decreasing with decreasing tip-collector distance from 70 mm in S1 to 50 mm in S2. Our studies reveal, albeit on a small number of samples, that this behavior is preserved also upon incorporation of magnetic nanoparticles. In addition, the distribution of the fiber diameters for the S1 sample is wider than the one for S2. This is indicative of a less controlled electrospinning process in the case of the S1 sample.



(a)



(b)

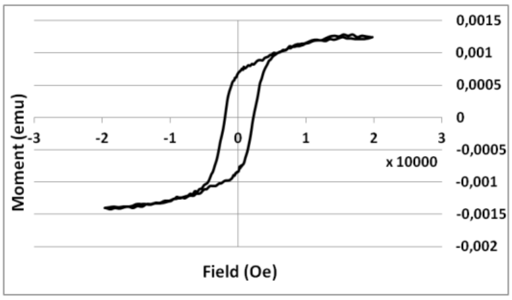
Fig. 4: *Fiber diameter distribution for S1 (a) and S2 (b).*

The magnetic properties of the electrospun S1 and S2 were measured at room temperature. Typical magnetization hysteresis loops are shown in Fig. 5. Table 2 is presenting the magnetic coercivity (H_c) values, the saturation magnetization (M_s) and the remanent magnetization (M_r). The coercivity (H_c) is the external applied magnetic field necessary to return the material to a zero magnetization condition, and the remanent magnetization (M_r) is the residual magnetization after the applied field is reduced to zero.

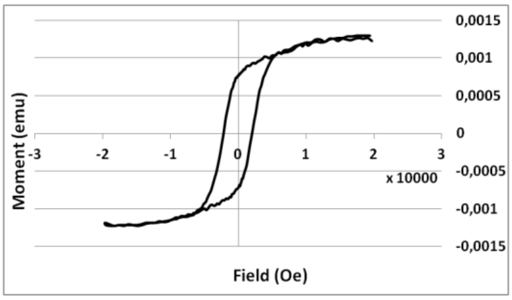
Table 2: *Magnetic properties of electrospun composites.*

Characteristic	**S1**	**S2**
Coercivity H_c (G)	2097.0	2102.1
Saturation magnetization M_s (emu/g)	1.24E-3	1.27E-3
Remanent magnetization M_r (emu/g)	6,893E-4	7.713E-4

Comparison of the hysteresis loops in Fig. 5 and magnetic properties in Table 2 reveals that there are no significant differences between the investigated samples. The magnetic coercivity decreases from 4141.4 G for pure barium ferrite nano-particles to around 2100 G after the nano-particles were dispersed in the polymer matrix. This decreased coercivity is due to the smaller amount of nano-particles in the polymer solution (1.0 wt %) and the increased nano-particles distance for the single-domain nano-particles, as compared to the close contact of the pure barium ferrite nano-particles. Also, the remanent magnetization for both electrospun composite decreased compared to the remanent magnetization of the pure nano-powder. Again, this is related to the weight percentage content of the nano-particles in the polymer fibers.



(a)



(b)

Fig.5: *Magnetic hysteresis loops of the electrospun fibers S1 (a) and S2 (b).*

5. CONCLUSIONS

Polyethylene oxide-based fibers containing magnetic $BaFe_{12}O_{19}$ nano-particles have been successfully produced through electrospinning. Two samples, denoted as S1 and S2, were selected for further investigation of their structural and magnetic properties. The process parameters corresponding to the production of S1 and S2 differ only in the tip-collector distance which is larger for S2. SEM images and fiber diameter distributions reveal that, as previously shown for pure PEO electrospun fibers, the average fiber diameter is decreasing with decreasing tip-collector distance. In addition, the distribution of the fiber diameters for the S1 sample is wider than the one for S2. This is indicative of a less controlled electrospinning process in the case of the S1 sample. Investigation of the magnetic properties of the composite fibers, reveal as expected a ferrimagnetic behavior for both samples. No major differences between the magnetic properties of S1 and S2 were observed in terms of hysterezis loops, coercivity and remanent magnetization. However, both the magnetic coercivity and the remanent magnetization are smaller in the electrospun samples compared to the pure barium ferrite nanoparticles.

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REFERENCES

[1] D. Li, T. Herricks, Y. Xia, "*Magnetic nanofibers of nickel ferrite prepared by electrospinning*", in Applied Physics Letters, vol. 83, issue 22, pp. 4586-4588, 2003.

[2] C.-J. Li, B. Wanga, J.-N. Wang, "*Magnetic and microwave absorbing properties of electrospun Ba(1-x)LaxFe$_{12}$O$_{19}$ nanofibers*", in Journal of Magnetism and Magnetic Materials, vol. 324, issue 7, pp. 1305-1311, April 2012.

[3] C.-J. Li, B. Wanga, J.-N. Wang, "*Electrospun SrRe$_{0.6}$Fe$_{11.4}$O$_{19}$ magnetic nanofibers: Fabrication and characterization*", Materials Letters, vol. 64, issue 5, pp. 586-588, March 2010.

[4] J. Zhao, Y. Cheng, X. Yan, D. Sun, F. Zhub, Q. Xue, "*Magnetic and electrochemical properties of CuFe2O4 hollow fibers fabricated by simple electrospinning and direct annealing*", in CrystEngComm, vol. 14, issue 18, pp. 5879-5885, 2012.

[4] J. Byun, H.A. Patel, C.T. Yavuz, "*Magnetic $BaFe_{12}O_{19}$ nanofiber filter for effective separation of Fe_3O_4 nanoparticles and removal of arsenic*", in Journal Nanoparticles Research vol. 16, pp.1-12:2787, December 2014

[5] I-H. Chen, C.-C. Wang, C.-Y. Chen, "*Fabrication and characterization of magnetic cobalt ferrite/polyacrylonitrile and cobalt ferrite/carbon nanofibers by electrospinning*", in CARBON, vol. 48, issue 3, pp.604 – 611, March 2010.

[6] J.M. Deitzel, J.D. Kleinmeyer, J.K. Hirvonen, N.C.B. Tan, "*Controlled deposition of electrospun poly(ethylene oxide) fibers, Polymer"* in Polymer, vol. 42, issue 19, pp.8163-8170, September 2001.

[7] H. Kojima, "*Ferromagnetic Materials*", vol. 3, Ed. E.P. Wohlfarth, North Holland, 1982, Amsterdam, pp.305.

[8] B. Cramariuc, R. Cramariuc, R. Scarlet, L.R. Manea, I.G. Lupu, O. Cramariuc, *"Fiber diameter in electrospinning process"*, in Journal of Electrostatics, vol. 71, no. 3, pp. 189-198, 2013.

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

SOLUTIONS FOR QUALITY IMPROVEMENT OF UPHOLSTERY AND INTERIOR DESIGN PRODUCTS

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Abstract: *Quality assurance by satisfying the demands of the beneficiaries is the prime objective of any commercial society. The demands of the beneficiary are at the root of the creative and design process, finalized by elaborating the product and process documentation. When designing a product it is necessary to take into account the real demands of the user, while establishing the final presentation will take into consideration the perceived requirements. Seeing as the customer demands regard both the presentation and the commercial product value, its functionality (wear behavior), as well as under duty response, the quality of a product can be perceived differently by competent customers and unadvised ones.*
For the knitted fabrics industry, raising the expectations and improving knitting and finishing technology, it could lead to producing knitted fabrics with upholstery specific features.
Any action towards quality (planning, controlling, improving, assessing) analyses the relationship between user requirements, functions and quality features of the products.
Starting from the analisys of the correspondence between the quality requirements of the beneficiaries and the functions of the knitted used in upholstery items and interior design, the purpose of this paper relies in presenting some applicable sollutions in order to improve the quality level of these products. Similarly, some offerts of the producers are presented so that the beneficiaries cand make fully aware decisions.

Key words: *quality, requirements, functions, knitted, mattress, solutions*

1. INTRODUCTION

Quality assurance by satisfying the demands of the beneficiaries is the prime objective of any commercial society. The demands of the beneficiary are at the root of the creative and design process, finalized by elaborating the product and process documentation. When designing a product it is necessary to take into account the real demands of the user, while establishing the final presentation will take into consideration the perceived requirements.

1.1 Quality requirements imposed by the beneficiary

Beneficiary requirements target both the presentation and the commercial value of the product, its functionality (behavior during usage), as well as its behavior under the action of the solicitation it is subjected to (availability).

Demands regarding the presentation value derive from the fact that any product in order to enter the sphere of interest of a potential customer must transmit an aesthetic message through style, model, chromatic combinations, novelty elements, etc. These demands determine the degree of product amenity and implicitly its success on the market.

Demands targeting the commercial value apply to the presentation approach of the product for sales, as well as the information given by it (fibrous composition, dimensions, brand, maintenance etc.).

Availability requirements derive from the fact that a product must fulfill the functions for which it was created, in specific usage conditions, until the appearance of physical or moral ageing.

The functions of a product represent the interface between the beneficiary demands and the quality characteristics, expressing the way the product fulfills the role for which he was created, in the conditions imposed by society and the ambient. The optimal choice of quality characteristics for a certain product is especially difficult taking into consideration that these must meet the explicit and implicit requirements of the beneficiaries, found in a permanent change and evolution.

2. CORRESPONDENCE BETWEEN DEMANDS – FUNCTIONS – QUALITY CHARACTERISTICS FOR KNITTED USED IN MATRESS MANUFACTURING

Traditionally the furniture and automobile industry has been using woven materials for upholstery. Lately, however, knitted fabrics are used on a larger scale; this was possible due to the following facts:

- ❖ the creation of knitted fabrics which show both woven fabrics features (mechanical stress resistance, limited elasticity) and knitted fabrics features (3D modelling capacity, high volume, wide choice of models, nice touch feeling, economical efficiency);
- ❖ new knitting technologies were developed;
- ❖ the production of knitting machines used specifically for upholstery knitted fabrics;
- ❖ using a wide variety of fibres with superior features.

2.1 Correspondence between demands – functions – quality characteristics

For upholstery and interior design items, the correspondence between the possible demands expressed by the beneficiary, renditioning them in technical terms, quality functions and characteristics determined [1], is presented in table 1.

Table 1: *Correspondence demands – functions – quality characteristics for mattresses*

Demand type	**Demand description and its rendition in technical terms**	**Determined function**	**Examples of quality characteristics**
Demands expressed by the customer			
Dimensional correspondence	Existence on the market of multiple mattresses sizes, so they can easily adapt to the imposed dimensions	**Constructive function** (composition, structure, auxiliary materials content, dimensional correspondence)	**Dimensional characteristics** (length, width, thickness) **Physical characteristics** (voluminosity, tightness**)** **Structural parameters of the knitted**
Pleasant aspect	Perception of the user when he analyses visually the model, aspect, used material, color or chromatic combination, aspect of used stitches etc.	**Esthetic function**	Design, chromatic combination, glossiness, shininess, manufacturing and assemblage aspect

Demand type	Demand description and its rendition in technical terms	Determined function	Examples of quality characteristics
Demands expressed by the customer			
Comfortable	User perception during mattress utilization	**Comfort function (**ensuring thermo-physiological and psycho-sensorial comfort)	**Thermo-physiological comfort characteristics** (thermo-isolation capacity, permeability to vapors, air, water, ventilation capacity etc.) **Psycho-sensorial comfort characteristics** (handle, electrostatic charge etc.)
Conservation of shape, aspect and colors	Necessity that the mattress be durable, not change shape, aspect, colors and dimension under the action of the solicitation it is subjected to during usage	**Availability function** – product capacity of being able and available to use for a pre-established time period (maintainability)	**Characteristics regarding durability** (resistance to static and dynamic solicitations – breaking, slashing, snapping, friction) **Characteristics regarding usage behavior** (dimensional stability, color resistance, light resistance etc.)
Easy maintenance	Product behavior in use and home-keeping maintenance		**Characteristics targeting under usage behavior** (resistance to microorganisms, chemical cleaning capacity, low soiling capacity, high efficiency cleaning –short time, low quantity of cleaning agents, capacity to remedy and reconditioning)
Cheapness	Product price in relation to its quality	**Economical function**	**Economical characteristics** (prime material consumption, price, efficiency, marketability)
Collateral demands			
Obtaining it through technological manufacturing	Manufacturing capacity of the mattress	**Technological function**	Space formation capacity, flexibility, extensibility, elasticity.
Not affecting the human health and protection of the ambient	Product influence on user (protection against harmful factors) and ambient	**Ecological function**	Content of harmful substances, inflammability, decay capacity in biological environment
Transmission of information to the user	Product capacity of being known before and during usage	**Knowledge function**	Content of tags, stamps, packaging type that contains information about the product (size, dimensions, fibrous composition, maintenance etc.) and the producer (brand).

2.2 Correspondence between demands – applicable solutions

For knitted used in upholstery items, it is shown in table 2 the correspondence between the user requirements and a couple of applicable solutions meant to respond concretely and efficiently to these [2, 3, 4].

Table 2: *The relationship between requirements – functions – solutions which can be applied*

No.	User require-ments	Function	Solutions which can be applied
1.	**Maintain-ing the shape and size while in use**	**Construc-tive technologi-cal function**	➢ Producing integrated knitted fabrics with "padded" finish; the thickness comes by inserted filling fibres between the two knitted fabric layers;
			➢ Improving elastic rebound after normal use stress, by creating a Jacquard structure with high volume filling fibres, fixed between the knitted fabric's two layers by connection points;
2.	**Protecting the body from the elements**	**Protection function**	➢ Using advanced technology fibers to protect the users against insects, fungus, bacteria and acarians;
			➢ Using fibers with a high fire ignition threshold, and finishing technologies to reduce fabrics flammability;
			➢ Creating composite materials to wick away moisture from the body contact zones and stopping its diffusion to the deeper layers of the mattress through applying a water proof layer.
3.	**Ensuring sensorial and thermic comfort**	**Comfort function**	➢ Using natural fibres which can absorb and wick away moisture, allow air circulation and regulate temperature feeling (warm or cool sensation according to the outside temperature);
			➢ Using technologically advanced synthetic fibres, which can create large volume structures and have a natural fibres feel;
			➢ Using fibres witch contain microcapsules to emanate a nice odour upon touching the knitted fabric;
4.	**Maintai-ning and imporo-ving health**	**Ecological function**	➢ Creating high purity materials with antibacterial functions;
			➢ Inserting carbon micro-fibres with antistatic, antibacterial and against dust functions within knitted structures;
			➢ Using smart fibers/knitted fabrics which could improve health by raising muscle tissue oxygen levels and change textile temperature according to the environment temperature;
			➢ Using an anti-allergens eco finish.
5.	**Environ-mental protection**	**Ecological function**	➢ Using recyclable materials, biodegradable materials and organic natural fibers;
			➢ Using non-polluting finishing technologies.
6.	**Showing some new features – structure, colors, layer aspect**	**Esthetic function**	➢ Making variate patterns and the 3D-effects according to the drawing pattern and the thickness of the fabric;
			➢ Making the drawing pattern of the connection points between the two fabric's faces determines the quilted effect ;
			➢ Using fancy yarns;
			➢ Using a color pallet accoring to the domain trends;
			➢ Using fibers with a different degree of shines within the pattern drawings.
7.	**Stress resistance during use**	**Durability function**	➢ Using fibers with a high mechanical stress endurance;
			➢ Using fibers with filaments and a pilling resistant material;
			➢ Producing knitted structures with high resistance against homogenous and heterogenous friction;
			➢ Using fibers and knitted structures with high endurance for cyclical stress (pull – return, repeated bending and compression).
8.	**Dirt resistant and easy cleaning**	**Maintain-aility function**	➢ Using advanced technolgies to produce dirt proof and moisture proof materials;
			➢ Using fibers and a finish technlogy to ensure a fast and efficient cleaning.

3. SOLUTIONS OFFERED BY THE PRODUCERS

Depending on the demands concept solicited by the beneficiaries, in proportion with the quality product, the producers can offer multiple variants of solutions of which descriptive presentation give notice to the user, so that he can choose according to his whishes the optimal variant. In table 3, is presented as example a model of offer by a material production firm (primary knitted) [3, 4, 5, 6, 7] intended for mattresses manufacturing:

Table 3: *Offered solutions by the producer*

No.	Function	Offered solutions	Solutions description
1.	**Constructive technological function**	QuickFit®	QuickFit® mattress covers are quilted and assembled at the desired dimensions. According to wishes, the producer can also offer mattresses with the border already quilted.
		Bungee®	Bungee® is an extremely elastic knitted, that unlike other materials, will keep its thickness and nice handling (softness) even when stretched. With Bungee® the filling and quilting of the mattress becomes unnecessary. The versatility of the material is given by its elasticity, making it fit for any mattress production. Bungee® can be also used for making pillow cases.
2.	**Comfort function**	ThermoCool ™	ThermoCool™ is designed in order to optimize the thermo-regulation capacity of the human body during the night. Realized from an unique and intelligent blend of natural fibers, it adapts shape and temperature according to the sleeping person, enhancing as such the comfort during sleep. ThermoCool™ is a multifunctional and ecological knitted.
		CoolMax®	CoolMax® has a hexagonal structure of the component fibers, sweat being transferred to the exterior surface of them where it evaporates very fast. The CoolMax® material is obtained though the DuPont fabrication process. In the humidity control tests, this type of knitted is perfectly dry after approximately 30 minutes. The structure of the fibers prevents forming stains. Because it is not chemically or electro-statically treated, these proprieties are still active even after a high number or washings.
		REBORN®	REBORN® is a polyester fiber obtained through the recycling of PET bottles. Materials fabricated with REBORN® fibers are easy to dye, resistant to UV radiations, extremely soft and flexible, ameliorating comfort during sleep.
		Tencel®	Tencel® has excellent humidity dissipation quality and a good air permeability. Thus Tencel® dries fast.
3.	**Ecological function**	Bodyfit®	The „intelligent" knitted Bodyfit® takes into consideration the different pressure exerted by body parts and adjusts its elasticity accordingly, ensuring the desired comfort. The client can choose the design and color of the knitted used in the mattress production.
		Bamboo	Bamboo yarns are fabricated with 100% bamboo pulp. Being totally biodegradable and sustainable, bamboo is the most ecologic material of the XXI century. The bamboo obtained knitted has antibacterial and antifungal proprieties and are exceptional absorbent.
		Silk	Silk fiber proteins are similar to the human skin ones. Silk can absorb up to 30% of its weight in water without seeming moist. The silk yarn is resistant compared to it thickness, rarely being attacked by moths.

No.	Function	Offered solutions	Solutions description
		Soia	Soy fiber are gained from the discards resulted following the soy oil extraction, mainly from crushed beans and husks. Soy fibers have a high breaking resistance and good thermo-insulation proprieties. The resulted material retains heath during winter and is cool during summer, having a special texture because of the yarn count. It is also cheap, compared to othe natural materials.
		Argentum+®	Materials from the selection Argentum+® combine humidity regulating technologies with an inovative finishing based on Silver ions. The mattress remains cool and dry during sleed and the silver ions destroy bacteria that can cause unpleasent smells.
4.	**Durability function Maintain-ability function**	Flax	Flax is a natural fiber that resists very well to wear. The realized materials have a soft texture and are easy to dye. Out of the natural fibers, flax is the most resistant (its break resistance is 11 times higher than cotton). Flax fibers have a natural soiling resistance and they absorb a high quantity of water (20%) before becoming moist to the touch.
		Lotus Advanced	Lotus Advanced is a material soiling and wet resistant with proprieties alike Teflon. The effect was obtained using nanotechnology. The dirt traces can be wiped out with a moist cloth, similar to shiny surfaces. Although theoretically the material doesn't need washing, this is possible because the treatment is applied only on fiber level and not to the entire material, so that it can "breathe" and not affect comfort during sleep.

4. CONCLUSIONS

Quality insurance by satisfying the demands of the beneficiaries is the prime objective of any commercial society. These demands target both the presentation and the commercial value of the product, its functionality, as well as its behavior under the action of the solicitation it is subjected to. The activity of creation, design and improvement of product quality, always begin with the analysis of their functions and are finalized by the compilation of the technical documentation for product and process. This fact implies the translation of the requirements expressed through the voice of the beneficiary in technical notions specific for the production.

This paper presents different solutions meant to respond as efficiently as possible to the beneficiary requirements and offered models of the producers. Depending on the concept of the solicited requirements, in rapport to the product quality, manufacturers offer various solutions whose descriptive presentation informs the users. The purpose relies in making fully aware decisions and adopting according to desire the optimal variant.

REFERENCES

[1] E. Moisescu, "*Asigurarea calității*", Ed. Performantica, Iași, 2007
[2] http://www.online-home.ro
[3] http://www.desleeclama.com
[4] http://www.ramedepat.ro/saltele
[5] http://www.ikea.com/ro/ro/catalog/categories/departments/bedroom/10609/
[6] http://www.deslee-interior.com/functions/content.
[7] http://www.dormeo.ro/

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

REVIEW ON SIGNIFICANT CHARACTERISTICS OF FUNCTIONALIZED TEXTILE PRODUCTS

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Abstract: *The modern society is in a permanent transformation, therefore the textile industry has to continuously change and adapt their processes and products to be environmental friendly and to meet customer expectations in the today's highly technologized world. In order to meet the requirements of the actual needs of society and the technological progress, the concept of the textile products has evolved, nowadays providing benefits in a variety of application such as comfort, healthcare, protection, agriculture, information, transportation, military equipment, sporting and outdoor products etc. Functionalisation of textiles represents the process that grant to textiles properties beyond the aesthetic and decorative attributes.*
The paper presents textiles with multiple functionalities such as fibres, yarns and textile structures and their significant characteristics: water repellency/vapour permeability, heat transfer, camouflage effect, ecotoxicological properties, antimicrobial activity and flammability. The assessment of efficiency of these characteristics is performed by modern and reliable physical and chemical procedures: measurement of water vapour resistance of textiles, determination of thermal resistance, spectral reflectance measurement in infrared range, phthalates determination by gas chromatography, determination of certain carcinogen aromatic amines by high performance liquid chromatography and gas chromatography.
There are processes conducted in textile industry, from the fibre stage to fabric, that are harmful to environment. In this context, sustainability of textile industry implies manufacturing not only of competitive products but also environmentally friendly and safety products. Therefore, the content of potentially hazardous chemicals (e.g. azo dyes, formaldehyde, phthalates, pesticides, chlorinated phenols etc) is limited in finished textile.

Key words: *characteristics, multifunctional textile, eco textile, functionalization*

1. INTRODUCTION

The modern society is in a permanent transformation, therefore the textile industry has to continuously change and adapt their processes and products to be environmental friendly and to meet customer expectations in the today's highly technologized world. The textile industry is focused on developing and supplying versatile multifunctional apparel and products, the complexity of the fabrics is increasing constantly. Nowadays, textiles evolved behind the commodity materials zone, being essential in providing extended protection in arduous conditions and improved hygiene [1]. In the actual context, an advanced understanding of fabric behaviour and their characteristics is mandatory in the engineering of functional textiles [2].

Functionalisation of textiles represents the process that grant to textiles properties beyond the aesthetic and decorative attributes and can be obtained by one of the procedures listed bellow:

- fibre itself (characteristics of the polymer or additives before fibre spinning);
- the technology applied to produce the yarn, fabric or material (as example, by using various types of fibres or layers);
- textile finishing [3].

The paper presents textiles with multiple functionalities such as fibres, yarns and textile structures and their significant characteristics: water repellency/vapour permeability, heat transfer, camouflage effect, ecotoxicological properties, antimicrobial activity and flammability. The assessment of efficiency of these characteristics is performed by modern and reliable physical and chemical procedures: measurement of water vapour resistance of textiles, determination of thermal resistance, spectral reflectance measurement in infrared range, phthalates determination by gas chromatography, determination of certain carcinogen aromatic amines by high performance liquid chromatography and gas chromatography.

3. MULTIFUNCTIONAL TEXTILES

3.1 Multifunctional fibres and yarns

A wide range of functional fibres are available for the textile manufacturer: conventional fibres (natural, artificial, synthetic), higher elastic modulus and breaking resistance fibres (e.g. para-amides, ultra-high-molecular-weight polyethylene), chemical and flame resistant fibres (meta-aramides, polytetrafluorethylene), high performance inorganic fibres (carbon, glass, ceramic, boron), ultra-thin fibres and advanced fibres (microfibres less than 0.5 dtex in width, high resistant to ultraviolet radiation fibres, fibres that absorbs solar energy, thermochromic fibres, perfumed fibres, antibacterial fibres, aseptic chlorofibres, tubular fibres, anti-static fibres, flame retardant fibres etc).

In order to respond to the actual needs of society and the technological progress, the concept of the fibres evolved to being used in a variety of application such as comfort, healthcare, protection, agriculture, information, transportation, military equipment, sporting and outdoor products etc. [4]. It should be emphasized here, also the significance of conductive textiles and their extended applications in medical, space, defense, industrial fields in which they create added value [5].

The functionalities can be grouped in multiple functionalities fibres, systematised fibres and biomimetics fibres. The water vapour permeable/waterproof materials (prevents the penetration and absorption of liquid water but are permeable to water vapour and air) or flexible fibres that have high tenacity at low temperatures (high resistance to stretch) represents multiple functions fibres. For example, the systematized functionalities can be presented the fibres that store the heat (absorbs light and converts it to heat), or by the ones having antimicrobial properties (inhibits microbes spreading). The biomimetics fibres have a structure that replicates biological structures and their features. A representative case for biomimetic fibres is Morphotex® (developed by Nissan Motor, Teijin and Tanaka Kikinzoku), made of different layers of polyester and polyamide. The colour is not obtained by means of dyes or pigments, only by light interference on different fibre structures, as it was encountered at Morpho butterflies that resides in the rainforests (Figure 1) [6], [7].

In a same manner as fibres, multiple-function yarns have to meet the functional properties specific to the applications for which they are manufactured. The yarns used for protective products should have resistance to safety hazards factors such as heat, fire, chemical or mechanical damage. There are many types of yarns developed for multifunctional products manufacturing, the most frequent being: aramid filament yarns, glass filament yarns, carbon filament yarns, high-density polyethylene yarns etc [8].

Fig. 1*: Morphotex® fibres [7]*

3.2 Multifunctional textile structures/products

Multifunctional textile structures/products are manufactured mainly for their technical performances and functional properties, and not for their decorative features. Development of products that uses textile materials designed for specific application, offers new perspectives and a transdisciplinary engineering approach.

Today, textiles serve in diverse and complexes areas, from life protection to surviving in hostile environment, leading to promotion of human health (Figure 2) and improvement of life quality.

Fig. 2*: Protective equipment in hostile environment [9]*

The challenge in the textile innovation is to obtain the synergistic effects of functional products in order to respond to the multifaceted requirements from the domains of medicine, biotechnology, nanotechnology, physics and computing.

It has been concluded that the functional clothing can be grouped in several comprehensive classes: protective-functional (environmental hazard protective, biological, chemical and radiation hazard, NBC, protective), medical-functional (injury protective, therapeutic and rehabilitative, bio-sensing), sports-functional, vanity-functional, clothing for special needs and cross-functional assemblies (multifunctional performance, protection, life support, comfort, communication) [10].

4. SPECIFIC CHARACTERISTICS OF MULTIFUNCTIONAL TEXTILE PRODUCTS

Textile multifunctional fabrics features a large variety of specific characteristics, such as: stain resistant, self-cleaning, waterproof, oil repellent/water repellent, breathable, moisture absorption, photosensitivity/anti-adhesive, durability, anti-aging, thermal insulation, flame retardant, antistatic, non-allergenic, light, weight, UV protection, controlled release of active chemical agents (e.g. drugs, cosmetics, perfumes), antimicrobial, deodorant, non-carcinogenic etc.

Further, is enclosed a summary of the most frequent characteristics performed in order to assess the quality performance of the textile and their compliance with environmental and safety requirements.

Water repellency/ moisture vapour permeability of multifunctional apparels has a key role in protection from the environment and maintenance of thermal comfort [11]. These properties are critical for personals that perform activities ranging from rapid movement to immobilisation. The tendency of a water droplet to spread out over the fabric surface mainly depends on the contact angle of the water droplet and the fabric surface. Water repellent textiles have many uses including industrial, consumer and apparel purpose [12].

The heat transfer of complex clothing provides moisture wicking and thermal balance. The capability of a textile to wick moisture relies mainly on the size and number of capillaries in the fibre, yarn, fabric and the combination of clothing layers. Whereas, the thermal insulation is corelated to the trapped air between the fabric and the wearer’s skin and/or in the interstices of the textiles [13]. Recently, thermally conductive and highly aligned boron nitride (BN)/poly(vinyl alcohol) (PVA) composite (denoted as a-BN/PVA) fibres were used to improve the thermal transport properties of textiles for personal cooling (Figure 3) [14].

