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ANNALS OF THE UNIVERSITY OF ORADEA
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DIGITAL TRANSITION FOR ROMANIAN TEXTILE INDUSTRY

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Abstract: *This paper presents aspects concerning the e-learning courses for the Romanian textile sector in the context of digital transition. In the framework of the ADDTEX Erasmus+ project, INCDTP developed three interactive lessons covering digital aspects of the textile industry. The proposed courses for digital transition cover aspects related to data acquisition, visualization, and analytics-based descriptive, diagnostic, predictive, prescriptive, augmented, and real-time analytics, including mathematical and business modelling by artificial intelligence. The proposed courses gradually introduce the learner to digital knowledge, starting from basic principles necessary for technicians, graduates, engineers, professionals, managers, and mentors. In order to achieve the objectives of the ADDTEX project, the developed courses and certification tools for different specialization levels cover digital aspects that could support innovation in the development of new products based on mathematical models and business modelling, promotion of entrepreneurship and improving the quality and relevance of employers' skills. In addition, data visualization of historical data record stored in data warehouse for analysis and data visualization using specific tools (scatter, combo, list or stacked plots) help in quick visualization of the aspects related to performance and improves the business outcomes. The courses related to digital transition are available on the Addtex project website and offer learners certificates for completing the courses after the courses after completing the course modules and the electronic tests assigned to each module.*

Key words: *digital, courses, textile, data, analytics, visualization***.**

1. INTRODUCTION

In the EU-27, the technical textiles industry represents approximately 30% of the total textile turnover, with an increase of 27% of the total textile production. Technical textiles are "fibers, threads, 2D and 3D materials" that meet technical rather than aesthetic criteria.

The technical textiles industry generates innovative products with high added value but is highly fragmented, comprising many European SMEs that specialize in certain types of products or technologies.

The main objectives of the ADDTEX project covering digital transition are to support innovation in the context of the digital, intelligent and ecological transition, the development of new products and business models, Promotion of entrepreneurship, supporting the new products development based digital tools and improving the quality and relevance of skills developed and certified through education and training systems. The specific objectives of the ADDTEX project are:

-Analysis and evaluation of the needs of the private sector after COVID-19 for the transition to a European economy based on digital, intelligent, ecological components and zero carbon emissions;

-Realization of personalized professional training programs;

-Encouraging the transfer of know-how between universities and the business environment;

-Development of hubs to support communication between companies and universities through clusters.

2. COURSES DEVELOPMENT

The Digital transition courses for technicians and graduates (figure 1) contain 6 lessons, from which INCDTP was involved in developing 1 lesson related to data acquisition, visualisation and analytics.

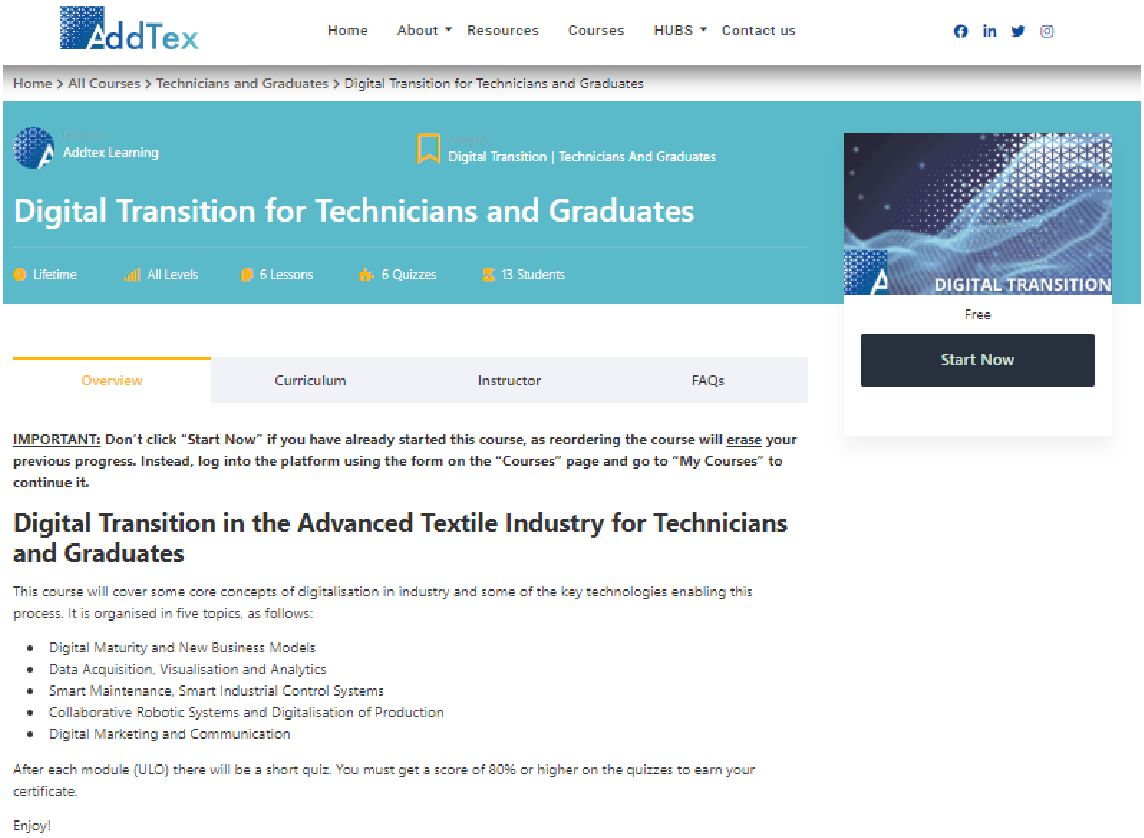


***Fig. 1:** Digital Transition for technicians and graduates*

The first lesson developed by INCDTP for technicians and graduates aims to introduce learners to basic data acquisition and visualization knowledge. Data analytics analyzes raw data sets using performant software tools based on sophisticated algorithms to understand the relationship between variables and obtain trends and adequate conclusions.

Data analytics can be used for business optimization and maximizing profit. The objective of using data analytics is to understand the relationship between various variables and to obtain trends and adequate conclusions. Overall, data analytics can be used for business optimization and maximizing profit.

Data analystics can be performed using descriptive, diagnostic, predictive, prescriptive, augmented and real-time analytics software applications. Data sources for analytics are OLTP, OLAP databases, current transactions and data collected in real-time and historical data (data warehouse). In data warehousing (figure 2), the initial data are collected for multiple data sources in different formats (numerical, char, text, files). After that, data are extracted, transformed, and loaded and in the end, these data can be visualized and used for reports or business intelligence applications.

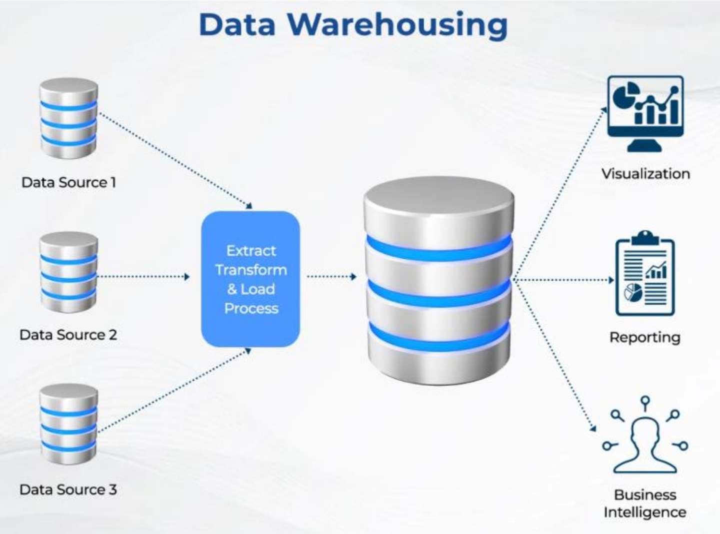


Fig.2: *Data sources used for the data warehouse [1]*

Data can be acquired in real time through textile sensors, e-commerce store software, sales management software, virtual shopping platforms, ERP software, and OLTP databases. Data processing and extracting valuable information uses methods such as regression analysis, factor analysis, cohort analysis, Monte Carlo simulations and time series analysis. At the same time, data visualization involves using histograms, regression plots, scatter plots, and bar and line charts to visualize the results [2].

The second lesson developed by INCDTP is included in the digital transition for engineers and professionals, which is related to the mathematical methods used to process experimental data. Experimental data is measured data from physical experiments. This physical process is characterized by the set of measured data (Table 1). Mathematical and statistical methods may further analyse the set of data. The scatter plot is the first mathematical statistical processing of this experimental data (Figure 1).

Table 1. *Tensile strength for the different solution concentration*

Sample test	**20 g/l**	**30 g/l**	**40 g/l**	**50 g/l**
1	501 N	503 N	509 N	515 N
2	498 N	510 N	513 N	512 N
3	503 N	512 N	516 N	517 N
4	515 N	506 N	512 N	520 N

5	504 N	508 N	514 N	516 N
Average	504.2 N	507.8 N	512.8 N	516.0 N
Std. Dev.	***6.45 N***	***3.49 N***	***2.58 N***	***2.91 N***

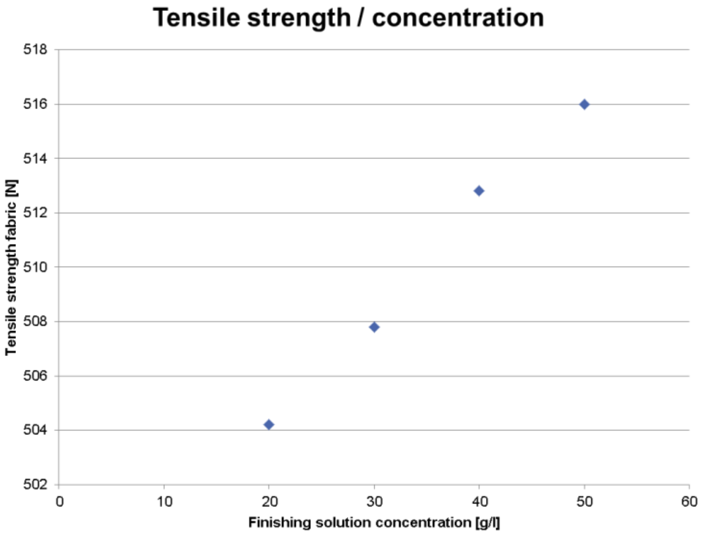
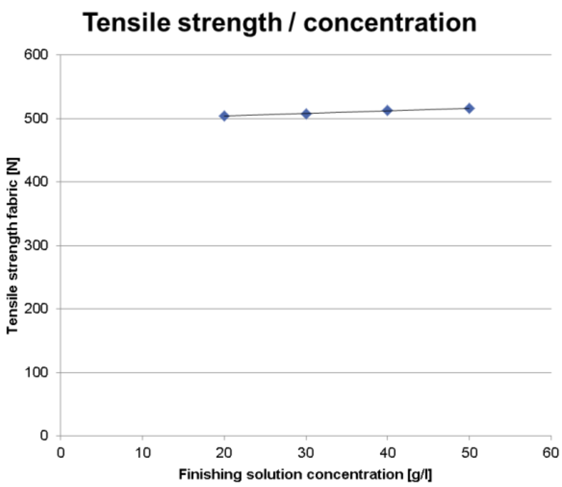


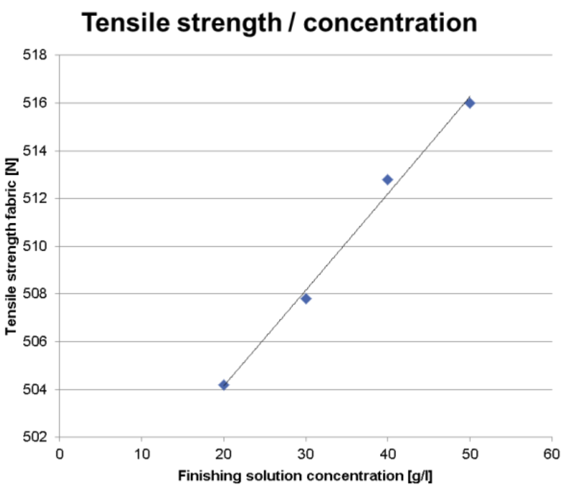
Fig. 3: *Scatter plot of the warp tensile strength in relation to the solution concentration*

From the scatter plot (figure 3), we can observe that the higher the solution concentration, the higher the tensile strength.

This lesson describes the linear interpolation (1) and exponential interpolation (2). As a consequence of computing the parameters, we get the analytic relation of the linear trendline (1) and the analytic relation of the exponential trendline (2) (figure 4 a, b).



a. Linear trendline of the warp tensile strength in relation to the solution concentration



b. Exponential trendline of the warp tensile strength in relation to the solution concentration

Fig. 4: *Tensile strength/concentration interpolation*

$$y=0.404x+496.06 \quad (1)$$

$$y = 496.23e^{0.000792x} \quad (2)$$

Where:
y = tensile strength [N]
x = solution concentration [g/l]

The third lesson developed by INCDTP was included in the digital transition courses for managers and mentors. This lesson presents aspects related to data analytics aspects that can be added to business processes to predict sales, take into account production and advertising costs, study the behaviour of the customers and, predict future actions and make decisions about future product developments and the necessary team to achieve the objectives [3-6]. The Business Analytics Value Chain (figure 5) consists of [7] identification of new business challenges, data audit, preparation and execution, analytics knowledge discovery, test and learn knowledge management and execution and continuous optimization. In order to perform data analytics, it is necessary to have specialized human resources (e.g. database specialists, report developers, Python developers, AI developers and data analysts using tools such as SQL, BI tools, or cloud-based services to extract, load and transform data.

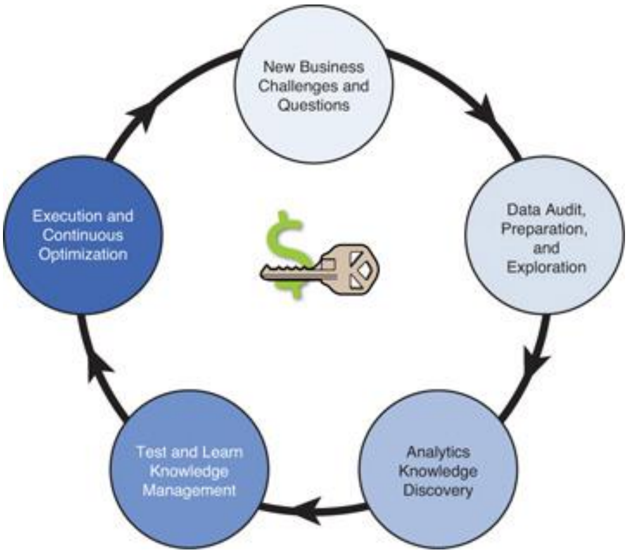


Fig. 5: *Analytics business value chain [3]*

5. CONCLUSIONS

The proposed lessons in the framework of the ADDTEX Erasmus+ project can help technicians, graduates, engineers, professionals, managers and mentors from the textile industry improve their knowledge about data analysis, acquisition and visualization to generate business growth through customer behaviour and sales prediction. In addition, business analytics require adequate software products and human resources.

Accurate data fitting and development of the model help in sales, production and behaviours (competitors or customers) prediction and outlines elimination. Predictive analytics involves several steps, such as data sampling, selecting the appropriate algorithm, predicting the target/type and using a machine learning model to anticipate the results.

In the case of using historical data records (massive volume of data) for analysis, the data visualization (e.g., scatter, combo, list, or stacked plots) helps in the quick visualization of the aspects related to performance and improvement of the business outcomes [8].

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ANNALS OF THE UNIVERSITY OF ORADEA
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EQUILIBRIUM MODELING OF ACRYLIC DYEING WITH CATIONIC DYES

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Abstract: *This article presents a complex set of research activities related to the sorption analysis of the process of dyeing acrylic fibers with cationic dyes to clarify the complex events during the adsorption of dye molecules for fibers and their diffusion into the interior. Typical acrylic fibers were used for dyeing with cationic blue dye. The fiber samples were dyed in a constant bath, the initial dye concentration and dyeing time were varied. The results reveal that the degree of dye exhaustion on acrylic increases as the initial concentration of dye increases. A longer time carries a higher degree of exhaustion, the same happens with the amount of adsorbed dye per unit mass of the acrylic. Isothermal linear modeling of the dyeing process gives results according to which the Langmuir model best covers the experimental points, thus confirming the existence of monolayer dye adsorption, with a uniform distribution of adsorption heat and affinity over the homogeneous fiber surface. The Freundlich and Hill–de Boer isotherm models give somewhat weaker results for the interpretation of equilibrium acrylic dyeing.*

Key words: *acrylic fibers, cationic dye, dyeing, isotherm models, dye exhaustion.*

1. INTRODUCTION

Acrylic fibers are widely used in the textile industry for the production of various textile materials and products. Acrylic fibers have a small amount of anionic centers, so they can be easily dyed with dyes that have a positive charge, i.e. cationic dyes. Cationic dyes bind to acrylic fiber by ionic bonds and are by far the most important class of dyes used for these fibers. In terms of performance, acrylic fibers are very similar to wool, they have a number of excellent properties, such as good elasticity, softness and voluminousness. Acrylic fiber textiles usually exhibit bright color, good light fastness, excellent antibacterial properties and insect resistance. Depending on the use, acrylic fibers can be processed into pure products or mixed with other fibers. Acrylic-based fabrics are widely used in clothing, home textiles and decoration [1].

When the acrylic fiber comes into contact with the cationic dye, a high mutual affinity occurs. They combine rapidly with the anionic groups of acrylic fibers, which usually results in uneven adsorption and poor even properties.

In addition to the rapid adsorption of dyes on the surface of acrylic fibers, it is also important how the dyes diffuse into the interior of the fiber. Under normal conditions, there are not enough gaps, ie. the intermolecular space in the fibers is very small, so cationic dyes hardly diffuse into the acrylic fibers. Usually, this problem is solved by increasing the dyeing temperature. A lot of water and energy is consumed during dyeing. The problem of poor evenness is solved by adding surfactants to the dye bath. All of this puts an additional burden on the quality and quantity of waste water, making treatment more difficult. To meet the demands of cleaner production, new highly efficient and environmentally friendly dyeing techniques are being tested [2].

Acrylic fibers have a pronounced molecular structure, a well-developed crystalline region, small cavities and a hydrophobic surface. All this makes it difficult to dye with high molar mass dyes, which is why acrylic fibers are mostly dyed at temperatures above 95 °C. The glass transition temperature (Tg) of acrylic fibers plays an important role in the dyeing of these fibers. At temperatures lower than Tg, the diffusion of dye molecules into the fibers is difficult due to the regular structure, at temperatures higher than Tg the thermoplasticity and mobility of segments of the polymer chains increases and facilitates the diffusion of dye molecules into the fibers. Therefore, a further increase in temperature causes an increase in the adsorption of dye on acrylic fibers [3].

Finishing textile material by dyeing, from a theoretical and practical point of view, is a very complex procedure. Practically speaking, textile dyeing is the pinnacle of finishing, which gives the textile material a final, visually improved, and commercially usable product appearance. When dye molecules enter the fiber, their movement is restricted not only due to the influence of physical bonding forces but also due to the molecular structure and physical properties of the fibers [4].

Important factors in the dyeing process are the chemical composition and structure of the fiber. Dyeing systems are complex, multi-component and largely determined by the relationship between fiber properties and dye properties. Determining a direct and precise correlation between the chemical structure of the fibers and the chemical structure of the dye cannot be fully achieved, considering the complexity of the fibers as a substrate, the complexity of the dye structure, and the large number of parameters that act in the dyeing process [5].

Studio research in the field of textile dyeing has always been a challenge for researchers because it is a very interesting, always current, and perspective-innovative area of textile technology. Every new knowledge in this area, in addition to the efficiency for which it was first designed, implies a review of the background, ie. the consequence of the application of new technologies on the environment and therefore environmental protection [6].

This paper presents a complex set of research activities related to the sorption analysis of the process of dyeing acrylic fibers with cationic dyes to clarify the dynamic and therefore very complex events during the adsorption of dye molecules for fibers and their diffusion into the interior. Understanding these activities will facilitate the understanding of dyeing conditions and the definition of specific parameters decisive for the achievement of even dyeing, as well as high dye exhaustion.

2. EXPERIMENTAL PART

2.1 Materials and Methods

In the experimental part of the work, acrylic fibers (Lebanteks, Serbia) with basic properties were used: fineness 2.5 dtex, breaking strength 10 cN, and breaking elongation 22%. Cationic dye C.I.Basic Blue 41 (Textilcolor, Switzerland), molecular formula $C_{20}H_{26}N_4O_6S_2$, and molar mass 482.57 g/mol, was used for dyeing.

The dye used belongs to the mono azo class of dyes, it is a dark purple powder, soluble in water, and it is used for dyeing acrylic and wool fibers, knitted fabrics, fabrics, carpets, etc.

The dyeing-adsorption test was performed in such a way that a 0.5 g acrylic sample was dyed in a constant volume solution of 50 cm^3, with different dye concentrations (10, 20, 30, 40, 50, and 60 mg/dm^3). Distilled water was used in all dyeing cases. The dyeing time was 10, 20, 30, 50 and 60 min. The equilibrium time of dyeing is 60 min, namely, it has been shown that with longer dyeing there are no significant changes in the degree of exhaustion of this dye. The aqueous dye solution also contained electrolyte Na_2SO_4 (10%), while the dyeing temperature was 95 °C, in an acidic medium, pH 4.5.

UV-VIS spectrophotometry and a Cary 100 Conc UV-VIS device, Varian (absorption maximum at 590 nm) were used to determine the concentration of the dye in the solution.

The degree of dye exhaustion [7] is calculated using the equation:

$$Exhaustion\ degree = \frac{C_0 - C_t}{C_0} \cdot 100\ \ (\%) \tag{1}$$

where: C_0 and C_t (mg/dm^3) - initial and dye concentration at time t.

The amount of adsorbed dye [8] was obtained through the forms:

$$q_t = \frac{C_0 - C_t}{w} \cdot V \quad \text{and} \quad q_e = \frac{C_0 - C_e}{w} \cdot V \tag{2}$$

where: q_t (mg/g) - mass of adsorbed dye per unit mass of fibers in dyeing time t; q_e (mg/g) - mass of adsorbed dye per unit mass of fibers in equilibrium; C_e (mg/dm^3) - equilibrium concentration of the dye in the solution; w (g) - fiber mass and V (dm^3) - volume of dyeing solution.

The Langmuir linear isotherm [9] was used to quantitatively describe the adsorption:

$$\frac{1}{q_e} = \frac{1}{q_m} + \frac{1}{b \cdot q_m} \cdot \frac{1}{C_e} \tag{3}$$

where: q_e - adsorption capacity (mg/g); C_e - equilibrium concentration of adsorbate in solution (mg/dm^3); q_m - the maximum amount of adsorbate on the sorbent (mg/g); b - the ratio of adsorption rate constant and adsorbate desorption rate constant (dm^3/mg).

The Freundlich model is represented by the following linear equation [10]:

$$ln\, q_e = ln\, K_F + \frac{1}{n} ln\, C_e \tag{4}$$

where: K_F $(mg/g)\cdot(dm^3/mg)^{(1/n)}$ and n - constants characteristic of the observed system: cationic dye, acrylic and water.

The Hill–de Boer linear equation was used to describe the case of mobile sorption with lateral interaction between adsorbed dye molecules [11]:

$$ln\left[\frac{C_e \cdot (1-\theta)}{\theta}\right] - \frac{\theta}{1-\theta} = ln\, K_1 - \frac{K_2 \cdot \theta}{R \cdot T} \tag{5}$$

where: K_1 - Hill–de Boer constant (dm^3/mg); θ - fractional (partial) coverage; R - universal gas constant (kJ/mol·K); T - temperature (K); K_2 - energy constant of interaction between adsorbed molecules (kJ/mol).

3. RESULTS AND DISCUSSION

The influence of initial dye concentration on dye exhaustion and amount of adsorbed cationic dye during standard dyeing, for different times, is given by diagrams in Figure 1 and 2. There is continuity in the changes during the growth of the initial dye concentration. With the increase in dye concentration, the degree of dye exhaustion from the dyeing bath decreases, and the amount of adsorbed dye increases. With the increase in the concentration of the dye in the solution, initially, there is a slightly weaker decrease in the percentage of exhausted dye, but at the end of the dyeing, after C_0=50 mg/dm^3, this decrease would be more intense, for each dyeing time, from 10 to 60 min. The longest dyeing time causes the highest degree of exhaustion and the highest amount of dye adsorbed by the fibers.

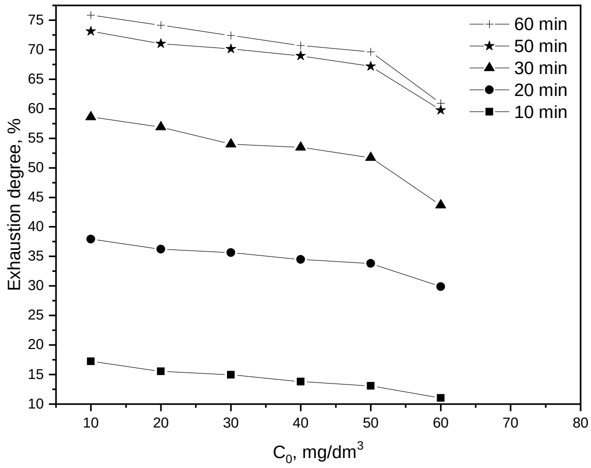

Fig. 1: *Degree of dye exhaustion vs initial dye concentration*

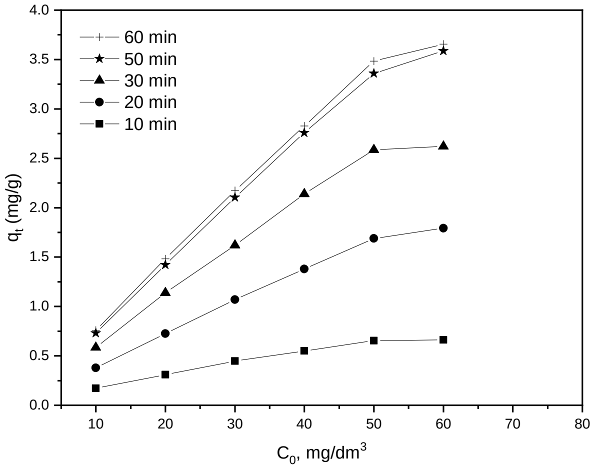

Fig. 2: *Degree of the amount of adsorbed cationic dye vs initial dye concentration*

Figure 3 gives a comparative representation of the mentioned Langmuir models, through linear fitting of experimental data. The high functionality of the variables is noticeable in the diagrams, which indicates the fact that the Langmuir adsorption isotherm can be taken seriously in consideration of the explanation of the sorption of cationic dye on acrylic fibers. The fitted curves pass through the experimental points with a slight deviation.

The parameters of Langmuir sorption model, as well as the values of the coefficients of determination R^2, are given in Table 1.

According to the values of R^2, from tab. 1, it can be seen that the adsorption of blue cationic dye on acrylic has very high values (0.998), which assumes the absolute functionality and acceptability of the monolayer sorption model for the description of the equilibrium dyeing.

The equilibrium parameter, R_L, lies between 0 and 1, i.e. the value is 0.29, which means that the adsorption of the cationic dye is suitable for acrylic (tab. 1).

Once a dye occupies a site, no further adsorption can take place at that site; intermolecular attractive forces decrease rapidly as the distance increases. There is no interaction between dye molecules adsorbed on neighboring sites, adsorption on the surface is localized, which means that the adsorbed molecules are present at specific and localized sites [12].

According to the visual inspection of the linear regression line from the diagram in Figure 4, it is observed that the Freundlich model covers the experimental points very well, ie. the position of the regression line is very close to the ideal position of the fitted curve that follows the closest path to the experimental points.

The results from Table 1 confirm that n > 1, that is, 1/n < 1, (1/n = 0.73), which shows that the dye adsorbs well under the given test conditions. Values of the parameter n close to unity indicate a reduced intensity of adsorption and represent a guide in which direction and in which way the dyeing process should be conducted [13].

Also, according to the data from Table 1, it is noted that the coefficient of determination of the Freundlich isotherm (0.968) is weaker compared to the one obtained for the Langmuir expression, which means that it is a good but not the best functionality.

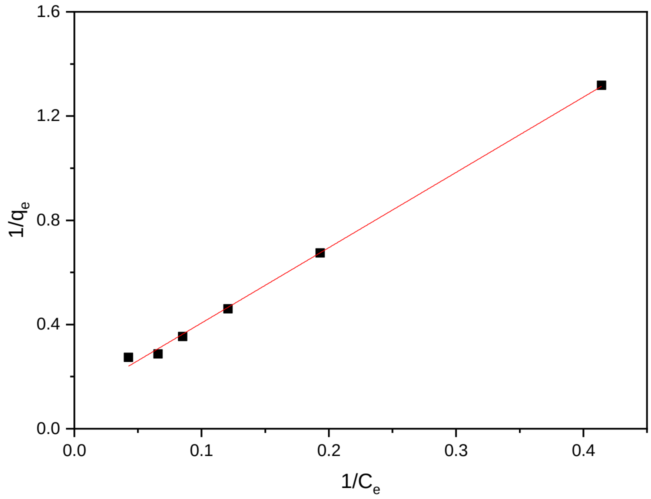

***Fig. 3**: Langmuir linear regression models for equilibrium dyeing of acrylic fibers*

The existence of mobile sorption with lateral interactions between adsorbed dye molecules was verified using the Hill–de Boer equation. The graphical representation of this model is done through the diagram in Figure 5 and obviously, the linearity of the fitted curve is present about the experimental points.

More specifically, quantitative analysis, through the data given in tab. 1 and the amount of the statistical parameter (R^2=0.907), confirms a good result, with the indication that the results of this isotherm cannot be accepted for the dominant description of coloring. There is the presence of lateral interactions between cationic dye molecules on the surface of acrylic fibers.

Given that the parameter K_2 has a positive value and a high value, it means that there is an attraction between adsorbed dye molecules, otherwise there would be repulsion [11].

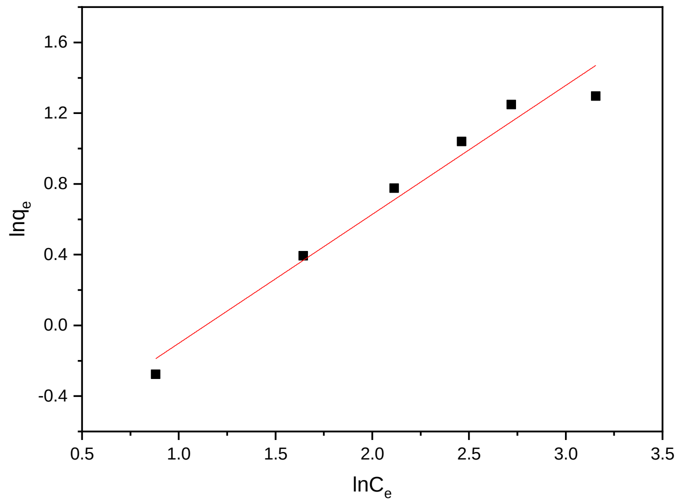

Fig. 4*: Freundlich linear regression models for equilibrium dyeing of acrylic fibers*

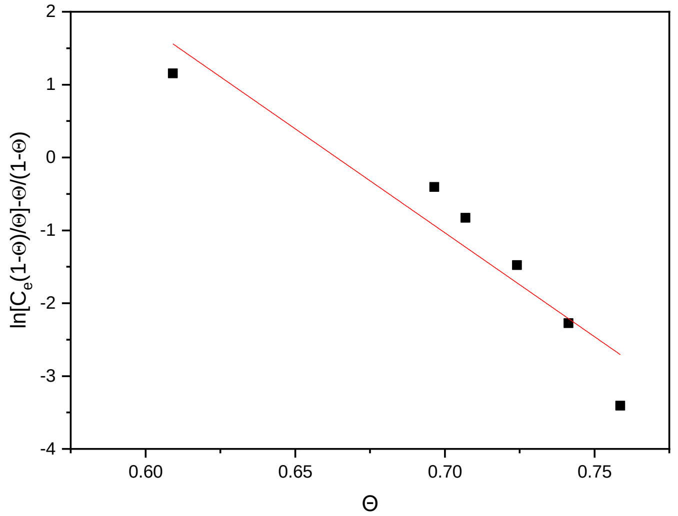

Fig. 5*: Hill de Boer linear regression models for equilibrium dyeing of acrylic fibers*

Table 1: *Analytical expressions of linear isotherms with coefficients for the cationic dye–acrylic fiber system*

Model	Analytical expression	Model parameters		R^2
Langmuir	$\frac{1}{q_e} = \frac{1}{8.54} + \frac{1}{0.34} \cdot \frac{1}{C_e}$	q_m, mg/g	8.54	0.998
		b, dm^3/mg	0.04	
		R_L	0.29	
Freundlich	$ln\, q_e = -0.84 + 0.73 \cdot ln\, C_e$	K_F, (mg/g)·(dm^3/mg)$^{(1/n)}$	0.43	0.968
		n	1.37	
Hill-de Boer	$ln\left[\frac{C_e \cdot (1-\Theta)}{\Theta}\right] - \frac{\Theta}{1-\Theta} = 18.95 - 28.92 \cdot \Theta$	K_1, dm^3/mg	$5.9 \cdot 10^{-9}$	0.907
		K_2, kJ/mol	88.49	

5. CONCLUSIONS

When dyeing, one should be very careful when designing the final form, given that the textile material is a very complex system with a large number of variable parameters. According to the results of the research on the dyeing of acrylic fibers, the results that could be accepted and used more can be singled out.

By modeling the dyeing process, data is obtained that connect the concentration of dye, temperature, the presence of electrolytes, and the efficiency of the achieved dyeing on acrylic, that is, the amount of waste dye left in the bath after dyeing.

The process of dyeing acrylic fibers with a typical representative of cationic dyes of various concentrations gives good results at 95 °C. The degree of dye exhaustion on acrylic increases during the increase of the initial dye concentration. A longer time carries a greater degree of exhaustion. At lower initial dye concentrations, a higher percentage of exhaustion occurs and this trend is maintained mostly throughout the dyeing process. A larger amount of dye in the solution or a longer dyeing time results in a slightly larger amount of adsorbed dye per unit mass of the adsorbent.

Isothermal linear modeling of the dyeing process gives results according to which the Langmuir model best covers the experimental points, followed by the Freundlich model, and finally the Hill-de Boer isotherm. In the specific case of dyeing, the existence of monolayer dye adsorption is confirmed, with a uniform distribution of adsorption heat and affinity over a homogeneous surface.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ANALYSIS OF DIFFERENT TREATMENTS OF MATERIALS INTENDED FOR MATTRESS COVERS

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Abstract: *The study on the chemical treatment of mattress cover materials for domestic and medical use is particularly important to understand how these materials can be improved in terms of resistance to different factors and durability in different contexts. In this paper, the materials for making three mattress covers (two mattress covers for home use and one mattress cover for hospital/medical care) were treated and tested in order to obtain basic information about the chemical treatment of fibers in mattress covers. Chemical treatments applied to materials can significantly influence their quality, strength and durability. It is essential to achieve the desired performance depending on the use of the mattress cover. The tests performed have provided valuable basic information regarding the behaviour of treated materials under different conditions, giving a clearer picture of their strength and the potential benefits or disadvantages of the chemical treatments applied. We noticed that chemically treated materials showed greater stain resistance and are easier to clean compared to untreated ones. Also, chemical treatments have helped to increase the durability of materials, thus extending the life of mattress covers. We used materials such as cotton, polyester and microfiber to make the mattress covers, and then subjected them to various chemical treatments to test their resistance to various external factors, such as blood stains or other liquids.*

Key words: *mattress cover, chemical treatments, fibers, household, medical regimen.*

1. INTRODUCTION

It is essential that mattress cover manufacturers comply with safety and health standards in the fibre treatment process to minimise risks for users [1].