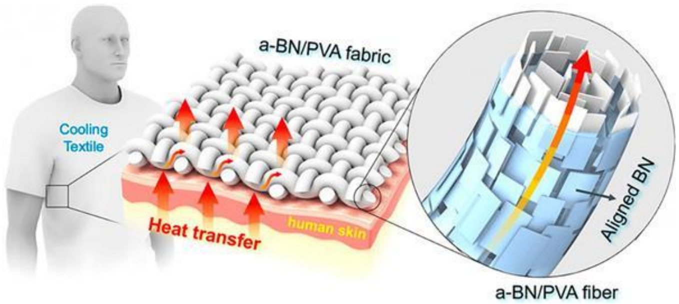

Fig. 3*: Heat transfer through a-BN/PVA fabric/products [14]*

The camouflage properties of the textiles concealed military personnel or equipment, being critical for surviving in a hostile environment. Camouflage pattern depends on their application needs (winter, forest, desert etc.) and must cover a wide range of the electromagnetic spectrum. [15]. The investigation of the camouflage effectiveness, in the visual and near IR radiation spectral ranges was conducted by measuring the fabrics reflectance with a spectrometer and, the optimum reflectance values in the near IR spectral range for each colour of pattern were determined [16].

There are processes conducted in textile industry, from the fibre stage to fabric that are harmful to environment. In this context, sustainability of textile industry implies manufacturing not only of competitive products but also environmentally of friendly and safety products. Various dyes and solvents used by the textile industry have been found to have mutagenic and carcinogenic properties.Therefore, the content of potentially hazardous chemicals (e.g. azo dyes, formaldehyde, phthalates, pesticides, chlorinated phenols etc) is limited in finished textile [17], [18].

The development of new technologies for antimicrobial functionalization of textiles provided benefits for various applications, such as protection of textile materials from decomposition, generation of more effective wound dressings, and the prevention of infections or malodors resulting from bacterial growth, inhibiting microbes from spreading [19], [20].

The flammability hazard of textiles has a major impact in many fields (protective equipment, children wears, furniture etc), therefore correlation of the fibres composition with flammability properties were investigated [21]. Fire-retardant technical textiles have been developed from a variety of textile fibres, the choice of which is largely dependent on the cost of the fibre and its end-use.

5. CONCLUSIONS

This review focuses on recent advances and trends on multifunctional textiles characterization and applications. Textile industry play a key role in industry, social area and our environment, so safety and confidence in fabrics quality is essential. Characterisation of fabrics relies on a comprehensive knowledge of physical, mechanical and chemical properties fibres, yarns, textile structures and their correlation with textile performances and compliance with ecological requirements. Lately, the innovation in the textile field reaches remarkable performances in a very short period. By functionalization, the textile materials are provided with specific features and extended uses, beyond the common ones, for example low flammability, thermal insulation, moisture vapour permeability, water repellency, ballistic protection, antimicrobial activity.

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REFERENCES

[1] S. Ramkumar, "*Fabrics go multifunctional*", Advanced Textiles Source, August, 2017 [Online] Available: https://advancedtextilessource.com/2017/08/21/fabrics-go-multi-functional/

[2] P. Venkatraman, "*Fabric Properties and Their Characteristic*", In: Materials and Technology for Sportswear and Performance Apparel, 2015, ISBN 9781482220513

[3] L. Almeida, "*Functionalisation of Textiles - Future Perspectives*", 2015, [Online]. Available: https://www.technicaltextile.net/articles/functionalisation-of-textiles-3174

[4] M. Miraftab, "*Technical Fibers*", In: Handbook of Technical Textiles, edited by A. R. Horrocks, S. C. Anand, Woodhead Publishing, 2000, ISBN 1 85573 385 4, pp. 25-33

[5] I. Yuce, M. Yukseloglu, S. Canoglu, "*An Analysis of Conductive Fibers as Smart Textiles*", Annals of the University of Oradea. Fascicle of Textiles, Leatherwork, 2018, pp. 105-111

[6] T. Hongu, O. G. Phillips, M. Takigami, "*New millennium Fibers*", Woodhead Publishing Limited and CRC Press LLC, 2005, ISBN 10: 1-85573-601-2

[7] https://asknature.org/idea/morphotex-structural-colored-fibers/#.XH-w-iIzaUk

[8] R. H. Gong, X. Chen, "*Technical Fibers*", In: "*Handbook of Technical Textiles*", edited by A. R. Horrocks, S. C. Anand, Woodhead Publishing, 2000, ISBN 1 85573 385 4, pp. 57-59

[9] https://clothingindustry.blogspot.com/2017/12/functional-clothing.html

[10] G. Deepti, "*Functional clothing – Definition and classification*", Indian Journal of Fibre & Textile Research, vol. 36, December 2011, pp. 321-326

[11] W. Faming, Z. Chengjiao, "*Moisture absorption and transport through textiles*". In book: Engineering of high-performance textiles Part II, Edition: 1, Chapter: 11, Publisher: Elsevier, 2017, pp.247–275, DOI: 10.1016/B978-0-08-101273-4.00009-3

[12] K. P. Chowdhury, "*Performance Evaluation of Water Repellent Finishes on Cotton Fabrics*", International Journal of Textile Science, vol. 7, no. 2, 2018, pp. 48-64, DOI: 10.5923/j.textile.20180702.03.

[13] L. Baker, H. L. Chen, B. Cluver, "*The effect of textiles on clothing physiological comfort while backpacking in the cold*", Journal of Textile Engineering & Fashion Technology, 2017;2(1); pp. 266–272, DOI: 10.15406/jteft.2017.02.00044

[14] G. Tingting, Y.Zhi, "Three-Dimensional Printed Thermal Regulation Textiles", ACS Nano, vol. 11, nr. 11, 2017, pp. 11513

[15] S. Kovacevic, I. G. Schwarz, V. Durasevic, Vedran, "*Analysis of Printed Fabrics for Military Camouflage Clothing*", Fibres & Textiles in Eastern Europe, 2012; 20, 3(92), pp. 82-86

[16] V. RUBEŽIENĖ, Ingrida PADLECKIENĖ, *Evaluation of Camouflage Effectiveness of Printed Fabrics in Visible and Near Infrared Radiation Spectral Ranges*", ISSN 1392–1320 MATERIALS SCIENCE (MEDŽIAGOTYRA), vol. 14, no. 4, 2008

[17] Oeko-Tex® Standard 100, International Association for Research and Testing in the field of Textile Ecology, 2015

[18] Z. Singh, P. Chadha, "*Textile industry and occupational cancer*", J. of Occupational Medicine and Toxicology, 2016

[19] H. Haase, L. Jordan, L. Keitel, C. Keil, B. Mahltig, "*Comparison of methods for determining the effectiveness of antibacterial functionalized textiles*", PLoS ONE , 12 (11), 2017, [Online] Available: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0188304

[20] M. Naveed, "*Performance on Antibacterial Finishes for Textile Applications*", Trends in Textile Engineering & Fashion Technology, vol. 2, nr. 5, 2018, ISSN 2578-0271, DOI: 10.31031/TTEFT.2018.02.000548

[21] A. S. Khalifah., G. Sabyasachi, G. Malucelli, "*Recent Advances for Flame Retardancy of Textiles Based on Phosphorus Chemistry*", Polymers, 8, 2016, pp. 319

ANNALS OF THE UNIVERSITY OF ORADEA
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FULLY AUTOMATIC APPROACHES FOR CROSSED-POINTS DETECTION IN WOVEN FABRIC RECOGNITION

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Abstract: *Fabric analysis is done to determine fabric weave patterns used in the weaving process. The analysis of fabric-weave patterns still relied on human inspection until the middle of the 1980s. Since then, a number of studies have been made of automatic pattern recognition of woven fabric. One of the major problems in automatic woven fabric recognition is bow to detect the areas of interlacing warp and weft yams. This problem is termed 'crossed-points detection', the difficult problem. In this work, new and fully automatic methods containing Otsu, Isodata, Li, Mean Minimum, Triangle and Yen thresholding algorithms and based on Fourier image-analysis techniques as well are proposed. The application of these methods to plain woven fabric demonstrates the ability to solve such crossed-points-detection problems. Finally, the algorithms are evaluated visually by superposing the detected grid image on the initial woven-fabric image. Grid images obtained by Otsu and Isodata thresholding methods involve the crossed points better than other methods. Besides, vertical lines that extracted with Li method are more left than lines that detected using other methods. Moreover, results from Mean method is close results of Otsu and Isodata. Similarly, Mean and Minimum method's result is close to results of Otsu and Isodata. In Triangle and Yen methods, while horizontal lines are extracted, vertical lines are not extracted. All the detected crossed-points are displayed independently and may be saved as file-format images for further processing.*

Key words: *Woven fabric recognition, fabric weave patterns, Fourier image analysis, crossed-points detection, texture analysis.*

1. INTRODUCTION

Fabric analysis is done to determine fabric weave patterns used in the weaving process. A woven fabric made of the cross combination of warp and weft yams has a two-dimensional lattice structure [1]. In determining fabric-weave patterns, there are two questions to answer: (i) How can we detect the areas of the interlacing warp and weft yams? This problem is termed 'crossed-points detection'. In the crossed-points areas, it is useful to observe that there are two possible states: warp over weft yam or weft over warp yam. Then the second question is: (ii) How can we detect which yam is over the other in this area? This problem is termed 'crossed-states detection'. This study aims at answering the first question, whereas the problem posed in the second question will be investigated in further work.

The analysis of fabric-weave patterns still relied on human inspection until the middle of the 1980s [1]. Since then, a number of studies have been made of automatic pattern recognition of woven fabric. In 1989, Kinoshita et al. determined the type of weave patterns in woven fabric by analysing two-dimensional Fourier-transform patterns of the reflected image. They established some relationships between the structural units of weave type and weave-power spectra. In 1996, Bugao Xu discriminated between the weave patterns based on the analysis of radial and angular histograms of the corresponding power spectra. These two methods (Kinoshita et al., 1989; Xu, 1996) are global in the sense that they make a discrimination of fabric-weave patterns without analysing the states of the crossed points [1],[2]. Consequently, these methods do not allow us to draw a diagram of a woven fabric from the analysis of a real one. Other methods were by Ohta et al. (1986), and Tae Jin Kang et at. (1999) [3],[4]. In their work, the problem of crossed-points detection is only solved for simple woven fabrics (without skewness or design) by using image-analysis techniques. Furthermore, Ohta's method needs a series of dilatation and thinning processes that must be stopped interactively by making subjective judgment or visual control by the user. This method requires a prior measure of warp- and weft-yams width, which also presents another inconvenience.

Tae Jin Kang's method (1999) uses two image acquisitions, a transmissive one and a reflective one. In the transmissive image, dark areas indicate the location of warp and weft yams; and bright spots represent the spaces between interlacing yams since light cannot be transmitted through the yams. The transmissive image of the woven fabric is converted to a binary image, and the positions of white-pixel objects are found after the central co-ordinates of white pixels are connected horizontally and vertically. Then, an initial grid image is made, error lines are removed, and missing lines are inserted. Finally, the data set of crossed-points is completed. Compared with Ohta's method, this procedure is fully automatic and does not require any subjective visual control. Unfortunately, it presents two problems. The first one is that it requires two image acquisitions. The second, as was mentioned by Tae Jin Kang, is the demand for appropriate alignment of yams parallel and perpendicular to the image axes.

From the above critical remarks of Ohta's method and Tae Jin Kang's procedure, it appears that the problem of crossed-points detection remains a difficult task for simple woven fabric. This problem is still unsolved for woven fabric with skewness or non-periodic design. To overcome this problem, we propose new and fully automatic methods containing Otsu, Isodata, Li, Mean Minimum, Triangle and Yen thresholding algorithms for crossed-points detection based on Fourier image-analysis techniques.

2. MATERIAL AND METHOD

In this study, the image of yarn-dyed plain-woven fabric was captured by Canon EOS 550D 18.0 megapixel digital single-lens reflex camera with ISO-800, 5.6 f-step, shutter speeds of 1/60th of second and RGB true colour mode. With the size of 500 x 500 pixels, a yarn-dyed fabric image including one kind of colour yarn is shown in image (a) in **Fig.** . During the recognition process, all the woven fabric images used in this paper are shown in image (a) in **Fig.** .

The Visual Studio Code 1.33.0 and Python 3.7.2 were used as the software tool to examine the process, and the CPU of the computer used in the experiment is Intel Core i5-2400 CPU 3.10GHz. The computer has 12.0 GB ram, and runs on Microsoft Windows 10 Build 1809. Pyplot module from Matplotlib 3.0.2 providing a MATLAB-like interface was used for plotting images and spectrums. Pyplot is a Matplotlib module which NumPy (Numerical Python) 1.16.1 package, a math library, allowing us to do scientific calculations quickly was used for scientific computing.

Image processing algorithms in Scikit-Image 0.14.2 containing algorithms for filtering, morphology, analysis, feature detection, segmentation, geometric transformations, colour space manipulation, and more were used. It is designed to work as integrated with Python numerical and scientific libraries NumPy and SciPy, respectively.

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$$I_Y = 0.2125 I_R + 0.7154 I_G + 0.0721 I_B \quad \textbf{(1)}$$

2-D discrete Fourier transform (DFT):

$$F(u,v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y) e^{-j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)} \quad \textbf{(2)}$$

where $f(x,y)$ is a digital image of size M x N.

2-D inverse discrete Fourier transform (IDFT):

$$f(x,y) = \frac{1}{MN} \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} F(u,v) e^{j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)} \quad \textbf{(3)}$$

for x = 0,1,2, ..., M - 1 and y = 0,1,2, ..., N -1.

$F(u,v)$ is a function that generally returns complex value and its Power Spectrum is an observable real valued function, which is defined in **Eq. (4)**. Because of limitations of most image-display systems like Matplotlib, the transform in **Eq. (5)** was used in this paper.

$$P(u,v) = |F(u,v)|^2 \quad \textbf{(4)}$$

$$D(u,v) = log\{1 + P(u,v)\} \quad \textbf{(5)}$$

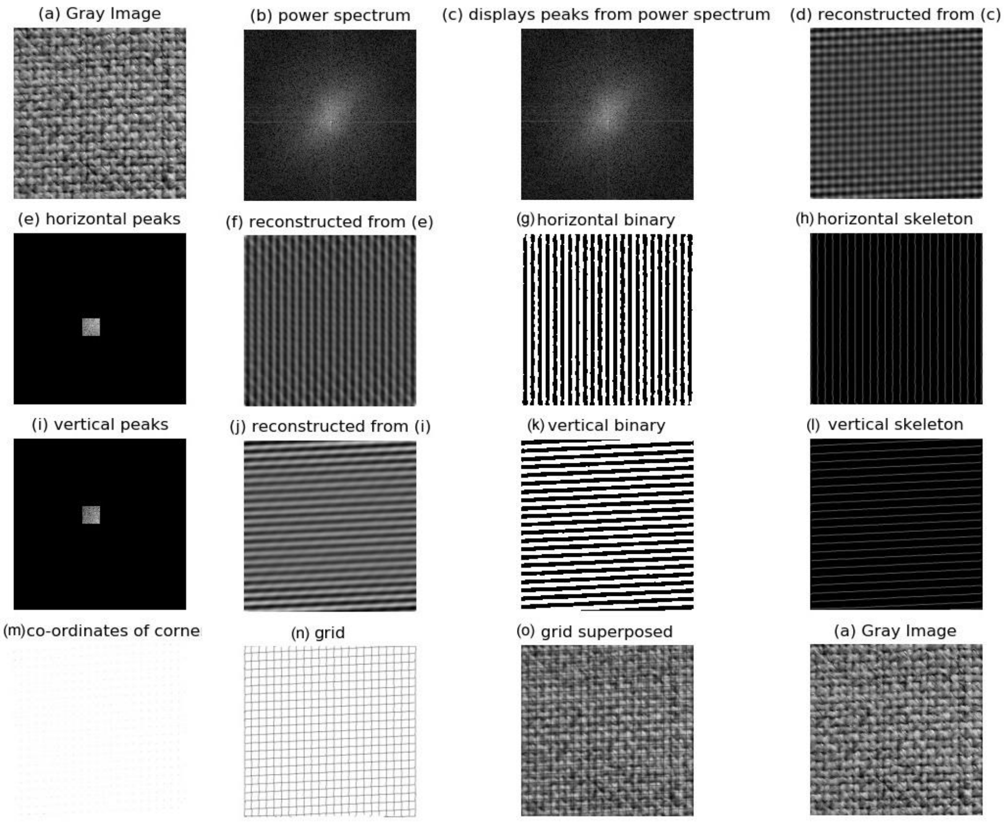

Fig. 1: *Images of detected warp, weft yarn from plain fabric weave image and crossed points of yarns*

2.1. Detection of Warp and Weft Yarns

To extract periodic yarn patterns in woven fabric image, Fourier transform was used. Frequency transform shows all periodic yarns in peaks in the power spectrum ($P(u,v)$) image. Peaks on power spectrum represents weft yarns and warp yarns. Reconstructed image that inverse Fourier transform of phases of selected peaks is illustrated warp and weft yarns. In a spectrum of weave, horizontal line peaks are related with warp yarns, and vertical line peaks are related with weft yarns. Choosing power spectrum peaks in horizontal and vertical peaks is able to detect warp and weft yarns. To make explicit the yarns from background, a threshold algorithm is proposed to use. Thresholding image is made binary the image. In order to skeletonize the yarn image, yarns are thinned to one-pixel width lines by a thinning algorithm.

Fig. shows an example to illustrate the detection of warp and weft yarns from plain woven fabric. Image (a) displays the grayscale project of original image. Image (b) and (c) represent power spectrum of grayscale image and Image (d) is reconstructed image of selected peaks of frequencies. If peaks are selected like in image (e), the reconstructed image (f) will display warp yarns. Likewise, if peaks are selected like in image (i), the reconstructed image (j) will display weft yarns.

2.2. Binarization and Skeletonization of Detected Warp and Weft Yarns

Thresholding functions change each pixel in an image with 1 (a black pixel) if the image intensity $I_{u,v}$ is less than some fixed constant t or a 0 (a white pixel) if the $I_{u,v}$ is greater than t. **Eq. (6)** constitute a simple thresholding method [5].

$$g(x,y) = \begin{cases} 1, & if\ f(x,y) > t \\ 0, & if\ f(x,y) \le t \end{cases} \tag{6}$$

The warp yarn lines image (g) and weft yarn lines image (k) are extracted by using seven thresholding methods. These are Otsu, Isodata, Li, Mean, Minimum, Triangle and Yen algorithms.

Otsu's algorithm tries to find a threshold value t, which minimizes the intra-class variance, defined as a weighted sum of variances of the two classes:

$$\sigma_\omega^2(t) = q_1(t)\sigma_1^2(t) + q_2(t)\sigma_2^2(t) \tag{7}$$

where

$$q_1(t) = \sum_{i=1}^{t} P(i)\,, q_2(t) = \sum_{i=t+1}^{I} P(i)\,, \mu_1(t) = \sum_{i=1}^{t} \frac{iP(i)}{q_1(t)}, \mu_2(t) = \sum_{i=t+1}^{I} \frac{iP(i)}{q_2(t)}, \sigma_1^2(t) = \sum_{i=1}^{t}[i-\mu_1(t)]^2 \frac{P(i)}{q_1(t)}, \sigma_2^2(t) = \sum_{i=t+1}^{I}[i-\mu_2(t)]^2 \frac{P(i)}{q_2(t)}$$

Isodata thresholding algorithm calculates a threshold t for a gray projected Image [6]. If mean of all pixels in image is less than or equal to t, it will be called as m_L, and if mean of all pixels in image greater than t, it will be called as m_H. Threshold t is able to find in **Eq. (8)**.

$$t = \frac{m_L(t) + m_H(t)}{2} = m(t) \tag{8}$$

Li's Minimum Cross Entropy thresholding method based on the iterative version of the algorithm [7],[8]. It computes threshold value by Li's iterative Minimum Cross Entropy method.

Mean thresholding method uses the mean of grey levels as the threshold [9].

$$\bar{X} = \sum_{i=0}^{n} \frac{X_i}{n} \tag{9}$$

Minimum thresholding method based on minimum method [10]. The histogram of image is smoothed until there are only two maxima. Then the minimum of two maxima is selected as threshold.

Triangle algorithm based on finding the grey value that gives maximum distance d [11]. d is the distance of a line is constructed between the maximum of the grey value histogram and the lowest value in the image.

Yen's thresholding method based on Yen's entropy algorithm [12]. It defines entropic correlation as **Eq. (10)**.

$$TC(T) = C_b(T) + C_f(T) = -log\left(\sum_{g=0}^{T}\left[\frac{p(g)}{P(T)}\right]^2\right) - log\left(\sum_{g=T+1}^{G}\left[\frac{p(g)}{1-P(T)}\right]^2\right) \tag{10}$$

Warp yarn lines and weft yarn lines are obtained by applying Skeletonize thinning algorithm to 1-pixel width warp yarn lines image (h) and weft yarn lines image (l) [13].

Lastly, the corner coordinated image (m) is acquired by intersecting image (h) and image (l). And the grid image (n) is acquired by superposing image (h) and image (l). Then image (o) is obtained by superposing grid image (n) and original image (a).

3. RESULTS AND DISCUSSIONS

In Otsu thresholding method, Horizontal lines generally pass over weft-yarns as illustrated in **Fig.** . A few lines coincide with topside or bottom-side of weft-yarns. Vertical lines are over edge of warp-yarns. Using Isodata thresholding method, Horizontal lines generally pass over weft-yarns, and vertical lines touch edge of warp-yarns as shown image (a) in **Fig.** . Image (b) in **Fig.** shows extraction of yarn lines with Li thresholding. Horizontal lines trace to middle of weft-yarns. Vertical lines pass over side of warp yarns. In Mean thresholding method, A few horizontal lines pass over middle of yarns or edge of yarns. Vertical lines generally pass over edges of yarns. It is illustrated on image (c) in **Fig. .** In Minimum thresholding method, Horizontal lines pass over topside and bottom side of yarns or edge of weft-yarns as shown image (d) in **Fig. .** Vertical lines are over left side of warp yarns. Using Triangle thresholding method, a few horizontal lines pass over topside and a few horizontal lines pass over bottom side of yarns as illustrated in image (e) in **Fig.** . Vertical lines are not able to acquire with Triangle thresholding method. Using Yen's thresholding method, A few horizontal lines pass over topside and a few horizontal lines pass over bottom side of yarns as shown in image (f) in **Fig.** . Vertical lines are not able to acquire with Yen's threshold method.

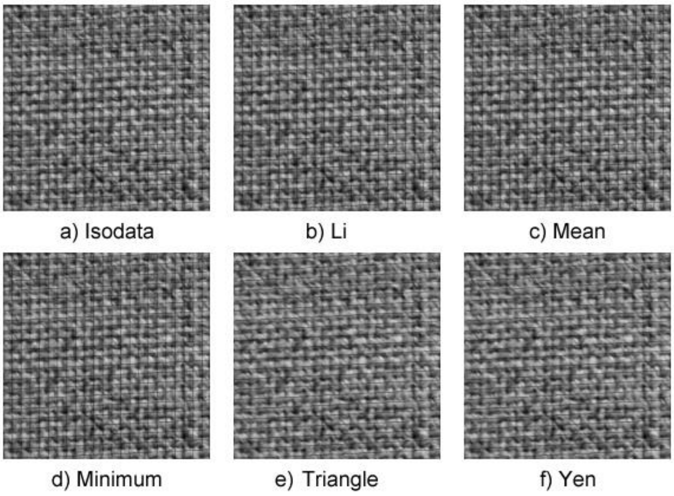

Fig. 2: *Extraction warp and weft yarns with Isodata, Li, Mean, Minimum, Triangle and Yen thresholding methods*

According to result, Threshold selection methods give close results, but Triangle and Yen methods don't give any result on warp yarns. Reconstructed image from selected peaks of power spectrum has close gray intensity value. Gray intensities of the image seem to have been collected in nearby regions on histogram. Otsu, Isodata, Li, Mean and Minimum methods are basically tried to search mean of grayscale intensity. Thence, these methods give same yarn-lines results. Triangle and Yen methods are best for images that has homogeneous gray instensity. Thence, Triangle and Yen methods is not able to give a yarn-lines result

4. CONCLUSION

To overcome the limitation of algorithms for automatic crossed-points detection by using image-analysis techniques, in this investigation fully-automatic algorithms containing Otsu, Isodata, Li, Mean Minimum, Triangle and Yen thresholding methods and also based on Fourier image-analysis techniques have been developed. By applying the proposed algorithm to woven-fabric images, crossed-points are easily detected with high precision in plain woven fabric.

Vertical line obtained by Otsu and Isodata thresholding method passing along the warp yarns, on the other hand vertical lines represent better than horizontal. The best grid images are obtained by Otsu and Isodata thresholding methods. Besides, vertical lines that extracted with Li method are more left than lines that detected using other methods. Moreover, results from Mean and Minimum method is close to results of Otsu and Isodata. Similarly, In Triangle and Yen methods, while horizontal lines are extracted, vertical lines are not extracted.

With a non-periodic design, such as flowers, which may sometimes occur over a woven-fabric background, as well as to fabric with skewness the problem of crossed-points detection becomes very difficult. To overcome this problem and to complete our automatic system for woven fabric recognition, the problem of crossed-points detection in fabrics with skewness or with non-periodic design and the problem of crossed-states detection will be investigated in future works.

REFERENCES

[1] M. Kinoshita, Y. Hashimoto, R. Akiyama, and S. Uchiyama, “*Determination of Weave Types in Woven Fabrics by Digital Image Processing*” Sen’i Kikai Gakkaishi (Journal Text. Mach. Soc. Japan), vol. 40, no. 11, pp. P463–P467, 2012.

[2] Bugao Xu, “*Identifying Fabric Structures with Fast Fourier Transform Techniques*”, Text. Res. J., vol. 66, no. 8, pp. 496–506, 2008.

[3] K. Ohta, K. Takahashi, and M. Saeki, “*Pattern Recognition of Fabric Surfaces*”, Sen’i Kikai Gakkaishi (Journal Text. Mach. Soc. Japan), vol. 41, no. 8, pp. P424–P432, 2012.

[4] T. Jin Kang, C. Hoon Kim, and K. Wha oh, “*Automatic Recognition of Fabric Weave Patterns by Digital Image Analysis*”, Text. Res. J., vol. 69, no. 2, pp. 77–83, 1999.

[5] R. Gonzalez and R. Woods, “*Thresholding*”, Digital image processing. Pearson Education, 2002.

[6] TW. Ridler and S. Calvard, “*Picture Thresholding Using an Iterative Selection Method*”, IEEE Transactions on Systems, Man, and Cybernetics, vol. 8, no. 8, pp. 630-632, 1978.

[7] C. Li, Chun Hung and Lee, “*Minimum cross entropy thresholding*”, Pattern Recognit., vol. 26, no. 4, pp. 617--625, 1993.

[8] C. H. Li and P. K. S. Tam, “*An iterative algorithm for minimum cross entropy thresholding*”, Pattern Recognit. Lett., vol. 19, no. 8, pp. 771–776, 1998.

[9] C. A. Glasbey, “*An Analysis of Histogram-Based Thresholding Algorithms*”, Graph. Model. Image Process., vol. 55, no. 6, pp. 532–537, 1993.

[10] J. M. S. Prewitt and M. L. Mendelsohn, “*The Analysis of Cell Images*”, Ann. N. Y. Acad. Sci., vol. 128, no. 3, pp. 1035–1053, 1966.

[11] G. W. Zack, W. E. Rogers, and S. A. Latt, “*Automatic measurement of sister chromatid exchange frequency*”, J. Histochem. Cytochem., vol. 25, no. 7, pp. 741–753, 1977.

[12] J. C. Yen, F. J. Chang, and S. Chang, “*A New Criterion for Automatic Multilevel Thresholding*”, IEEE Trans. Image Process., vol. 4, no. 3, pp. 370–378, 1995.

[13] T. Zhang and C. Suen, “*A fast parallel algorithm for thinning digital patterns*”, Communications of the ACM, vol. 27, no. 3, pp. 236-239, 1984.

INNOVATIVE METHODS OF ANALYSIS AND DIAGNOSIS OF NATURAL AND SYNTHETIC POLYMERIC MATERIALS

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Abstract: *The study of natural and synthetic polymeric materials from modern and contemporary textile artworks can give scientists some difficulties in identification of the fibers or other components. Sometimes, time or environmental conditions can damage quite enough textile articles and because of that more and more techniques have been developed in order to assess the need to a better analysis of the samples. In addition to the lack of analytical equipment that can sometimes appear, a big problem is also the interpretation of the results. The main advantage of modern and contemporary textiles is that these products are easier to analyze because the time and environmental conditions at which they were exposed to do not have yet a major impact on them. In this paper are presented several types of analyzes and equipment that have non-destructive or micro-destructive properties. Some of these techniques have been used for decades, while others have been developed recently. Besides Scanning Electron Microscopy (SEM), one of the most used equipment in cultural heritage field are further summarized: Fourier Transform Infrared Spectroscopy (FTIR), Differential Scanning Calorimetry (DSC), Direct Analysis in Real Time (DART), Surface-Enhanced Raman Scattering (SERS), Raman spectroscopy, Gas and Liquid Chromatography (GC and LC). These techniques are used for ancient textiles and also for the modern and contemporary ones.*

Key words: textile, artworks, non-destructive techniques, contemporary period, modern period.