It is important that consumers are informed about the materials used in mattress production and that the chosen products meet the safety and health standards [2].

Changes in Californian furniture flammability testing rules have shifted the focus from foam products to their covers [3], so the prevalence of these additives in current mattress covers is an important unknown. "Certi-PUR-US" is an industry-based certification program requiring foam products to be free of heavy metals, PBDEs, TDCPP or TCEP ("Tris") flame retardants, as well as numerous flame retardant additives [4], [5].

Consumers may think that CertiPUR-US certified mattresses have undergone rigorous testing and do not contain hazardous substances [6].

2. MATERIALS AND METHODS

Natural fibers such as cotton, linen, wool and silk tend to be more comfortable due to their breathability and ability to absorb moisture. They can provide a pleasant sensation to the skin and may be more suitable for people with sensitive skin or allergies. On the other hand, synthetic fibers such as polyester or nylon are often preferred for certain characteristics, such as water resistance and quick drying. However, they can be less breathable and retain more heat compared to natural materials. Fibrous mixtures between natural and synthetic fibers can combine the advantages of both types of fibers, giving textile products properties that meet several requirements.

In this paper, the materials for making three mattress covers (two mattress covers for home use and one mattress cover for hospital/medical care) were treated and tested in order to obtain basic information about the chemical treatment of fibers in the new mattress covers.

The constituent components of the three mattress covers were each undersampled by cutting each layer and then it was proceeded to collecting the samples in small, labeled bags. Each sample was sampled over its entire layer depth, with section areas of approximately 1 - 2cm. This paper highlights the difference in finishing treatments, depending on the areas of use of knitted materials, intended for mattress covers [7].

All samples were made with a Motic Fig. 1 microscope, which is commonly used in research laboratories. They are known for their durability, precision optics and user-friendly interface.

***Fig. 1**: Motic microscope* [7]

***Table 1:** Treatment of household cover (mattress) type 1*

Treatment	**LIKROLL**
Recipe	Citric Acid 0.2% Elastofin STO501 1.4%, Temp:150^{0}C
Request width	229-231 cm
Request weight	267-278 gr/m^2
Composition	18% Viscose, 82%Pes
Color	Opera,Black, Basalt, Black

***Table 2:** Treatment of household cover (mattress) type 2*

Treatment	**LIKROLL**
Recipe	Citric Acid 0.2% Elastofin STO501 1.4%, Temp:150^{0}C
Request width	229-231 cm
Request weight	354-369 gr/m^2
Composition	25% Viscose from Bamboo, 75%Pes
Color	Bleached, Natural, Maldive, Ciment

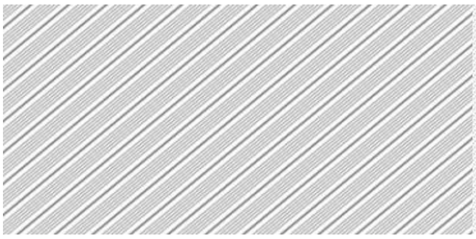

Fig. 1*: Treated material for household cover (mattress) type 1*

Fig. 2*: Treated material for household cover (mattress) type 2*

The main components of each mattress cover tested and their observed compositions are summarised in Tables 1, 2 and 3. The different components of the two mattress covers, for home use, which were mixtures of Citric Acid 0.2%, Elastofin STO501 1.4%, / pick-up 100% poids/weight control, Temp:1500C, compared to covers intended for hospital use, which have in their composition Citric Acid 0.2% Elastoin STO501 1.4% Tanabiotic 0.7%, Temp:1200C, are different and require immersion treatment, to get that 100% to 150% solution load.

Table 3: *Treatment of cover (hospital mattress)*

Treatment	PADDER
Supplements	Active Biotic
Recipe	Citric Acid 0.2% Elastofin STO501 1.4% Tanabiotic 0.7%, Temp:120^0C
Request width	239-241 cm
Request weight	340-354 gr/m^2
Composition	18% Viscose, 3,5% Elastne, 78,5%Polyester
Color	Natural, Nude

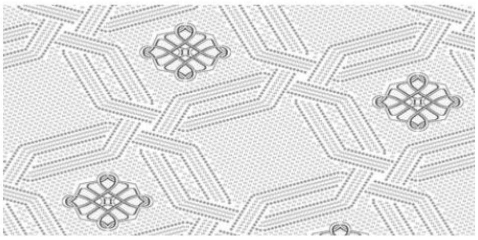

Fig. 3*: Antiseptically treated cover material (mattress)*

The tests performed showed that chemically treated materials showed increased stain resistance and were easier to clean compared to untreated materials. Chemical treatments have also helped strengthen the fibers and increase their durability.

It is important to note that chemical treatments can also have certain disadvantages, such as potential impact on the environment or possible harmful effects on the health of users. Therefore, it is advisable to use them responsibly and to use safe chemical treatment methods to maximize the benefits and minimize the risks.

3. CONCLUSIONS

This paper highlights the difference in finishing treatments, depending on the areas of use of knitted materials, intended for mattress covers.

In conclusion, chemical treatments can be beneficial for improving the quality and durability of mattress covers, and this information is valuable for textile manufacturers and end consumers alike.

It is also very important to properly educate consumers about the impact of chemicals on their health and the environment. Consumers should be aware of the potential risks associated with chemicals used in the products they purchase and be encouraged to opt for safe and sustainable products.

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ANNALS OF THE UNIVERSITY OF ORADEA
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EFFECT OF ELASTANE ON MOISTURE MANAGEMENT IN HIGH-PERFORMANCE SPORTSWEAR

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Abstract: *Nowadays, more and more articles for sportswear, but not only, include elastane yarns. Stretch clothing plays an important role in optimizing the performance of the wearer by providing freedom of movement, maximizing comfort, minimizing the risk of injury, and reducing friction. This study aimed to investigate the fabric moisture management properties with dependency on elastane yarn linear density. Experiments were conducted with two series of plated knitted fabrics. The ground yarns were: 30% Outlast®Viscose / 70% Cotton, 14.75 tex, and a Dacron® 702 WSD 1.7/38, 14.30 tex (Coolmax®). The plating yarns were 22 dtex, 44 dtex, and 77 dtex Creora®, plated at every feeder by using the electronic feeder. The Outlast®/Cotton material is superior in water vapour transmission and Colmax® in drying capacity, regardless of the fineness of the elastane yarn. In terms of liquid water management, correctly selecting the appropriate linear density of elastane yarn can optimize the functionality of sportswear.*

Keywords: knitted structure, stretch clothing, water absorption, vapour diffusion, drying capacity.

1. INTRODUCTION

Comfort in movement is a key feature of modern sportswear fabrics, and the use of elastic yarns to improve the elasticity of the fabric and increase comfort in movement is a very common method. Stretch clothing plays an important role in optimizing the wearer's performance by providing freedom of movement, maximizing comfort, minimizing the risk of injury or muscle fatigue, and reducing friction [1]. According to the literature, to improve fabric elasticity and shape retention, 2% of elastane is enough but for high-performance garments, such as swimwear and active sportswear, the elastane content can increase up to 30% [2]. Depending on the requirement of the level of the stretch of the clothing, it can be classified into two categories. The requirement of an elasticity level below 30% is called elastic comfort and the stretch level requirement above 30% is called power stretch and is relevant for certain types of sportswear such as swimwear and compression clothing [3].

Moisture transport in fabrics determines their functionality during activities that involve a high metabolic activity and that cause the human body to sweat. In this case, sweat must be eliminated in the form of water vapour that evaporates from the surface of the skin and through diffusion is transported by the clothes to the outside environment and/or in the form of liquid moisture through wicking. When liquid sweat is present, the moisture absorption by a fabric is characterized by in-plane and transplanar wicking [8]. Several relevant parameters, such as the geometrical properties of the pores formed by the fibers (intra-yarn) and yarns (inter-yarn), the surface properties of the fibers, and the fiber moisture absorption capacity have an influence on moisture transport in porous fabrics [4].

The present study investigates the effect of elastane yarn linear density on the moisture management properties of the knitted fabrics used in active sportswear.

2. MATERIALS AND METHODS

2.1 Materials

Two series of 3 knitted fabrics were produced using the 8-feed Single-Jersey Circular Knitting Machine MERZ – MBS. The ground yarns were: 30% Outlast®Viscose/70% Cotton, 14.75 tex, and a Dacron® 702 WSD 1.7/38, 14.30 tex (Coolmax®). The plating yarns were 22 dtex, 44 dtex, and 77 dtex Creora®, plated at every feeder by using an electronic feeder BTSR KTF 100 HP. The plating yarn input tension was 4 cN and for the main yarn 2 cN. The yarns selected for this study allow a comparison between two completely different types of materials (in terms of their affinity to water), the Outlast®/Cotton material being hydrophilic, while the Coolmax® material is hydrophobic. These materials were selected because they are used to produce high-performance sportswear, and due to the different approaches to achieving the thermo-regulating effect. Outlast®Viscose/Cotton yarn incorporates thermally active material, i.e., paraffinic phase change material (PCM) microcapsules within the viscose fiber structure (Fig. 1), according to the Outlast Technology, and the thermo-regulating effect results either from heat absorption or heat emission of the PCM [5], [6]. The thermoregulation effect of Coolmax® relies on moisture management due to the shape of the fibers, namely the multi-channel cross-section (Fig. 2), which applies the capillary theory and absorb sweat and moisture from the surface of the skin, transport it to the fabric surface and then evaporate [7], [8].

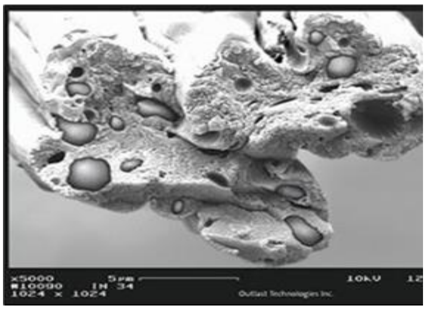

Fig. 1*: Outlast® Thermocules in viscose fiber [6]*

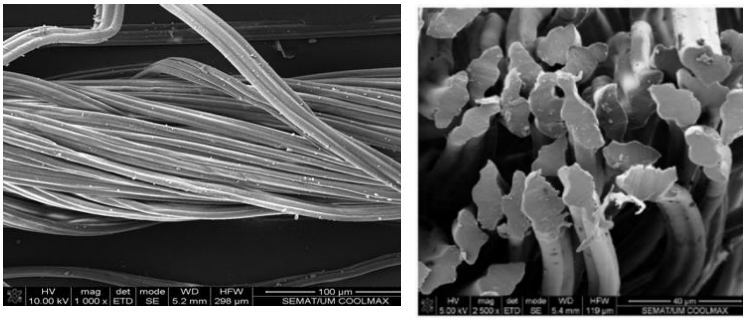

Fig. 2*: SEM image of Coolmax® yarn [9]*

2.2 Methods

Water vapour permeability

The ability of clothing ensembles to transport water vapour is an important factor of physiological comfort. When vapour passes through a textile layer, two processes are involved: diffusion and sorption-desorption. Water vapour diffuses through a textile structure in two ways, simple diffusion through the air spaces between fibers and yarns, and along the fiber itself. The factors associated with knitted fabric's thickness and construction determine moisture vapour transport properties, especially in low-density open textile structures. Das et al. [10]. concluded that, at a specific concentration gradient, the vapour diffusion rate along the textile material depends on the porosity of the material and also on the water vapour diffusivity of the fiber. Diffusivity of the material increases with the increase in moisture regain. In the same way, moisture transport through the sorption-desorption process will increase with the hygroscopicity of the material. Fiber-related factors, such as cross-sectional shape, do not play a significant role in water vapour transfer [11].

The water vapour permeability was determined on SDL Shirley Water Vapour Permeability Tester M – 261, according to the standard BS 7209-1990. The cup method is a very common method for testing the moisture transfer ability of fabrics. It is used to measure the rate of water vapour transmission perpendicularly through a known area of the fabric to a controlled atmosphere. In this method, a sample covers a cup containing distilled water and is placed in a controlled environment of 20 ºC and 65% relative humidity. By adjusting the initial weight of water in the cup to 46 cm3, a constant air gap was set between the water surface and the sample. The tests lasted for 16 hours and the weight of each cup was recorded initially and after 16 hours. The water vapour transmission rate (WVTR) in grams per hour per square meter was calculated by the following equation:

$$\mathrm{WVTR} = \frac{\mathrm{G}}{\mathrm{t} \cdot \mathrm{A}} \quad (\mathrm{g/m^2/h}) \tag{1}$$

where, G is the weight change of the cup with the fabric sample, in grams, t is the time during which G occurred, in hours, and A is the testing area in square meters.

The index of the water vapour transmission rate was calculated by the following equation:

$$\mathrm{I} = \frac{\mathrm{WVRT}}{\mathrm{WVRT_r}} \cdot 100\ (\%) \tag{2}$$

where $\mathrm{WVTR_r}$ is the water vapour transmission rate of the reference fabric.

For liquid transport within fabrics, textile researchers distinguish two phenomena – wettability and wickability [12]. The term ‘wetting’ is usually used to describe the displacement of a solid–air interface with solid-liquid interface. Wicking is the spontaneous flow of a liquid in a porous substrate, driven by capillary forces. As capillary forces are caused by wetting, wicking is a result of spontaneous wetting in a capillary system. Wetting and wicking processes occurring during the wearing of clothes have a practical significance in clothing comfort [13], [14]. Many test methods have been developed to measure liquid water absorbency and water transport in fabrics. These methods measure different aspects of the moisture management characteristics of fabrics [12], [15].

Diffusion capacity

Diffusion capacity expresses the rate of water diffusing on the fabric surface and represents the fabric’s instantaneous water (perspiration) absorbency and transferring ability. To measure the diffusion ability, the sample fabrics were placed flat on a hydrophobic board with the outer surface facing down. The area (mm^2) was measured with water allowed to diffuse at 15, 30, and 60 seconds after dripping 0.2 ml of water using a precise dropper whose tip was 10 mm above the fabric surface. The measurement was repeated at five different points and the average of the diffusion area (mm^2) was taken to indicate the diffusion capacity of the fabrics.

Wicking - Transverse "plate" test or in-plane wicking test

In-plane wicking is a test method used to evaluate the ability of a textile structure to transport liquid moisture horizontally within the plane of the fabric. This test is used to determine the performance of a textile in applications where it is important for moisture to be distributed uniformly across the fabric surface, such as in sportswear, medical textiles, and outdoor clothing.

The apparatus used to determine the in-plane wicking consists of a horizontal glass plate fed from below with water through a capillary tube from a reservoir placed on an electronic balance. The sample is placed on the glass plate and is held in contact with it (and with water) applying another glass plate on top of it. The changing weight of the reservoir is measured by an electronic balance to determine the rate of liquid uptake by the textile material in the sample. Similarly, apparatus has been used by Buras, Hussain & Tremblay-Lutter, and McConnell [16].

Drying capacity

The drying capacity of textiles refers to the ability of a textile material to dry quickly after being wet, either through exposure to moisture or washing. It is an important property for textiles used in various applications, such as sportswear, outdoor clothing, and medical textiles, as it can affect the comfort and performance of the wearer. Textiles with high drying capacity can quickly wick away moisture and evaporate it, keeping the wearer dry and comfortable.

To determine the drying capacity, the fabrics cut into circular samples of 100 cm^2 were left on a flat surface under standard atmospheric conditions (temperature 20 ± 2°C, 65 ± 2% RH) and their weight (W_f) was determined. To determine the drying rate, 1 ml of water was dripped onto each sample using a precision dropper whose tip was 10 mm above the surface of the fabric, and the wet weight (W_0) at the initial stage was recorded. The weight change (W_i) was measured periodically at 10-minute intervals. The remaining water ratio (RWR) was calculated at each interval using the following equation:

$$\mathrm{RMR} = \frac{W_i - W_f}{W_0 - W_f} \cdot 100 \ \ (\%) \qquad \textbf{(3)}$$

The RWR was used to express the drying ability of the fabrics as wetted.

3. RESULTS AND DISCUSSION

Dry relaxation was performed for 48 hours by placing the samples on a flat surface in standard atmospheric conditions (20 ± 2°C and 65 ± 5% RH), before testing the properties.

Since the transfer of moisture through textile materials is strongly influenced by the inner structure of the material, the influence of the elastane yarn density on the dimensional properties of the knitted structures was also analyzed. The results can be summarized as follows [17]:

The higher the linear density the higher the tension of the elastomeric yarn, which makes stitches closer to each other and, consequently, stitch density increases. With an increased linear density of the elastane thread, the compactness of the fabric expressed by the tightness factor and density increases. The loop length of ground yarn decreases when the elastane yarn density increases - the tension applied by thicker elastane yarn is higher and consequently, the loop length is lower. The fabric weight per unit area increases with the increase of elastane linear density. The thickness of both types of fabrics slightly increases with the elastane yarn linear density.

Water vapour permeability

For both types of raw materials, the structures are relatively tight and the compactness is similar for a certain value of the linear density of the elastane yarn. Differences in water vapour transmission are due to the diffusion of water vapour through the fibers. Outlast®/Cotton fabrics have higher water vapour permeability (Fig. 3). This result is attributed to the fact that Outlast®/Cotton fabrics have higher moisture regain than Coolmax® fabrics, causing higher diffusivity. Hygroscopic Outlast®/Cotton fabric facilitates better water vapour transfer from the humid air close to the sweating skin and releases it in dry air.