1. INTRODUCTION

Textiles have been a fundamental part of human life since the beginning of civilization [1, 2]. Thus, like any artwork, textiles can also be divided into historical periods. Thereby, the modern components can be framed between 1860 and 1970 while the contemporary components represent any textile item from 1980 to the present.

19th centuries had the most dramatic impact on textiles. Up until that point, the production of all types of textiles - be that clothing, tapestries or just the raw materials - had been a laborious process. Everything was done by hand and, though this was time consuming, it meant that individuals had greater control over what they produced - and what they charged. The invention of automated means of production, like the power loom, posed a threat to traditional livelihoods and sparked the Luddite rebellion as workers feared they would be replaced by machines.

The purpose of this study is to summarize the methods of analysis and diagnosis of natural and synthetic polymeric materials that refer to modern and contemporary textile artworks.

One of the most important requirements for the characterization methods of textile artworks is to be non-destructive or at least micro-destructive.

2. TECHNIQUES USED IN ANALYSIS AND DIAGNOSIS OF NATURAL AND SYNTHETIC POLYMERIC MATERIALS THAT CAN BE APPLIED TO MODERN AND CONTEMPORARY TEXTILE ARTWORKS

The following methods will be discussed below: Scanning Electron Microscopy, Fourier Transform Infrared Spectroscopy, Differential Scanning Calorimetry, Raman spectroscopy, Nuclear Magnetic Resonance spectroscopy, X-Ray techniques. In Table 1 are presented several techniques used in fiber identification, while in Table 2 can be found some techniques used in dyes identification.

Fourier Transform Infrared Spectroscopy is one of the most common techniques used in artworks analysis. In textile artworks and artefacts FTIR has played an important identification role for fibers, dyes and even polymers and additives used in restoration.

Differential Scanning Calorimetry (DSC) was studied as an alternative qualitative method for identifying different textile animal hair fibers. Differentiation of speciality or luxury fibers (such as cashmere) from other animal cheaper fibers (such as sheep's wool or yak) is essential to repress adulteration of textile products. Moreover, DSC analysis can be used to distinguish fibers of different types and affected by industrial textile treatments like bleaching, steaming, descaling and stretching.

Scanning Electron Microscopy (SEM) can be used to analyse the morphology of fiber and fabric surfaces. The method applied is not destructive, enabling the re-testing of the same sample with another method.

Direct Analysis in Real Time (DART) is an ion source that produces electronically or vibronically excited-state species from gases such as helium, argon, or nitrogen that ionize atmospheric molecules or dopant molecules. With the aid of DART, exact mass measurements can be done rapidly with high-resolution mass spectrometers. DART mass spectrometry has been used in pharmaceutical applications, forensic studies, quality control, and environmental studies [3].

Surface-Enhanced Raman Scattering (SERS) is a technique in which the Raman scattering signal is greatly enhanced when organic molecules with large delocalized electron systems are adsorbed on atomically rough metallic substrates; fluorescence is concomitantly quenched. SERS provides a very powerful analytical alternative for art applications.

Raman Spectroscopy is a spectroscopic technique used to observe vibrational, rotational, and other low-frequency modes in a system. Raman spectroscopy is commonly used in chemistry to provide a structural fingerprint by which molecules can be identified. Raman spectroscopy has some unique advantages such as: non-contact and non-destructive analysis, no sample preparation needed and last, but not least, samples can be in various states such as gas, liquid, solution, solid, crystal, emulsion can be analyzed.

Liquid Chromatography is a separation technique in which the mobile phase is a liquid and the elution is, in the majority of cases, carried out in a column. Due to the fact that the an analyte properties to be analysed by liquid chromatography is its solubility in a proper solvent, there are several samples from modern and contemporary textile artworks that can be analysed by this method. There are different liquid chromatography techniques such as: High Performance Liquid Chromatography (HPLC), Ultra-High Pressure Liquid Chromatography (UHPLC), Reversed-Phase Chromatography (RP-HPLC), ion chromatography, size exclusion chromatography (SEC) and so on. Liquid chromatography techniques are used for the determination of dyes, lipids, inorganic salts (mainly anions) etc.

Gas Chromatography-Mass Spectrometry (GC-MS) is an analytical technique that can be used to identify sealants, adhesives, organic pigments and dyes [4-7].

Table 1: *Techniques used in fiber identification*

Technique	Short description of the study	Reference
FTIR	The aim of the paper was to compare various wool and hair fibers of FTIR spectra and to show the possibility of distinguishing some animal fibers and even fibers' colors. The results have shown that natural black wool spectrum can be distinguished from the white wool fiber's spectrum, while white goat hair's and black goat hair's spectra do not differ and are similar to white wool spectrum.	[8]
	In this paper was analyzed raw, alkali treated (with NaOH) and wax removed fibers of ligno-cellulosic samples and it can be observed a difference regarding the bands attributed to the stretching vibrations of C=O and C-O groups between raw and wax removed fibers compared with NaOH treated fibers. The groups mentioned before are a part of hemicelluloses and these are soluble in aqueous alkaline solutions.	[9]
	Despite their ostensible similarity, it is apparent that just minor differences in the composition of the various cellulosic plant fibers allow them to be distinguished by ATR FTIR spectroscopy, whether the fibers are presented unprocessed or in textile threads. Preliminary investigations also suggest that this technique is applicable to the characterization of such fibers in paper. There may be some ambiguity, though, when dyes or other finishing agents contribute to overlapping infrared bands, or where there is marked fiber deterioration.	[10]
DSC	Differential Scanning Calorimetry curves of different types of animal hair were compared and the fibers were identified according to the established criteria. Wool fibers show a DSC trace with a bimodal endothermic peak in the temperature range of 230–255ºC; on the contrary, cashmere DSC trace shows a single endothermic peak at 241 ºC and a shoulder at 236 ºC. The DSC curves of yak and goat fibers show a broad endothermic event at 237 ºC.	[11]
	Samples of Mohair (25.2 µm), Cashgora (20.8 µm), Cashmere (13.9 µm) and Yangir (13.6 µm) were investigated through thermal denaturation. The results revealed appreciable differences of the DSC traces in the temperature range 230-250°C.	[12]
	DSC was used for the analysis of two textiles of industrial production (used as representative modern commercial silk) and three historical silk micro-samples (weight < 2 mg; area < 1 cm^2). Considering the secondary structures of the historical samples, it was possible to hypothesize the different degradation paths followed by each sample through natural aging. By DSC analysis, the modern silk samples presented a different behavior compared to historical samples.	[13]
SEM	SEM was applied in the analysis of archaeological textile samples of finds from the Roman period and the Middle Ages. SEM analysis allowed identifying the material as flax due to "nodes" typical for linen medieval tablet-woven silk fabric. Comprehensive analysis shows that medieval wool (15th century) was much thicker than that from the 2nd century. It confirms the premise that there was a very high level of wool manufacturing in the Roman period.	[14]
	SEM was used to analyze different dyed and undyed Coptic textile samples which were collected from different Egyptian areas. After comparing all SEM photos it was noticed that the linen samples are more degraded than the wool samples. On one hand this may be due to the dyes on the wool textile, which may play a role in inhibiting the deterioration of these textiles and on the other hand it may be due to the faster deterioration of cellulosic textiles such as linen rather than than wool by the different deterioration reasons.	[15]

Table 2: *Techniques used in dyes identification*

Technique	Short description of the study	Reference
HPLC	HPLC with spectrophotometric detector has been used for the identification of compounds from textile dyes. The entire process was carried out in three stages: first, chromatographic measurements were made on purified dyes and natural dyeing substances collected from various sources. Then HPLC data were recorded for extracts of dyes from contemporary dyed fibers, which were dyed with dyestuff extracted from raw material purchased from Kremer. Finally, the extracts from fibers taken from ancient Coptic objects were analyzed under two sets of chromatographic conditions. Identification of dyes extracted from the objects was based on retention times and on UV-VIS spectra recorded for sample extracts and standards.	[16]
HPLC-PDA	In this study high liquid chromatography with diode array detectors (also known as DAD or PDA) was used in the cases of natural dyestuffs (it is well known that these natural dyestuffs contain various coloring substances). The most efficient analytical method for the determination of these dye components is the one that has at least two steps, such as: one step that leads to a separation (and thus purification) of the components (such as chromatography) and a second step: the detection of each component (spectrometry). Due to the fact that 30 and 40 years ago suitable techniques weren't yet developed it is thus advisable to recheck ancient-dye analyses.	[17]
GC-MS	This paper presents a GC–MS method with TMTFTH extraction that can be used as an alternative for dye analyses based on liquid chromatography.	[18]
	The analytical procedure based on GC-MS was applied to the analysis of standard solution of flavonoids and on non-aged and aged wool dyed specimens. The analytical procedure succeeded in identifying the flavonoid chromophores in raw materials and in dyed yarns. In fact, although a derivatization step is needed, GC-MS was proved to be a selective, sensitive and relatively fast technique.	[19]
DART	DART-MS is a sensitive, rapid and preparation-free method very useful for identifying the primary organic dye chromophores in natural fiber textiles (wool, silk, cotton and linen). Dyes were readily identified in freshly dyed textiles and in cotton skeins that were manufactured more than a century ago.	[20]
SERS	SERS analysis is maybe one of the best methods for the identification of dyes in ultramicroscopic samples of paints and glazes, at the level of specificity provided by Raman spectroscopy. SERS not only fills an important gap in the cultural heritage scientist toolbox: the application of SERS to works of art has emerged as the leading practical application of the technique.	[21]
SEM with EDAX Sapphire and Gatan CL3þ system Raman spectroscopy	The combination of more than one technique increased the reliability of the results. While Cathodoluminescence has shown a similar spectra and EDX has identified Br in the sample, only Raman spectra shows the absolute proof that the ancient and contemporary dyes are identical.	[22]
Raman spectroscopy	The characterization of the binding media and pigments in modern and contemporary paintings is important for designing safe conservation treatments, as well as for determining suitable environmental conditions for display, storage and transport. Raman spectroscopy is a suitable technique for the in situ non-destructive identification of synthetic organic pigments in the presence of the complex binding media characteristic of synthetic resin paints or color lithographic inks.	[23]

3. CONCLUSIONS

The present paper summarizes the main methods to investigate textile artworks objects. These methods are using modern equipments that show remarkable properties such as: sensibility, sensitivity, rapidity in analysis, once purchased do not show high cost of use and last, but not least, are micro or non-destructive. Moreover, these techniques can be used together for a more accurate analysis and interpretation of the samples, either archaeological or modern and contemporary.

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REFERENCES

[1] Gillow, J., Sentance, B. (1999). *World Textiles*. pp. 10-11.

[2] Barber, E.W. (1994). *Women's Work: The First 20,000 Years*. pp. 42-70.

[3] Gross, J. H. (2014). *Direct analysis in real time—a critical review on DART-MS*. Analytical and Bioanalytical Chemistry, 406 (1), pp. 63–80.

[4] Beck, C. W., Smart, C. J., Ossenkop, D. J. (1989). *Residues and linings in ancient Mediterranean transport amphoras.* Archaeological chemistry, Advance in Chemistry Series, pp. 369–380.

[5] Heron, C., Evershed, R. P., Chapman, B., Pollard, M. (1989). *Glue, disinfectant and "chewing gum" in prehistory*. Archaeological sciences 1989: Proceedings of a conference on the application of scientific techniques to archaeology, 9, pp. 325–331.

[6] Gebremariam, K. F., Kvittingen, L., Banica, F. G. (2016). *Physico-chemical characterization of pigments and binders of murals in a church in Ethiopia*. Archaeometry, 58(2), pp. 271–283.

[7] Wei, S., Ma, Q., Schreiner, M. (2012). *Scientific investigation of the paint and adhesive materials used in the western Han dynasty polychromy terracotta army, Qingzhou, China*. Journal of Archaeological Science, 39(5), pp. 1628–1633.

[8] Zemaytyte, R., Jonaitiene, V., Milasius, R., Stanys, S., Ulozaite, R. (2006). *Analysis and identification of fiber constitution of archaeological textiles*. Materials Science (MEDŽIAGOTYRA), 12(3).

[9] Karthik, T., Murugan, R. (2013). *Characterization and analysis of ligno-cellulosic seed fiber from pergularia daemia plant for textile applications*. Fibers and Polymers,.14(3), pp. 465-472.

[10] Garside, P., Wyeth, P. (2003). *Identification of cellulosic fibers by FTIR spectroscopy - thread and single fiber analysis by Attenuated Total Reflectance*. Studies in Conservation, 48, pp. 269- 275.

[11] Tonetti, C., Varesano, A., Vineis, C., Mazzuchetti, G. (2015). *Differential scanning calorimetry for the identification of animal hair fibers*. Journal of Thermal Analysis and Calorimetry, 119, pp. 1445–1451.

[12] Vineis, C., Aluigi, A., Tonin, C. (2008*). Morphology and thermal behaviour of textile fibers from the hair of domestic and wild goat species*. AUTEX Research Journal, 8 (3), pp. 68-71.

[13] Badillo-Sanchez, D., Chelazzi, D., Giorgi, R., , Cincinelli, A., Baglioni, P. (2018). *Characterization of the secondary structure of degummed Bombyx mori silk in modern and historical samples*. Polymer Degradation and Stability, 157, pp. 53-62.

[14] Cybulska, M., Jedraszek-Bomba, A., Kuberski, S., Wrzosek, H. (2008). *Methods of chemical and physicochemical analysis in the identification of archaeological and historical textiles*. FIBERS & TEXTILES in Eastern Europe, 16(5), pp. 67-73.

[15] Abdel-Kreem, O., El-Nagar, K. (2005). Non-*destructive methods to investigate the deterioration extent of coptic egyptian textiles*. Journal of Textile and Apparel, Technology and Management, 4(4).

[16] Trojanowicz, M., Orska-Gawryś, J., Surowiec, I., Szostek, B., Urbaniak-Walczak, K., Kehl, J., Rejniak, H., Wróbel, M. (2004). Chromatographic *investigation of dyes extracted from Coptic textiles from the National Museum in Warsaw*. Studies in Conservation, 49, pp. 115.

[17] Koren, Z. C. (2005). *Chromatographic analyses of selected historic dyeings from Ancient Israel*, Janaway R. and Wyeth P. (eds.) Scientific Analysis of Ancient and Historic Textiles: Informing, Preservation, Display and Interpretation, pp. 194-201.

[18] Poulin, J. (2018). *A new methodology for the characterisation of natural dyes on museum objects using gas chromatography–mass spectrometry*. Studies in Conservation, 63(1), pp. 36-61.

[19] Colombini, M. P., Andreotti, A., Baraldi, C., Degano, I., Łucejko, J. J. (2007). *Colour fading in textiles: A model study on the decomposition of natural dyes*. Microchemical Journal, 85, pp. 174–182.

[20] Selvius DeRoo, C., Armitage, R. A. (2011). *Direct identification of dyes in textiles by Direct Analysis in Real Time-Time of Flight Mass Spectrometry*. Analytical Chemistry, 83, pp. 6924–6928.

[21] Casadio, F., Leona, M., Lombardi, J. R., Vanduyne, R. (2010). *Identification of organic colorants in fibers, paints, and glazes by Surface Enhanced Raman Spectroscopy*. Accounts of Chemical Research, 43(6), pp. 782-791.

[22] Christina Margariti, C., Protopapas, S., Allen, N., Vishnyakov, V. (2013). *Identification of purple dye from molluscs on an excavated textile by non-destructive analytical techniques*. Dyes and Pigments, 96, pp. 774-780.

[23] Polonca Ropret, P., Centeno, S. A., Bukovec, P. (2008). *Raman identification of yellow synthetic organic pigments in modern and contemporary paintings: Reference spectra and case studies*. Spectrochimica Acta Part A, 69, pp. 486–497.

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

THE IMPACT OF THE RIGHT CHOICE OF FABRICS ON USERS OF PUBLIC TRANSPORT

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Abstract: *The paper presents the role and importance that the right choice of materials has on the final result of the design process of the interior of public means of transport. Establishing a balance between technical restrictions and the user's perception on the interior space can be seen in the presentation of a case study on the project "Co-working Tram" made in 2018, part of the cultural project "Iasi – City of Painted Trams", initiated by designer Silviu Teodor-Stanciu. The study emphasizes the optimisation of the identification process of seats upholstery, adapted for a mean of transport with multiple functions. The choosing and personalisation of the upholstery fabrics is made taking into account the graphic theme, the predominant colour and last, but not least, the resistance of the fabric to tear, each seat from a public mean of transport being used daily by an average number of passengers.The study presents the advantages of using synthetic leather for the seat upholstery of public means of transport not only for the resistance to tear, but also for the various possibilities of personalising the fabric through printing press printing. Through this procedure one can quickly obtain various visual effects, with minimal investments in comparison to conventional techniques. Also, the study shows the fact that the personalisation of trams is realised with the implication of volunteer students of the Design Department, emphasizing once more the importance of applied traineeship.*

Key words: *design process, interior design, personalised upholstery, synthetic leather, public transport.*

1. INTRODUCTION

The design process of the interiors of public means of transport is a very strict one on what concerns the ergonomics of the furniture, respecting the passing aisles, the arrangement of sustaining elements and the choosing and placement of the lighting system. The process of choosing the fabrics and finishes is also a strict one, due to the fact that it has to ensure the functional part through visibility, washable, anti-adhesive features, and to offer the passenger a raised level of comfort through colours and textures. In order to encourage the citizens to use the public transport system, the project "Iasi – City of Painted Trams" was created in Iasi, a project initiated by Tramclub Iasi NGO with the support of the local transport company and the "George Enescu" National University of Arts, Iasi. The project has as objective the personalisation of the trams of Iasi with the help of volunteer students of the Design Department, under the guidance of designer Silviu Teodor-Stanciu.
Also, the project offers students the opportunity to get involved, through applied traineeships, in the aesthetic part of Iasi, having a direct contact with the economical environment. Thus, students of the Industrial Design, Graphic Design, Interior Design and Textile Design departments work together and interract with professionals from the field, experience which is training them for their future designer career.

2. GENERAL INFORMATION

2.1 Context

The project “Iasi – City of Painted Trams” includes currently 12 means of public transport themed personalised, among which the most representatives being the Union Tram, the Media Tram, the Literature Tram, the Education Tram, the Ia (National blouse) Tram, the Centennial Tram and the Co-working Tram (Fig. 1).

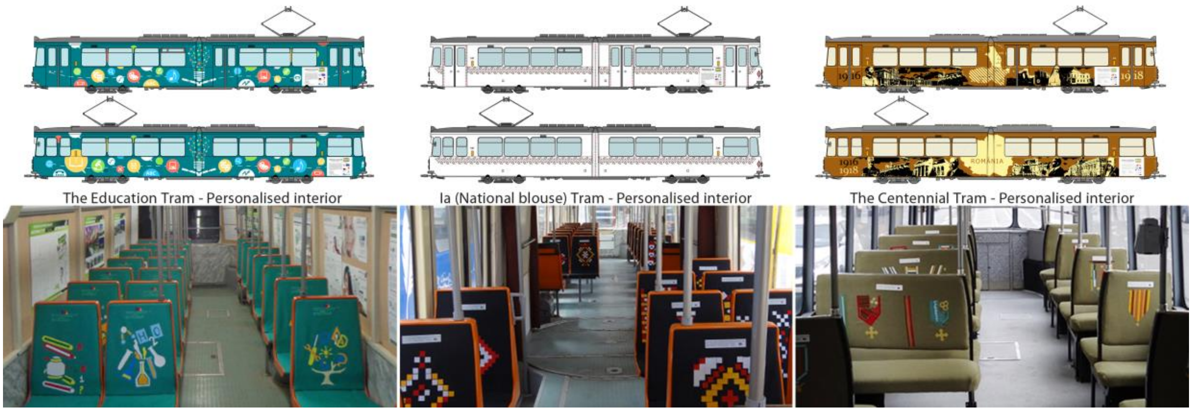

Fig. 1*: “Iasi – City of Painted Trams” project - themed personalised means of public transport*

Apart from the exterior personalisation, the transport means were also modified on what concerns the interior design. The modifications do not interfere with the arrangement of the inside furniture, nor of the supporting elements. The changes of the interior refer to replacing the seat upholstery, adding some accessories (shelves, library bookshelves, monitors, etc.), elements which can correlate the hall’s aspect with the message conveyed by the tram’s exterior themed personalisation. The choosing and personalisation of the upholstery fabrics is made taking into account the graphic theme, the predominant colour and last, but not least, the resistance of the fabric to tear, each seat from a public mean of transport being used daily by an average number of 1.000 passengers.

2.2 Case Study

The Co-working Tram (Fig. 2) was created in 2018 in order to support and pass on the values of the International Movement of Co-working in the community of Iasi, movement initiated in 2005 by Brad Neuberg in San Francisco, USA. Co-working represents a social-professional binder, which prevents the isolation of freelancers inside their home environment, leading to the efficiency of working schedule and the growth of work quality. Co-working also means a working style which implies a common working space, most often for people who have related occupations.

The graphic composition applied on the tram presents, through visual language, the constituent elements of the Co-working movement: community, connection, communication, synchronization, technology. The composition is marked in the middle by a linear graphic element of big scale, which suggests the interference between domains, these being chromatically marked by placing a dynamic colour – turquoise near a non-colour – white. Aiming that the tram could be used temporarily as a hub or mobile conference space, the vehicle was improved with free wi-fi and seven sockets placed in the interior in order for passengers to charge their phones and laptops. Also, in the articulation area, a mini-library was placed, containing publications from the economic and IT area.

Fig. 2*: The personalisation process of the Co-working Tram*

2.3 Choice of Fabrics

The intervention with the biggest impact on the aesthetic shaping of the interior was the replacement of the seat upholstery. The seats were covered with synthetic leather[1], a fabric which does not retain odours[2], can be easily cleaned and does not need much time to dry after the cleaning process such as conventional textile fabric upholstery (plush). By using this fabric one creates the visual analogy with the image of the elegant office chairs. Black synthetic leather was chosen for this project, which is in contrast with the orange frame of the seats and which also offers elegance to the interior. For a superior mechanic resistance the chosen leather was placed on a textile rack, this type not damaging the fabric's flexibility[2]. The fabric's finish imitates the texture of cattle leather[3]. The fabric was later personalised with suggestive graphic elements taken from the exterior composition, rearranged in a pattern[4] proportionate to the seats size (author: Architect Tiberiu Teodor-Stanciu). The synthetic leather was printed[5] in two colours (white – turquoise) at a local printing press (Fig. 3). Samples of the printed fabric were submitted to the physical-chemical and physical-mechanical tests ordered by the beneficiary. The fabric was tailored and applied on the detachable racks of the seats by mechanic sewing[6] and gluing of the seams with an adhesive made of chloroprene rubber, phenol resin, solvents and additives. The fabric was mildly tensed in order to take the shape of the sponge layer of the seat profile. All the 43 seats of the tram were processed in the sewing department of the Public Transport Company in Iasi.

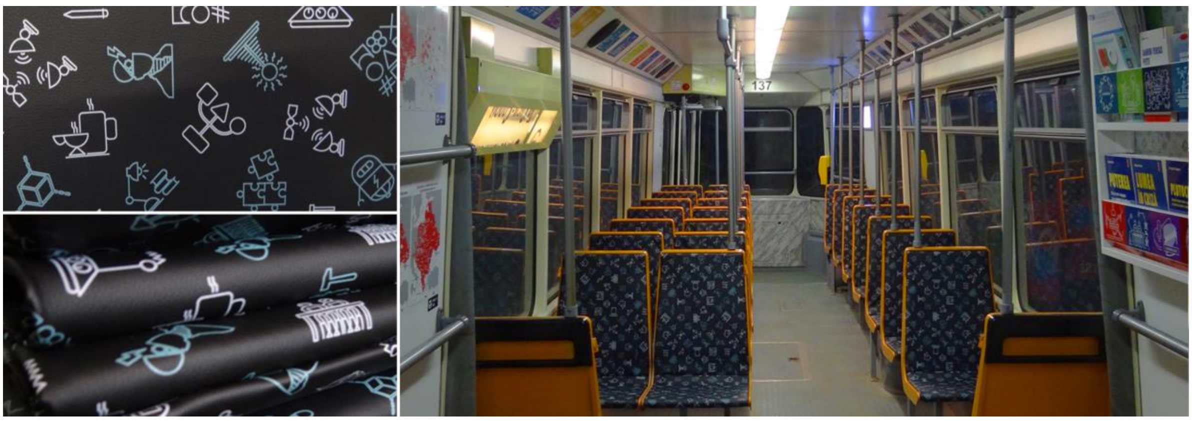

Fig. 3*: The personalisation process of the interior through the upholstery*

3. CONCLUSIONS

The Co-working Tram was publicly presented on the 13th of May 2018, the project being a point of attraction for the local co-working hubs and the multinational companies in Iasi, but also in Romania. Shortly the tram was rented by Google and Fablab Iasi in order to hold a dynamic, unconventional conference. Thus, the guests from Romania and from abroad had the opportunity to attend the conference and visit Iasi in the same time. The partial redesign of the interior, the placement of monitors, of sockets and the possibility to connect to the internet have transformed the tram into a moving conference space (Fig. 4).

The interior atmosphere was completed by the personalised upholstery of the seats, which offered the guests a physical and visual comfort. The usage of highly qualitative fabrics, carefully engraved and processed, can radically change the perception on an interior space, a normal tram ride being able to transform into a positive, memorable experience.

Fig. 4*: Digital Bloom Conference which took place in the Co-working Tram*

REFERENCES

[1]***Dicționar tehnic, Editura Tehnică, București, 2004.

[2] C., Shaeffer, "*Sew Any Fabric: Quick Reference to fabrics from A to Z*", Krause Publications Craft, 2003, ISBN 1-4402-2033-6, p.37.

[3] R., Kanigel, "*Faux Real: Genuine Leather and 200 Years of Inspired Fakes*", University of Pnnsylvania Press, 2007, ISBN: 978-0812221329, pp.173-246.

[4] A., Richards, "*Pattern Making Pimer*", B.E.S. Publishing, 2012, ISBN-13:978-1438000839, pp.60-61.

[5] B., Fellowes, "*A-to-Z of Printing: Printing on Leather*", [Online]. Available https://www.rolanddga.com/blog/2018/06/06/l-for-leather

[6] R., Singer, "*Fabric Manipulation: 150 Creative Sewing Techniques*", David & Charles, 2013, ISBN: 978-1446302447, pp.122-130.

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ALTERNATİVE FIBERS II: PINEAPPLE, POLAR BEAR, BANANA AND CARIBOU FIBERS

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Abstract: *Recently, with increases rapidly of the need for new raw materials and products in the textile sector, the use of alternative fibers has gained importance. Specific characteristics of alternative fibers are thinness, length, strength, brightness, biodegradable and undulation (for hair origin fibres). The increasing of researching in these characteristic material properties in the past several decades has increased the interest of alternative fibres. A lot of work has been done around the world on about alternative fibres. Alternative fibers can be used alone or mixed together with conventional fibers. In mixed fibers could be seen more efficiently properties such as viscoelastic behavior, processing, tensile strength and flexural. Hair origin fibres (polar bear and caribou) especially provides thermal insulator to keep warm. Herbal fibres (pineapple and banana) composed of composites because of their eco-friendly, easy availability and high reinforce, renewable and specific characteristic properties. With the recent developments in composite technology, alternative herbal fibres based composites are expected to be developed in global sustainability. For these reasons, alternative fibres could be used in a variety of areas. The aims of this review are to explain properties, production methods and applications of alternative fibers including pineapple, polar bear, banana and caribou fibers. With the development of the fiber industry, it is thought that the importance given to these fibers will increase.*

Key words: *Pineapple Fibres, Polar Bear Fibers, Banana Fıbers, Caribou Fibers, Alternatives Fibres*

1. INTRODUCTION

In the last decades, as the need for new raw materials and products in the textile sector has increased rapidly, the use of alternative fibers has gained importance. Alternative fiber production is laborious and requires special knowledge and prices are quite high but their mixed fibers with conventional fibers have more efficiently properties such as viscoelastic behaviour, processing, tensile strength and flexural. This study examines some fibers that are not commercially used by means of literature review method. Pineapple fibers in the first part of the study, polar bear hairs in the second section, and in the third section, the fibers obtained from the banana tree and caribou hairs in the last part have been analysed.

2. PINEAPPLE FIBERS

Pineapple fiber (Ananas bracteatus) grows up coastal regions in tropical countries such as India, Malaysia, etc. (see in Fig. 1(a)). Pineapple plant is 1-2m height and width and belongs to the Bromeliaceae family [1-2]. Pineapple mostly cultivated for its fruits (see in Fig.1 (b)) and is the source of bioactive compounds, particularly in proteolytic enzymes and a very rich source of bromelain enzyme which supplies to help digestion and inflammation [2]. Pineapple leaf fibre (PALF) (see in Fig.1 (c) and 1 (d)) is produced by the mechanical method and retting method in water. Fresh leaves yield about 2 to 3% of fibres [3]. The diameter of the elementary fiber is 25–34 µm [1] and multicellular lignocellulosic with very small lümen size [3]. Physical and mechanical properties of PALF could be seen in Table 1. PALF has superior properties such as high specific strength, eco-friendly, stiffness, fine quality, the structure is without mesh, hygroscopic, low density, relatively inexpensive and abundantly available [4-5]. In addition, superb mechanical properties of PALF is directly related to high cellulose content (70 – 80%) (see in Table 2) and relatively low microfibrillar angle (14°). Due to the perfect properties viewed by PALF they can be used as high potential reinforcing efficiency for application in composite matrices. Properties such as viscoelastic behavior, processing, tensile strength, flexural, and impact properties of the composites connected with fiber length, fiber loading, and fiber orientation [6]. The two main deficiencies of using PALF is the hydrophilic character of the cellulose structure and the low processing temperature permissible [7]. Make away with these disadvantages, the surface of the fiber must change by physical and chemical methods to reduce the hydrophilic nature of the natural fiber and thereby improve the fiber-matrix bond [6].

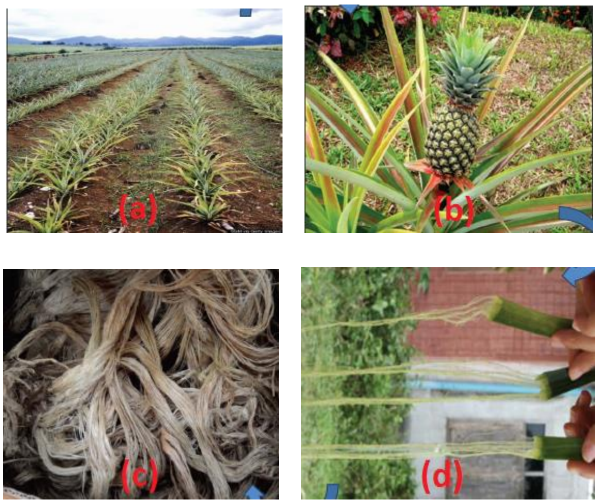

Fig.1: *(a) Pineapple field, (b) Fruit of pineapple, (c) Pineapple leaf fibres, (d) Fibres from pineapple leaves [2]*

Natural fibre based composites have great attention because of their eco-friendly, easy availability, high reinforce, renewable and specific characteristic properties. Useful composites in good strength can be produced with PALF as reinforcing material for the polymer matrix comprising mainly polysaccharides and lignin and other compounds. PALF reinforced composites are composed of thermosets (polyester and epoxy) [7], thermoplastic (polyethylene, poly(propylene [9]), poly(vinyl chloride)), rubber and cements matrices [2]. It is important to the properties of composites related to individual components and interfacial compatibility of PALF. Between fiber and adhesion, the matrix is obtained by mechanical connection of the fiber and surface ends into the matrix [2]. With the recent developments in composite technology, PALF based composites are expected to be developed in global sustainability.

***Table 1**. Physical and mechanical properties of PALF [8]*

Properties	***PALF***
Density/(g _ cm_3)	1,44
Diameter(mm)	20–80
Tensile strength (MPa)	413–1 627
Young's modulus/GPa	34,5–82,51
Elongation at break/%	1,6

Table 2. Chemical composition of PALF [8]

Content	***PALF***
Cellulose wt.-%	70-82
Lignin wt.-%	5-12
Microfibrillar/spiral angle (Deg.)	14
Moisture content wt.-%	11,8

3. POLAR BEAR FIBERS

Polar Bear lives in the Arctic region, where the environmental temperature is extremely cold as –50 °C [10]. Polar Bear Hair is white and semitransparent [11] and capability to keep warm, because of their hollow hairs [12]. The transparent section has relatively good light and thermal conduction. The hair of polar bear has labyrinth cavity structure (see in figure 2) and this cavity enables the animal to absorb energy from its outside for thermal insulator to keeping warm [11].

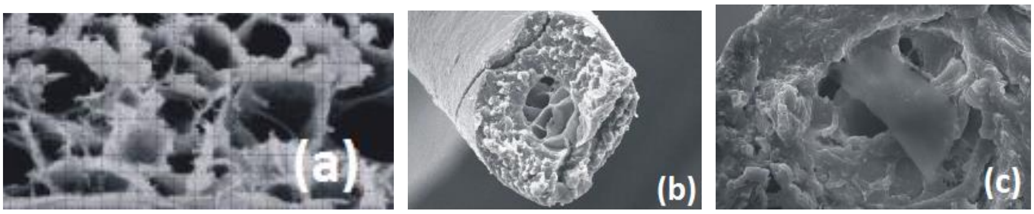

Fig.2: *(a) Inner morphology [13], (b) Scanning Electron Micrographs of Polar Bear Hair [11]*

Polar Bear Hair has not used in the textile production sector, has formed a model to produce some chemical fibers. For example, DuPont inspired by thermolite fiber inside the polar bears, the thermal resistance of the products manufactured from this fiber is also high. High volume Non-Thermolite fibers are also very light fibers for which they are empty [13].

4.BANANA FIBERS

Banana fibers are obtained from the plant types of M. cavendishi and M. sapientum that produce edible fruit types. India and Brazil are the largest banana producing countries, but data on fiber production are few. The fibers are obtained mainly from the plant stem. Approximately 1 kg of good quality fiber is obtained from about 37 kg of stem of banana fruit. Fibers are obtained by hand or with retting method, or by using raspadors or separating it from the stem by using a chemical substance like NaOH at boiling temperature [14]. Banana fiber is a kind of fiber containing 60-65% cellulose (in figure 3) [15].

Banana fibers have been used in many studies to produce composite surfaces [16-19]. Although banana fibers are used for paper production, the production of Kijoka Banana Fiber Cloth, which dates to the 13th century, continues in Okinawa [14]. This fabric is known for its smoothness, lightness, air permeability, fineness and strength [20]. Banana fiber becomes increasingly popular in using multiple sectors such as tea bags and car tires.

Fig 3: *Banana fiber [19], [21]*

5. CARIBOU FIBERS

Caribou animals live in northern climates, are terrestrial herbivores and feed on lichens (see in figure 4(b)) [22]. It could be insulating the cool air because of the presence of air-filled cells. Caribou hairs (in figure 4 (a)) have high insulating properties but there are quite short, low tensile strength and low resistance. Therefore, it cannot be producing fabric construction of caribou hairs. Only, the fabric is made with mixture of wool range from %20 to %33 and mixture are blended by carding. Use of more caribou fibers than these ranges will cause a strength reduction of fabric [23].

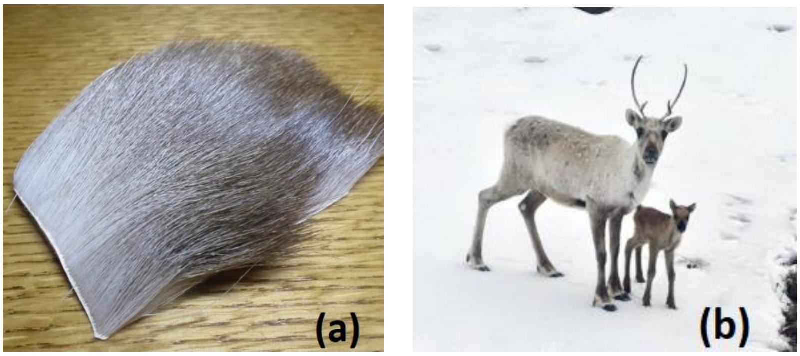

Fig 4: *Caribou hairs [24] and Caribou animals [25]*

6. CONCLUSION

In this review study, pineapple, polar bear, banana and caribou fibers were examined. Characteristic material properties and production conditions of these alternative fibers were investigated. In the light of the obtained data, polar bear and caribou fibers especially provide thermal insulator to keeping warm and pineapple and banana fibers composed of composites because of their eco-friendly, easy availability, and high reinforce, renewable and specific characteristic properties. It can be concluded that with the development of the fiber industry, it is thought that the importance given to these fibers will increase. This review could be useful in understanding parameters and raise awareness for the use of alternative fibre production technology.

REFERENCES

[1] A.K.Jakubowska, E. Bogacz & M. Zimniewska, "*Review of Natural Fibers. Part I—Vegetable Fibers"*, Journal of Natural Fibers, 9: 3, 150-167, 2012.

[2] M. Asim, Khalina Abdan, M. Jawaid, M. Nasir, Zahra Dashtizadeh, M. R. Ishak, & M. Enamul Hoque, "*A Review on Pineapple Leaves Fibre and Its Composites"*, International Journal of Polymer Science, Article ID 950567, pp 1-16, 2015.

[3] S. Mishra, A. K. Mohanty, L. T. Drzal, M. Misra, G. Hinrichsen, "*A Review on Pineapple Leaf Fibers, Sisal Fibers and Their Biocomposites"*, Macromolecular Materials and Engineering, 289, pp955-973, 2004.

[4] B. M. Cheriana, A. L. Leão, S. Ferreira de Souza, S. Thomas, L. A. Pothanc, M. Kottaisamy, "*Isolation of Nanocellulose from Pineapple Leaf Fibres by Steam Explosion"*, Carbohydrate Polymers 81, pp. 720–725, 2010.

[5] B. M. Cherian, A. L. Leão, S. Ferreira de Souza, L. M. Manzine Costa, G. Molina de Olyveira, M. Kottaisamyc, E.R. Nagarajan, S. Thomas, "*Cellulose Nanocomposites with Nanofibres İsolated from Pineapple Leaf Fibers for Medical Applications"*, Carbohydrate Polymers 86, 1790–1798, 2011.

[6] N. Lopattananon, K. Panawarangkul, , K. Sahakaro & B. Ellis, "*Performance Of Pineapple Leaf Fiber–Natural Rubber Composites: The Effect of Fiber Surface Treatments",* Journal of Applied Polymer Science, 102(2), 1974–1984, 2006.

[7] S. Mishra, M. Misra, S. S. Tripathy, S. K. Nayak and A. K. Mohanty, "*Potentiality of Pineapple Leaf Fibre as Reinforcement in PALF-Polyester Composite: Surface Modification and Mechanical Performance"*, Journal of Reinforced Plastics and Composites, 20: 321, 2001.

[8] A. K. Mohantya, M. Misraa, G. Hinrichsen, *"Biofibres, Biodegradable Polymers and Biocomposites: An Overview*", Macromolecular Material and Engineering, 276/277, 1–24, 2000.

[9] R.M.N. Arib, S.M. Sapuan , M.M.H.M. Ahmad, M.T. Paridah, H.M.D. Khairul Zaman, "*Mechanical Properties of Pineapple Leaf Fibre Reinforced Polypropylene Composites"*, Materials and Design 27, pp. 391–396, 2006.

[10] Q.-L. Wang, "*Fractal Analysis of Polar Bear Hairs*", Thermal Scıence, Vol. 19, Suppl. 1, pp. S143-S144, 2015.

[11] He, J.-H., "*Can Polar Bear Hairs Absorb Environmental Energy?"* Thermal Scıence, Vol. 15, No. 3, pp. 911-913, 2011.

[12] Y. Cui, H. Gong, Y. Wang, D. Li, and H. Bai, *"A Thermally Insulating Textile Inspired by Polar Bear Hair"*, Advanced Materials, 30, 1706807, pp 1-8, 2018.

[13] S. M. Gamze. Ö. Nilgün, *"Hayvansal Liflerden Üretilen Giysilerin Isıl Konfor Özellikleri"*, 11. Ulusal Tesisat Mühendisliği Kongresi, 2013.

[14] S. K. Batra, "*Other Long Vegetable Fibers: Abaca, Banana, Sisal, Henequen, Flax, Ramie, Hemp, Sunn, and Coi",* Handbook of Fiber Chemistry Third Edition. Ed. M. Lewin. 453-520, 2007.

[15] Y. Bulut, U. H. Erdogan, "*Usability of Cellulose Based Natural Fibers as Reinforcement Materials in Composite Manufacturing*", The Journal of Textiles and Engineers, 18(82), 26-35, 2011.

[16] W. Jordan, P. Chester, "*Improving the Properties of Banana Fiber Reinforced Polymeric Composites by Treating the Fibers"*, Procedia Engineering 200, 283–289, 2017.

[17] N. Amir, K. A. Z. Abidin, F. B. M. Shiri, "*Effects of Fibre Configuration on*

Mechanical Properties of Banana Fibre/PP/MAPP", Natural Fibre Reinforced Polymer Composite. Procedia Engineering 184, 573 – 580, 2017.

[18] M. Ramesh, T.S. A. Atreya, U. S. Aswin, H. Eashwar, C. Deepa. "*Processing and Mechanical Property Evaluation of Banana Fiber Reinforced Polymer Composites"*, Procedia Engineering 97, 563 – 572, 2014.

[19] R. Karthick, K. Adithya, C. Hariharaprasath, V. Abhishek, *"Evaluation of Mechanical Behavior of Banana Fibre Reinforced Hybrid Epoxy Composites",* Materials Today: Proceedings 5, 12814–12820, 2018.

[20]Kogei Japan, (2019, March 10). [Online], https://kogeijapan.com/locale/en_US/kijokanobashofu/#_HISTORY (accessed 10.03.2019).

[21] Internet Article. (2019, April 7). [Online], https://www.fibre2fashion.com/industry-article/3577/banana-fibers-variability-and-fracture-behaviour

[22] J. A. Lokken, G. L. Finstad, K. L. Dunlap & L. K. Duffy, *"Mercury İn Lichens And Reindeer Hair From Alaska: 2005–2007 Pilot Survey"*, Polar Record 45 (235): 368–374, 2009.

[23] R. Goodfellow, "*Fabrıc From A Blend Of Carıbou Haır And Wool"*, United States Patent, Patent Number: 4.751.117, 1988.

[24]Internet Article. (2019, April 7). [Online], https://www.troutlore.com.au/product/natures-spirit-caribou-hair-natural/

[25]Internet Article. (2019, April 7). [Online], https://www.nps.gov/articles/mineralcontraints.htm

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

PREDICTIVE MAINTENANCE OF THE AUTOMATED SEWING MACHINES IN TEXTILE INDUSTRY

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Abstract: *One of the most used approaches to schedule maintenance is condition-based maintenance. The automated sewing machines are state-of-the-art complex machines that operate at high speeds, where vibrations and noises are generated by their moving parts. The levels of vibrations and noises increase at the high-speed working regime and when some components are worn out. Within this context, the aim of this paper was the development of a software product based on fuzzy logic to schedule the replacement of the needles of the automated sewing machines based on their condition monitoring. The research was carried out on an automated sewing machine that operated at the recommended working speed of 3500 stitches/minute. The sewing material was polyester and NM 80 sewing needles were used. Vibration measurement was performed using the Top Lab-GBDT-L device, while the Center 322 sonometer was employed to measure the level of noise. The integrated software environment R was employed to develop the software product. This software allows the establishment of the time when the replacement of these needles should be done taking into account their noise level and vibrations amplitude. An example demonstrates the effectiveness of the software product for the replacement of the needles of automated sewing machines.*

Key words: *needles, noise, vibrations, fuzzy, software.*

1. INTRODUCTION

Condition-based maintenance is one of the most used approaches to schedule maintenance in different industries [1]. In condition-based maintenance, different measures can be employed to monitor the degradation state of analyzed equipment or machines [2]. In the case of textile machines, their condition has been monitored through vibration sensors [3], resistive strain gages [4], thermographic camera [5] or sonometers [6]. Then, a prediction of their time-to-failure can be performed based on the monitoring process.

The automated sewing machines are state-of-the-art complex machines that operate at high speeds (5000-7000 stitches/minute). During operation, vibrations and noises are generated by the moving parts of automated sewing machines. The levels of vibrations and noises increase at the high-speed working regime and when some components are worn out [7].

Within this framework, the purpose of this paper was to develop a decision system based on fuzzy logic for predicting the failure of needles of automated sewing machines, considering their vibrations amplitude and noise level.

2. EXPERIMENTAL PART

The research was carried out on an automated sewing machine that operated at the recommended working speed of 3500 stitches/minute. The sewing material was polyester and NM 80 sewing needles were used. Vibration measurement was performed using the Top Lab-GBDT-L device with the vibration sensor placed on the OZ axis (Figure 1). The Center 322 sonometer was employed to measure the level of noise.

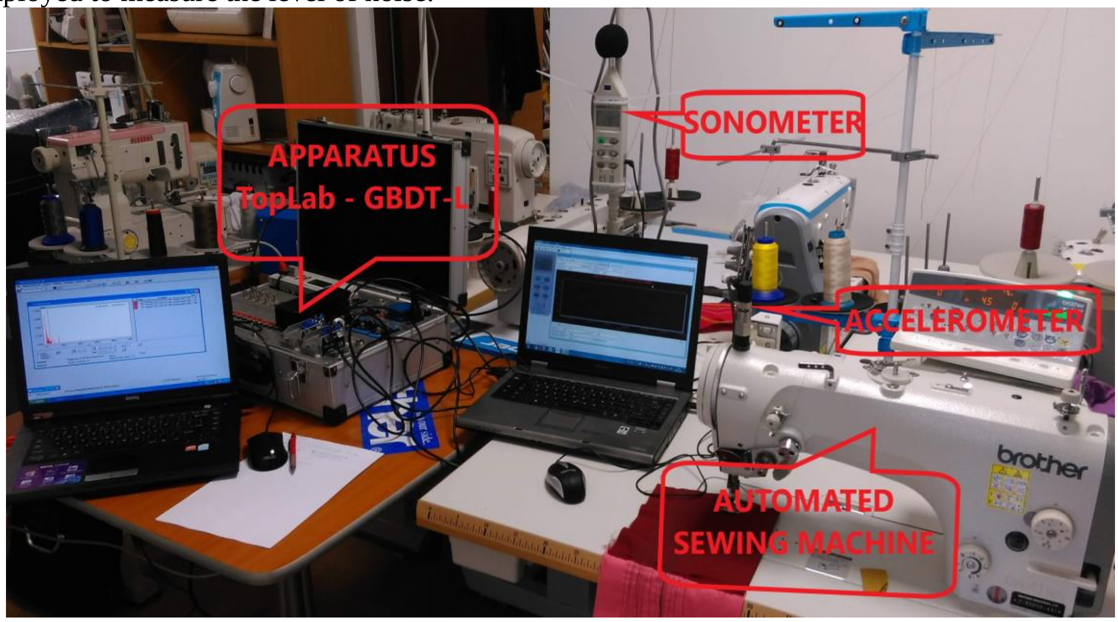
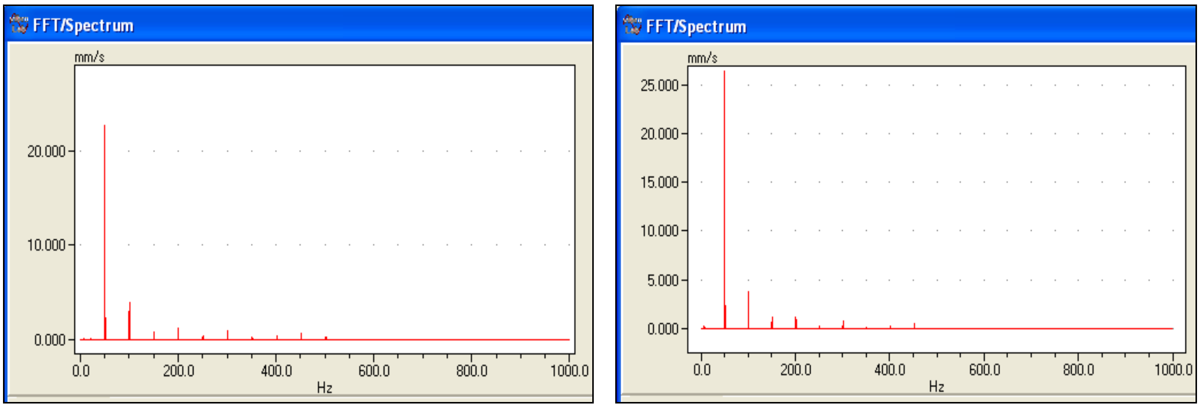


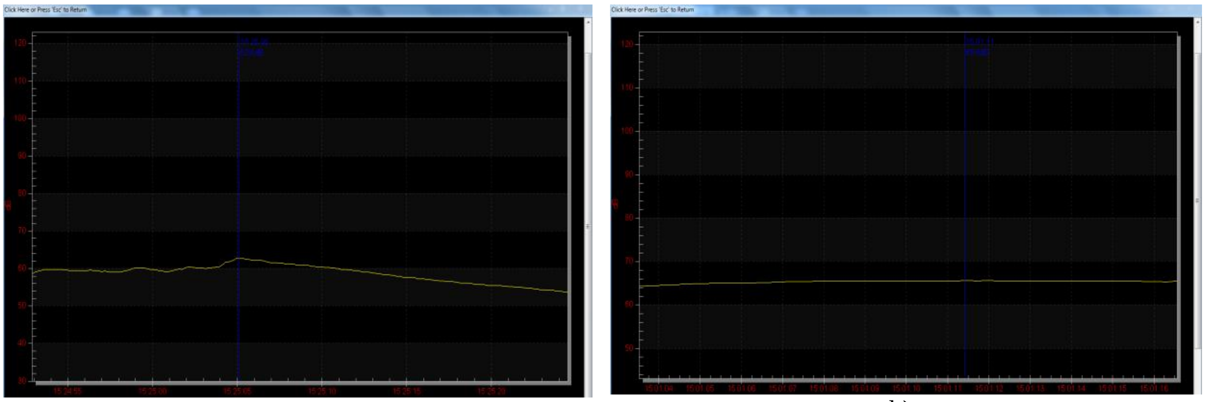
Fig. 1: *Measurement of vibration and noise level for the analyzed automated sewing machine*

The amplitude of vibrations and noise level were measured for a new needle and a defective needle. Figure 2 depicts the amplitude of vibrations for the employed needles, while figure 3 shows the noise level for the same needles.



a) b)

Fig. 2: *The amplitude of vibrations for a) new needle and b) defective needle*



a) b)

Fig. 3: *The noise level for a) new needle and b) defective needle*

3. A SOFTWARE PRODUCT BASED ON FUZZY LOGIC FOR MAINTENANCE SCHEDULING OF THE NEEDLE OF AUTOMATED SEWING MACHINE

A software product based on fuzzy logic was developed to schedule the replacement of the needles. The software determines when the needle should be replaced, depending on the vibration amplitude and the noise level. The development of this software product was achieved through the integrated software environment R.

The software product (Figure 4) contains 2 input variables (noise level expressed in db and vibration amplitude expressed in mm/s), 1 output variable (duration of operation of the needles to their replacement expressed in minutes) and 25 rules for the fuzzy rule base. Figure 5 shows the inference of the fuzzy decision system.

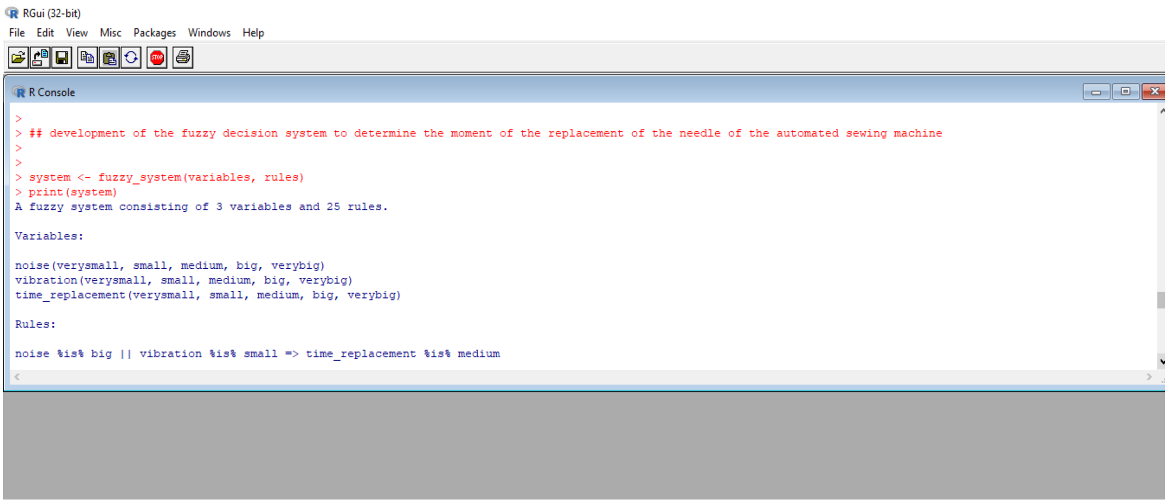


Fig. 4: *The software product for the needles replacement*

As an example, if the noise level is 64.1 dB and the vibration amplitude is 24.81 mm/s, then using the software product the replacement of the needles should be carried out after 85.49541 minutes of operation.

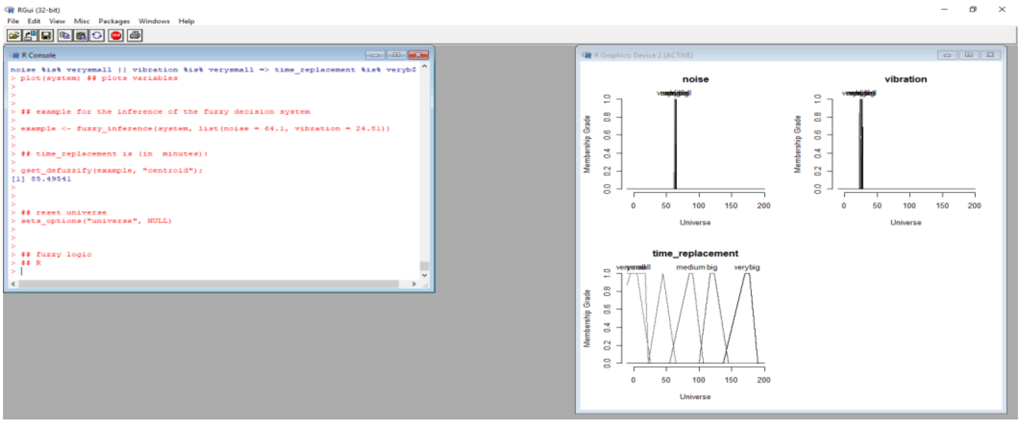


Fig. 5: *The inference rules of the fuzzy decision system for the needles replacement*

5. CONCLUSIONS

In this paper, a software product based on fuzzy logic was developed to schedule the replacement of the needles of automated sewing machines. The software product was developed using the integrated software environment R. Based on noise level and vibrations amplitude, it allows the establishment of the time when the replacement of these needles should be done. An example illustrated the employment of the software product.

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REFERENCES

[1] Prajapati, A., Bechtel, J., Ganesan, S. (2012). Condition based maintenance: a survey, Journal of Quality in Maintenance Engineering, 18(4), 384–400.

[2] Kaiser, A.K., Gebraeel, N.Z. (2009). Predictive Maintenance Management Using Sensor-Based Degradation Models, IEEE Transactions on Systems, Man, and Cybernetics—Part A: Systems and Humans, 39(4), 840-849

[3] Baron,P., Kočiško,M., Dobránsky,J. (2018). The dynamic parameters correlation assessment of the textile machine highspeed bearings in changed technological conditions, Measurement, 116, 575–585

[4] Baban,C.F., Radu,I.E., Baban,M. (2002). Integrated system for reliability-modeling of cold plastic deformation tools used in car industry, Annual Reliability and Maintainability Symposium. 2002 Proceedings (Cat. No.02CH37318), 212-216

[5] Baban,C.F., Baban,M., Suteu, M.D. (2016), Using a fuzzy logic approach for the predictive maintenance of textile machines, Journal of Intelligent & Fuzzy Systems, 30(2), 999-106

[6] Şuteu,M.D., Baban,C.F., Baban,M., Toth(Kiss),E., Pancu,R.M. (2017) Maintenance planning of the sewing needles of simple sewing machines, Annals of the University of Oradea, Fascicle Textiles, Leatherwork, XVIII(2), 99-102

[7] Talukdar, M.K.(2001). Noise pollution and its control in textile industry, Indian Journal of Fibre and Textile Research, 26(1), 44-49

ANNALS OF THE UNIVERSITY OF ORADEA
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INFLUENCE OF FUNCTIONALIZATION TECHNOLOGIES WITH NANOPARTICLES ON THE SUSTAINABILITY OF INDUCED EFFECTS

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Abstract: *Textile mats of 100% cotton, 55% polyester/ 45% cotton and 100% polyester, white and dyed, were functionalized by: CeO_2 NPs spraying technology on a test device made at UT Dresden after oleophobization with Rukostar EEF6 or Nuva N 2114 and impregnation by applying oleophobic treatment with NUVA N 2114 or Rukostar EEE 6 simultaneously with the functionalization with CeO_2NP. Analysis of the size and shape of CeO_2 NPs was achieved by using SEM electronic microscopy, TEM and dynamic light scattering (DLS) transmission microscopy. The durability of CeO_2 NPs deposition on the surface of the textile materials was studied for the initial samples compared with those tested for acid/ alkaline perspiration, washing and wear (rubbing) revealed by SEM determinations. The statistical indicator of dispersions (medium average, standard deviation, dispersion and variation coefficient) were used to compare the morphology of NPs on the surface of textiles materials (dimension and distances). The average amount of NPs deposited on the textile by the spraying technology was smaller than with the impregnation one. The antibacterial characteristics of textiles materials treated with CeO_2 in correlation with fibrous composition, color and the oleophobic agent were determined.*

Key words: *textile mats, spraying, nano-particles, functionalization, additives*

1. INTRODUCTION

The market of products using nanotechnology could reach about a thousand billion dollars a year in 2015. Nanotechnology is developing at a fast pace globally, with a short duration between the effective date of an invention and its commercialization. According to the Nanotechnology Consumer Products Inventory, over 600 such products are currently produced by 322 companies in 20 countries. Ultra-fine particles (UFPs) are a category of particles that, when inhaled, can cause negative health effects [1]. These particles have a diameter of up to 100 nm and are therefore true nanoparticles in terms of size. Their nanometre size differentiates them from large particles (with diameter of up to 10µm, PM10) and fine particles that pollute the air (with diameter up to 2.5µm, PM2.5) [2]. The most important properties of nanomaterials in nano-bio interactions are dimension, shape, purity, surface area, charge, hydrophobicity, aggregation state, crystallinity, electron energy level, and the potential to generate ROS. These properties can be correlated with the biological results according to a set of structure-activity flow diagrams, an example being shown in Fig. 1.