When comparing fabrics made of the same yarn, the WVTR is primarily a function of fabric thickness and porosity. Fabric thickness is an important factor because it determines the distance through which moisture vapour traverses from one side of the fabric to the other, and the transportation of water vapour through a thin fabric will be easier. Also, fabric density plays a significant role in influencing behaviour. The diffusion of vapour molecules through air space in a fabric is a major contributor to total water vapour transport. The higher water vapour transmission rate for fabrics with lower elastane yarn linear density might be attributed to the comparatively higher porosity of these fabrics.

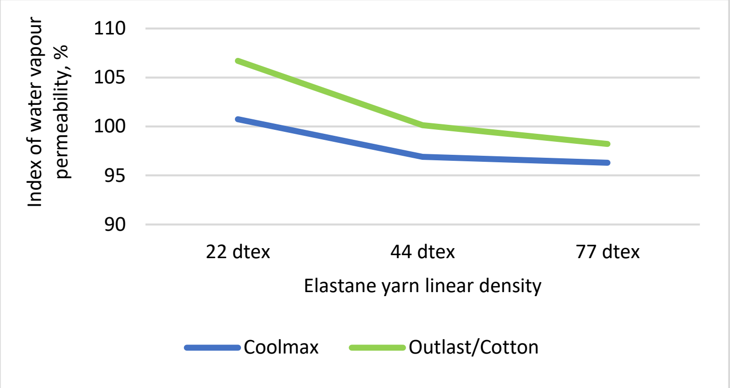

Fig. 3*: Influence of elastane linear density on fabric water vapour transmission rate*

Diffusion capacity

In the Coolmax® fabrics, the hydrophobic character and special morphology of the fibers are the main factors promoting water diffusion by capillary action. Capillary action is the process by which liquid is drawn into narrow spaces, such as the gaps between fibers, due to the combined forces of adhesion and surface tension. The larger surface area of the fibers and more channels on the surface (Figure 2) facilitate the diffusion of water through capillarity. The water diffusion capacity for 15, 30, and 60 seconds is plotted in Fig. 4. When 44 dtex elastane yarn is used the best diffusion capacity was obtained. For more open structures (22 dtex elastane yarn) the diffusion area reduces, probably due to the increase in inter-yarn open space that reduces the capillary action. For structures with a higher tightness factor (77 dtex elastane yarn), the diffusion area is also reduced, and the higher bulk density reduces the rate of capillary migration. So, in this case, the best conditions for water diffusion are achieved neither by the most compact nor by the most open structures, but rather by structures that fall between the two extremes. There is an optimal balance between the level of openness and the level of compactness in textile structures that allows the best water diffusion capacity. This concept is important for the development of textiles that are designed to manage moisture, such as sportswear.

For Outlast®/Cotton fabrics, in addition to the transfer of water through capillarity, there is also the absorption of water in the fibers which have a strong hydrophilic character. Due to this phenomenon of water absorption into the fibers, the spreading of water (diffusion area) is slower for samples with greater thickness and weight. Thus, structures with lower density and lower thickness (22 dtex elastane yarn) have the highest water diffusion capacity (Fig. 5).

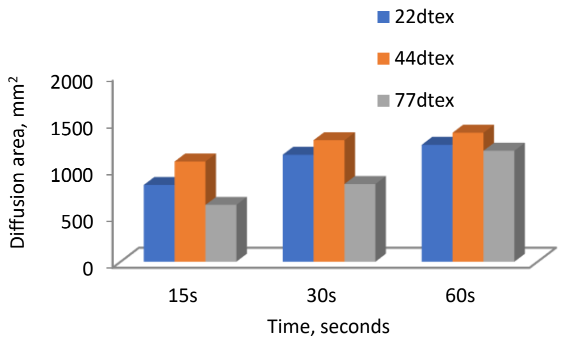

***Fig. 4**: Influence of elastane linear density on diffusion capacity of Coolmax® fabrics*

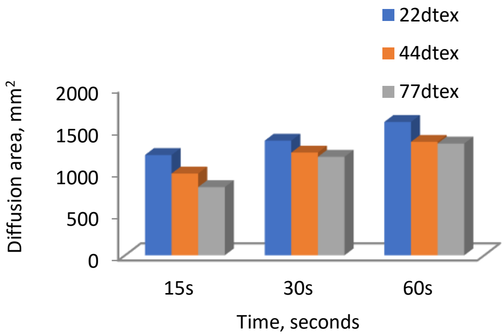

***Fig. 5**: Influence of elastane linear density on diffusion capacity of Outlast®/Cotton fabrics*

Wicking - in-plane wicking test

The amount of water (ml) absorbed by the fabrics with time in the case of the in-plane wicking test is shown in Fig. 6 and Fig. 7. Using those data, the polynomial curves have been fitted for all the fabrics (with r^2 values higher than 0.99). In-plane wicking rate (rate of water uptake) has been calculated from the fitted curves. The water absorption rate gradually became constant after about 3 minutes.

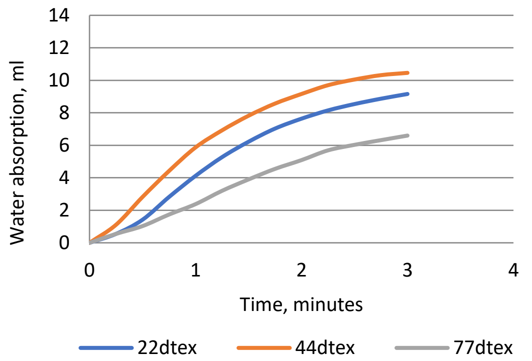

***Fig. 6**: In-plane wicking test of Coolmax® fabrics*

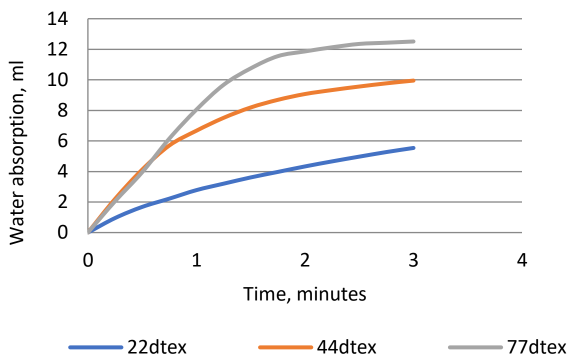

***Fig. 7**: In-plane wicking test of Outlast®/Cotton fabrics*

Outlast®/Cotton knit fabrics have a better capacity and water absorption rate compared to Coolmax® knit fabrics. These results can be explained by the hydrophilic character of viscose and cotton fibers.

For Coolmax® fabrics, as with water diffusion capacity, the knitted fabric with 44 dtex elastane yarn has the best water absorption capacity and the highest rate of water absorption, followed by those with 22 dtex yarn. The structure with the highest bulk density (with 77 dtex elastane yarn) presents the lowest water absorption capacity. All the curves show an inflection point, corresponding to a 10 % - 15 % water ratio in the fabrics above 100 % RH equilibrium moisture regain. The wicking starts right at the beginning of the measurement, and until this concentration of water (10 % - 15 %), must be due to intra-yarn water transport (as opposed to inter-yarn) because capillary forces are larger inside the yarns. Due to the relatively low water concentration at the beginning, it will first fill the smaller intra-yarn voids. For a higher water concentration, the inter-yarn wicking starts, and the rate of the wicking process increases. This result is consistent with that obtained by Birrfelder P. et al [8].

For Outlast®/Cotton fabrics, the structure with the highest thickness and mass per unit area (with 77 dtex) has the highest water absorption capacity and rate of water uptake, due to the hydrophilic character of the cellulose fibers. The greater the weight and thickness, the more water will be absorbed. In this case, the ranking of the samples is exactly the opposite compared to that of water diffusion capacity.

Drying capacity

The Coolmax® fabrics dried completely faster than Outlast®/Cotton fabrics. The drying time for Coolmax® fabric structures was between 130-160 minutes and for all Outlast®/Cotton fabric structures was about 240-250 minutes (Fig. 8 and Fig. 9).

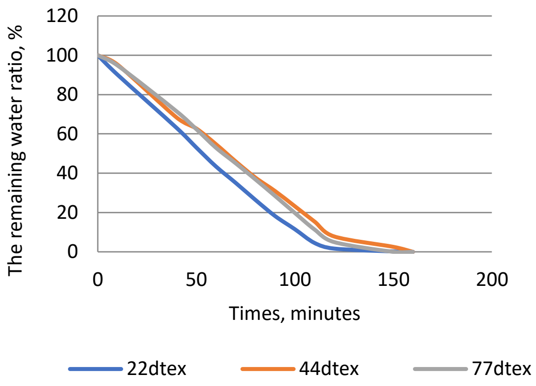

***Fig. 8**: Drying rate of Coolmax® fabrics*

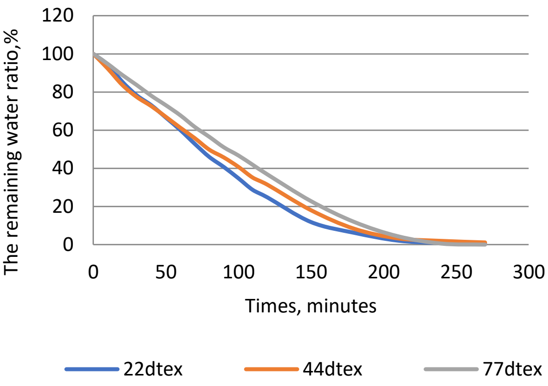

***Fig. 9**: Drying rate of Outlast®/Cotton fabrics*

The results showed that the drying rates of the fabrics from Coolmax® were higher, which can be attributed to their lower moisture regain values. Also, probably, due to the Coolmax® fiber multi-channel cross-section (Fig. 2), the rate of capillary migration is higher, and that enhances the water transmission to the fabric surface and release.

When fabrics of the same material are considered, thickness and density appear to be the factors that most influence the drying rate. For both Coolmax® and Outlast®/Cotton, fabrics with the thinnest elastane yarn, 22 dtex, (respectively lower thickness and lower density) have the higher drying rate. The drying rate has significantly slowed down after 100 - 110 minutes for Coolmax® fabrics and after about 150 minutes for Outlast®/Cotton fabrics. Thus, the curves show an inflection point, corresponding to about 10 % remaining water ratio in the fabrics above 100% RH equilibrium moisture regain for all fabrics. The first part of the curve, having a higher slope, corresponds to the moisture released from the void spaces between yarns, and the second part of the curve with a lower slope corresponds to the release of moisture retained in interfiber capillaries in the case of Coolmax® fibers and in interfiber capillaries and within fibers in case of Outlast®/Cotton fabrics.

4. CONCLUSIONS

The Outlast®/Cotton material is superior in water vapour transmission and Colmax® in its drying capacity, regardless of the fineness of the elastane yarn. Regarding the wicking properties (water absorption ability and area of diffusion of water) it can be concluded that by selecting the appropriate linear density of the elastane yarn the fabric can be optimized for its ability to absorb and distribute moisture, which is important for comfort and performance during physical activity.

Overall, the results of this study are an important tool in the design of sportswear products adapted to the requirements of effective sweat management, emphasizing the importance of material selection and design for achieving optimal performance.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

CONSTRUCTIVE DEVELOPMENT - FUNCTIONAL CLOTHING FOR CHILDREN BORN PREMATURELY

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Abstract: *The design and development process of clothing products for premature babies includes a set of requirements for these types of functional products for this group of wearers. The clothing products intended for premature children must ensure the functionality of the product and the safety of the child who wears it, by respecting the dynamic effects transposed in the constructive additions, provided in the proposed design method. The addition system adopted in the developed design method meets the dynamic needs of premature babies. Designed clothing contributes to improving the condition of the premature baby in the incubator through functions adapted to the requirements and conditions imposed. These products can provide comfort and utility to everyone involved: parents, doctors and children. Therefore, the development of functional clothing for premature infants in intensive care ensures the maintenance of body temperature within normal limits and the comfort of children, and facilitates the necessary medical procedures. Research has shown that the design of new textile products for premature babies has an important role in development and growth.*

Key words: *design method, functional products, specific requirements, premature babies.*

1. INTRODUCTION

The new approach in designing clothing products for children, with flexible structure, is based on the following principles [1-4]:

• the principle of exchanging functional elements;
• the principle of universality of functional elements;
• the principle of multi-functionality of elements;
• the principle of transformation.

Thus, for the design and manufacture of functional clothing products for children born prematurely, the following aspects were taken into account:

- the study of the variability of the values of the anthropometric indicators;
- the study of the constructive parameters of the basic models, for the clothing products for premature babies, according to the dynamics of changes in the dimensional indicators, according to the degrees of prematurity;

- the study regarding the adoption of some compositional-constructive elements that lead to the extension of the life cycle of clothing products for children.

2. GENERAL INFORMATION

2.1 Body product design for premature babies

When designing the body clothing product for premature children, the dimensional characteristics (table 1) and the necessary additions (table 2) for the construction of the basic pattern were initially identified, after which the model pattern of the product was made according to the technical drawing.

Table 1. *Anthropometric characteristics for the design of the basic pattern of the body product for children born prematurely.*

Anthropometric characteristic	Calculation relationship	Value, cm
Product length (Lp)	Lp = 0,5 * Lc + 5 cm 0,5*44+5 = 27	27
Body length (Lc)	Lcorp = 44 cm	44
Half Chest Circumference (Chest Circumference/2)	32,6/2 = 16,3	16,3
Back length to waist (Lst)	Lst = 0,25*Lc +A A = 5 cm 44*0,25+5 = 16 cm or Lst+5=11,61+5 = 16,61	16,61
Sleeve cut depth (Arm)	Arm = 0,5*Lst-2cm = 11,61*0,5+1 = 6.80 cm	6,80
Sleeve cut width(lrm)	lrm = 0,25*(St+A) = 0,25*(16,3+2)=4,57 cm A = 2 cm	4,57
Back width (ls)	((ls*0,5+A = 14,84*0,5 = 9,42	9,42
Face width (ls)	ls	9,42
Seat height(St)	0,5*St + A=8,2+1 = 9,2	9,2
Shoulder length (Lm)	0,3*Lm = 0,3*14,92=4,47 cm	4,47
Sleeve length	14,92 cm	14,92
Neck semiperimeter (Pg)	Pg*0,5 = 19,11*0,5 = 9,55	9,55

Table 2. *The additions used to design the basic pattern of the body product for babies born prematurely*

Additions	Value, cm
Back Length Addition to Waist (ALst)	5
Additional seat height (AÎș)	1
Product width addition (Al.p.)	4
Back Neck Cut Width Addition (Args)	1
Back neck cut depth (Args)	1
Front neck cut width addition (Argf)	1
Front neck cut depth (Argf)	2
Sleeve Cut Depth (Arm)	1

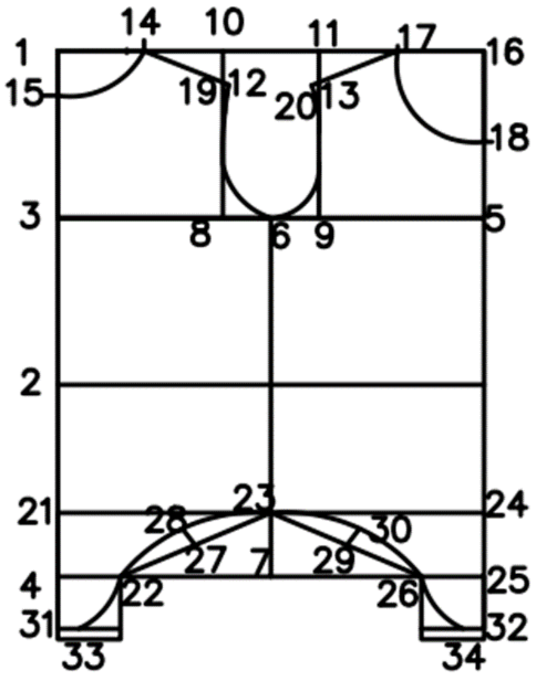

Fig. 1. *Basic bodysuit pattern for premature babies*

The development of the basic pattern was also carried out in the automated design system "JULIVI", Ukraine. "JULIVI" is a complex of 2D and 3D programs for designing and modeling clothes of various sizes and styles. The "JULIVI" system includes the "Design" program, which allows the design of the basic pattern using any method (Müller, Unified method of clothing design of the Council for Mutual Economic Assistance – UMCD CMEA) etc.

The steps taken to design the clothing products were as follows:

1) drawing up the model draft analyzing the requirements imposed on this category of carriers
2) development of the model pattern;
3) obtaining the final outline of the product;
4) development of the product prototype;
5) testing the prototype in specialized medical centers;
6) development of the final model constructions applying the recommendations of neonatologists from the medical centers of the care wards for premature babies [5-6].

The clothing products are intended for premature babies in the prematurity group with a body weight between 1500-2000 g, who are in the neonatal intensive care unit and require adapted clothing products. Medical specialists who participated in the study said that the use of these clothing products in the intensive care unit is welcome, as it will actually facilitate their work, due to easy access to medical equipment.

5. CONCLUSIONS

The design of functional clothing ranges for children aims to meet the specific requirements of this category of wearers and of the team of specialists who are directly involved in the medical procedures to which these children are subjected. In order to obtain suitable products, anthropometric data, children's degree of development and advanced methods of designing products with shoulder and waist support will be taken into account.

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ANNALS OF THE UNIVERSITY OF ORADEA
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BRIEF ASPECTS REGARDING GREENWASHING AND THE EUROPEAN UNION'S GREENWASHING PROPOSED DIRECTIVE

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Abstract: *As the whole world is more and more concerned with aspects regarding the protection of the environment, many companies, including those in the textile field, adopt an environment-friendly attitude in their marketing and advertising policies. This attitude is noticeable through the use, in advertising campaigns, of expressions like: "sustainability", "eco products", "green products". However, these statements are not always true. Greenwashing involves creating a false impression or generating misleading information about a company's products as being environmentally sound. From another perspective, greenwashing can materialize in the form of attempts of a certain company to emphasize the sustainable aspects of the products, in order to overshadow its involvement in environmentally damaging practices. Due to these facts, it is extremely important for the European Union to take measures to combat this phenomenon, by adopting the Greenwashing Directive. The aim of this paper is to present the essential aspects of greenwashing and how it seriously affects the environment, in strong connection with the human rights. Moreover, some details regarding the future Greenwashing Directive will be presented, along with those regarding the Green Claims Directive, made in order to protect consumers from misleading marketing practices or advertising and help them make better purchasing choices.*

Key words: *environment, human rights, consumer, misleading information, legal protection*

1. INTRODUCTION

The phenomenon that consists of creating a false appearance according to which a product, an activity or a policy of a company appears to be more friendly to the environment than it is in reality or less harmful to the environment than it is in fact, is called greenwashing. The purpose of using these techniques, which are practically induced in the consumer, is to make the products more attractive and, as a consequence, to increase the number of potential buyers, especially those who are also interested in protecting the environment. By using greenwashing, a significant impact is made on environmental protection, because this practice represents an obstacle in the fight against climate change. Greenwashing promotes false solutions to climate change and at the same time distracts attention from concrete actions that could be taken.

2. ENVIRONMENTAL PROTECTION AND THE HUMAN RIGHTS

There is a strong connection between aspects related to environmental protection and human rights, because through the existence of a clean, healthy and thus sustainable environment, the fulfilment of several fundamental human rights can be ensured.

Among the fundamental human rights that have an inherent connection with environmental protection, the first target is the right to life. According to art. 3 of the Universal Declaration of Human Rights [1], “everyone has the right to life, liberty and security of the person”. The International Covenant on Civil and Political Rights (ICCPR) [2] reiterates in its art. 6 that “every human being has the inherent right to life”. It is obvious that actions harmful to the environment directly affect the right to life, especially through climate changes that may occur as a result of these actions. Regarding the right to health; art. 25 of the Universal Declaration of Human Rights states that “everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services”. According to World Bank reports, climate change will cause “health impacts [that] are likely to increase and be exacerbated by high rates of malnutrition,” including potential increases in vector-borne diseases and “heat-amplified levels of smog [that] could exacerbate respiratory disorders” [3].

Due to the fact that the global market, therefore including the European one, is more and more concerned with sustainability, the practice of greenwashing has unfortunately become a fairly common practice, due to the desire of companies to be in the best possible position in these circumstances. The close connection between the protection of consumer rights and the protection of the environment can also be seen from the perspective of promoting sustainable practices and responsible consumption, by encouraging them, having the direct effect of combating greenwashing.

3. ASPECTS REGARDING GREENWASHING

As shown before, greenwashing refers to the practice of the companies that includes conveying false or misleading information by presenting their products as being environmentally friendly. It usually involves using deceptive advertising or marketing tactics to convince the consumers that the company’s products, goals and policies are indeed environmentally sound. Greenwasshing can be found in advertising, sponsorship and public messaging in the media, including on social media.

Examples of greenwashing tactics are [4], [5]: changing the name or label of a product to make it seem more natural, even if it contains harmful chemicals; launching elaborate and expensive campaigns that portray highly polluting companies as being eco-friendly; claiming to take measures in order to reduce a company’s polluting emissions, while in reality there is no plan in this sense; applying on products, in an intentional way, misleading labels such as “green” or “eco-friendly,” which can be easily misinterpreted as these terms do not have standard definitions; claiming to avoid illegal or non-standard practices that are, in fact, irrelevant to a product; communicating the sustainability attributes of a product in isolation of brand activities (and vice versa) – e.g. a garment made from recycled materials that is produced in a high-emitting factory that pollutes the air and nearby waterways.

The textile industry is one that generates quite many environmental problems, one of the most common of them being that of the gas emissions, causing air pollution, being known that 10% of the global greenhouse gas emissions is caused only by the textile industry [6].

In 2015, the leaders of the world that gathered at the United Nations Climate Change Conference in Paris reached a historical agreement, known as the Paris Agreement, in order to tackle climate change and its negative impact on the environment, by setting goals in order to substantially reduce global greenhouse gas emissions [7]. Since the adoption of this Agreement, that entered into force in 2016, an increasing number of companies have declared themselves willing to reduce their greenhouse emissions to net-zero, but the plans on which these decisions are based are quite questionable, as the companies have not shown much transparency regarding this aspect. However, it has been shown that, although greenwashing remains a challenge in the fashion industry, significant efforts are significant efforts are made to stop the pollution phenomenon. A recent report found that 60 per cent of sustainability claims by European fashion giants are “unsubstantiated” and “misleading”, a fact that has led confusion for consumers and growing mistrust of what is and is not sustainable [5].

4. THE PROPOSED GREENWASHING DIRECTIVE

All the before-shown aspects are relevant and extremely important if we want to find if we want to find a motivation for the fact that the European Union is interested in adopting legislation on greenwashing.

At the middle of January 2024, the European Parliament adopted a proposal of a European Directive which aims at improving product labelling and banning the use of misleading environmental claims [8]. The first steps were taken by the European Commission, on March 2022, by submitting a Proposal for a Directive of the European Parliament and of the Council amending Directives 2005/29/EC and 2011/83/EU as regards empowering consumers for the green transition through better protection against unfair practices and better information. In the explanatory memorandum, it is shown that: “the proposal aims to contribute to a circular, clean and green EU economy by enabling consumers to take informed purchasing decisions and therefore contribute to more sustainable consumption. It also targets unfair commercial practices that mislead consumers away from sustainable consumption choices. Furthermore, it ensures a better and more consistent application of EU consumer rules” [9]. The aim of this Directive is to protect consumers from misleading marketing practices or advertising and help them make better purchasing choices, as they will be provided with better product information. In order to achieve this, a number of marketing practices related to greenwashing will be added to the EU list of prohibited commercial practices and in addition, new rules on informing consumers on a product’s durability will be introduced in the new Directive [10].

The future Directive will define the notion of “environmental claims” as “any non-mandatory messages or representations, irrespective of their form, used in the context of a commercial communication, and which state or imply that a product, product category, brand or trader has a positive, zero, less damaging or improved impact on the environment” [10].

Summarizing, by enforcing the future Directive [8], [10]: the advertising and product labelling will become clearer and more trustworthy for the consumers by banning the use of general environmental claims like “environmentally friendly”, “natural”, “green”, “energy efficient”, “biodegradable”, “climate neutral” or “ecological” without proof; in other words, making generic environmental claims without being able to demonstrate excellent environmental performance relevant to the claim will be prohibited; the use of sustainability labels will also be regulated and only sustainability labels based on official certification schemes or established by public authorities will be allowed in the EU; this means that, for example, displaying a voluntary trust mark or quality mark that is not established by public authorities will be prohibited; another aim is to make both consumers and producers focus more on the durability of the products. In case of infrigements, companies will be subject to penalties, including fines and confiscation of revenues.

This future directive is intended to coexist and to be completed by the one referring to the Green Claims Directive, which will be more specific and elaborate the conditions for using environmental claims in greater detail, aiming to prevent companies from making misleading claims about the environmental benefits of their products and services and to assure consumers that the claims regarding the green nature of the products are reliable, comparable and verifiable [11].

5. CONCLUSIONS

This paper addresses a topic of maximum interest nowadays, showing the concern of the European Union in this aspect. Greenwashing is a very it is a very harmful process, first of all for the environment. As the environment is affected, some fundamental rights of the individuals are also affected, such as the right to life. The lack of uniform European regulations for green claims favours greenwashing and has also a negative impact on the consumer's buying decisions. In addition to these, companies that have opted for sustainability as a priority in their operations are also disadvantaged. Therefore, the rapid adoption of legislation in this field is essential.

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THE CREATION OF CUSTOM AVATARS WITH LOWER LIMB AMPUTATION - A SUSTAINABLE MODEL IN FASHION INDUSTRY

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Abstract: *In the digital age, virtual avatars have become fundamental tools in the process of creating individualized clothing. Avatar customization is redefining the standards of the fashion industry, highlighting the importance of individuality and inclusion. This innovation opens up new opportunities for designers and manufacturers, facilitating the creation of clothes adapted to consumer preferences, simultaneously reinforcing the need for social fashion industries as a catalyst for change and environmental responsibility. The implementation of personalized avatars expands the boundaries of the fashion industry, allowing consumers to express their own identity and style in an authentic and unique way. This innovative approach not only encourages diversity and inclusion, but also helps reduce resource consumption and carbon emissions associated with the production process, promoting a more sustainable perspective in the fashion industry. In addition, personalized avatars facilitate interaction between brands and consumers through digital platforms, strengthening communities around the values and missions of these brands. The purpose of this work is to present the research on the creation of personalized avatars that present leg amputations, using various methodologies and technological approaches. The stages described in the paper give us an insight into the process of developing the personalized avatar, using elements created in specialized software. The main contribution is exploring how personalized avatars can provide innovative solutions for lower leg amputees by customizing the design to the individual needs of the user.*

Key words: *specialized software, personalized avatar, digital prosthesis*.

1. INTRODUCTION

Information technologies have become a central element in various industries, including the fashion industry. In this context, avatars - virtual representations of the wearers - have become increasingly important in the clothing creation process, opening up new opportunities for growth and innovation, promoting diversity and sustainability in fashion [1].

Creating custom avatars with calf amputation is an example of a sustainable model in the fashion industry for several reasons. Firstly, this model encourages inclusion and diversity in clothing design, offering solutions tailored to the individual needs of amputees. Secondly, custom avatars help reduce the waste of materials and resources because consumers can get a clearer idea of how clothes fit them before they physically purchase them. Additionally, these digital technologies can help reduce environmental impact by reducing the need to produce and transport physical clothing samples. Moreover, avatars are also widely used in the clothing customization process, giving customers the opportunity to create their own designs and test different combinations of colors, materials and styles before making a purchase. This direct interaction between consumers and products helps increase customer satisfaction and strengthen customer relationships.

2. RESEARCH ON THE CREATION OF THE CUSTOM AVATAR WITH LOWER LEG AMPUTATION

The method of integrating elements into an existing avatar was used to create the avatar with lower limb amputations. This technique allows the generation of a realistic representation of a person without the need for advanced knowledge in the field of 3D graphics. The main advantages of this approach include the low cost and fast speed of creating the 3D avatar and the ability to test the clothing in both static and dynamic form [2, 3].

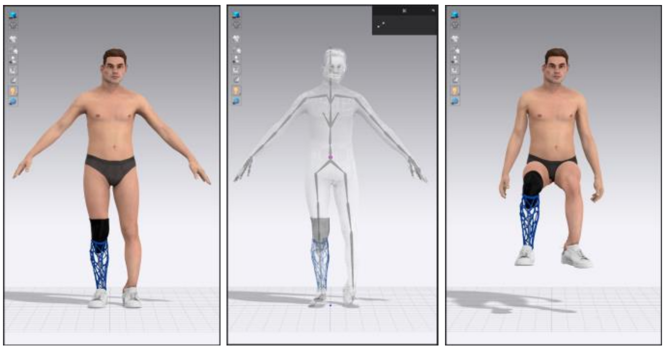
During the stages of creating the avatar with calf amputation, the Daz Studio software [4] was used, in which the prosthesis was manipulated; and CLO3D, in which the final result was obtained [5, 6].

Next, we present the attempts made to create virtual avatars with calf amputation (table 1).

Table 1: *The presentation of the creation stages of the digital avatar with calf prosthesis*

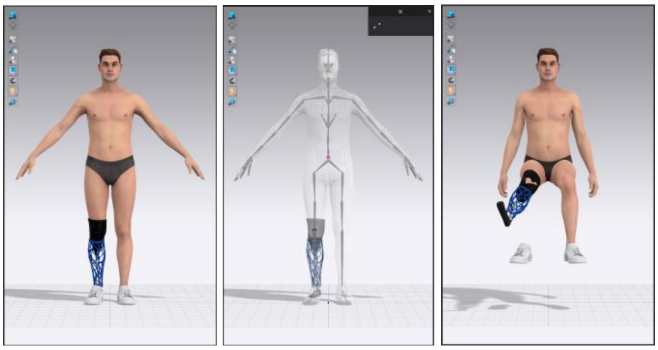
Sample 1. Initial data: CLO3D avatar, Daz Studio prosthetic			
The creation steps of the avatar			
No	**Test No. 1**	**Test No. 2**	**Test No. 3**
1	Prosthesis selection from the Daz Studio software library	Prosthesis selection from the Daz Studio software library	Prosthesis selection from the Daz Studio software library
2	Adapting the position of the prosthesis in Daz Studio	Adapting the position of the prosthesis in Daz Studio	Adapting the position of the prosthesis in Daz Studio
3	Exporting the prosthesis from Daz Studio in obj format	Exporting the prosthesis from Daz Studio in obj format	Exporting the prosthesis from Daz Studio in obj format
4	Selecting the avatar from the CLO library and changing the dimensional feature values	Selecting the avatar from the CLO library and changing the dimensional feature values	Selecting the avatar from the CLO library and changing the dimensional feature values
5	Creating the opacity map in Adobe Photoshop	Creating the opacity map in Adobe Photoshop	Creating the opacity map in Adobe Photoshop
6	Visualising the amputation of avatar leg in CLO using opacity map	Visualising the amputation of avatar leg in CLO using opacity map	Visualising the amputation of avatar leg in CLO using opacity map
7	Importing and placing the prosthesis in CLO	-	Importing and placing the prosthesis in CLO
8	Exporting the avatar and prosthesis from CLO to obj format to form a single object	-	Importing and placing the prosthesis on the healthy leg
9	-	-	Changing the opacity of the prosthesis on the healthy limb
10	-	-	Exporting the avatar and prosthesis from CLO to obj format to form a single object
11	Importing the avatar in CLO	Importing the prosthesis as a trim object in CLO	Importing the avatar in CLO
12	Converting the avatar in CLO	Attaching the prosthesis to the avatar's leg in CLO	Converting the avatar in CLO

The results of the prosthetic avatar creation tests are shown in 1, 2 and 3 figure.



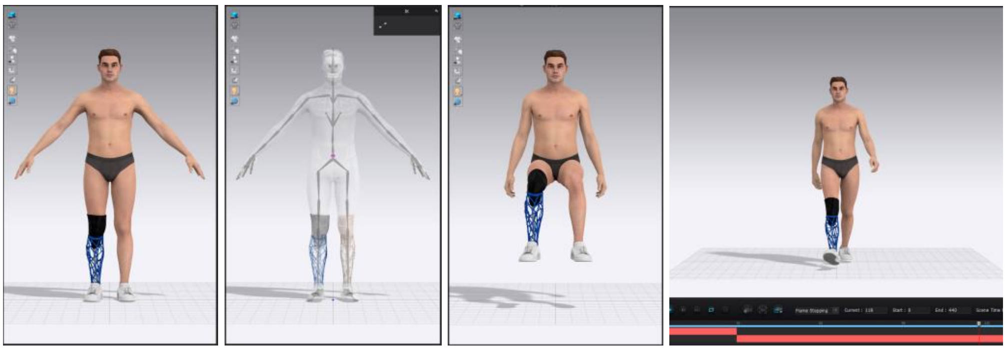
a *b* *c*

Fig. 1*: The result of Test No. 1: a - visualization of the avatar in statics, b - visualization of the skeleton of the avatar in statics, c - visualization of the avatar with the modified body position*



a *b* *c*

Fig. 2*: The result of Test No. 2: a - visualization of the avatar in statics, b - visualization of the skeleton of the avatar in statics, c - visualization of the avatar with the modified body position*



a *b* *c* *d*

Fig. 3: *The result of Test No. 3: a - visualization of the avatar in statics, b - visualization of the skeleton of the avatar in statics, c - visualization of the avatar with the modified body position, d - viewing the avatar in dynamics*

Performing an analysis of the obtained results, we notice that not all avatars correspond to the criteria submitted to them (table 2).

Table 2: *Analysis of the obtained results*

No	The analyzed criterion	Test results		
		No. 1	No. 2	No. 3
1.	Creating the avatar with calf amputation	+	+	+
2.	Changing the external visual characteristics of the avatar	-	+	-
3.	Changing the dimensional characteristics	+	+	+
4.	Changing the body position	-	-	+
5.	Checking the placement of the product on the avatar's body in statics	+	+	+
6.	Checking the placement of the product on the avatar's body in dynamics	-	-	+
7.	Animation	-	-	+

As a positive result that will be used in further research to create personalized clothing, the avatar obtained from Test No. 3 can be considered. It has only one disadvantage: the non-change of the visual external characteristics of the avatar, information that is not important in the creation and verification of digital clothing.

3. CONCLUSIONS

The creation of personalized avatars with calf amputations is an essential and innovative initiative in the current context of digital technology and social inclusion. For the fashion domain, this is a necessary approach that brings significant benefits to several amputees, fashion designers and manufacturers.

Analyzing the experiments presented above, we notice two major directions for creating the digital avatar with a prosthetic leg:

1. Creating the avatar by integrating a prosthesis into the body of an existing avatar and converting it – samples 1 and 3;

2. Creating the avatar by converting it and then integrating a prosthesis into its body – sample 2.

Furthermore, we can note that all attempts allowed to obtain a digital avatar with amputations of the lower limbs, however their shape was not perfect in all of them. We also obtained avatars that allow the modification of dimensional characteristics.