The surface properties of the particles determine the cellular uptake pathways, the subcellular processing mechanisms and the cytotoxicity [3,6]. The Fenton reaction is one of the mechanisms by which the metallic impurities on the CNT surface can induce ROS generation (Fig. 2)[5]

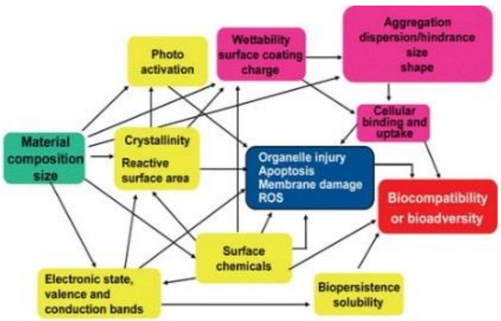

Fig. 1: *Structure-activity flow diagram*

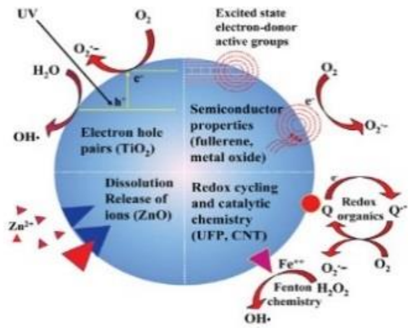

Fig. 2: *Fenton reaction*

Finally, the particle dissolution (e.g. ZnO, CdSe, Cu) can produce free ions capable of inducing ROS generation and toxic effects in cells. Fever of metal smoke may be an example of this type of toxicity [4]. Cerium was discovered in Sweden by Jöns J. Berzelius and Wilhelm von Hisinger and independently in Germany by Martin Heinrich Klaproth in 1803. The element's name comes from the asteroid Ceres, discovered two years earlier by Giuseppe Piazzi. Cerium is the most abundant of the lanthanides. It is not found freely in nature, but it is found in a series of minerals, mainly alanine, bastnaesite, monazite. From a commercial point of view, cerium is prepared by chloride electrolysis or by melted fluoride reduction with calcium. Cerium has 30 of isotopes whose half-life is known, with mass numbers of 123 to 152. Of these, three are stable, 136Ce, 138Ce and 140Ce. The most abundant isotope is 140Ce at 88,5%. SEM images of CeO2 were obtained by using the FEI Quanta 200 scanning microscope (Fig.3).

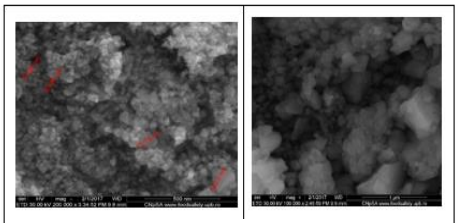

Fig.3: *SEM images*

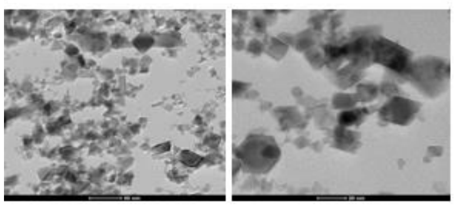

Fig. 4: *TEM images*

The TEM images in the light field (Fig. 4) on the CeO_2 NP reveal that the sample is made up of particles of a polyhedral shape with an average size of 11.86 nm ± 0.49 nm. The particles have a very large variation in size and shape (Fig. 5).

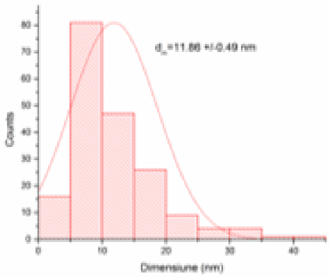

Fig. 5: *Size distribution diagram*

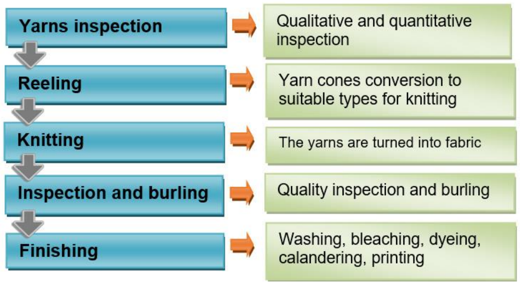

Fig.6: *Technological process*

100% cotton, 45% cotton/ 55% polyester and 100% polyester knitted fabrics were made according to the technological process presented in Fig. 6.

Table 1: *The obtained characteristics*

No.	Parameters	Variant		
		100% cotton	45% cotton/ 55% polyester	100% polyester
1	Yarn diameter, mm	0,18	0,17	0,12
2	Loop width/ loop height, mm	0,81/0,97	0,77/0,92	0,25 si 0,26/2,26
3	Stitch density, wales/50mm	62	65	217
4	Stitch density, rows/50mm	52	54	192
5	Loop length, mm	3,82	3.63	1,29
6	Mass, g/m^2	98,53	84,96	44,45
7	Coverage linear factor	21,22	21,35	35,0
8	Coverage surface factor	0,88	0,87	5,6

The knitting process was done on the 12 GG Shima Seiki SIG 123 machine and the characteristics of the obtained structures are presented in Table 1 that relives a higher values of coverage linear and surface factors of 100% polyester, compared to knits of 100% cotton and 45% cotton/ 55% polyester (35 vs. 21.22 and 21.34 respectively 5.6 vs 0.88 and 0.78).

Dispersion formula with UPW and solvent were prepared for which the following were used: 742 g UPW (MilliPure) and 1026 g ethanol (w> 99.9%) in a glass flask of 2 l; there were added 14.40 g of 2-butanone (MEK, w=9.5%), 10.80 g of HCI (w=37%) and 7.20 g of triethanolamine (w=100%); after sonication for 15 min., the dispersion was manually shaken for 1-2 minutes.

The EDS spectra for the CeO_2 dispersions in UPW/ solvent are presented in Fig. 7, show that the CeO_2 mass is of 62.0% in the UPW dispersion and of 24.5% in the solvent.

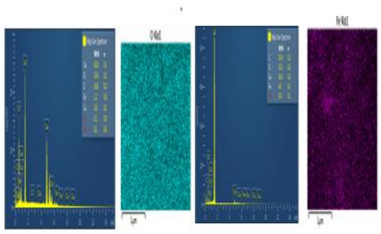

Fig. 7: *Spectre EDS-UPW /solvent*

The knitted fabrics were treated with Nuva N2114 or Rukostar EEE6 oleofobizing agents and functionalized with CeO_2 in UPW/ solvent dispersions by spraying (different steps) or impregnation (pad-roll) technology (in the same phase). For the application of CeO_2 NP by spraying technology, the equipment designed and developed by the Dresden-Germany Technical University was used. The 20x20 cm samples of 100% oleophobeized cotton knits with Nuva N 2114 and Rucostar EEE6 were spray-treated in the test chamber with CeO_2 dispersions in UPW and solvent. The spraying of various CeO_2 NP dispersions was done with 5 second spraying pulses. The treatment recipe used in pad-roll technology included: 70 g/ l Nuva N2114/ Rukostar EEE6, 20 ml/l dispersion of 5% CeO_2 NP in ethylene glycol/ water dispersion, 0.5 ml/l 60% acetic acid (1 ml/100% dog), 80% degree of take-up, drying at 110°C, condensation at 140°C for 2 min.

The influence of the treatment solution on the shape and dimensions of CeO_2 NP was studied on the Auriga model workstation produced by Carl Zeiss SMT Germany FESEM-FIB with the GEm columnal field emission source in the beam spectra. There were used: the Everhart Thornley SESI Secondary Electron Detector with Faraday Cup in sample chamber or the columnal anular inLens Secondary Electron Detector.

In Fig. 8 are presented SEM images of solutions containing NUVA N2114 and dispersion in UPW and solvent of CeO_2 NP.

The average dimensions of CeO_2 NP in the Nuva N 2114 solution and CeO_2 dispersion are lower for UPW dispersion (16.1 nm vs. 23.7 nm), but the standard deviation and coefficient of variation are higher than the NUVA solution N 2114 and CeO_2 dispersion in solvent (46.2 and 5.78% vs. 21.14 and 3.52%).

From the analysis of the statistical indices of the evolution of CeO_2 sizes in solutions of the oleofobising agent Rukostar EEE6 and their dispersions in UPW and solvent it is observed that the average size of CeO_2 in the solution of RuKostar EEE6 and dispersion in UPW is at the same level as in the dispersion in solvent, with the difference that the standard deviation and the coefficient of variation are higher (80.6 and 8.06% vs. 46.5 and 5.8%). The statistical indicators of the CeO_2 size in the Nuva N2114 solution and in the UPW dispersions and in the solvent are better than in the case of the Rukostar solution and the same type of dispersions.

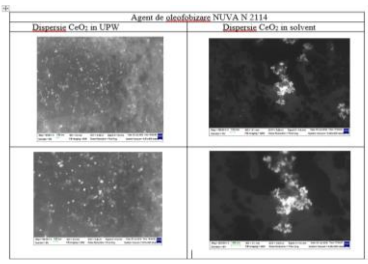

***Fig. 8**: SEM images of solutions*

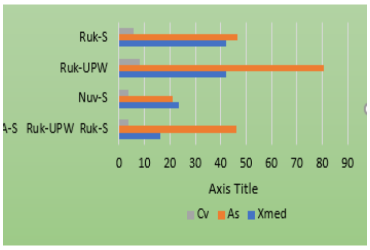

***Fig.9:** Statistical indicators*

From the analysis of the SEM images, a tendency of the NPs to agglomerate in the solvent/ polymer matrix was observed, but their morphology remains similar, respectively irregular polyhedrons and octagonal shapes (Fig. 9).

The NPs amount deposited on textile materials was analyzed by the Air ion counter and ICP-OES methods, which showed that it is less than 5 mg/kg for the spraying technology and more than 400 mg/kg for the impregnation and does not decrease significantly from the initial knits to those after the resistance tests on acid/ alkaline perspiration, washing and rubbing.

The statistical indicators of the dispersion (mean, coefficient of variation, standard deviation and dispersion) evaluated by the SEM images analysis (Fig. 10) showed the evolution of the sizes and distances between the CeO_2 NPs on the surface of the initial knits and after the resistance treatments on acid/ alkaline perspiration (Fig. 11), washing and friction (Fig. 12) which varies depending on: the nature of the dispersion and oleofobizing agents, the fibrous composition and the presence of the dyestuff on the textile support.

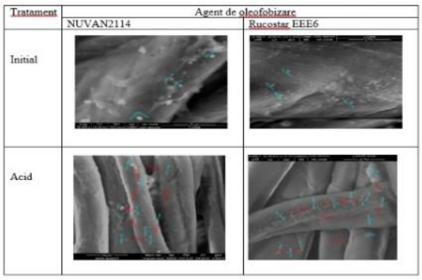

Fig. 10: *Dispersion indicators evaluation*

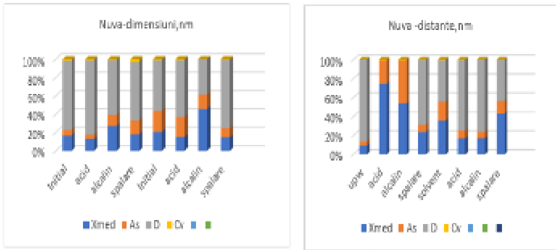

Fig. 11: *NP Evolution (perspiration)*

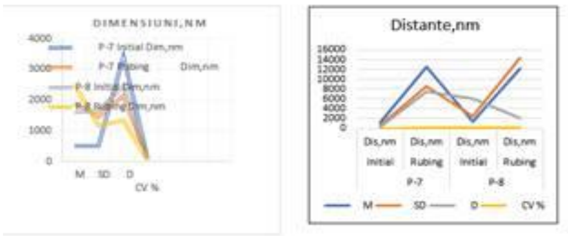

Fig. 12: *NP Evolution (washing and friction)*

Fig. 13: *Fungi*

The antifungal efficacy tests performed with Candida albicans, Trichophyton interdigitale and Epidermophyton floccosum showed that (fig.13):

- Testing for Candida albicans revealed high microbial reduction rates of over 80%, varying according to the material used (dyed/ undyed).

Thus, it could be seen that for 100% cotton, higher degrees of microbial reduction were recorded, due to a mechanical retention rate of the cells on the material (compared to polyester). At the same time, it has been observed that the presence of the dye on the material can contribute to a slightly higher degree of microbial reduction.

- Tests for interdigital Tricophyton revealed variations in the degree of reduction in both the fibrous composition and the treatment variant from which the material was part (NUVA + CeO_2 in UPW or Nuva in solvent), not respecting a particular pattern. Thus, for the variant "NUVA + CeO_2 in UPW", the highest rate of reduction of the microbial population had knitted from 45% cotton/ 55% polyester, dyed, 79.3%, and the lowest, 100% polyester with 69.28%. For the variant "Nuva + CeO_2 in solvent, the highest discount rate was presented by 45% cotton/ 55% polyester, painted with 84.19% and the lowest 45% cotton / 55% polyester, white, with 79.41%.

- The tests for Epidermophyton floccosum revealed that for the variant "NUVA + CeO_2 in UPW", the highest rate of reduction of the microbial population had knitted of 100% polyester, dyed, with 67.76%, and the lowest knit: 45% cotton/ 55% polyester, white, with 52.06%. For the "Nuva + CeO_2 in solvent" variant, the highest reduction rate was 100% cotton, dyed, with 70.57% and the lowest, the 100% polyes ter, dyed with 55.31%.

2. CONCLUSION

- Knitted materials from 100% cotton, 45% cotton /55% polyester and 100% polyester, raw and dyed were treated after oleophobic treatment or in same process with CeO_2 NP by spraying and padding technology.
- SEM and TEM analysis of CeO_2 and dispersions of CO_2 in UPW (ultrapure water) and solvent have evidenced the medium dimension (10-50 nm) and their polyhedral shape; EDS analysis has evidenced that dispersion with CeO_2 with UPW contains a greater quantity of NP (62%) when compared with solvent dispersion (24,5%). The quantity of NP deposited on knitted materials surface has evidenced a value less than 5 mg/kg at the spraying technology and a value more than 400 mg/kg at padding, which do not decrease significantly after acid/ alkaline perspiration tests, washing, rubbing tests. Statistic indicators of dispersion have evidenced the evolution of dimensions and distances between CeO_2 on surface knitting in initial phase and treated of acide/ alkaline perspiration, washing and rubbing tests, which are depending on: nature of oleophobic agent, fiber composition and presence of dyestuff on the textile material.
- The antifungal efficacy tests performed with: Candida albicans, Trichophyton interdigitale and Epidermophyton floccosum showed that these are depending on the nature of the fiber composition, the colour and treatment of the textile support.

ACKNOWLEDGEMENTS

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REFERENCES

[1] Agency Toxic Subst. Dis. Regist. (ATSDR). 2005. "*Toxicological Profile for Zinc.*"Atlanta, GA: US Dep. Health Hum. Serv. Public Health Serv http://www.atsdr.cdc.gov/toxprofiles/tp60.pdf

[2] Araujo JA, Barajas B, Kleinman M, Wang X, Bennett BJ, et al. 2008. "*Ambient particulate pollutants in the ultrafine range promote early atherosclerosis and systemic oxidative stress*", Circ. Res. 102:589–96

[3] Arimoto T, Kadiiska MB, Sato K, Corbett J, Mason RP. 2005. "*Synergistic production of lung free radicals by diesel exhaust particles and endotoxi",* Am. J. Respir. Crit. Care Med. 171:379–87

[4] Brook RD, Franklin B, Cascio W, Hong Y, Howard G, et al. 2004. "*Air pollution and cardiovascular disease: a statement for healthcare professionals from the expert panel on population and prevention science of the American Heart Association"*, Circulation 109:2655–71

[5] Brown JJ. 1988. "*Zinc fume fever",* Br. J. Radiol. 61:327–29

[6] Chen HW, Su SF, Chien CT, Lin WH, Yu SL, et al. 2006, "*Titanium dioxide nanoparticles induce emphysema-like lung injury in mice"*, FASEB J. 20:2393–95

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

A SURVEY ON WOVEN FABRIC DEFECTS

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Abstract: *There are many studies in the literature to find and identify woven fabric defects. However, the systems developed have been designed to identify only certain defects due to the large number of defect types. Moreover, a method that works well for identifying a defect type may not work for another defect type. In addition, some mistakes are easy to recognize, while others are difficult to recognize. In this study, different clustering and classification techniques have been investigated and studies detecting and recognizing fabric defects using these techniques have been investigated. Clustering algorithms are often used to detect defects while classification methods are used to recognize the defect types. When we look at the literature, the most common clustering algorithm for fabric defect recognition is K-means algorithm, while the most common classification technique is neural networks. In general, neural networks have been used in the vast majority of studies. The automatic recognition of fabric defects has not yet achieved the desired level of success. Approximately 80 percent of studies conducted on this field have only developed a model, but have not compared the method they used with other methods. So, very little work has been tested in more than one method.*

Key words: *Image processing, textile, woven fabric, clustering, classification, fabric defects.*

1. INTRODUCTION

Defect detection systems have been developed to automate systems controlled by human power. There are many advantages of automatic detection; reducing the loss of human power, decreasing the time and cost required for the control, giving more accurate results, being recorded during the detection to prevent next defects [1]. Textile is one of the areas which automatic defect detection systems are used. There are more than 70 different kinds of defects that originate from the machine during fabric production and these defects reduce the quality of the fabric. Fabric defects that occur during fabric production originate from machine or yarn. They can be divided into defects in the warp direction and defects in the weft direction. Ala and İkiz [2] have encountered 3211 defects in 140062 meters of fabric in their study.

Detection of defects based on human power brings problems. According to Dorrity et al.'s study, even a highly trained staff in the field of quality control can detect about 70% of defects in fabrics [3]. In addition, the control is limited to the working time of staff. Some of the automated systems in this area are intended to detect the defects only, and some of them classify them after detecting the defects. Due to the large number of defect types that can occur in fabrics, studies to classify defects are only making this classification for certain defect types.

In this study, the systems that detect and recognize the fabric defects are examined in two groups, one based on clustering and the other based on classification. In Section 2, we refer to clustering algorithms and examine some studies that use these algorithms to perform defect detection in the fabric. In addition to that, K-Means algorithm is examined in detail. Classification algorithms, related some studies and neural networks (the most used classification technique in fabric defect identification) are mentioned in Section 3. Besides, Section 4 mentions general conclusions.

2. CLUSTERING ALGORITHMS

Clustering is an unsupervised learning technique that groups data according to their similarities [4]. So, each cluster is a collection of similar objects. There are many clustering algorithms and they are divided into five main groups according to the methods they use. The first method is the partitioning based clustering algorithms. Clustering operation is started from one cluster that covers all objects. Then, partitioning is performed iteratively. K-Means [5], K-Medoids [6] and K-Modes [7] are the most known clustering algorithms based on partitioning. Second is the hierarchical clustering. It can performed using two types: Agglomerative and Divisive. Tree structure is used in both types. Divisive method is a top-down method while agglomerative method is bottom-up. There is one cluster in divisive method. Besides, the number of elements determines the number of clusters in agglomerative method. BIRCH (Balanced Iterative Reducing and Clustering using Hierarchies) [8], CURE (Clustering Using REpresentatives) [9], ROCK (RObust Clustering using linKs) [10] and Chamelon [11] are some of the most known hierarchical based clustering algorithms. Third is the density based clustering. Objects are divided into three groups; core, border and noise in this clustering type. Neighbourhoods are taken into account for each object. Clusters with different shapes can be discovered in density based algorithms. DBSCAN [12] and OPTICS (Ordering Points to Identify the Clustering Structure) [13] are the most known clustering algorithms based on densities. The fourth method is grid based clustering. Clusters are formed based on the grid structure [14]. Data is partitioned into cells. Clustering is done by measuring the cell densities. CLIQUE (CLustering In QUEst) [15], STING (STatistical INformation Grid) [16] and WaveCluster (WAVElet based CLUSTER) [17] are the most known grid based clustering algorithms. The fifth and the last one is model based clustering. It is assumed that data objects are created by a model. Then, they are associated with each other based on some strategies. EM (Expectation-Maximization) is the most known model based clustering algorithm [18].

According to the research done, partitioning based clustering algorithms [19], [20], [21] and model based clustering algorithms [22] are used in fabric defect detection. Bu using 45 samples, missing warp, missing weft, oil stains and holes were detected. The clusters are correctly determined when the membership degrees of the clusters are examined [19]. By using two dataset; 1st dataset: box, star and dot patterned fabrics (85 fabrics with defect, 81 fabrics without defect), 2nd dataset: three different fabric types (plain and twill jeans fabric, viscous patterned fabric and plain linen fabric) 28 fabrics with defect, 12 fabrics without defect, hole, broken end, thick bar, thin bar, multiple netting, and knot were detected with a success rate of 95% [20]. In another study [21] defects were detected with a success rate of 96% in low computation time. Eeight different defect types were detected with model based clustering giving the best and effective result [22].

2.1 K-Means Algorithm

One of the most known algorithms is K-Means algorithm. k is the number of clusters and the algorithm divides the data to k groups. At the beginning, k cluster centers are determined. Each object is assigned to the cluster, which has nearest cluster center to this object. The distance between objects and cluster centers is generally calculated using Euclidean distance formula. m is a cluster center and p is a point in a dataset. Euclidean distance between m and p is calculated. n denotes the size of the data in the equation. After all points have been assigned to the closest cluster, the new cluster centers are calculated. This process continues until the cluster centers are stable.

Although K-Means algorithm is widely used, it has some disadvantages: 1) The result depends on the k parameter input, and determining the best parameter for large and multidimensional data becomes a problem. 2) Identification of the initial cluster centers can be in various ways. Determination of the cluster center in different ways can change the result. 3) In addition to these, this algorithm does not give good results for overlapping data sets.

3. CLASSIFICATION ALGORITHMS

Classification algorithms, unlike clustering algorithms, are a supervised learning technique. The number of classes and the characteristic features of the classes are known in advance. Objects are grouped into classes whose properties are known. Some classification techniques are Decision Trees, Bayesian Classifier, Support Vector Machine (SVM), K Nearest Neighbour (KNN), and Neural Networks (NN). The most common technique used to detect fabric defects is neural network and the support vector machine is second. Decision trees are structures that divide the data into groups by applying decision rules. Each class has a label. Decision rules are applied until the elements in each class have the same label (until homogeneity in classes is achieved). In the study of Hanmandlu and his colleagues to find defects in fabrics, the features introduced by the approaches of Local Directional Patterns (LDP), Local Binary Patterns (LBP), Speeded up Robust Features (SURF) and Scale Invariant Feature Transform (SIFT) are used in the fuzzy decision tree [23]. Experimental results show that the properties obtained by the LDP approach are more successful than the properties obtained from other approaches in determining the fabric defect. Bayesian classifier performs a statistical calculation, using a quantity of training data inserted into the system before, to estimate which class the test data belongs to. The more elements the training data has, the more certain it is to find out which class the test data belongs to. The algorithm runs according to a k value entered in the K-nearest neighbour technique. For each element, the nearest k elements of this element are looked at. To find out which class an element belongs to, the k elements around it are looked up. The assignment system of this element depends on the surrounding elements, which are in majority. Distance calculations are made to find the nearest elements and the Euclidean distance measure is usually used when making this calculation. The most common classification method for detecting fabric defects is artificial neural network. Artificial neural networks are mentioned in Section 3.1. Support vector machine is divided into linear and non-linear support vector machines. In Linear SVM, the optimal decision line that divides the data into two is determined and the element to be classed is assigned to a class according to this decision line. In non-linear SVM, data is moved to a space, which has dimension larger than the size of the input space, and the multiple planes, which the data can be best separated, are searched in this space.

There are studies using classification algorithms to find the fabric defects and the type of defects: By using 128 images (70 images for training, 58 images for testing) colour yarn, spot, missing yarn and hole were detected with Bayes technique [24]. Fabrics without defects were determined with a 100% success rate. Total success rate is 99.19%. A light-weighted 100% cotton plain-woven raw fabric was used for experiments of KNN [25]. Hole, tear, nep and foreign yarn were detected. Defects were recognized with a 96% success rate. Types of the defects and locations of them were recorded in the developed interface. By using a camera with 512 × 512 pixel resolution, weft lacking, warp lacking, hole and oil stain were detected with NN [26]. The defects of warp lacking and weft lacking were recognized with a success rate of up to 95%, while the defects of hole and oil stain were recognized with a 100% success rate. By using 144 gray level images (Eight different fabric defects, 16 samples for each defect type) for network training and test steps, double ends, double picks, missing end, missing pick, hole, light filling bar, cobweb and oil stain were detected with NN [27]. Fuzzy neural network has superior classification ability than neural network according to the experiments. By using 45 samples, warp threads, weft threads, oil stains and hole were detected with NN [28]. It is seen that high performance is obtained when the system is tested using the regression curve. By mading tests on the images of fabrics, 256 × 256 pixels and 8 bit resolution, in NN, while mispick, netting multiplies and thin bar were detected for twill woven fabrics, double-weft, thin bar, broken ends and slack pick were detected for plain woven fabrics [29]. The system developed is quite successful and it has low cost. By using images taken by a camera with a 512 × 512 pixel sensor in SVM, missing yarn, spot, hole and oil stains were recognized with a 94.84% success rate. [30]. Oil patch, oil warp, broken warp, oil weft, hair and sundries were detected with SVM on 500 real fabrics [31]. The developed system is successful in finding and classifying common monochrome cloth defects. Defects were recognized with a success rate of up to 94%. By using databases of Parvis (1117 elements) and Tilda (1333 elements) in SVM, thin bar, broken end, thick bar, double weft, slack end, missing draw, wrong draw, bad selvage, oil stain, missing weft, loom fly and without defect were recognized with a success rate of 99.11% for Parvis database, while slack end, broken end, hole, rip, kink, oil stain, missing weft, unrelated corpus and without defect were recognized with a success rate of 92.87% for Tilda database [32]. By using Tilda database in SVM, broken end, hole, kink, oil stain, missing weft, unrelated corpus and without defect were detected [33]. When the LBP was used, 85.2% of the defects were successfully classified, while 79.9% of them were classified when the co-occurrence matrix was used. In addition, LBP is more advantageous in terms of computation time.

3.1 Neural Network

The artificial neural networks used for the first time in the work of McCulloch and Pitts in the 1940s have received considerable attention, especially since the 1980s. It has advantages like high learning ability, low cost, consistency, adaptability to various fields [34]. Artificial neural networks are the systems, which the working structure of the human brain is sampled and developed. The network that neurons connect to each other has the ability to learn. The learning process that the person performs from birth is modelled on artificial neural networks and the system is trained by using examples. In the literature, most of the studies to classify fabric defects use neural networks. The learning phase in the artificial neural network is performed by inputs. Each input is multiplied by its weight indicating the effect on the artificial neural cell. All the products are summed and net input is calculated. Then, the output of this cell is computed using an activation function. The output obtained in one cell can be an input of another cell. In some artificial neural networks, outputs from one layer are fed back to the previous layer. These networks are called feedback neural networks.