Thus, the creation of personalized avatars with lower leg amputees for the development of special clothing represents an initiative with enormous potential for improving the quality of life and autonomy of people with disabilities. By integrating these technologies into the design and production process of adjusted clothing, this allows the assurance of greater diversity, accessibility and inclusion in the fashion industry.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

SUSTAINABILITY ENHANCING OF TEXTILE INDUSTRY THROUGH SMART PROGRAM IMPLEMENTATION: CASE OF REPUBLIC OF MOLDOVA

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Abstract: *The textile and clothing industry is a key sector of the Moldovan economy, built on its strong industrial past and longstanding manufacturing traditions. Having maintained steady growth, the Textile Industry is one of the country's most resilient sectors to economic changes and has demonstrated growth over decades. Moldova textile and clothing manufacturing industry's path forward involves balancing automation and digitalization with sustainable practices, ensuring access to the EU market, and strengthening its position in the regional fashion industry. This article explores the Moldovan fashion manufacturing industry's resilience, growth, and adaptation to global challenges and trends. It focuses on the implementation of the SMART program, aimed at improving efficiency, productivity, and sustainability in the Moldovan clothing factories. The paper presents findings from the application of consultancy services in this sector, emphasizing the importance of digitalization, automation, and adherence to international quality and sustainability standards. The research underscores the critical role of external expertise and financial incentives in modernizing production processes and advancing sustainable practices in the industry.*

Key words: *sustainability, competitiveness, production systems, efficiency, consultancy*

1. INTRODUCTION

The industrial revolution brought an unprecedented economic growth, but it also boosted the deepening of many social and environmental problems. In the textile industry, besides the stable economic growth, social and environmental problems have come to the fore because this industry involves a lot of labor, on the one hand, and on the other hand, it is the second polluter after the oil industry. In a report of the European Parliament published in 2020, approx. 10% of global greenhouse gas emissions come from the clothing industry. It exceeds the greenhouse gas emissions generated by air transport and maritime transport taken together [1].

At the current stage sustainability and responsibility have become more and more growing trends, including textile industry. These metrics began to translate into behavioral and purchasing trends. With increasing consumer awareness, textile manufacturers and brand owners are paying increasing attention to sustainability and responsibility. This sector has adopted practices and strategies that reduce environmental impact and respect workers' rights. It has become a trend that seeks to produce clothing and textiles in an environmentally and socially responsible manner.

Sustainable fashion aims to minimize the environmental impact of textile and clothing production, improve the working conditions of textile workers and ensure an ethical and fair supply chain.

Efforts are being made in the Moldovan textile industry to implement sustainable practices. To achieve sustainability in this sector, it is necessary to address different aspects of the production chain.

2. IMPLEMENTATION OF SMART PROGRAM DESIGNED TO ADVANCE COMPETITIVENESS AND SUSTAINABILITY IN MOLDOVAN CLOTHING FACTORIES

The changes that have occurred in the last years, including the influence of the COVID-19 pandemic, have created new paradigms for ensuring competitiveness and sustainability for fashion industry [2].

Sustainability and social compliance, Slow fashion, Technology and digital transformation and Demand for higher value at lower price now became the burning elements for competitiveness [3]. To keep pace in a such competitive environment, Moldovan fashion Industry enjoyed significant support from external consultancy offered by the Moldova Competitiveness Project (MCP) financed by USAID, Sweden, and UK Aid.

As consultants of the MCP Project we conceptualized and assisted light industry companies to implement a SMART (Streamline Manufacturing, Accountability, Resource Efficiency, and Transparency) Factory Program based on five pillars intrinsically linked: 1. Streamline manufacturing process; 2. Technology improvement and automation; 3. Design and product development, pattern design; 4. CRS and sustainability and 5. Transparency (Figure 1).

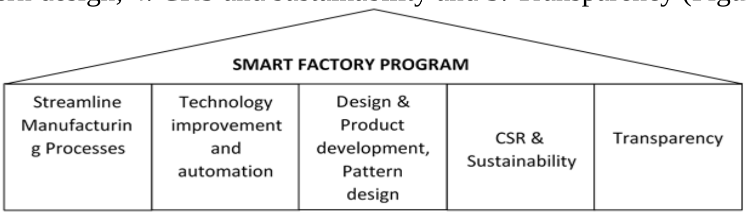

Fig. 1. *Five intrinsically linked pillars of SMART Factor Program [6]*

The specific objectives of the SMART consultancy program include enhancing efficiency and productivity, reducing lead and output times, minimizing work-in-progress items, improving product quality, and advancing manufacturing practices towards higher value-added and more sustainable processes.

The five intervention areas of SMART program are interconnected and feed into each other to produce the desired results.

1. *Streamline Production*: This area focuses on improving manufacturing processes by implementing industrial engineering principles and quality control methods to make manufacturing more efficient. The causal relationship here is direct: by streamlining production, the program aims to enhance the efficient use of resources, including labor (through less movement and higher speed), equipment (improving performance), space (reducing stock), and time (reducing the production cycle).

2. *Resource Efficiency*: Efficient use of resources is achieved through interventions in the streamline production area. Resource efficiency then leads to the implementation of LEAN tools, which are methods that help eliminate waste and optimize processes.

3. *Social Compliance*: This area involves conducting social audits and establishing occupational safety management systems, which ensure that the improvements in production do not come at the expense of the workers' well-being. This area is essential for maintaining ethical standards and for the factory's sustainability.

4. *Transparency*: The transparency component covers working conditions, pay, and business ethics. Improved social compliance contributes to better transparency in the organization. In turn, transparency in these areas helps to maintain accountability within the enterprise, which is crucial for both internal and external trust and reputation.

The causal relationships among these intervention areas are cyclical and reinforcing. For example, streamlined production not only leads to resource efficiency but also better social compliance, as efficient processes can improve working conditions. In turn, better social compliance can enhance transparency in the organization, ensuring that improvements are well-documented and communicated, which further promotes an environment of accountability. This accountability leads back to the need for streamlining production, as it requires continuous monitoring and optimization of processes. Moreover, improved transparency regarding working conditions and pay can lead to increased employee satisfaction and motivation, which contributes to higher productivity and better-quality work. This can create a positive feedback loop where improvements in one area can stimulate improvements in others, ultimately leading to the results highlighted in the SMART Program, such as higher productivity, reduced losses, and increased pay.

This integration underscores the interconnected nature of these intervention areas, as they all contribute to the overall goal of improving the performance and ethical standards of the manufacturing processes within the Moldovan garment industry

The SMART Program was implemented in conjunction by APIUS Moldova Light Industry Association and development partners USAID, Sweden, and the UK through their Moldova Competitiveness Project and Future Technologies Activity [4].

The SMART Program was implemented in two iterations, each focusing on a specific group of progressive Moldovan clothing factories.

Iteration 1, which took place from 2015 to 2019, for a group of 23 clothing factories, emphasized productivity enhancement through improved methods and process refinement, incorporating LEAN management concepts, as well as technical assistance in quality systems and small grants for production automation [5, 6].

Iteration 2, extending from 2020 to 2023, continued the SMART Program for a larger group of 27 clothing manufacturing enterprises, with a stronger focus on factory automation through larger grants, as well as structured support for social compliance and quality standards implementation

The components of the SMART program included:

1. International Expertise Paired with Domestic Consultancy: Highly specialized experts in production and quality systems from Germany were deployed to beneficiary factories as part of several consultancy iterations focused on factory process improvement and efficiency. This involved conducting factory audits, identifying production bottlenecks, developing process improvement plans, and providing support for their implementation. Consultant conducted on the job training that was deemed as more effective and in depth than group training. The international experts collaborated with local consultants who helped localize the recommendations and offered intermittent support in between.

2. Financial Incentives in the Form of Non-Reimbursable Grants: These grants were designed to incentivize quality certification, digitalization, and automation in the beneficiary factories. Grants averaged 5,000 USD to 50,000 USD, depending on factory size. Grantssupported industry to advance technological innovations, incentivizing factories to upgrade via purchasing high precision equipment, CAD-CAM for automation of pattern design and cutting, printing and embroidery machines, special machines, etc.

3. Study visits for executive management teams of Moldovan factories to advanced factories in Romanian Joint Ventures to observe efficient production floors and encourage change and improvement.

4. Smart Factory Unit: This unit was established as part of the APIUS Moldova Light Industry Association. It played a crucial role in project management for consultancy services, application writing for factory automation grants, as well as facilitated and co-funded the certification costs of quality management systems and social compliance standards for beneficiary factories.

The implementation of the SMART Program in a pilot group of 23 garment enterprises in Moldova from 2015 to 2019 resulted in a significant increase in productivity, averaging between 20-25%. The program also indirectly impacted the 4,300 employees in these enterprises, reflected in increased employee salaries. Some factories were able to increase employee wages as high as 30 percent compared to industry average. The 'Before' and 'After' context was thoroughly documented at factory level for each improvement measure, comparing them with performance indicators across various areas [5, 6]

A critical aspect of this program was the enhancement of production processes, reduction of losses, and increase in efficiency through the implementation of Lean Management tools. The interventions targeted several key areas:

1. *Human Element (Hand)*: The program involved analyzing the movements of operators to evaluate work methods and proposing measures to eliminate redundant movements. This approach, combined with new production methods and on-the-line training for operators, led to an increase in operator speed and productivity by up to 20-25%.

2. *Machinery (Equipment)*: It was observed that operators were working slower than the standard with sewing machines. Workplace training for operators and the implementation of time-saving tools helped increase productivity rates and reduce the production cycle.

3. Space: Often, production flows were inefficiently configured, and systems for transporting work-in-progress or finished products were underdeveloped. Improvements in the organization of the production line and internal transport systems resulted in productivity increases of up to 10%.

4.Time: The use of new methods for time standard determination and time study applications successfully reduced the production cycle.

Overall, the SMART Program's implementation in the Moldovan garment industry demonstrates the effectiveness of targeted consultancy, training, and the adoption of lean management and modern production techniques in enhancing productivity and efficiency.

3. SMART PROGRAM IMPACT ON ADVANCING SUSTAINABILTY REQUIREMENTS AT FACTORY LEVEL

In recent years, the fashion industry has faced growing pressure to adopt sustainable practices, driven by concrete initiatives and actions, including more recent EU policies like the

Circular and Sustainable Textile Strategy, reflecting an increasing recognition and commitment to sustainability and responsibility in the European fashion industry [7].

The implementation of quality management and social responsibility systems is an essential step within the SMART consultancy program, aiming not only to increase efficiency and productivity but also to introduce sustainable practices in factories. However, less than one-third of local factories have adopted or implemented any quality, environmental, or social responsibility standards, posing a barrier to the competitiveness of the light industry for export During the period 2015-2019, the SMART program (via its Iteration 1) assisted a pilot group of 23 Moldovan apparel factories in implementing Integrated Management Systems based on the requiremens of tree International standards ISO 9001 for quality management, ISO 45001 for occupational health and safety, ISO 14001 for the environment as well as SMETA (Sedex Members Ethical Trade Audit) social audits incorporating responsible business practices and BSCI (Business Social Compliance Initiative) audits recognized by the industry and European clients [5, 6].

Medium-sized companies were selected, with a total of 4,750 employees (an average of 206 employees per company) and oriented towards exporting to the EU. The factories were assisted by an external local consultant specialized in quality systems to conduct internal audits, make necessary process improvements, and optimize production organization, as well as prepare for certification by an authorized body.

Each factory received an incentive voucher in the form of monetary cost-share of (50 to 70 percent of) the certification costs, to encourage factories to pursue certification as the end objective. In the following years, another incentive voucher was given to factories to encourage recertification or pursue another certification from the list of sustainability standards eligible for the SMART program, as it was observed that factories did not necessarily undertake efforts to maintain or expand the certification(s).

The qualitative analysis of data collected during the pilot project on the implementation of Integrated Management Systems as a tool for advancing sustainability in Moldovan clothing factories has revealed several key trends and patterns:

1. *The Significance of Corporate Social Responsibility* (CSR): CSR plays a major role for competitiveness of companies in the Moldova's fashion manufacturing industry, especially when it comes to access on the EU market, whether as contractors for manufacturing services or exporting locally designed and made clothing to EU consumers that increased their sustainability requirements. Responsible business practices, including accountability, transparency, and environmentally friendly practices, are necessary for the future success of factories and industry. They are becoming increasingly important to international clients, especially European clients, who demand these practices from their suppliers.

2. *International Standards*: European clients encourage and even require Moldovan suppliers to follow international standards (ISO 9001, ISO 14001, ISO 45001), implement codes of conduct, and undergo supplier social audits (SMETA, BSCI) to demonstrate adherence to environmental requirements and good working conditions. Factories in the SMART pilot program reported sustainability standards as a condition for exporting to clients in the UK and Germany.

3. *Internal Improvement Effect*: SMETA and BSCI social audits, as well as occupational health and safety management systems like ISO 45001, have allowed factories to assess and improve workplace standards and conditions to meet global supply chain requirements. This has had a positive impact on the 4,750 employees. Such a system not only enhances working conditions and employee safety but also provides guarantees for meeting local legal requirements and addressing workplace safety concerns, ultimately increasing employee satisfaction.

These trends emphasize the need for an integrated and holistic approach to meet sustainability and CSR requirements in the textile industry. Moldovan companies are positioning themselves as reliable manufacturing partners in response to these changes. The APIUS association continues the implementation of this program [8]

CONCLUSIONS

The vision for the Moldovan fashion industry is to evolve into a sector characterized by high-value addition, efficiency, innovation, and sustainability. This transition requires external expertise and assistance, as evidenced by the productivity challenges faced by local factories. Programs like SMART, which emphasize modernization, digitalization, and adherence to sustainability and quality standards, are crucial in this transformation process.

Due to a growing demand for sustainability, quality compliance, and ethical practices in the fashion manufacturing sector. Moldovan factories need to rapidly adapt to these demands to maintain competitiveness in the EU market. Initiatives like the SMART program have been instrumental in guiding factories towards sustainable and efficient practices, but there remains a gap in the digitalization and widespread adoption of international standards and practices.

The implementation of the SMART program demonstrated that the increase in labor productivity can cover the labor shortage in industry. This requires a focus on digitization and automation to increase productivity and efficiency. However, the industry's move towards automation and digitization must be strategic and financially supported, given the limited investment in technology modernization by local factories.

The SMART program must be supported in order to be implemented in large proportions in the Moldovan fashion industry.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

CRITICAL PRINCIPLES AND ELEMENTS OF A FASHION COLLECTION DESIGNING

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Abstract: *A generally accepted approach to fashion design is to consider a complex system based on different parameters or basic elements such as shape and form, line, color, and textures and basic principles: proportion and scale, balance, unity (harmony), rhythm, and emphasis.*
The paper presents the most important elements that influence the impact and quality of a fashion collection: the sketch of the garment (color, shape, texture of the textile materials) and sustainability (as a consequence of circular economy), while the dematerialization and application of SWOT analysis, improve the economic yield.
To better understand the vision of the specialists in fashion design regarding the most important elements that define a garment collection, 5 detailed criteria are presented. In this regard, the answers of the specialists involved in the designing and development of the new middle-price and middle-end fashion garment collection on a survey are presented and a ranking has been done.

Key words: *garment, fashion design sketch, sustainability, dematerialization*

1. INTRODUCTION

Fashion design is a kind of art dedicated to the creation of clothing, shoes, and other lifestyle accessories. The synergy of textiles and garments is an integral part of fashion design. Fashion designers need to have a profound understanding of how textile materials and structures affect the design and function of the garment, as well as haptic knowledge obtained from hands-on experiences with fabrics [1]. Worldwide, up to 300 million employees are involved in the textile fashion industry, a true economic power that contributes more than 1.3 billion dollars to the global economy [2], [3]. Regardless of the type of fashion design, *haute couture*, *luxury fashion*, *ready-to-wear fashion*, *economy fashion*, *or fast fashion*, designers start with an idea, image, or feeling that motivates them and then, through a creative process, they develop that inspiration into a design concept and finally a finished product.

Essential for a fashion designer is to express their vision and creativity, helped by art, emotions, people, nature, etc. through their design work and transmit their inspiration to the audience, as good they can [4].

Fashion designers are permanently in line with fashion market requirements, being interested in learning new things by upgrading their collections with the trend. A designer should also have some knowledge and experience in tailoring (cutting, draping, sewing, etc.) and be able to tell the difference between different fabric quality levels [5]. By sketching designs, selecting patterns, fabrics, and accessories, and giving instructions to workers, a fashion designer creates original clothing and footwear pieces. Today, the fashion industry is more and more interconnected with the digital world, both in the creation process (using digital instruments) and in the commercialization of the products (using digital platforms and digital marketing strategies).

As a huge industry with very large market potential, the fashion industry received last year's special attention from the sustainability perspective concentrated on mitigating the harmful impacts of the industry on the natural environment [6]. The main focus is on the production and use of particular types of textiles, minimizing consumption of resources, modifying the production process (e.g., concerning the use of certain chemical substances), efficient use of fabrics (zero waste), and their reuse (recycling and upcycling) [7] more recently known the broader heading of a circular economy [8], [9]

This paper approaches the key fashion design principles from the perspective of fashion designers. For a complete perspective, a survey with 5 generic questions has been proposed by the partners involved in the Digital Fashion Erasmus + Project.

2. KEY PRINCIPLES AND ELEMENTS FOR A FASHION DESIGN

While technological investment becomes strategic as the fashion market experiences a growing speed of fast fashion trends, specialists define 5 main principles, generally available, that lead to a good fashion design and transform any garment into a masterpiece (Fig. 1) [10]

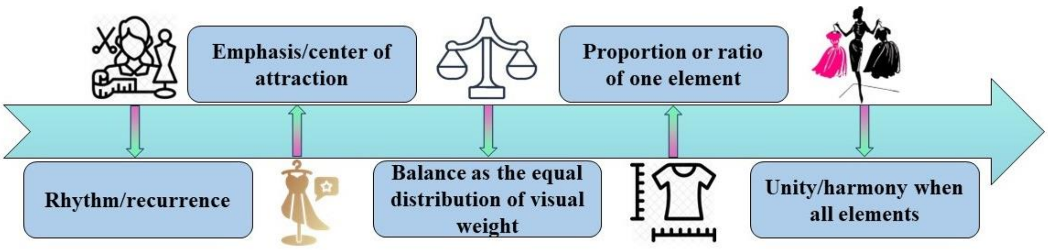

Fig. 1*: 5 main principles for a good fashion design*

The Erasmus+ project DigitalFashion is a Strategic partnership project for Higher Education, planned for the period 01 Feb. 2022 – 31 Ian. 2025. The project aims to *internationalize digital skills* in fashion and technology, *bridging the existing gap* in digital skills in fashion by introducing new teaching and learning methodologies of digital fashion co-design in a virtual environment and *promoting collaboration* among the partners in online international teaching and learning by addressing the digital skill gaps in the fashion and textile programs that partner countries have in common, targeting the textile and clothing industry. The consortium of the project is formed of 6 education and R&D partners from 5 European countries: Romania France, Belgium, Portugal, and Slovenia, being led by INCDTP Bucharest.