4. CONCLUSION

In this study, clustering algorithms, which are unsupervised learning technique, and classification algorithms, which are supervised learning techniques, are mentioned and studies using these algorithms in fabric defect recognition are examined. When we look at the literature, the most common clustering algorithm for fabric defect recognition is K-means algorithm, while the most common classification technique is neural networks. In general, neural networks have been used in the vast majority of studies. Clustering algorithms are used to detect defects [19-22], while classification methods are used to recognize the defect types [24-33]. The defects of missing warp and missing weft are recognized with a success rate of up to 95%, while the defects of hole and oil stain are recognized with a 100% success rate in the study performed by Kuo and Lee [26]. Some defect types are easily classified while recognition of some defects is difficult. It is necessary that both can classify the same defects in order to compare the performance of two studies. The study performed by Mottalib et al. [24] give the highest success rate (99.19%) according to our examinations. They use Bayesian classifier. It may be concluded that studies on fabric defect recognition using the Bayesian classifier should be increased to achieve a good level of success.

The automatic determination of fabric defects has not yet achieved the desired level of success. Approximately 80 percent of studies conducted on this field have only developed a model, but have not compared the method they used with other methods. So, very little work has been tested in more than one method.

REFERENCES

[1] Ö. Kısaoğlu, "*Fabric quality control systems*," Pamukkale University Journal of Engineering Sciences, vol. 12(2), pp. 233-241, 2006.

[2] D.M. Ala, and Y. İkiz, "*A statistical investigation for determining fabric defects that occur during production*," Pamukkale University Journal of Engineering Sciences, vol. 21(7), pp. 282-287, 2015.

[3] L. Dorrity, G. Vachtsevanos, W. Jasper, "*Real-time fabric defect detection and control in weaving processes*," National Textile Center, pp. 143-152, 1995.

[4] F.G. Yasar, and G. Ulutagay, "Challenges and possible solutions to density based clustering", in Proc. IEEE IS, 2016, pp. 492-498.

[5] J.B. MacQueen, "*Some methods for classification and analysis of multivariate observations*," in Proc. of 5th Berkeley Symposium on Mathematical Statistics and Probability, 1967, pp. 281–297.

[6] L. Kaufman, and P.J. Rousseeuw, "*Clustering by means of Medoids*", in Statistical Data Analysis Based on the L1 Norm and Related Methods, Y. Dodge, Ed. North-Holland, 1987, pp. 405–416. ISBN: 0444702733

[7] Z. Huang, "*Extensions to the k-Means algorithm for clustering large data sets with categorical values*," Data Mining and Knowledge Discovery, vol. 2(3), pp. 283-304, 1998.

[8] T. Zhang, R. Ramakrishnan, and M. Livny, "*BIRCH: An efficient data clustering method for very large databases*," in Proc. of the ACM SIGMOD, 1996, pp. 103–114.

[9] S. Guha, R. Rastogi, and K. Shim, "*CURE: An efficient clustering algorithm for large databases*," Information Systems, vol. 26 (1), pp. 35–58, 2001.

[10] S. Guha, R. Rastogi, and K. Shim, "*ROCK: A robust clustering algorithm for categorical attributes*," Information Systems, vol. 25(5), pp. 345-366, 2000.

[11] G. Karypis, E.H. Han, and V. Kumar, "*CHAMELEON: A hierarchical clustering algorithm using dynamic modeling*," IEEE Computer Journal, pp. 68-75, 1999.

[12] M. Ester, H.P. Kriegel, J. Sander, and X. Xu, "*A density based algorithm for discovering clusters in large spatial databases with noise*," in Proc. 2nd Internat. Conf. on Knowledge Discovery and Data Mining, 1996, pp. 226-231.

[13] M. Ankerst, M.M. Breunig, H.P. Kriegel, and J. Sander, "*OPTICS: Ordering points to identify the clustering structure*," in Proc. of the 1999 ACM SIGMOD, 1999, pp. 49–60.

[14] T. Sajana, C.M. Seela Rani, and K.V. Narayana, "*A survey on clustering techniques for big data mining*," Indian Journal of Science and Technology, vol. 9(3), pp. 59-65, 2016.

[15] R. Agrawal, J. Gehrke, D. Gunopulos, and P. Raghavan, "*Automatic subspace clustering of high dimensional data*," Data Mining and Knowledge Discovery, vol. 11(1), pp. 5-33, 2005.

[16] W. Wang, J. Yang, and R. Muntz, "*STING: A statistical information grid approach to spatial data mining*," in Proc. of the 23rd VLDB Conference, 1997, pp. 186- 195.

[17] G. Sheikholeslami, S. Chatterjee, and A. Zhang, "*WaveCluster: A multiresolution clustering approach for very large spatial databases*," in Proc. of the 24th VLDB Conference, 1998, pp. 428-439.

[18] A.P. Dempster, N.M. Laird, and D.B. Rubin, "*Maximum likelihood from incomplete data via the EM algorithm*," Journal of the Royal Statistical Society, vol. 39(1), pp. 1-38, 1977.

[19] S. Faouzi, "*Classification of Fabric Defects Using Image Analysis and Fuzzy C-Means Method*", presented at the Conf. of Applied Research on Textile, Hammamet, Tunisia, 2014.

[20] A.A. Hamdi, M.S. Sayed, M.M. Fuad, and M.M. Hadhoud, *"Unsupervised Patterned Fabric Defect Detection using Texture Filtering and K-Means Clustering"*, presented at the Int. Conf. on Innovative Trends in Computer Engineering, pp. 130-144, 2018.

[21] S. Thorave, and M.S. Biradar, "*New Technology for Fabric Defect Detection Based on K-means Algorithm*," IOSR Journal of Engineering, vol. 4(3), pp. 15-20, 2014.

[22] J.G. Campbell, C. Fraley, D. Stanford, F. Murtagh, and A.E. Raftery, "*Model-Based Methods for Textile Fault Detection*," International Journal of Imaging Systems and Technology, vol. 10, pp. 339-346, 1999.

[23] M. Hanmandlu, D.K. Choudhury, and S. Dash, "*Detection of fabric defects using fuzzy decision tree*," International Journal of Signal and Imaging Systems Engineering, vol. 9(3), pp. 184-198, 2016.

[24] M.M. Mottalib, T. Habib, M. Rokonuzzaman, and F. Ahmed, "*Fabric Defect Classification with Geometric Features Using Bayesian Classifier*", in Proc. of 3rd International Conference on Advances in Electrical Engineering, 2015, pp. 137-140.

[25] K. Yıldız, A. Buldu, and M. Demetgul, "*A thermal-based defect classification method in textile fabrics with K-nearest neighbor algorithm*," Journal of ındustrial Textiles, 2014.

[26] C.F.J. Kuo, and C.J. Lee, "*A Back Propagation Neural Network for Recognizing Fabric Defects*," Textile Res. J., vol. 73(2), pp. 147-151, 2003.

[27] C.C. Huang, and I.C. Chen, "*Neural Fuzzy Classification for Fabric Defects,*" Textile Res. J., vol. 71(3), pp. 220-224, 2001.

[28] M. Jmali, B. Zitouni, and F. Sakli, "*Fabrics Defects Detecting using Image Processing and Neural Networks*," Information and Communication Technologies Innovation and Application, 2014. DOI: 10.1109/ICTIA.2014.7883765.

[29] A. Kumar, "*Neural network based detection of local textile defects*," Pattern Recognition, vol. 36, pp. 1645-1659, 2003.

[30] H. Abdellah, R. Ahmed, and O. Slimane, "*Defect Detection and Identification in Textile Fabric by SVM Method*," IOSR Journal of Engineering, vol. 4(12), pp. 69-77, 2014.

[31] T. Dongli, X. Zhitao, Z. Fang, G. Lei, and W. Jun, "*Cloth Defect Classification Method Based on SVM,*" International Journal of Digital Content Technology and its Applications, vol. 7(3), pp. 614-622, 2013.

[32] V. Murino, M. Bicego, and I.A. Rossi, "*Statistical classification of raw textile defects*," in Proc. of the 17th International Conference on Pattern Recognition, 2004. DOI: 10.1109/ICPR.2004.1333765

[33] Y. Ben Salem, and S. Nasri, "*Woven Fabric Defects Detection based on Texture classification Algorithm*", presented at the 8th International Multi-Conference on Systems, Signals & Devices, Germany, 2011.

[34] A.K. Jain, J. Mao, and K.M. Mohiuddin, "*Artificial Neural Networks: A Tutorial*," Computer, vol. 29(3), pp. 31-44, 1996.

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

MECHANICAL AND MORPHOLOGICAL PROPERTIES OF SOLUABLE STARCH BASED NANOFIBERS

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Abstract: *Starch is one of the most important renewable and environmentally friendly source in sustainable societies, in addition to its remarkable potential to manufacture nanofiber through electrospinning method. This method is an inexpensive and simple process for the fabrication of micro- and nano-scale fibers. The current study refers that soluable starch (SS)/Poly (vinyl alcohol) (PVA) nanomats were fabricated in the same process parameter values that flow rate, voltage and distance using electrospinning method.*
In this study, processability, tensile strength and morphology of five different mass ratios (10:90, 15:85, 20:80, 25:75, 30:70) of SS/PVA solution were investigated. Also, viscosity, conductivity values and fiber diameters of samples were compared according to starch content in solution. Surface morphologies of nanofibers were determined by Field emission scanning electron microscope (FE-SEM) and mechanical properties of the resultant products were characterized by Universal test machine.
The results showed that uniform and bead-free nanofibers were produced at the sample 2 (15:85) mass ratio of SS/PVA. A better vertical mechanical strength was obtained at sample 2 (15:85) mass ratio as compared with other samples. On the other hand, sample 3 (20:80) had the slighly highest horizontal mechanical strength than sample 2. The average diameters of electrospun samples ranged from 79.6 to 136nm.

Key words: *electrospinning, starch, PVA, tensile strength, morphology*

1. INTRODUCTION

Electrospinning which an inexpensive and simple synthesis method for one-dimensional (1D) nanostructures such as nanofibers.

Starch which is a polysaccharide [1] is widely obtained from many natural sources i.e. cassava, corn, potatoes, and wheat. It has many advantages as its nontoxicity, biodegradability [2][3] and long-term durability so that it uses as a filler to strengthen plastics or as a matrix to develop composite structure. Besides its advantages, starch offer many disadvantages including water sensitivity, brittleness, and poor mechanical properties [4].

Poly (vinyl alcohol) (PVA) is an electrospinable, biodegradable [5], biocompatible, nontoxic and synthetic water soluble polymer[6] that is generally used for biomedical applications in tissue engineering and wound dressing [7][8][9][10][11].

In the present study, nanofibers that are the blends of PVA and soluable starch (SS) in the different mass ratios (SS:PVA; 10:90, 15:85, 20:80, 25:75, 30:70) fabricated using same electrospinning process parameters such as voltage, flow rate and distance. Solution characterization tests that are viscosity and electrical conductivity were performed. Then, morphological and mechanical strength studies of nanomats carried out.

2. MATERIALS AND METHODS

2.1. Material

Nanofiber solution was prepared with PVA polymer granules and soluable starch. Poly (vinyl alcohol) (PVA) was purchased with molecular weight of 70.000 g/mol. Soluable starch was dissolved in Dimethyl sulfoxide (DMSO) (purity ≥ 99.9 %) . All these ingredients were supplied by Merck firm.

2.2. Methods

Firstly, PVA solution 12% (w/v) was prepared by dissolving of PVA polymer granules in distilled water at 80℃ under constant stirring for 2 hr. Following that, %10 w/v starch was dissolved in (DMSO) at 100°C for 1 hour. Lastly, the prepared solutions were mixed in different mass ratio such as 10:90, 15:85, 20:80, 25:75 and 30:70 (Starch:PVA) in Table 1.

Electrospinning was performed in Inovenso, NE300 Nanospinner laboratory type machine at room temperature using a cylindrical collector covered with oily paper. The five prepared solutions were fed to a 10 ml plastic syringe which connected to a stainless steel needle for electrospinning. The electrospinning parameters such as feed rate, voltage and needle to collector distance were fixed as 0.4 ml/h, 25 kV, and 13 cm respectively. Total production time for each sample adjusted as three hours.

Table 1: *Process parameters of solution*

Sample No	Starch/PVA	Flow (ml/h)	Voltage (kV)	Distance(cm)	Time (h)
1	10: 90	0,4	25	13	3
2	15: 85	0,4	25	13	3
3	20: 80	0,4	25	13	3
4	25: 75	0,4	25	13	3
5	30: 70	0,4	25	13	3

The viscosity of the solutions was determined by using viscometer (Brookfield DV-E Viscometer, USA) at room temperature. The viscosity measurement was performed with S21 spindle at 100rpm. The electrical conductivity values of the solutions were measured by conductivity meter (WTW Cond 3110, Germany) at room temperature.

Morphological characterization of the electrospun nanofibers were done using Field Emission Scanning Electron Microscopy (FEI SIRION XL30 FEG). The mechanical properties (Tensile strength and elongation at break) of electrospun nanomats in the horizontal and vertical directions were tested with Instron 4411 Universal Test using 30 mm/min stretching speed.

Nanomats were cut into rectangular pieces as 50 x 10 mm (length x width) at room temperature. Five different samples were used to analyze each sample.

3. RESULTS AND DISCUSSION

The nanofiber structure and properties are influenced by the viscosity of polymer solution [12]. It is reported in the literature that increase in starch concentration resulted an increase in viscosity and conductivity [1]. But in this study, viscosity and conductivity decrease with increasing amount of SS shown in Figure 1. The reason for this is thought to be caused by SS (soluable) rather than starch. Liu and others reported that the increase in starch ratio decreases viscosity and nanofiber diameter by using soluable starch [13].

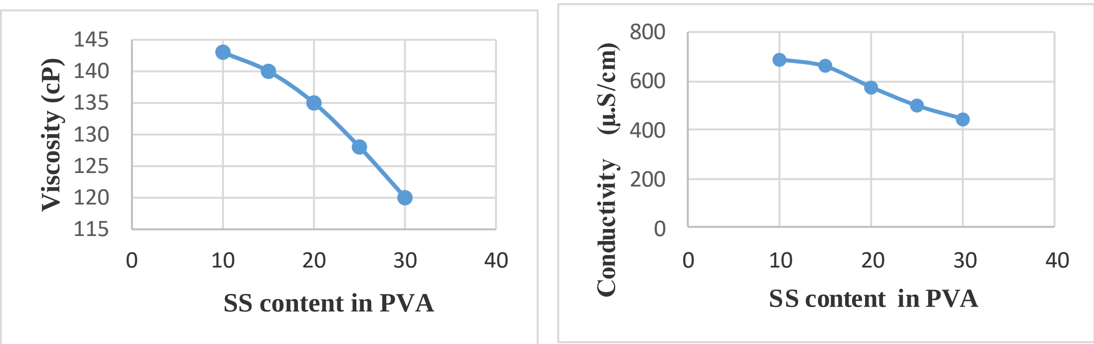

Fig. 1*: The viscosity and conductivity of the polymer solution with the changes of SS ratios in PVA*

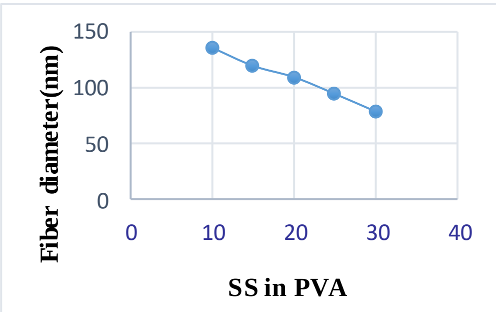

Fig.2*: Average fiber diameter of samples with the changes of SS ratios in PVA*

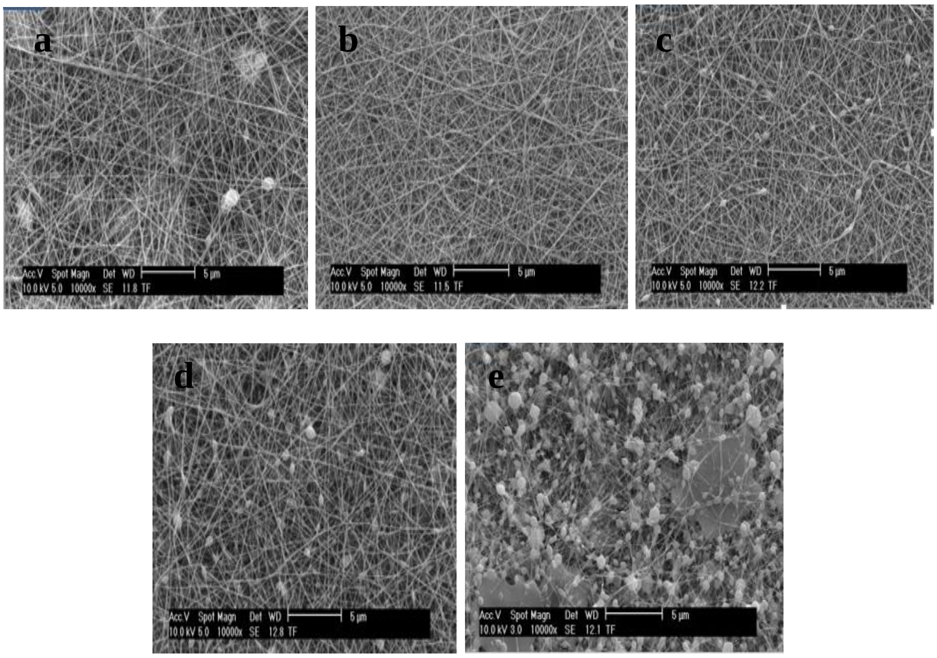

***Fig 3**: Scanning electron microscope images of the nanofibers at x10.000 of magnification*

a)10:90, b)15:85, c)20:80, d)25:75, e)30:70

The SEM image of SS/PVA nanofibers with various SS ratio are given in Figure 3. Scanning electron microscope images of sample 2 (15:85) (Figure 3 (b)) indicate that the nanofibers are smooth, bead-free, and randomly oriented. However, as seen in Figure 2 sample 1 (10:90) has shown slightly better results than sample 2 (15:85). On the other hand, the high ratio of soluable starch sample 5 (30:70) exhibits too much beads, and nonuniform nanofibers because of low viscosity, conductivity and fiber diameter.

The fibers diameter which was calculated on the SEM image by using the Image J illustrated in Figure 2. The highest fiber diameter (136 ± 10 nm) belong to sample 1 (10:90). The thinner fibers belong to sample 5 (30:70). The average fiber diameter decreases from 136 to 79,6. In this study, it was observed that the decrease in viscosity decreases the produced nanofiber diameter. And, as the conductivity of the solution decreased, the nanofiber diameter decreased.

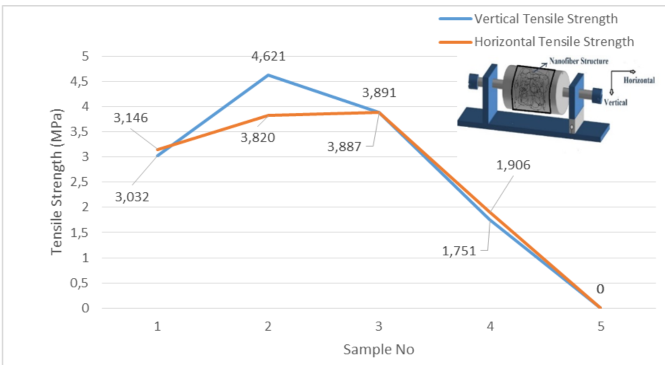

***Fig 4:** Mechanical properties and vertical-horizontal directions of samples*

The mechanical properties of SS/PVA samples are given in Figure 4. It was showed that the highest vertical tensile strength was obtained for sample-2 (15:85 SS/PVA), followed by sample 3 (20:80 SS/PVA), sample 1 (10:90 SS/PVA) and lastly sample 4 (25:75 SS/PVA). It was indicated that the highest horizontal tensile strengths was acquired respectively sample 3, sample 2, sample 1 and sample 4. Mechanical strength of sample 5 cannot be measured the reason of a very brittle structure. The reduction in average fiber diameter leads to this dramatic decrease of the tensile strength. The mechanical strength decreased generally as the amount of SS increased.

4. CONCLUSIONS

SS nanofibres were fabricated successfully by blending with PVA to enhance the spinnability of the starch using electrospinning technique. Measurements showed that the mass-varying proportions of SS in solution had a significant effect on solution properties (viscosity and conductivity), fiber diameter, morphology and tensile strength. An increase of SS proportion in solution is able to reduce nanofiber diameter. Uniform bead free SS/PVA nanofibers were obtained at the concentration of SS (10 w/v %) and PVA (12 w/v %) in the mass ratio of 15:85. Sample 5 (30:70) is fragile and does not have enough strength because of very few nanofibers and so many beads. Sample 2 (15:85) has the best total strength due to non-bead and uniform structure of nanomat. A higher ratio of SS in sample 5 (30:70) resulted non-uniform and more beaded structure, and lower mechanical strength of nanofibers than the rest of sample.

So far, many researches have been conducted on nanofibers and electrospinning; still, more controllable, more cost effective, more environmentally friendly and safer methods are of essential importance to future applications of nanofibers [14]; therefore with this current study we believe that future studies will be high interest of biodegradable nanofibres i.e. SS starch films.

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REFERENCES

[1] V.R. Giri Dev, T. Hemamalini, ‘’*Porous electrospun starch rich polycaprolactone blend nanofibers for severe hemorrhage’’*, International Journal of Biological Macromolecules, vol. 118, pp. 1276-1283, Jun 2018.

[2] M. El Achaby, N. El Miri, A. Aboulkas, M. Zahouily, E. Bilal, A. Barakat, A. Solhy, ‘*’Processing and properties of eco-friendly bio-nanocomposite films filled with cellulose nanocrystals from sugarcane bagasse*’’, International Journal of Biological Macromolecules, vol. 96, pp. 340-352, March 2017.

[3] B. Montero, M. Rico, S. Rodríguez-Llamazares, L. Barral, R. Bouza, ‘’Effect of nanocellulose as a filler on biodegradable thermoplastic starch films from tuber, cereal and legume’’, Carbohydrate Polymers, vol. 157, pp. 1094-1104, February 2017.

[4] H. Kargarzadeh , J. Huang , N. Lin , I. Ahmad , M. Mariano, A. Dufresne, S. Thomas, A. Gałeski, ‘’*Recent Developments ˛ in Nanocellulose-based Biodegradable Polymers, Thermoplastic Polymers, and Porous Nanocomposites’’*, Progress in Polymer Science, vol. 87, pp. 197-227, December 2018

[5] C.C DeMerlis, D.R. Schoneker, ‘’*Review of the oral toxicity of polyvinyl alcohol (PVA)’’,* Food and Chemical Toxicology, vol. 41, pp. 319–326 , Mar 2003

[6] S. Estevez-Areco, L. Guz, R. Candal , S. Goyanes, ‘’*Release kinetics of rosemary (Rosmarinus officinalis) polyphenols from polyvinyl alcohol (PVA) electrospun nanofibers in several food simulants’’*, Food Packaging and Shelf Life, vol. 18, pp. 42-50, December 2018.

[7] A.M. Abdelgawad, S.M. Hudson, O.J. Rojas, ‘’*Antimicrobial wound dressing nanofiber mats from multicomponent (chitosan/silver-NPs/polyvinyl alcohol) systems’’*, Carbohydrate Polymers, vol. 100, pp. 166-178, January 2014.

[8] R.P. Gonçalves, W.H. Ferreira, R.F. Gouvêa, C.T. Andrade, ‘’*Effect of chitosan on the properties of electrospun fibers from mixed poly(vinyl alcohol)/chitosan solutions’’*, Materials Research, vol. 20, pp. 984-993, May 2017

[9] C. Zhang, X. Yuan, L. Wu, Y. Han, J. Sheng, ‘’*Study on morphology of electrospun poly(vinyl alcohol) mats’’*, European Polymer Journal, vol. 41, pp. 423-432, March 2005.

[10] Y.-T. Jia, J. Gong, X.-H. Gu, H.-Y. Kim, J. Dong, X.-Y. Shen, ‘’*Fabrication and characterization of poly (vinyl alcohol)/chitosan blend nanofibers produced by electrospinning method’’*, Carbohydrate Polymers, vol. 67, pp. 403-409, February 2007.

[11] S. Azmi, S.I.A. Razak, M.R. Abdul Kadir, N. Iqbal, R. Hassan, N.H.M. Nayan, A.H. Abdul Wahab, S. Shaharuddin, ‘’*Reinforcement of poly(vinyl alcohol) hydrogel with halloysite nanotubes as potential biomedical materials’’*, Soft Materials, vol. 15, pp. 45-54, Nov. 2017.

[12] E. Yeniay, L. Öcal, E. Altun, B. Giray, F.N. Oktar, A.T. Inan, N. Ekren, O. Kilic and O. Gunduz, ‘’*Nanofibrous wound dressing material by electrospinning method’’*, International Journal of Polymeric Materials and Polymeric Biomaterials, 2018.

[13] Z. Liu, J.H. He, ‘’*Polyvinyl alcohol/starch composite nanofibers by bubble electrospinning’’*, Thermal Science, vol. 18, 2014, pp. 1473–1475.

[14] R. Keskin, I, Gocek, “*Nanofibre Production(Review)”,* Annals of The University of Oradea Fascicle of Textiles , Leatherwork, 2016, pp.81-86.

ANNALS OF THE UNIVERSITY OF ORADEA
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AN APPROACH FOR PROGRAMMING FOOTWEAR PATTERNS CUTS

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Abstract: *The saving of leather, an extremely important objective in footwear manufacturing, requires following certains steps in the process of cutting the component parts of a footwear article in order to obtain better use of the leather surface. With this regard, the paper presents how to program the cuts of the outer parts of a shoe item in the cutting department, respectively a model of women shoes. For the chosen item, there were done single cuts for one number of size (10 options), as well as combined cuts of two distinct sizes (45 options).*
Programming uppers cuts consists in their practical realization, followed by choosing the optimal cuts in order to obtain the best global utilisation index.
The value of the global utilisation index depends on the values of the utilisation indices of the simple and combined cutting ways, the programming strategy and the iteration mode of the cutting options.
By using the simple and combined cuts, for the developed program resulted a 72.04% global utilization index versus 70.64%, obtained by scheduling only single cuts, requiring a quantity of 91 hides. In the case of cuts options with higher utilisation indices, a judicious programming strategy can lead to an efficient cutting, close to the best automatic data processing program.

Key words: *cuts, utilisation index, optimal nesting, programming, iteration*

1. INTRODUCTION

When using leather hides in the manufacture of footwear, an optimum nesting of the outerparts is required in the process of uppers cutting, in order to obtain the best utilisation index. The cutting of uppers is the process which cut out the patterns from specified leather hide for making shoes.

The value of the utilisation index depends on the patterns nesting option, so that a maximum utilisation of the leather surface results during cutting [1].

The nesting of the patterns on the leather surface is conditioned by the contour and the area of the hide, the topographical regions and the presence of flaws, the outline of the patterns and their positioning restrictions in the topographic areas of the leather, as well as the ways of combining the size numbers between them [1, 2].

Programming the cuts of the outer parts of the upper assembly for a shoe item implies two distinct stages [3, 5]:

a) making all possible options using both simple cut (single size number) and combined (two distinct size numbers of the same shoe);

b) choosing the optimized cutting options so that to cut the quantities of semi-finished products required for the manufacturing program in order to obtain the best global use index.

This paper presents the results of programming the cuts of the outer parts of a shoe item, respectively a women shoes model, in the cutting department of flexible footwear patterns.

2. CUTTING PATTERNS

For the chosen item, respectively a shoe model for women, of sizes in metric system 23, 23.5,…………….., 27.5, there have been done both simple cuts of a single size (10 options), as well as combined cuts of two distinct size numbers (45 options), presented in table nr.1.

Table 1: *Different cuts*

N (cm)	Identification of simple and combined cutting									
23	C_1									
23.5	C_2	C_{11}								
24	C_3	C_{12}	C_{20}							
24.5	C_4	C_{13}	C_{21}	C_{28}						
25	C_5	C_{14}	C_{22}	C_{29}	C_{35}					
25.5	C_6	C_{15}	C_{23}	C_{30}	C_{36}	C_{41}				
26	C_7	C_{16}	C_{24}	C_{31}	C_{37}	C_{42}	C_{46}			
26.5	C_8	C_{17}	C_{25}	C_{32}	C_{38}	C_{43}	C_{47}	C_{50}		
27	C_9	C_{18}	C_{26}	C_{33}	C_{39}	C_{44}	C_{48}	C_{51}	C_{53}	
27.5	C_{10}	C_{19}	C_{27}	C_{34}	C_{40}	C_{45}	C_{49}	C_{52}	C_{54}	C_{55}

After nesting the patterns on the entire surface of the hide so that their number ensures a whole number of footwear pairs for the number of size considered, the utilisation index was evaluated with the foolowing equation [1] :

$$I_u = \frac{nA_S}{A_P}100, \ /\%/ \quad \textbf{(1)}$$

where: Iu – utilisation index of the leather surface, /%/;

n – the number of entire products (pairs) arranged on the leather surface;

AS – set area (the area of the net surface of the patterns for one product), /dm2/;

AP – area of the leather hide, /dm2/.