3. KEY ELEMENTS FOR A PARTICULAR WOMEN CLOTHING COLLECTION

While the 5 elements presented in Fig. 1 are considered generally available as pillars in designing, the specialist partners of The Digital Fashion E+ project elaborated a survey with 4 questions to understand what the most important principles of fashion design in a particular case of a casual collection of women’s garments of age category 25- 40 years and of mid-price level (middle-end fashion brand).

3.1 The 3 most important fashion design elements - Q1

When creating a collection of clothing for women aged 25-40 with a medium price range, it's important to consider their fashion tastes and preferences, as well as current trends. From the point of view of the questioned design specialists, there are three fashion design elements to consider.

One of the most important visual elements in a fashion collection is ***color.*** There are multiple color systems: ***Hues colors:*** *primary* (RYB- red, yellow, blue, RGB-red, green, blue, CMYK- cyan, magenta, yellow, and key (black)); *secondary* (combination of two primary colors); ***Tertiary colors*** (combination of a secondary color with a primary color) and complementary (more than opposite base hues on the color wheel), with different properties as temperature saturation and value, tint, shade, tone, and mute, that have a strong impact on the perception of a piece of clothing.

On the other hand the ***material texture,*** with two components (**tactile** - that can be felt by touch (rough, smooth) and visual - that can be seen (shiny, dull, matte) strongly affects the look of a garment, the feel, its lucidity in a way influencing the appearance of the person wearing the garment.

Shape - defined as the silhouette, or overall outline of a garment or other item, can influence how it fits and looks. A shape is a two-dimensional area that stands out from the space around it due to variations in contour, color, or material. Shapes can be geometric or organic. It's important to consider different body shapes and create options that fit different body types so that all types of clients will find something appropriate to wear.

3.2 The successful combination of the fashion design elements – Q2

Some designers consider up to 12 elements that make up the essence of fashion design, but the 3 most relevant and universal are the color, texture, and shape.

The right application of these elements helps a fashion designer enhance the look of an outfit. By combining these elements in a "mix and match" fashion, it is possible to create an endless variety of styles, having as basements the basic pieces of clothing.

The interdependence of these elements can be seen in the success of fashion creation, and a correct forecast on the part of fashion researchers/designers in choosing these elements determines future clothing trends. It implicitly develops new tastes of the final consumers.

To be considered a successful combination of design elements, according to various designers, it is necessary to follow the following sequence: form – colors – material - sustainability - dematerialization, usually defined as a process that consumes fewer resources than former processes but still increases the value.

The shape and finish of a garment are strongly influenced by the type and texture of the fabric. When designing women's clothing, especially when the buyers are in the 25 to 40 age category and the mid-price segment, it is important to consider fashion shapes and forms of outfits first and foremost. This large segment generally wants comfortable and fashionable clothes, where the color and functionality of the clothes play a well-defined role and must be taken into account in defining and designing the collections. Also in creating synergy and unity, the type and structure of the respective lines and texture of the material can determine important changes in an outfit from the point of view of the wearer's posture and dynamics, when combined harmoniously.

To create a coherent collection aligned to the individual and group requirements of the consumer, designers will apply the elements of clothing design in a balanced and consistent way, but a particular understanding of it is also essential.

A well-defined collection creates excitement and delivers a high level of consumer satisfaction. A proposed successful combination of the fashion design elements is schematically presented in Fig. 2

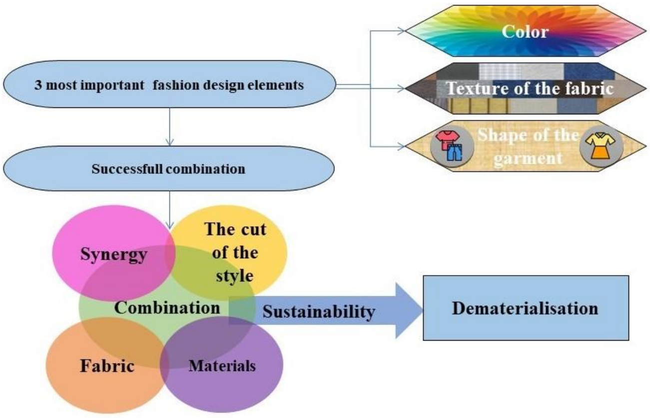

***Fig. 2**: Swot analysis of the aforementioned collection*

3.3 The applying a swot analysis to this design process – Q3

Every fashion brand or business needs a swot analysis to know its present and future position concerning competitors. Swot analysis including strengths, weaknesses, opportunities, and threats is a useful instrument for understanding where the related fashion brand or business stands in the larger fashion marketplace to meet the needs/expectations of the target public.

Establishing, precisely defining, and promoting brand identifiers greatly influences consumer perception. According to the specialists interviewed, designing a garment in the context of a brand requires that the image, style, price, and target consumer audience are very well defined. The price level of a brand also determines its risks, so at a medium price, the likelihood of it being fashion-oriented is lower, so the expectations of the target group are also lower. In this context, it is necessary to analyze the level of consumer satisfaction and therefore the level of sales.

In the context of a rapidly changing fashion clothing market, developing a Swot analysis of each style of clothing can highlight possible opportunities that should be exploited (e.g. new clothing for a new target group of consumers), and threats should diminished/eliminated (reduction in price of a collection due to competition).

If a new collection is born out of the inspiration and talent of designers, a responsible SWOT analysis by the marketing team defines it and carves a safer path to the target market. This will develop an effective design strategy with a competitive edge during the design process and market launch.

According to the interviewed designers, the analysis of the weakness of a casual collection of women’s garments of age category 25-40 years and of mid-price level leads to the following arguments:

- the moderate price range may limit the materials and quality of materials that can be used within the collection.
- the market for women's clothing aged 25-40 is growing, which can provide opportunities for sales growth and market share. This is the biggest opportunity and the strongest point.
- the use of durable and sustainable materials can attract consumers who are interested in

sustainable development and ethical issues

A schematic SWOT analysis for a mid-range designed collection is presented in Fig. 3.

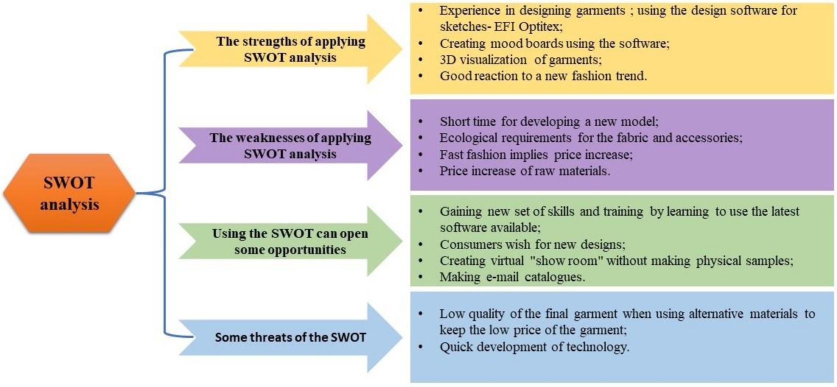

Fig. 3*: Swot analysis of the aforementioned collection*

3.4 The threats when designing the garments – Q4

The main threats indicated in the case of the collection of clothing for women aged 25-40 with a medium price range are schematically presented in Fig, 4.

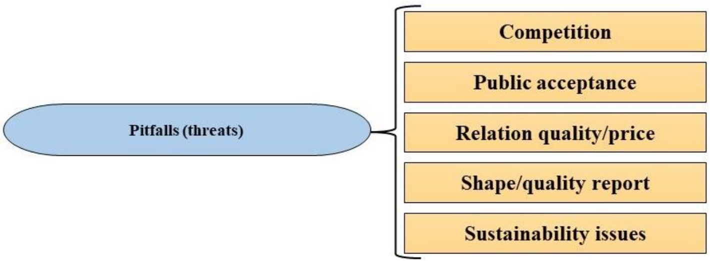

Fig. 4*: The threats of the aforementioned collection*

The past experiences showed that a good understanding of the brand's "red line", trends, and market analyses is important before drafting SWOT analyses, in the context of the rapid changes in the market. Given the market situation, other particular principles only have the function of expressing some principles more than others. It would rather say the principles serve other requirements that need to be considered.

A market ready and open for the adoption of new fashion trends is an open door for designers to take advantage of new design elements and translate them into strengths in their marketing strategy.

4. CONCLUSIONS

Principles and key fashion design elements have been established from the questionnaire by the designers. Based on the feedback it can be concluded that the design fashion elements are very important when designing a collection and that the 3 most important elements are: Color, Shape of the garment, and Texture of the fabric, but the successful combination of them is the key for the consumer's satisfaction. To create a coherent collection aligned with the individual and group requirements of the consumer, designers have to use the elements of clothing design in a balanced and consistent way and understand its particularities.

Also, can be concluded that a SWOT analysis can be applied in the design process and can be used to meet the needs/expectations of the targeted customers.

ACKNOWLEDGEMENTS

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

OIL ABSORBENCY AND PLIABILITY PROPERTIES OF N95 RESPIRATOR TEXTILE SUBSTRATES IMPREGNATED WITH ALOE VERA AND SODIUM CHLORIDE

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Abstract: *In this study, it was aimed to assess oil absorbency properties besides pliability of polypropylene substrate materials used to produce respirator N95 masks with samples impregnated in Aloe Vera and NaCl salt solutions. Salt solutions of samples were 1, 5 and 10 weight %. Aloe Vera content was kept constant as 33 wt % of mixtures in which sample was impregnated. Aloe Vera impregnated samples were better to absorb glycerol compared to control samples in sinking tests. Polypropylene samples impregnated into Aloe Vera added salt solutions outperformed oil absorbency of Aloe Vera impregnated samples with shorter absorption time intervals during sinking. Wicking tests with droplets of glycerol and the areas of droplet capillary absorption showed that control samples had better oil wicking properties, but still all impregnated samples showed degrees of capillary intake of glycerol droplet during wicking tests. Masks need to ensure a stable breathing area and also a certain amount of flexibility. Bending length test results proved Aloe Vera impregnated respirator substrates had shorter bending length, as a result better pliability, compared to control samples.*

In conclusion, the property of absorbing glycerol is a sign of hydrophobicity which is good for preventing human body fluids from sticking on the fibrous materials such as wound dressing or facemasks touching wounds that are on their healing process. The hydrophobic characteristics of the N95 mask fabric might be a good candidate for patients that have to wear masks over some wounded body part as hydrophobic wound dressings are good candidates to heal wounds with thick exudates which are coagulation of proteins in the wounds and have hydrophobic characteristics. Increase of pliability for N95 respirator substrates might give freedom to give shape to the mask and increase face fitness of the respirator.

Key words: *N95 respirators, Aloe Vera, sodium chloride, oil absorbency, pliability.*

1. INTRODUCTION

Respirators and surgical face masks have been a part of our lives since the corona virus (Covid 19) pandemic. Surgical masks are loose fitting personal protective equipment (PPE) that cover the nose and mouth of the wearer while respirators such as N95, N99, and N100 are tight fitting masks with a facial seal [1]. Personal protective equipment (PPE) is essential for healthcare personnel to protect them from viral respiratory diseases such as influenza. Much of the influenza transmission study is concentrated on “the droplet spray-aerosol transmission” rather than contact transmission. Aerosol transmission can take place both in short distances as well as longer distances due to air currents [2]. Surgical masks are not designed to protect the wearer from inhaling airborne bacteria or virus particles, surgical masks are PPE designed to be worn by healthcare professionals, to catch bacteria in liquid droplets and aerosols that might be spread from the mouth and nose of the wearer (healthcare personnel) in order to protect the patient from healthcare personnel potential transmission risk due to their coughs and sneezes. Respirators are designed to provide protection to the wearer due to inhalation of airborne particles that might be possible danger risk to the inhaling person [1].

Hewawaduge et al (2021) studied antiviral efficiency of copper impregnated three-layer mask against SARS-CoV2 virus. The impregnated and coated outer layer contained 4.4 weight % of CuS (copper sulphite) while the impregnated middle nylon layer had 17.6 weight percent CuS [3]. Jung et al (2021) studied copper coated polypropylene (PP) filter face masks and concluded copper-coated antiviral PP filters could be key solutions for personal protective equipment but also for air-conditioning materials [4]. Although nano silver and nano graphene particle coated facemasks protect against Covid-19 virus, these nano particle coated masks pose health risks to the wearer such as DNA damage induction, in-vitro repeated dose toxicity dermal exposure and in-vitro skin sensitization [5]. Due to posed hazards of nano particle coatings on facemasks, natural coating materials are studied as possible candidates for facemask impregnation materials [6, 7]. Schorderet Weber et al (2022) studied the potential of coronavirus antiviral efficacy of salt coated face mask fabrics and concluded that salt coatings on facemasks disrupted the virus cells and the viral replication decreased, however pre-incubating the virus in hypertonic salt solutions did not reduce the infectivity of the Corona virus. Researchers used 0.9 weight (wt) %, 3.5 wt % and 35 wt % saline solutions for spraying and dip-coating face masks. The deposited salt was calculated by weighing the sample before coating and after drying at room temperature overnight. The findings of the study show that salt forms a protective antiviral barrier both on surgical masks and on household textiles to be used for home-made masks such as washable cloth masks [8]. Pepito et al (2022) studied the antimicrobial efficacy of OSS (Omani sea salt) saline loaded middle layer and whole mask of surgical mask materials. Fabrics were soaked in saline solutions for 24 hours. According to the study, 30 wt % salt loading did not show any antimicrobial activity, however 10 % sodium hydrogen carbonate ($NaHCO_3$) addition to OSS solutions showed antimicrobial efficacy both in dried samples and soaked samples [9].

As Aloe Vera contains biocomponents having potential action on microorganisms and having been used for hundreds of years for its healing potential, Z.Edis et al (2022) studied the antimicrobial efficacy of Aloe Vera on sutures, bandages and face masks. The researchers concluded that their Aloe Vera and iodine including compounds are effective in treating infectious diseases on sutures, bandages, unanimated surfaces and face masks [7]. Gorade et al (2021) investigated wicking property of microcrystalline cellulose (MCC) applied polypropylene (PP) fabric with the vertical strip wicking test at time intervals of 10, 30, and 60 seconds. The water wicking height increased at MCC applied PP fabric compared to the zero cm water wicking height at the untreated control PP sample [10]. Castillo et al (2022) increased the polypropylene fabric water absorption capacity to 5.8 g/cm2 hydrophilicity by surface modification using particles of a mineral, a zeolitized vitreous breccia [11]. N95 respirators have a ventilator fan and four layers: outer layer polypropylene non-woven layer, filter polypropylene layer, support modacrylic layer and mask inner polypropylene layer [12]. Spunbonded and meltblown nonwoven layers are laid in several combinations to ensure N95 respirator layers are obtained.

Many researchers studied filtration of respirator media including surgical masks and N95 masks [2], however, improvement ways of PPE masks in terms of fitting to the face, user seal effectiveness and several physical properties related to pliability and flexibility of mask materials are still emerging issues for research of surgical masks. In this study, it was the aim to assess oil absorbency properties besides pliability of respirator mask materials according to bending strength tests for Aloe Vera and NaCl salt impregnated respirator N95 masks.

2. EXPERIMENTAL APPROACH

2.1 Materials and Method

In this study pure sodium chloride (NaCl) from Riedel-de Haen, 100% Aloe Vera gel from CireAceptine Company, distilled water and a 250 g/m2 polypropylene spunbonded nonwoven fabric at 0.16 mm thickness from Mogul Textiles Company was used. The nonwoven substrates rolled on bobbins at 18 cm width were used as received. Aloe Vera gel was used as received from the plastic bottles sold in the market.

Preparation of Impregnation Baths

At trials, the nonwoven substrate did not take in any salt solutions. Aloe Vera added salt solutions were successful for impregnating polypropylene substrates. Samples codes and their mixture contents are shown in Table 1. Salt solutions of samples were 1, 5 and 10 weight %. Aloe Vera content was kept constant as 33 wt % of mixtures in which sample was impregnated.

NaCl solutions were mixed at 80 rpm at room temperature until stock solutions were obtained. NaCl stock solutions were prepared using distilled water at 10 wt%, 20 wt% and 25 wt%. Stock solutions were diluted to prepare impregnation baths. Aloe Vera gel was added into NaCl diluted solutions to obtain “salt and Aloe Vera” having solutions. To obtain ‘only Aloe Vera’ having samples Aloe Vera gel was diluted in distilled water and stirred at 80 rpm with the magnetic stirrer.

Impregnating Nonwoven Substrates

Nonwoven substrates were impregnated in the mixture baths for half an hour using Kucuker Textile brand laboratory type pad batch machine. Samples were padded at around 95-100 % liquor uptake during the impregnation period. For Aloe Vera containing samples, Aloe Vera gel weight was added into sodium chloride solutions to obtain 33 wt % of gel in mixtures. Impregnated samples were dried at 130 C° in laboratory type oven for four hours.

Table 1. Samples and codes

Sample code	Salt solution wt %	Aloe Vera gel wt %	Salt (g) in mixture	Aloe Vera gel (g) in mixture	Deionized water (g) in mixture
N_control	_	_	_	_	100
N_AV	_	33 wt %	_	33	67
N_s1_AV	1 wt %	33 wt %	1	33	66
N_s5_AV	5 wt %	33 wt %	5	33	62
N_s10_AV	10 wt %	33 wt %	10	33	57

Testing Methods

As polypropylene based materials showed neither any water absorption properties nor any water wicking properties, the absorption of glycerol by samples and the wicking of glycerol droplets were tested. Figure 1 shows a colored water droplet on the hydrophobic nonwoven substrate.