The basic principles of programming is [4]:

- ✓ Prioritizing the quantities of semi-finished products for cutting at best utilisation indices;
- ✓ Distribution in decreasing order of utilisation indices until the quantities of the programmed semi-finished products are finished.

For this purpose, table 2 is created with lines corresponding to the size numbers and columns corresponding to the cuts options. Table 2 is completed with columns that include the pairs required by size numbers for a 1000-pairs program, order of lines iteration and programmed semi-finished goods, as well as lines for columns order iteration and the need of hides to be programmed.

Thus, table 2 shows the number of pairs in the cases at the intersection of the column lines, both for single cuts and for combined cuts, and in some cases the quantities to be programmed are also marked.

3. PROGRAMMING CUTS OPTIONS

The cutting option with the best utilisation index is Iu = 74.9%, which implies cutting 10 pairs of size N = 27 for the chosen article on a hide leather surface of 142 dm^2. The pairs needed for size number 27 is 55 pairs, 6 hides being programmed.

Table 2: *Types of cutting*

Number of pairs	Order of lines iteration	N [cm]	Simple and combined cuts									
			C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
50	III	23	12	6	6	6 48	5	5	5	5	5	3
70	-	23.5		6								
130	VII	24			6							
145	IX	24.5				6 48						
155	IV	25					6					
145	VIII	25.5						5				
115	II	26							5			
90	V	26.5								5		
55	I	27									5	
45	VI	27.5										6
U[%]			69.4	70.6	71.9	73.2	68.7	70.0	64.2	65.3	66.0	63.6
Order of columns iteration						III						
Number of leather hides, units						8						

Table 2 *(continuation)*

Number of pairs	Order of lines iteration	N [cm]	Simple and combined cuts								
			C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}
50	III	23									
70	-	23.5	12	5	5	5	5	4 69	5	3	3
130	VII	24		6							
145	IX	24.5			6						
155	IV	25				6					
145	VIII	25.5					6				
115	II	26						7 119			
90	V	26.5							5		
55	I	27								6	
45	VI	27.5									6

U[%]	71.09	67.2	68.5	69.7	71.3	73.4	66.3	62.9	64.3
Order of columns iteration						II			
Number of leather hides, units						17			

Table 2 *(continuation)*

Number of pairs	Order of lines iteration	N [cm]	Simple and combined cuts									
			C_{20}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}
50	III	23										
70	-	23.5										
130	VII	24	11	6	6	8 136	8	4	5	4		
145	IX	24.5		5							11 99	5
155	IV	25			5							5
145	VIII	25.5				3 51						
115	II	26					3					
90	V	26.5						6				
55	I	27							5			
45	VI	27.5								6		
U[%]			68.3	69.3	70.3	70.3	70.8	68.5	60.0	71.1	68.3	65.2
Order of columns iteration						VII					IX	
Number of leather hides, units						17					9	

Table 2 *(continuation)*

Number of pairs	Order of lines iteration	N [cm]	Simple and combined cuts								
			C_{30}	C_{31}	C_{32}	C_{33}	C_{34}	C_{35}	C_{36}	C_{37}	C_{38}
50	III	23									
70	-	23.5									
130	VII	24									
145	IX	24.5	5	6	4	4	5				
155	IV	25						11 154	5	4	5
145	VIII	25.5	5				5		5		
115	II	26		4						4	
90	V	26.5			6						5
55	I	27				6					
45	VI	27.5					5				
U[%]			65.2	66.5	66.7	71.4	70.6	70.6	72.9	67.6	68.9
Order of columns iteration							IV				
Number of leather hides, units							14				

Table 2 *(continuation)*

Number of pairs	Order of lines iteration	N [cm]	Simple and combined cuts									
			C_{39}	C_{40}	C_{41}	C_{42}	C_{43}	C_{44}	C_{45}	C_{46}	C_{47}	C_{48}
50	III	23										
70	-	23.5										
130	VII	24										
145	IX	24.5										
155	IV	25	4	4								
145	VIII	25.5			10 20	5	3	3	6 66			
115	II	26				5				10	4	4
90	V	26.5					7				6	
55	I	27	6					7				5
45	VI	27.5		6					4 44			
U[%]			71.5	72.6	69.7	69	71.6	73.1	72.1	70.6	71	65.7
Order of columns iteration									VI			
Number of leather hides, units									11			

Table 2 *(continuation)*

Number of pairs	Order of lines iteration	N [cm]	Simple and combined cuts							Programmed semi-finished goods [pairs]
			C_{49}	C_{50}	C_{51}	C_{52}	C_{53}	C54	C_{55}	
50	III	23								48
70	-	23.5								69
130	VII	24								136
145	IX	24.5								147
155	IV	25								154
145	VIII	25.5								137
115	II	26	4							119
90	V	26.5		10 90	5	5				90
55	I	27			5		10 60	5		56
45	VI	27.5	5			4		4	9	44
U[%]			66.8	65.7	73.8	67.4	74.9	65.5	59.4	Programmed hides, 91 units
Order of columns iteration				V			I			
Number of leather hides, units				9			6			

Thus, it is marked 60 in the case formed at the intersection between the line corresponding to N = 27 with the column 53.

Also, in column 53 it will be marked the amount of 6 corresponding to the need of the hides, the first step of t iteration being completed. In order to be able to identify later the steps of the iteration, I is marked in the column of line iteration.

Consistently this stated principle is followed by searching the cuts in the descending order of options with the best utilisation index, respectively the cutting option with Iu= 73.8%. This cutting option can not be used because the size number N = 27 has been completely exhausted through programming from step I.

According to Table 2, the next cutting option in descending order of utilisation indices is the combined cutting between size numbers 23.5 and 26 with the Iu index = 73.4%. In this case from the hide surface a number of 4 pairs is obtained for N = 23.5 and 7 pairs for the size number N = 26. In the column 16 it is marked 69 at the intersection with the line corresponding to 23.5 and 119 at the intersection with the line corresponding to the size number N = 26. “II” is marked in the line iteration column and the quantity of 17 hides programmed at that step. This procedure is repeated till all the quantities of semi-finished products are completely programmed.

For this program the weighted average of the utilisation indices is calculated, obtaining the global utilisation index [4, 5]:

$$I_{ug}=\frac{\Sigma x_j\, I_{uj}}{\Sigma x_j} \qquad \textbf{(2)}$$

where : xj – the programmed quantities of hides ;
Iuj – utilisation indices for cutting options

By using simple and combined cuts options, 91 hides are needed in the developed cutting program, the global utilisation index being 72.04% compared to 70.64%, obtained by programming only simple cuts.

4. CONCLUSIONS

The value of the global utilisation index of the program depends obviously on the values of the utilisation indices of single and combined cuts.

Also, the value of this index depends on the programming strategy, the iteration mode of the cutting options, as shown in table 2.

Considering cuts with higher utilisation indices, a judicious programming strategy can lead to an efficient cutting program, close to the best automatic data processing program.

REFERENCES

[1] Harnagea F., Harnagea M.C., “*Bazele tehnologiei confecţiilor din piele și înlocuitori – Lucrări practice*”, Editura,, Performantica”, Iași 2013, p.19-24

[2] Volocariu R.S., *Procese de fabricaţie în industria confecţiilor din piele,* Editura ,,Gh.Asachi”, Iaşi 1999, p.65-69

[3] Rusu C., Frunză V., *Management și ingineria sistemelor de producție*, Iași 1991, p. 14-21

[4] Harngea F., Ionescu C., “*Programarea debitării reperelor ansamblului superior al încălţămintei”,*Al V-lea S impozion naţional Chimia și tehnologia pieilor, înlocuitorilor și confecţiilor din piele și înlocuitori, vol.II, Iași , 1989, p.242-248

[5] Greciuc T., “*Programarea debitării semifabricatelor din foi*,” rev. Industria ușoară, nr.7, 1984

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

EVOLUTION OF E-COMMERCE IN EUROPEAN UNION

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Abstract: *In this paper we analyzed the evolution of the sales concept. This concept has evolved over the last fifty years, and has undergone radical changes in recent decades. If before sales include selling space, where was a seller, merchandise and a buyer, today consumer can buy through internet and in this way he can buy faster and is no longer necessary the presence of a seller. European Comission proposed to creat a free digital market where the buyers can shop online out of borders and companies can sale online wherever in EU. Propose in 2015, the strategy regarding unique online market has became the base an a european digital society unite and sustenaible. Internet penetration growth in Europe is increasing at a steady pace and in this condition many more consumers are buying online and many more retailers are selling online. After implementing the strategy, the number of companies selling online start to grow, almost every year whit 1% more than year before, so in 2018, 17% of companies sale the merchandise online, but are big differences between countries: countries like Denmark, Ireland and Sweden have more than 30% companies wich sell online and in same time Italy, Romania and Bulgaria have less than 10%.*

Key words: *sales, e-commerce, European Union, strategy, consumer, internet.*

1. INTRODUCTION

The concept of sales has evolved over the last half century. If before sales include selling space, where was a seller, merchandise and a buyer, today seller's presence is no longer necessary. Sales can be done through catalogs, vending machines, sales door-to-door, or via the internet. If door-to-door catalog sales came in the middle of the last century, with easy access to the Internet, a new type of sales, sales through the Internet, has developed. The first company to use this method was Amazon in 1995, and after nearly twenty-five years, Amazon.com is the largest online retailer.

2. A MARKETING ORIENTATION

The decision to buy is influenced by several variables: forecasting the wants and needs of consumers, the ways how vendors present the products, the price. [1]

A retailer`s success is directly dependent on comsumer satisfaction, so is mandatory to be carrefull to the wishes and needs of consumers. In recent years, the way how retailers conduct business has developed and become more consumer-oriented. Retailers have to build a strategy to distinguish themselves from competition and their merchandise to meet the consumer needs but, in same time, retailers must go beyond strategies to gaine: they have to build an imagime in the eyes of consumer. In this condition, retailer has to change, to adapt to the new chalengies and to try to predict what consumer desire.

Companies, wanting to meet the consumer, have tried to communicate directly with him. Direct marketing is the way through both companies and consumers get the immediate response to their wishes. For many companies direct marketing is the only format that business is conducted. [1]

Direct marketing benefits consumer because is convenient, save time-consumer do not have to go to stores, it`s easy to compare merchandise and is open 24 hours a day. For the retailer benefits are divers too: the relationship whit consumer can be stronger, because the retailer can personalize the offer to the special needs and wants of consumer and to promote those offers through individualized communications.

3. E-COMMERCE IN EU

a. Legislative Premises for the unique European market

After the economic crisis from 2008, European Commission proposed a strategy to help European country to progress: smart growth-an economy based on knowledge and innovation-means strengthening knowledge and innovation as drivers of future growth.

The global demand for information and communication technologies is a market worth € 2 000 billion, but only one quarter of this comes from European firms. The quality of high-speed internet was weak and affects its ability to innovate, as well as on the on-line dissemination of knowledge and online distribution of goods and services. [2]

European Comission proposed to creat a free digital market where the buyers can shop online out of borders and companies can sale online wherever in EU.

Propose in 2015, the strategy regarding unique online market has became the base an a european digital society unite and sustenaible.

In the spirit of this strategy of the unique European market, in next period, between 2016 and 2017 have been achieved a few importants steps:

- eliminating roaming charges,
- upgrading data protection,
- cross-border portability of online contracts,
- agreement on providing free internet in public places. [3]

b. Evolution of e-commerce in UE

E-commerce is the sale or purchase of goods or services conducted over computer networks by methods specifically designed for the purpose of receiving or placing of orders. The payment and the delivery of the goods or services do not have to be conducted online. [4]

Table 1: *Evolution of e-commerce in UE 28 (%)*

Year	Companies selling online in UE
2014	15
2015	16
2016	17
2017	18
2018	17

Source: made by the author according to the Eurostat

Online retailling start to grow in Europe after implementing this strategy. In Table 1: Evolution of e-commerce in UE 28 we present the evolution of ecommerce in last five years in EU.

After implementing the strategy, the number of companies selling online start to grow, almost every year whit 1% more than year before, so in 2018, 17% of companies sale the merchandise online.

In Table 2: E-commerce sales in EU in 2018, we present present the situation of each Member State regarding e-commerce.

Table 2: *E-commerce sales in EU in 2018*

Country	Companies selling online (%)	Country	Companies selling online (%)
Austria	14	Italy	10
Belgium	29	Latvia	11
Bulgaria	6	Lithuania	22
Croatia	18	Luxembourg	12
Cyprus	12	Malta	21
Czech Republic	24	Netherlands	17
Denmark	32	Poland	13
Estonia	16	Portugal	19
Finland	21	Romania	9
France	16	Slovakia	13
Germany	20	Slovenia	18
Greece	11	Spain	19
Hungary	13	Sweden	30
Ireland	31	United Kingdom	20

Source: made by the author according to the Eurostat[5]

According to Eurostat database the states whit the highest number of companies wich sell online are: Denmark (32%), Ireland (31%), and Sweden (30%). In the bottom of this list are: Bulgaria (6%), Romania (9%) and Italy (10%).

We consider that these data are influenced by access to the Internet: Internet penetration growth in Europe (83% in 2018), but if in Northern European countries, Internet access is 95%, in the countries of SE Europe internet access is limited. [6]

4. EVOLUTION OF E-COMMERCE IN ROMANIA

In the previous chapter we found that Romania is the bottom of the list in terms of online e-commerce. In Table 3: Evolution of e-commerce in Romania, we will present the evolution of e-commerce in Romania in last five years.

Table 3: *Evolution of e-commerce in Romania (%)*

Year	Companies selling online in Romania
2014	7
2015	7
2016	7
2017	8
2018	9

Source: made by the author according to the Eurostat[5]

From the data presented in the table above, we can see that e-commerce is growing in Romania year after year. If in 2010 just 5% from the companies sell online, in 2018, 9% from companies sell online. [5] According to the European Ecommerce Report 2018, Romania has seen the largest e-commerce growth, with a significant growth rate of 37%. [6] We consider that e-commerce in Romania will continuu to grow provided investment growth and government support for developing digital skills among the population combined with the digital infrastructure.

5. CONCLUSIONS

European e-commerce is growing. After implementing e-commerce strategy proposed by the European Commission in 2015, was an increase in every year. Western European countries continue to lead the way, as the largest market for e-commerce, but these countries have mature e-commerce consumer-bases and are accustomed to ordering goods/services over the internet. Reasons for this include the advanced infrastructure, high internet penetration and high level of consumer trust and familiarity with online shopping.

In Central and Eastern European Countries achieved the highest e-commerce sales growth in 2016. [6] In Romania sales increased by 38% in 2017 and 37% in 2018 and will continuu to grow, because e-commerce is more popular with the younger generation and government have to provide acces to internet to a larger population and to continuu to implement the strategy for unique online market.

E-commerce, combined with the EU Single Market, is an opportunity to sell and shop across border without travelling or setting up shop in another country.

REFERENCES

[1] R. Clodfelter, "*Retail buying FromBasics to Fashion*", Fourth Edition, Ed. Fairchild Books, United States of America, pp. 4, 2013.

[2] *** Europe 2020 - A European strategy for smart, sustainable and inclusive growth, [Online]. Availeble: http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf

[3] *** Single market, [Online]. Availeble: https://europa.eu/european-union/topics/single-market_en

[4] *** Community Survey on ICT usage and e-commerce in Enterprises 2018, [Online]. Availeble: https://circabc.europa.eu/sd/a/1fbef4a1-4c31-4b6a-afe8-19ee6d7e3b0f/ICTEntr202018%20%20Model%20Questionnaire%20V%201.2.pdf

[5] EUROSTAT: E-commerce sales. [Online] Availeble http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_ec_eseln2&lang=en

[6] *** The European Ecommerce Report 2018: relevant findings outlined [Online]. Availeble: https://www.eurocommerce.eu/media/159952/2018.07.02%20%20Ecommerce%20report_annex.pdf

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

AVAILIBILITY OF LABOR FOR TEXTILE AND APPAREL FACTORIES IN ETHIOPIA: A CASE STUDY OF THE TIGRAI REGION

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Abstract: *The performance of the textile and apparel sector is affected by several factors which include raw material, machinery and labor force. The cost of labour, its level of training and availability can be one of the key factors that may influence the location of clusters of industries in a given region. Ethiopia, like many African countries is trying to move from agrarian to manufacturing economy, and it has earmarked the textile and apparel sector as one of the priority industries which will be used in the initial phrase. This research work concentrated on the availability of labour in the Tigrai region of Ethiopia. The research methodolody involved several methods which included; face to face interviews, focus group discussions, field visits and observations and sample survey. The survey took workers and management of Almeda Textile and Garment factory, Maa Garment and textile factory, Velocity Apparelz and the DBL group as its population. The results from this research work indicated that only 23.6 % of the respondents believe that workers are readily available. This is a very low figure. Most of the respondents (66.7%), reported that it is possible to find workers. This implies that factories have to go and extra step in order to get the workers. Labor turnover in the Tigrai region is high, with majority of the workers (58.5%) having worked for less than 3 years in the factories.*

Key words: *Labor turnover, Experience, Textile, Apparel**,** Tigrai, sample survey*

1. INTRODUCTION

Ethiopian like many countries in Africa has expressed a desire to move from agrarian economy to an industrial based economy [1]. One of the priority and strategic sectors earmarked for improvement of local industrial process is the textile and garment industry. Tigrai, one of the regional states in Ethiopia has strategically identified the light manufacturing industries as crucial in the transformation to the industrialization process of the region. As per the plans of the Tigrai regional state government the textile and garment industry is one of the priority sectors which are conducive and will attract local, regional and many international investors. Tigrai region has good road network, airport to Addis Ababa and railway connection to Addis Ababa and the port of Djibouti. It is worthy noting that despite the efforts taken by the central and regional governments, like Tigrai and Amhara to achieve industrialization, the industrial base of the country has remained low, contributing 12-14% to the GDP. Therefore, it goes without saying that the change from agrarian economy to industrial based economy will require a paradigm shift. This research paper considered the availability and experience of the laborforce in the textile and apparel industry in Ethiopia, by concentrating on the Tigrai region located in the northern part of Ethiopia. The rest of the paper is organized as follows: Section 2is literature review, followed by surveys the methodology. Section 4 presents the results and discussion of the research. Finally, section 5 concludes the paper based on the results obtained.

2. LITERATURE REVIEW

The Asian countries have established themselves as major textile and apparel manufactures. Considering, Pakistan whose textile and apparel industry accounts for substantial export earnings, raw material, machinery, energy, labour and policies affect the performance of the textile and apparel sector [2]. While the sector is shifting from labour-intensive to capital intensive, labour remains a major component of the industry. Infact lack of skilled labour has been listed as one cause of the decline of the textile and apparel sector in Pakistan [3]. The issue of lack of skilled laboir has also been noted in the Indian textile and apparel sub-sector, where a study by [4] reported that there is a need to train the workforce in the sector so as to improve productivity. A similar problem was also reported in Egypt [5]. In general the study of labour matters in a textile and apparel industries should include; financial incentives, training and fringe benefits. In Bangladesh, one of the key textile and apparel manufacturing countries in Asia, Ahmed et al [6] reported that an increase in minimum wages, surprisingly reported a negative impact for the workers, while improvements in labor productivity, recorded an overall improvement of the workers welfare. It is however imported to note that Bangladesh is known for availability of low cost low, when compared to othere regions [7]. Availability of cheap labor has also been reported to be one of the factors that has allowed Chinese textile and apparel to penertrate other markets, while In Iran the counter productivity of the labor in the textile and apparel industry is listed as one of the cause of the poor performance of the sector [8]. Ethiopian needs to study its strong and weak points with regaird to all industrial features it undertakes. In this research work we endeavour to look at the labor component in the textile and apparel industries with an aim of understanding its impact on the performance of the sector.

3. RESEARCH METHODOLOGY

3.1 Objectives of the study

The aim of this research work was to study the availability and experience of labor in the textile and apparel sector in Tigrai region in Ethiopia.

3.2 Methods of Data Collection

This research work employed several research methods, which included; face to face interviews, focus group discussions, and observations and sample survey.

3.2.1 Face to Face interviews

Semi-structured in-depth interviews with key informants who are knowledgeable about the issue under study were conducted. The key informants include federal and regional governmental officials, management of the textile and garment manufacturers in the region, textile and garment investors, and officials from Industrial Parks Corporation. Furthermore, key informant interviews were held with representatives from Confederation of Ethiopian Trade Unions and Ethiopian Employers Federation.

3.2.2 Focus group discussion (FGD)

The research team conducted series of FGDs with purposefully selected actors and stakeholders across the region and nation focusing on the productivity and competitiveness of the textile and garment sector, the challenges and success of one stop shop service and the industrial relations and working conditions of the sector. Participants of focus group discussion include officials and experts from textile and garment factories in the region, government representatives from Labor and Social Affairs Bureau, Trade, construction and Urban Development bureau of the region, and representatives from other governmental and non-governmental sectors. In so doing, effort was made to make the focus groups relatively homogenous in order to make participants/discussants feel free so that they reflect what they feel it is right. The discussions were moderated by members of the research team in which information was gained out of intense group interaction.

3.2.3 Sample survey

Aiming at complementing the information gained through the aforementioned qualitative research methods, the study also used sample survey as one principal method of data collection. The research team developed structured questionnaires that aim at collecting data from the available textile and garment industries in the Tigrai region.

The survey took workers and management of Almeda Textile and Garment factory, MAA Garment and textile factory, Velocity Apparelz and the DBL as its population. This forms all the major textile and apparel factories in the region. Therefore this research was able to get the participation of all the textile and apparel factories to participate in the study. With regard to sampling design, a systematic sampling design was used. In so doing, a sample of 97 employees were systematically drawn from several departments of the factories participating in the study. The samples of employees were taken in a way it represents all departments of the factory. Similarly, a sample of 21 individuals was selected from the management by taking the number of departments into account.

3.2.4 Method of data analysis

Both quantitative and qualitative data analysis was applied to answer the research questions and address the research objectives. The collected data concerning the objectives was analyzed using descriptive (charts, ratios, variances and others) methods. The qualitative part was analyzed using narrative and case study.

4. RESULTS AND DISCUSSIONS

4.1 Availability of labor force

Looking at the number of employees working in the textile and garment factories in Tigrai region, it was reported that more than 9200 workers are currently employed. However, considering the demand of the factories, it was found that there is a huge gap in the supply of manpower. For instance, Velocity Apparelz PLC, a recently established textile factory located in Mekelle, has the plan to recruit more than 14000 workers. But so far it has only around 1000 employees because it could not get the required number of labor force in the local market. Hence, it was observed that despite the fact that the region is characterized by high level of unemployment, especially among the youth, there is shortage of adequate supply of labor force that could address the labor demand of textile and garment sector of the region. The main factor mentioned for this problem was the level of pay of pay. Most companies pay an average of USD 50 per month. This salary is deemed low by most workers, and therefore prefers to look for employment in other sectors.

In addition to the gap in the availability of labor force, it was found that the textile and garment factories in the region face a profound problem in getting skilled manpower. Availability of knowledgeable and skilled workers play a pivotal role in determining firm's productivity and competitiveness. Regarding this, the management of the factories was asked whether they find skilled workers such as maintenance and repair workers, line workers, floor supervisors and managers in the local market.

As regards the availability of maintenance and repair workers, 66.7 per cent of them reported that knowledgeable and skilled maintenance and repair workers are not easily available (see Table 1). This leads to sever machine problems and more often than not, companies are compelled to seek for workers from skilled workers in Asian to carry out annual maintenance, as a stop gap measure. While some of the local workers along the expatriates and pick up relevant skills, labour turnover is also high.

***Table 1**: Availability of workforce in the Tigrai region*

Criteria	Maintenance and repair workers (%)	Line workers (%)	Floor supervisors (%)	Managers (%)
Difficult to find	9.5	9.5	4.8	23.8
Possible to find	66.7	66.7	66.7	52.4
Readily available	23.8	23.8	28.6	23.8

Regarding the availability of line workers, from group discussions and interviews it was found out that firms lack adequate access to skilled line workers, so they are compelled to train line workers. Supporting the information that was obtained from group discussions and interviews, the survey result shows that the availability of line workers is not adequate. More than 66 per cent reported that it is not easy to find skilled line workers. Besides, it was indicated that the availability of managers of different levels is not also adequate though the problem is less prevalent as compared to that of the availability of other workers. As the survey reveals 52.4 per cent of the respondents said that it is not easy to find skillful managers where as 23 per cent reported that they are readily available in the local market. However, it is important to note that although the availability of managers is relatively better than those of other categories of workers, it was recorded that the level of managers' turnover is a big challenge for the firms. In this case, remoteness of the area, amount of pay, related benefits and other personal reasons were mentioned as factors for higher rate of management turnover.

Different from this is the availability of floor supervisors. Only 4.8 per cent of the respondents believed that it is difficult to find floor supervisors. While 66.7 per cent reported that it is not easy to find floor supervisors, the remaining 28.6 per cent of respondents believe that floor supervisors are readily available in the market.

4.2 Workers Experience

Assuming that time spend by managers in a factory has a critical impact on productivity of the sector, general managers, department heads, and division heads were asked about the number of years they have worked in a factory. As shown in Fig. 1, it was found that 52.4 percent have 4-6 years of experience in one factory. Only 19 percent of the management has served their respective firms for more than 10 years, and 14.3 percent have stayed for 0-3 years in a given firm.

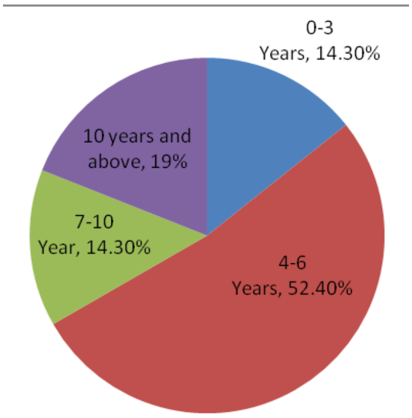

Fig. 1*: Expereince of Managers*

Similarly, effort was also made to study the level of experience of the other employees (non-mangers) in the textile and apparel factories in the Tigrai, region. Accordingly, as put in Fig. 2, it was found that a disproportionate size of employees (58.5 %) had a work experience of 0-3. This substantiates the view that textile and garment industries face high employee turnover. It was explained that the establishment of new textile firms owned by foreign nationals is posing a big problem in terms of workers turnover, to the older factories.

As reported from focus group discussions, most of the employees of recently established firms were initially workers in the older factories. It was explained that firms cannot maintain their employee, for they could not compete with the newly established foreign owned textile industries in terms of the amount of pay and other benefits. Hence, it can safely be concluded that firms which do not work hard to retain its workers, may not be able to compete with firms that are willing to provide better pay and terms of service.

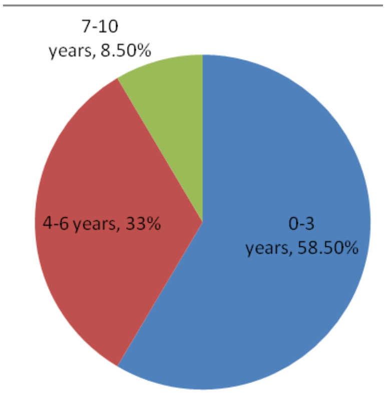

Fig. 2*: Expereince of Line workers*

This data shows that the level of management turnover is by far lower than employees' turnover in the textile industries of the Tigrai region. The possible reasons of the high turnover could be due to the remoteness of the region, from other parts of Ethiopia. Other possible reasons for high labor turnover include; amount of pay, related benefits and other personal reasons.

4. CONCLUSIONS

This research work concentrated on the availability of workers for the textile and apparel industry in the Tigrai region of Ethiopia five textile and apparel factories (Almeda Textile and Garment factory, Maa Garment and textile factory, Velocity Apparelz and DBL group). The results from this study showed that the factories in the region consider availability of workers a major problem, with 23.6% of the respondents reporting that workers are readily available, while a majority (66.7%), reported that it is possible to find workers. This implies that factories have to go and extra step in order to get the workers. Labor turnover in the Tigrai region is high, with majority of the workers (58.5%) having worked for less than 3 years in the factories. The level of workers who have worked for 7 to years 10 years was 8.5 %.

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REFERENCES

[1] Ministry of Finance and Economic Development (MoFED), "*Growth and Transformation Plan (GTP) 2010/11-2014/15, (2010)*". The Federal Democratic Republic of Ethiopia, Addis Ababa, Ethiopia.

[2] A. Malik, "*Demand for textile and clothing exports of Pakistan"*, 2005, Available at; http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.545.9762&rep=rep1&type=pdf

[3] M. S. Iqbal, F. M. Shaikh, B. Mahmood and K. Shafiq. "*Development of Textile Industrial Clusters in Pakistan*", Asian Social Science vol. 6, No. 11, pp. 123-140, 2010.

[4] R. Bhenda, "*Productivity in Indian apparel industry: paradigms and paragons"*, Journal of Textile and Apparel, Technology and Management, 2(3), pp. 1-9, 2002.

[5] R. Abdallah, C. Barry, M. Beal, A. Said and S. Vartanov, "*The Textile Cluster in Egypt, Microeconomics of Competitiveness*", May issue pp. 1-32. 2012.

[6] N. Ahmed and J.H.M.Peerlings, "*Addressing Workers' Rights in the Textile and Apparel Industries: Consequences for the Bangladesh Economy"*, World Development, vol. 37 issue 3, pp. 661-675, 2009.

[7] S. B. Saxena and B. V. Salze-Lozac'h, "*Competitiveness in the Garment and Textiles Industry: Creating a supportive environment, A case study of Bangladesh"*, Occasional paper no 1, The Asian Foundation, Dhaka, Bangladesh, 2010.

[8] J. H. Monfared and N. Vatankhah, *"Pathological study of iranian textile industry"*, Annals of the university of Oradea fascicle of textiles, leatherwork, XIV (2), pp. 15-20, 2013.

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

HARMONIZING ACADEMY WITH THE INDUSTRY: PERSPECTIVES ON THE ROMANIAN TEXTILE ENGINEERING CURRICULUM

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Abstract: *Changes in the business world as a result of economic instability, innovations in technology, the increasing diversity on the labor market, may be altering the kinds of competencies and general skills that universities are being called to deliver [1].It is the goal and responsibility of textile programs and faculties to producing graduates with the skills, competencies, and attributes to find employment and to be viable in their career. The purpose of this study was to identify the content of apparel and textiles curricula in textile programs at the bachelor level and then to establish which elements of that content were perceived as important to job performance in the occupational field of textile engineering, with emphasis on knitwear, garments engineer. It has been described the main textile programmes offered from Romanian universities and examined and compared similarities and differences between "Knitting and clothing technology" programme, the only common programme in all three universities that provides textile studies. This paper provides an overview of the careers in textile and textile product development, the universities offer, and the differences between, so that changes can be made to align important competencies.*

Key words: *careers in textile, textile supply chain, knitting and clothing technology*

1. INTRODUCTION

The garment industry is an important part of the textile industry, which is located at its downstream in the supply chain. The upstream of the textile industry include raw material suppliers of garments, midstream has raw material processors and garment manufacturers, while downstream have trade agents and brand owners.

Before 1989, the Romanian textile industry covered the entire supply chain, the complete production system that includes fiber manufacturing, spinning, weaving, dyeing, designing, cutting, sewing, and garment finishing. In the last decades, the offshoring process has led to an increase in the weight of clothing manufacture and the decline of other links in the value chain. Studies show that the Romanian clothing industry should focus on restoring the added value chain, on higher value-added, niche segments, developing brands and the image of products and processes, on developing new concepts and marketing strategies in order to survive in the competitive global market [2,3].While the job market suffers changes, textile education programs are striving to adapt to the ongoing changes and external threats in the academic environment.

In response to the constant changes in the textile industry (modify of the value chain, technologization and digitalization of the industry, eco-trend, and customer demands, etc) textile faculties or textile departments have been researching how to update their programs to respond at the social, technological, and economic requests. [4, 5]

2. CAREERS IN TEXTILE

Different career classification models are offered to cover this highly complex industry. The clothing industry includes design, production, marketing, and distribution of clothing, home, and technical textile [6, 7].Table 1 presents a summary of careers in design, textiles, textile engineering according to the Romanian Occupation Classification (COR) in accordance with the International Standard Classification of Occupations 2008 (ISCO-08) and the Romanian universities that provide the required qualification.

Table 1: *Careers in textile and textile product development*

Careers in textile and textile product development		**University**
2163 Product and garment designers	210607 Fashion designer	Fashion- fashion design/National Art University of Bucharest Fashion- fashion design/University of Art and Design ClujNapoca. Faculty of Arts and Design/West University of Timisoara Faculty of Arts/ University of Oradea Faculty of Design / "AurelVlaicu" University of Arad "George Enescu" University of Arts in Iasi
	216306 Product Development Pattern Maker	Faculty of Textiles, Leather and Industrial Management/ Gheorghe Asachi Technical University of Iasi (TUI) Textile Products Design and Technology/ Faculty of Engineering/"AurelVlaicu" University of Arad
Careers in Raw Materials and Manufacturing Manufacturing		
2141 Industrial and production engineers	214101 Leather and substitute engineer	Chemical technology of leather products and substitutes /(TUI) Technology and design of leather clothing and substitutes/(TUI)
	214102 Knitwear, garments engineer	Knitting and clothing technology (TUI), Faculty of Energy Engineering and Industrial Management / University of Oradea Faculty of Engineering/"AurelVlaicu" University of Arad Faculty of Engineering/"Lucian Blaga" University of Sibiu
	214103 Textile, leather engineer	Faculty of Textiles, Leather and Industrial Management/ (TUI)
	214105 Textile, leather technical designer	Technology and design of textile products (TUI)
	214106 Textile, leather consultant engineer	Technology and design of leather clothing and substitutes/ (TUI) Faculty of Energy Engineering and Industrial Management / University of Oradea
	214107 Textile-leather expert engineer	Technology and design of leather clothing and substitutes
	214108 Textile-leather inspector engineer	Technology and design of leather clothing and substitutes/(TUI)

	214109 Textile-leather referent engineer	
	214136 Manufacturing programmer / manufacturing launcher	Knitting and clothing technology **(TUI),** Faculty of Energy Engineering and Industrial Management / University of Oradea **(UO)** Faculty of Engineering/"AurelVlaicu" University of Arad**(UAVA)** Faculty of Engineering/"Lucian Blaga" University of Sibiu**(ULBS)**
Careers in Sales for the Fashion Retailer – are not specified separately		

3.KNITTING AND CLOTHING TECHNOLOGY PROGRAM IN ROMANIAN UNIVERSITIES

The question of determining the specific education needed by university licentiate of textile programs for successful entry into the working market has been approached from a variety of angles. The common point of several research studies is the accent on surveying the opinions of practitioners in the industry on the competencies and qualities needed by students entering the textile industry [8,9].Apparel construction and patternmaking are the competencies identified as essential by the participants. Ather recommendable competencies include understanding people, product development, organization and management, technology and communication,marketing and international trade, human resources, and environmental issues and sustainability.

Regarding the textile studies curriculum, there is differentiated between an industry orientation and a professional orientation [10]. A curriculum with an industry orientation involves examination of the apparel industry structure and responsibilities and focusing on business efficiency and profitability. A curriculum with a professional orientation is concentrated on the importance of applying integrated, broad-based clothing and textiles knowledge to professional decisions based on specific social, psychological, and cultural aspects of clothing, customer orientation, merchandise operations, and sustainable value chain.

A professional orientation integrates technical training with cognitive competence to train students to make future decisions that concern consumer satisfaction and business profitability[10].

Agency for Quality Assurance in Higher Education (ARACIS) is a body with legal prerogatives to issue and to propose to the Ministry of National Education advises and a recommendation based on its own evaluations, and provides the conceptual framework and describes the main activities and strategies provided by the processes of periodic authorization, respectively of external quality assurance. According of the Romanian Agency for Quality Assurance in Higher Education[11], the curricula of a study programme must be compatible with the national qualifications framework and with similar plans and study programmes from the member states of the European Union and from other countries. It has to include a set of fundamental disciplines, a set of specialized disciplines in the field and the complementary disciplines organized in compulsory disciplines and optional disciplines.In order to maintain accreditation, the Romanian textile study programmes must take inventory and develop their curricula regularly. The evaluation of quality in an institution is made within the three areas provided under the law: institutional capacity (institutional, administrative and managerial structures, material resources), educational effectiveness (the content of study programmes, learning outcomes, scientific research activities, financial activity), and quality management. The article will focus only on the content of study programmes.

In order to obtain accreditation, as a quality assurance modality that certifies the observance of standards by education, in the curricula, the ratio between the teaching hours and the other applied educational activities (seminars, laboratory activities, projects, traineeships, etc;) must be of 1/1, with no more than +/-20 % admitted deviation. Analyzing the link between industry and academia in terms of the textile industry is important for textile programs to give students a solid foundation of skills and knowledge sought by employers. Therefore, in the bachelor (Licence) study programme a 2-3-week traineeship per year beginning with the second year of study must be included, as well as a period for the elaboration of a diploma paper, during the final year of study. For traineeship periods, the university has to establish collaboration agreements with the practical units, which must specify the place and period of training and the organization mode and guiding principles.

Table2:*Comparison of the Curriculum for Knitting and Clothing Technology Programme*

Course name	No of hours			
	UO	**TUI**	**ULBS**	**UAVA**
Mathematics	84	56	112	112
Physic	42	56	56	42
Chemistry	42	112	84	70
Mechanics and Resistance of Materials, Machines Parts and	56	x	210	140
Mechanism	28	28	42	56
Electrotechnics	84	x	x	70
Technical Drawing and Infographics	112	x	x	28
Computing Programming and Programming Languages	42	56	56	42
Probability theory and mathematical statistics	84	126	126	28
Graphics Computer-Aided	70	112	154	x
Applied informatics				
The basics of computer-aided design technology	56	42	x	x
Textile Fibers	56	140	84	98
Textile Structures -knitting	56	56	56	42
Textile Structures (yarn)	56	56	98	56
Textile Structures (fabrics)	56	56	70	56
Comfort and functions of textile and leather products	56	56	42	42
Fundamentals processes in garments	112	140	168	168
Metrology in Textile-leather	56	56	70	42
Basis of processes in textile garments	84	112	112	56
Structure and design of garments	126	56	126	112
Structure and design of knitting	70	84	70	126
Clothing construction and shaping	56	84	x	x
Design of technological processes in garments	56	56	x	x
Practical Activity	180	180	180	180
Practical Activity for Diploma Project	60	60	60	60
Elaboration of theDiploma Project	56	56	56	70

Textile Finishing	56	42	112	70
Processes and Machines in Clothing	154	182	168	140
Processes and Knitting Machines	154	168	168	140
Computer Aided Design in Clothing	70	84	70	84
Computer Aided Design in Knitting	56	84	56	x
Time study	42	42	56	x
Basics of computer-aided ecological design/Ecological design	x	42	x	28
Fashion Design	56	70	98	140
Artistic Creation /drawing - optional	56	56	56	x
Basics of computer-aided ecological design/Ecological design	x	42	x	28
Economy	56	x	28	28
Management	56	84	42	42
Manufacturing management in the textile industry	x	x	56	42
General Engineering in Textiles&Leather	56	112	56	42
Analysis and Production-Cost Control Systems	56	x	56	28
Production Systems Engineering	56	x	56	x
Textile Quality Control	84	56	56	70
Marketing	x	28	56	x
Foreign Language: English	56	56	70	70
Second foreign language	28	14	14	14
Communication	28	28	x	14
Ethics and academic integrity	28	x	x	14

Textile engineering students today must be prepared for jobs that involve diverse skill sets, knowledge sets and experience to be successful. This goal is achieved through a set of disciplines included in the following categories: fundamental disciplines (cca 17%, hours: 560), required disciplines (max 90%, hours: 2800), mandatory optional courses (min 10%, hours 320), disciplines in the field (min 38%, hours: 1250), specialty disciplines (min 25%, hours: 1000), complementary disciplines (max 8%), optional courses (min 10 %).

From the analysis of the four curricula, we found the similarity of 75% of the programs, but ARACIS's requirement also allows the distinction of universities for the proposed programs. For example, the curriculum Knitting and Clothing Technology Programme Gheorghe Asachi Technical University of Iasi (TUI) contains specific disciplines such as Technologies knitwear on different types of vehicles (plus 168 hours compared to the other programs), product lifecycle management, prototyping diploma project. The Knitting and Clothing Technology Programme/University of Oradea (UO) focuses on IT disciplines: computer programming and programming languages, information systems for management, automation in garment manufacturing, the "AurelVlaicu" University of Arad (UAVA) offers a broader range of disciplines in the field of weaving, and the /"Lucian Blaga" University of Sibiu (ULBS) proposes a larger number of disciplines in the mechanical field.

4. CONCLUSIONS

Academic requirements for graduates of textiles and clothing programs should continue to form around the particular intellectual processes needed for well-prepared engineers. Students must develop the underlying intellectual, scientific, and technical principles to function in life and in professional roles without neglecting communication, ethical and managerial skills.

It’s important to recognize that fashion and textiles industry is changing and alignment of curriculum to all implicated stakeholders needs is important to the mission of academic institutions. As more companies are seeking the university graduates as an employee, the curriculum must be developed with professional competencies, allowed textile engineering programs to assess, redirect, or modify curriculum for better response to the market demand. Therefore is highly necessary that professors update their curricular by developing new courses, updating course objectives, adopting newer techniques, and integrating the subject matters within and between the disciplines in textile programs.

The curriculum and discipline-content competencies are established by departments in concordance with a set of rules settled by the accrediting agency. A more modern and flexible approach is expected in this institution too.

REFERENCES

[1]. Veltri, N. F., Webb, H. W., Matveev, A. G., & Zapatero, E. G. (2011). Curriculum mapping as a tool for continuous improvement of IS curriculum. *Journal of Information Systems Education*, *22*(1), 31.

[2]. FEPAIUS: Cum arataradiografiaindustrieiromanesti de textile, https://www.textilshow.ro/fepaius-cum-arata-radiografia-industriei-romanesti-de-textile/

[3]. Tripa, S., Cuc, S., &Oana, I. (2016). Revealed comparative advantage and competitiveness in Romanian Textile and Clothing Industry In: IndustriaTextila, 2016, 67(5), p. 338.

[4]. Sinclair, M. (April, 2008). Dreams: Education to reality. Apparel, 41(3), 57.

[5]. Voorhees, R. A., & Harvey, L. (2005). Higher education and workforce development: A strategic role for institutional research. In R. A. Voorhees, & L. Harvey (Eds.), Workforce development and higher education: A strategic role for institutional research (pp. 5-12). San Francisco: Jossey-Bass.

[6]. Frazier, B. J., & Cheek, W. K. (2005). Fashion industry career matrix: Encouraging students to explore fashion-related careers. *Clothing and Textiles Research Journal*, *23*(4), 375-384.

[7]. Gerber, T., & Saiki, D. (2010). Success according to professionals in the fashion industry. *The Career Development Quarterly*, *58*(3), 219-229.

[8]. Lee, Y. A. (2001). *Michigan apparel and textile industry: Characterization and needs assessment*. Michigan State University. Department of Human Environment and Design.

[9]. Laughlin, J., & Kean, R. C. (1995). Assessment of textiles and clothing academic programs in the United States. *Clothing and Textiles Research Journal*, *13*(3), 184-199. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1028.3033&rep=rep1&type=pdf

[10]. Fiore, A. M., & Ogle, J. P. (2000). Facilitating students' integration of textiles and clothing subject matter part one: Dimensions of a model and a taxonomy. *Clothing and Textiles Research Journal*, *18*(1), 31-45.

[11]. ARACIS- METHODOLOGY for external evaluation, standards, standards of reference and the list of performance indicators of the Romanian Agency for Quality Assurance in Higher Education, Approved by Government Decision No.915/2007 Published in the Romanian Official Gazette No. 25/11.01.2018 http://www.aracis.ro/fileadmin/ARACIS/Proceduri/2018/Metodologie_Mof_25_2018.pdf

ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ON-LINE MAGAZINE - OPPORTUNITY FOR FOOTWEAR MANUFACTURERS

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Abstract: *As in the whole world in the Republic of Moldova, the ICT sector is one of the main promoters of change in society and the business environment, and maintains a stable development dynamic. According to statistical data for the period 2014-2017 there has been a considerable increase in Internet access. Currently, e-commerce in the Republic of Moldova is at an early stage. Footwear companies have a great potential in e-commerce. Today the footwear industry is looking for strategies that allow it to diversify production, balance external orders with its own production, increase domestic sales, look for niches outside, and implement online trade. In order to boost e-commerce in Moldovan footwear companies, the authors propose several stages: planning for implementation; informing the consumer about the correct measurement of the foot size; creating the online store; promoting the online store; supporting the online store. And to create an online store footwear enterprises in Moldova, Chisinau, the authors used a specialized server "OpenCart" recommended by experts in information technology. The authors have estimated the costs of creating the online store, and it is suggested that the enterprise under consideration should adopt one of these two variants. In case the company does not have a large budget, it is proposed to implement the OpenCart program. In addition, if footwear is being developed, the second variant is proposed.*

Key words: *footwear, trade, consumer, Internet, benefits.*

1. INTRODUCTION

E-Commerce is the multitude of software and business processes necessary for business processes to work. It involves using the Internet and is one of the complex solutions, "integrated", they offer every technology. This means that a multitude of Internet service providers and providers need to work in a perfect timing for an ecommerce website to work. This means that a multitude of applications and Internet service providers must work together in perfect timing for an e-commerce site to work. At present, the impact of e-commerce on firms and society is particularly high, and those who will not use advanced systems will have difficulty in maintaining the market [1].

Following the analysis of the real situation of shoe industry's on-line trade, it was found that they accept small-scale modern technologies. A solution for speeding up the implementation of e-commerce from the point of view of the authors is that they need to be presented with the steps that need to be taken and estimated costs. The paper aims to develop and analyze the steps for the implementation of e-commerce and the estimation of the related costs for the footwear enterprises.

2. TRENDS IN THE DEVELOPMENT OF ELECTRONIC TRADE FOR FOOTWEAR ENTERPRISES

As in the whole world in the Republic of Moldova, the ICT sector is one of the main promoters of change in society and the business environment, and maintains a stable development dynamic. According to statistical data for the period 2014-2017 there has been a considerable increase in Internet access [2]. Both consumers and businesses have a different attitude towards modern technologies. These are reserved to call or not to the internet to know the market or to promote themselves or simply to benefit from lower costs. Only those who have accessed the Internet - are already making new profits in their accounts [3].

Currently, e-commerce in the Republic of Moldova is at an early stage. Footwear companies have a great potential in e-commerce. It is necessary to accept changes and develop their areas, as e-commerce will be directly responsible for the competitiveness and development of the national economy.

3. STAGES OF CREATING ONLINE SHOE STORE

The success of footwear companies across the country in the future largely depends on their ability to integrate into the wave of digital change, and last but not least, the ability of the country to overcome the key obstacles that are currently hampering the move forward. For shoes to be known, it requires promotion and advertising in the on-line environment. The footwear industry is looking for strategies that allow it to diversify production, balance external orders in relation to its own production, increase domestic sales, look for niches outside, implement on-line trade [4].

In order to boost e-commerce in Moldovan footwear companies, the authors propose several stages:

1. planning for implementation;
2. informing the consumer about the correct measurement of the foot size;
3. creating the online store;
4. promoting the online store;
5. supporting the online store.

3.1. Planning for implementation

Businesses have more options to develop their business, the decision not to opt for e-commerce or to open on-line shops in parallel with existing ones; to completely abandon traditional businesses and to focus solely on electronic business. A generic, multi-step methodology can be used to plan and implement an e-commerce solution. The process of implementing proposals is an important process for the enterprise and involves drawing up an action plan and moving it systematically to reach the planned outcome. In help, we can come up with the Gantt diagram, which involves planning all the actions that make up the proposed program for implementation, thus highlighting the periods necessary to bring change within the organization.

3.2. Informing the consumer about the correct measurement of the foot size

Consumers always complain that they can not find perfect shoes. Although there are standards, the sizes vary from one producer to another. For the consumer, the size system based on the length of the foot has the advantage of being correlated with the body size. On the other hand, the manufacturer prefers the size system based on the length of the block [5].

Therefore, consumers need to know which parameters should be known and measured to obtain a comfortable shoe. The footwear must fit perfectly on the foot, without being too long or too short.

Foot measurements can be made using the following techniques: manual (sheet, ruler, centimeter, etc.); computerized (various equipment available on the market). Manual techniques do not require high expense, but a number of errors can occur when measuring. Finally, we can not correctly identify the size of the shoe. And modern techniques are very expensive, with very high measurement precision. For a correct measurement with manual techniques, it is necessary to follow some instructions (figure 1) [6]: place the foot on a sheet of paper; draw a line at your fingertips, holding the right pencil at an angle of 90 °; measure the resulting distance with a ruler.

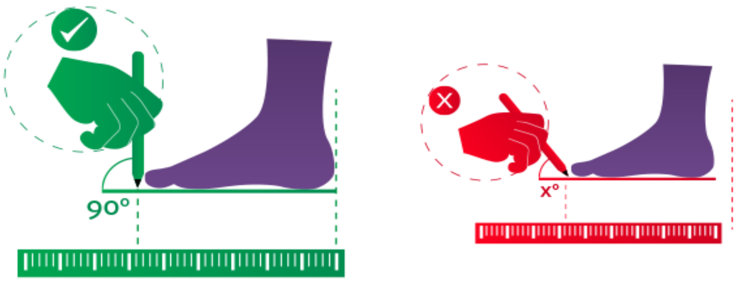

Fig. 1: *The correct position for leg measurement*

Currently on the market, there are special devices to measure foot size and area for children and adults (fig. 2) [7]. These tools are easy to operate, have high accuracy and does not occupy large space.

Fig. 2: *Instrument for measuring the size and perimeter of the fingers of the human foot*

Consumer education can be done through several ways: verbal by placing a specialized film on the correct measurement of the foot size; non-verbal - placement of footage imaging and instructions.

3.3. Creating the online store

In order to create the online store of a shoe enterprise in Moldova, the city of Chisinau, the authors used a specialized "OpenCart" server recommended by IT specialists (fig. 3). OpenCart is a free e-commerce platform with open source for online merchants. OpenCart provides a professional and reliable base for creating a successful online store. Which provides a professional and reliable basis for creating a successful online store. This fund is targeting a wide range of users from experienced web developers, looking for an easy-to-use interface for storeowners to simply launch their online business for the first time.

OpenCart has many features that will enable you to consolidate any business. Using OpenCart tools can help the online store realize its full potential [8].

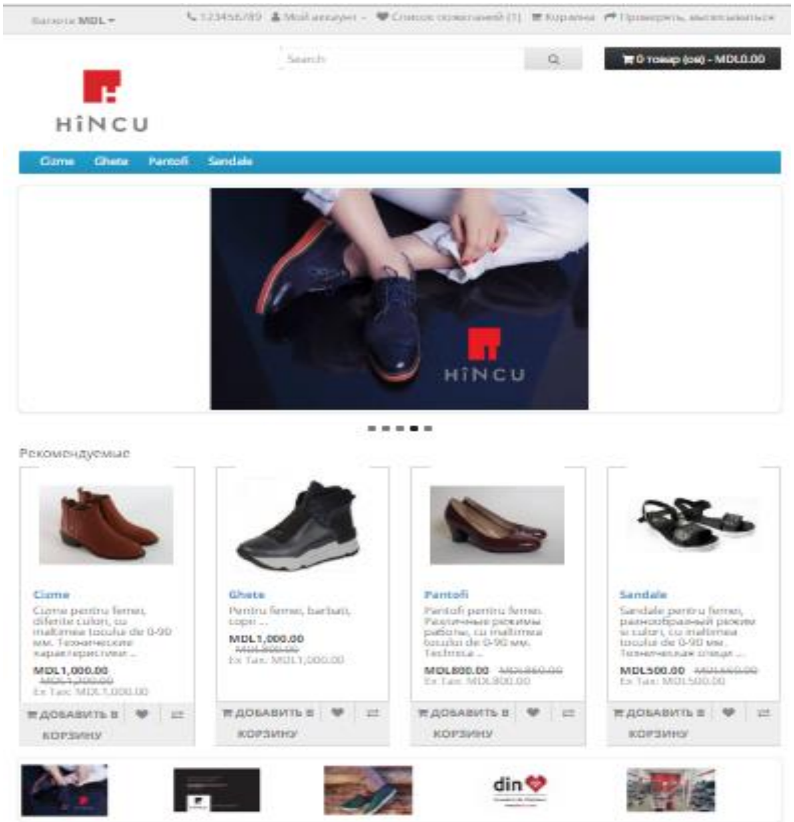

Fig. 3: *Example online shop for footwear enterprises*

3.4. Promoting the online store

Promoting online commerce contributes to informing the public about its existence within the footwear company. Namely, advertising will cause the consumer to try to access the online store page sooner. The entrepreneur who will offer the on-line marketing program, knowing that he will meet certain consumer needs that were not satisfied until then, will always make innovations or a renewal to meet all customer needs. The launch phase of online commerce is an important stage in the life cycle because at this stage the product creates an image in the mind of the consumer and is perceived in a certain way. Because the product is procured in the online environment, consumers are skeptical; the first buyers of the product are innovative customers.

If the product bought online does not meet the expectations of consumers who tested it, then they will be disappointed and will not repeat the purchase. For the product to be reaped, its benefits must be clearly communicated to potential consumers. There are several strategies for promoting products: radio ads, television, Internet, printed materials, promotional techniques.

3.5. Supporting the online store

As the online store is accessed, the promotion has to focus on the benefits it brings. Moreover, in order to increase efficiency, it is recommended to hire a person specializing in supporting and promoting online commerce. It will also be responsible for updating and refreshing all the information on the official and facebook homepage. The hired person will be more efficient because he will be marketing only attracting more and more potential customers.

4. PROPOSALS AND RECOMMENDATIONS

Following the study, some recommendations and suggestions are proposed:

1. Implementing the online store and hiring an IT person who is responsible for promoting, supporting and improving it.
2. Once the online trade is implemented by the company, new outlets will open, as well as minimize distribution costs, minimize paper transactions or even replace them entirely through electronic transactions.
3. Informing the company's customers about the possibility of purchasing footwear products already available on-line. Also, the methods and tools for measuring the size and width of the shoe correctly.
4. Implement the on-line trade on the territory of the city of Chisinau, to test what problems arise, what are the questions, and then enlarge the whole country and abroad.
5. Cost Estimation (Table 1): It is proposed that companies should take one of these two programs. If the enterprise does not have a large budget, it is proposed to implement the OpenCart program. In addition, in the case that the second part of the program will be fully developed.

Table 1: *Estimate costs*

Nr. order	Elements	Number	The price, lei
	Variant 1 - OpenCart		200
1	Specialist IT	1	6 000
2	Computer	1	16 000
3	Printer	1	5 000
4	Internet subscription	1	200
5	Armchair	1	600
6	Table	1	500
	Total	**7**	**28 500**
	Variant 2 – program completed	1	15 000
1	Computer	1	16 000
2	Printer	1	5 000
3	Internet subscription	1	200
4	Armchair	1	600
5	Table	1	500
6	Specialist IT	1	6 000
	Total	**7**	**43 000**

5. CONCLUSIONS

If the footwear enterprise accepts the implementation of online commerce, it will achieve the following benefits:

- the opportunity to sell and make their products known globally;
- access to new market segments (new clients);
- communication with suppliers and customers of the company implies a low cost and is more efficient;
- to start a successful online business, compared to a traditional business, you need a minimum investment;
- lower transaction costs - if the website is well done;
- facilitating the establishment of relations between potential partners;
- increasing the value of transactions by stimulating shopping;
- possibility to prepare the order for several days;
- the ability to set up products and immediately see real prices compared to the prices of several sellers;
- the ability to search easily in large catalogs - a company can build on a network already created a much larger catalog than it would fit in a mailbox;
- better customer interaction - the customer can receive on request e-mail information on the status of his order at any time (if the order has been received, the shipment is delivered etc.);
- lower entry cost by setting up and maintaining Web sites that are cheaper than traditional marketing methods.

The authors are aware of the risks that may arise in organizing on-line store, but careful analysis of the shoe sales experience in this form represents a reduction in that risk. The creation of on-line store alongside traditional ones is a real opportunity for the development of the footwear producers' business.

REFERENCES

[1]https://ibn.idsi.md/sites/default/files/imag_file/28_39_Comertul%20electronic_dezvoltare%20si%20perspective%20in%20comertul%20modern%20al%20intreprinderilor%20din%20raionul%20Cahul.pdf (accessed on 26.02.2019).

[2]http://www.statistica.md/public/files/publicatii_electronice/Anuar_Statistic/2018/19_AS.pdf (accessed on 26.02.2019).

[3] V. Capbătut, A. Gangan, "*Particularitățile internet marketingului în Republica Moldova"*, presented in: Conferinţa jubiliară Tehnico-Ştiinţifică a Colaboratorilor, Doctoranzilor şi Studenţilor consacrată celei de-a 50-a Aniversări a UTM, 20-21 octombrie, 2014, Chişinău, pp. 477-479, 2015.

[4] A. Ghelbet, "*Determinanții direcțiilor strategice de dezvoltare a ramurii/sectorului de încălțăminte din R. Moldova*", presented in: „Creativitate. Tehnologie. Marketing”, Al III-lea Simpozion internațional, CTM 2014, 31oct.-01 noiem.:, Chișinău, pp. 304-309, 2014.

[5] M. Costea, A. Mihai, "*Structura și proiectarea încălțămintei",* Ed.Performantica, Iași, 2015.

[6] http://www.bigstep.ro/content/15-grila-marimi (accessed on 20.02.2019).

[7] https://www.joom.com/ro/products/5bc59ff98b2c3701ebe189b8 (accessed on 20.02.2019).

[8] https://www.opencart.com/ (accessed on 22.02.2019).

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