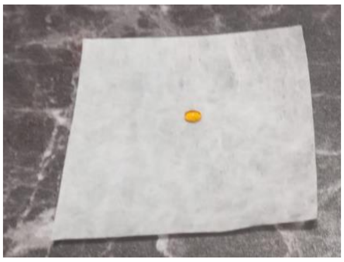

Fig. 1 *Hydrophobic polypropylene substrate (N_control) and a water droplet*

For glycerol absorption tests, sinking time test in glycerol was carried out. The sinking time indicates the affinity of the substrate to oleic fluids and proves absorption in the manner of a sponge taking fluid in its structure. Control polypropylene nonwoven samples had an approximately 24 second time for glycerol absorption, and Aloe Vera impregnated samples were better to absorb glycerol compared to control samples. Polypropylene samples impregnated into Aloe Vera added salt solutions outperformed oil absorbency of Aloe Vera impregnated samples with shorter absorption time intervals. Sinking times in glycerol show that Aloe Vera and sodium chloride impregnated samples have ability to take into hydrophobic fluids like oils and proteins. Table 2 shows sinking time of samples in glycerol.

Table 2. *Sinking time test results of samples in glycerol*

Sample code	**Sinking time (sec)**
N_control	24.25 ± 5.18
N_AV	2.75 ± 0.35
N_s1_AV	1.84 ± 0.61
N_s5_AV	1.21 ± 0.29
N_s10_AV	0.88 ± 0.11

Wicking tests were conducted with droplets of glycerol. During wicking tests with glycerol droplets, Aloe Vera and NaCl solutions impregnated samples (N_AV) and NaCl solution and Aloe Vera impregnated samples (N_s1_AV, N_s5_AV and N_s10_AV) showed smaller absorbed areas and lower capillary intake of hydrophobic fluid than pure polypropylene samples (N_control). Pure samples had better oil wicking properties, but still all impregnated samples showed degrees of capillary intake of glycerol droplet during wicking tests. The droplet absorbed area is slightly decreased with salt and Aloe Vera loading, which might be a chance to tune mask material hydrophobicity level according to usage areas and user needs. The sample areas of the absorbed glycerol droplet are listed in Table 3.

Table 3. *Absorbed area for "glycerol" droplet intake due to droplet wicking testing*

Sample code	**Droplet absorbed area (cm x cm)**
N_control	3.34 ± 0.29 x 2.3 x 0.26
N_AV	2.50 ± 0.10 x 2.15 x 0.21
N_s1_AV	2.61 ± 0.23 x 2.09 x 0.28
N_s5_AV	2.84 ± 0.21 x 2.06 x 0.32
N_s10_AV	3.02 ± 0.21 x 2.05 x 0.16

Bending length of Cantilever bending testing gives an idea about the pliability of textile materials. Even though masks need to ensure a stable breathing area, certain amount of flexibility is required to have face fit for N95 respirator masks. Aloe Vera impregnated respirator substrates show shorter bending length compared to control samples. Shorter bending lengths indicate better pliability. Polypropylene is a strong polymer with low elongation properties which leads polypropylene to be a bad option to ply or bend it due to its intrinsic low elongation values. Impregnating polypropylene respirator substrates into Aloe Vera and sodium chloride solutions increased the pliability of respirator substrates. Increase of pliability for N95 respirator substrates might give freedom to give shape to the mask and increase face fitness of the respirator. Table 4 show the Cantilever bending test results of the samples. Bending length test results proved Aloe Vera impregnated respirator substrates had shorter bending length, as a result better pliability, compared to control samples.

***Table 4**. Results for bending length*

Sample code	Bending length (cm) (C= L*/2)
N_control	1.85 ± 0.09
N_AV	1.43 ± 0.08
N_s1_AV	1.26 ± 0.11
N_s5_AV	0.98 ± 0.06
N_s10_AV	0.86 ± 0.03

L* is the length on the Cantilever ruler

3. CONCLUSIONS

Aloe Vera and salt loadings shortened sinking time of hydrophobic PP samples into glycerol. Polypropylene substrates showed hydrophobicity even when salt and Aloe Vera were impregnated on them. Wicking tests are tested with glycerol droplets. The droplet absorbed area is slightly decreased with salt loading, which might be a chance to tune mask material hydrophobicity level according to usage areas and user needs. The bending length “C” is decreased with salt loading and Aloe Vera application, the stiffness of polypropylene spunbond nonwoven is decreased by salt and Aloe Vera loading giving opportunity to shape the mask and increase face fitness of the respirator.

Wicking tests are a sign of good moisture transport, when conducted with water. However, our samples had no water absorption as they are originally polypropylene, a polymer that is hydrophobic. In this study, wicking area was calculated by letting a droplet of glycerol from 10 mm height. The property of absorbing glycerol is a sign of hydrophobicity which is good for preventing human body fluids from sticking on the fibrous materials such as wound dressing or facemasks touching wounds that are on their healing process [13]. The hydrophobic characteristics of the N95 mask fabric might be a good candidate for patients that have to wear masks over some wounded body part. Sinking times in glycerol show that Aloe Vera and sodium chloride impregnated samples have ability to take into hydrophobic fluids such as oils and proteins. The droplet absorbed area is slightly decreased with salt and Aloe Vera loading, which might be a chance to tune mask material hydrophobicity level according to usage areas and user needs. The hydrophobic characteristics of the N95 mask fabric might be a good candidate for patients that have to wear masks over some wounded body part as hydrophobic wound dressings are good candidates to heal wounds with thick exudates which are coagulation of proteins in the wounds and have hydrophobic characteristics.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

A COMPARISON BETWEEN SEVERAL TEXTILE-BASED ELECTRODES FOR FLEXIBLE SUPERCAPACITOR APPLICATIONS

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Abstract: *Combining the features of supercapacitors and textiles solves many of the downsides that conventional electronics have, such as heavy weight, lack of recyclable parts and toxicity. Generally, the electrodes that are used in the manufacturing of energy-storage devices are obtained using toxic solvents and corrosive acids, bases and salts. Herein, in order to address these issues, we report the preparation of seven flexible textile-based electrodes, in which the textile substrates consisted in a woven fabric with cotton and silver threads. One of the substrates was coated using a mixture of glycerol (GlOH), gum arabic (GA) and activated carbon (AC) and, for the rest of them, six different salts were added to this mixture – sodium chloride (NaCl), ammonium chloride (NH_4Cl), 1-butyl-1-methylpyrrolidinium hexafluorophosphate ($BuMePyPF_6$), sodium acetate (NaAc), ammonium hexafluorophosphate (NH_4PF_6) and carboxymethylcellulose sodium salt with low viscosity (NaCMC). Their electrical resistance was measured and the electrical conductivity was then computed. The GlOH-GA-AC-NH_4Cl electrode was found to be the most conductive one ($244 \cdot 10^{-4}$S/m), while GlOH-GA-AC-$BuMePyPF_6$ was the least conductive electrode ($73 \cdot 10^{-4}$S/m). The surface characterization of the materials was performed using SEM and EDX, through which the morphology electrodes was observed; the size and the shape of the aggregates formed determined the performance of the electrodes.*

Key words: *supercapacitors, textiles, energy storage, activated carbon, gum arabic*

1. INTRODUCTION

E-textiles are emerging hybrid materials that bring together the features of textile materials and electronics. They are promising candidates for the replacement of traditional devices because they can respond to stimuli in the environment [1], having many advantages, such as flexibility [2]. One way to turn textiles into versatile electronic devices is to integrate them with supercapacitors (SCs), which are hybrid devices that exhibit properties close to both capacitors and batteries. These devices are characterized by high power capacity, longevity, low weight, large heat range, ease of packaging and affordable maintenance [3]. Such devices consist of two electrodes, an electrolyte, and a separator [4]. The electrodes play a key role in the construction of a SC because, according to their energy storage mechanism, there are three types of SCs – electric double-layer capacitors (EDLCs), which owe their good capacitance to the electrostatic charge accumulation at the electrode–electrolyte interface; pseudocapacitors (PCs), based on fast and reversible redox processes at the electroactive material surface; hybrid capacitors (HCs), their capacitance being attributed to the capacitance of EDLCs and the pseudocapacitance [5]. In order to deliver the best results, these SC components need to be electrically conductive, thermally stable, resistant to corrosion, relatively cheap, non-toxic and they have to have a large specific surface area as well [6]. This is why carbonaceous materials represent a good option for the production of next-generation SC electrodes. Among them, activated carbons (ACs) are conductive, stable and cheap compounds. Another advantage of ACs is the variety of synthesis options, with a lot of precursor materials to choose from – wood materials, waste from agricultural and food industries (coconut shell, walnut shell, banana peel, coal-based materials (anthracite, bitumen), petroleum materials (petroleum coke, pitch) and plastic materials [7]. In this paper, seven textile-based SC electrodes were synthesized using glycerol, activated carbon, gum arabic and six salts, in order to determine the best formulation in terms of electrical conductivity and surface coating parameters.

2. MATERIALS AND METHODS

2.1. Materials

Glycerol and ammonium chloride were supplied by Consors SRL. Activated carbon was bought from Supelco Analytical. Sodium chloride and sodium acetate were supplied by Fluka. Gum Arabic, carboxymethylcellulose sodium salt with low viscosity, 1-butyl-1-methylpyrrolidinium hexafluorophosphate and ammonium hexafluorophosphate were purchased from Sigma-Aldrich. The woven fabric containing cotton and silver threads, acting as a textile substrate, was manufactured.

2.2. Synthesis of textile-based electrodes

All electrodes were synthesized using the same procedure and labeled as follows: GlOH-GA-AC, GlOH-GA-AC-NaCl, GlOH-GA-AC-NH_4Cl, GlOH-GA-AC-BuMePyPF_6, GlOH-GA-AC-NaAc, GlOH-GA-AC-NH_4PF_6 and GlOH-GA-AC-NaCMC. Gum arabic and glycerol (0.16:1 mass ratio) were mixed in a beaker, at room temperature, until GA dissolved. Then, the corresponding salt (0.11:1 mass ratio to GlOH) and AC (2:1 mass ratio to GA) were added to the polymer solution. In the case of GlOH-GA-AC-BuMePyPF_6 and GlOH-GA-AC- NH_4PF_6, the salts were melted in order to increase the homogeneity of the mixture. After thoroughly stirring it, the mixture was spread on a square-shaped fabric (3.25 cm on average, in length, and 0.5 cm in thickness) using a laboratory spatula. Finally, the coated fabric was placed on a Petri dish and kept inside an oven for one hour, at 100°C. The obtained materials are presented in **Fig. 1**.

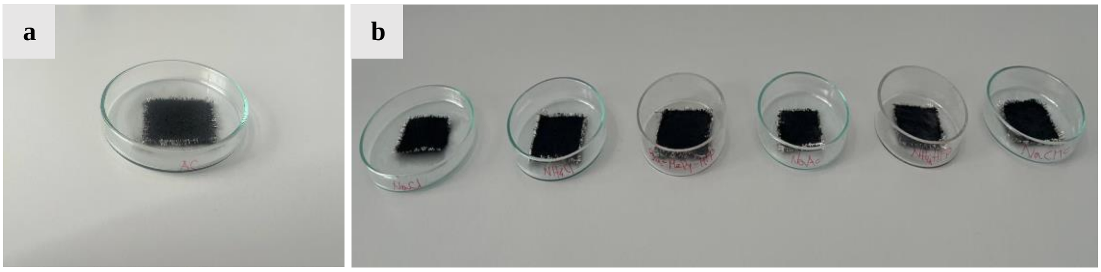

***Fig. 1**: a. The GlOH-GA-AC electrode; b. The six electrodes containing salts*

2.3. Electrical conductivity measurements

The electrical resistance of each electrode was measured using a Fluke digital multimeter. Five measurements were performed for each coated substrate and the average values were then computed and tabulated.

Table 1: *The linear electrical resistance of each electrode*

Electrode	**Linear electrical resistance, Ω/cm**
GlOH-GA-AC	$1.39 \cdot 10^4$
GlOH-GA-AC-NH_4Cl	$8.19 \cdot 10^3$
GlOH-GA-AC-NH_4PF_6	$8.61 \cdot 10^3$
GlOH-GA-AC-NaCMC	$1.45 \cdot 10^4$
GlOH-GA-AC-NaCl	$1.73 \cdot 10^4$
GlOH-GA-AC-NaAc	$2.02 \cdot 10^4$
GlOH-GA-AC-BuMePyPF_6	$2.73 \cdot 10^4$

Then, these values were used to determine the electrical conductivity for each material, by inverting the product of the linear electrical resistance (R_l) and the thickness (d) of each electrode.

$$\sigma = \frac{1}{R_l \cdot d}\ [S/m] \quad \textbf{(1)}$$

The obtained values are presented in **Fig. 2**.

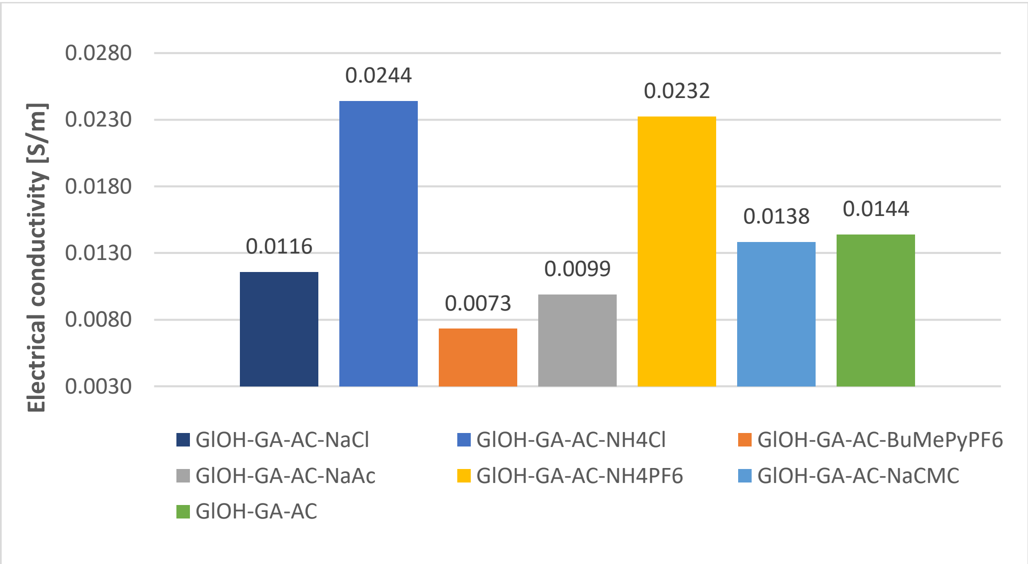

Fig. 2*: The electrical conductivity of each electrode*

2.4. SEM and EDX characterization

The surface morphology and the elemental composition of the electrodes were studied using SEM and EDX. The SEM images are presented in **Fig. 3**. It can be seen that AC formed aggregates with the GA solution and most of the salts, leading to porous irregular structures that favour the flow of electrons. In the case of GlOH-GA-AC-NH_4Cl, which exhibited the highest electrical conductivity, the porosity is lower and its shape is rather regular. The GlOH-GA-AC-BuMePyPF_6 electrode was found to be the least conductive and this could be attributed to the formation of the biggest aggregates, which hindered the charge storage.

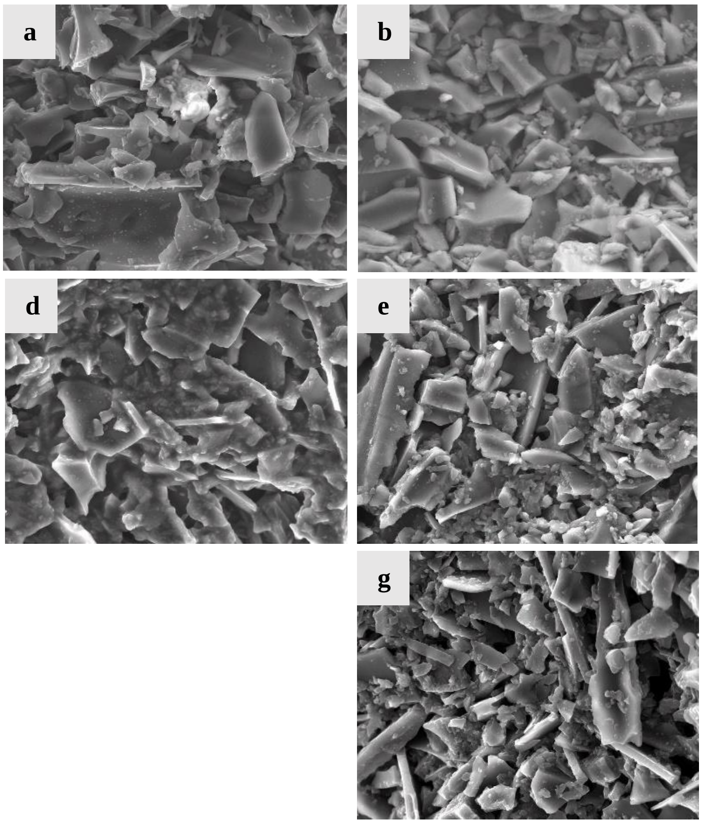

Fig. 3*: SEM images of the electrodes at a magnification of 4,000 times – a. GlOH-GA-AC-NaCl; b. GlOH-GA-AC-NH_4Cl; c. GlOH-GA-AC-BuMePyPF_6; d. GlOH-GA-AC-NaAc; e. GlOH-GA-AC-NH_4PF_6; f. GlOH-GA-AC-NaCMC; g. GlOH-GA-AC*

The EDX graph in **Fig. 4** shows the elemental composition of the GlOH-GA-AC electrode, against which the compositions of GlOH-GA-AC-NaCl and GlOH-GA-AC-NaAc were compared (**Fig. 5** and **Fig. 6**). The graphs prove that both mixtures containing salts have a good homogeneity, with all the expected elements appearing on them (C, O, Na and Cl). Nevertheless, the presence of other elements, such as Al and Si, indicate certain impurities.

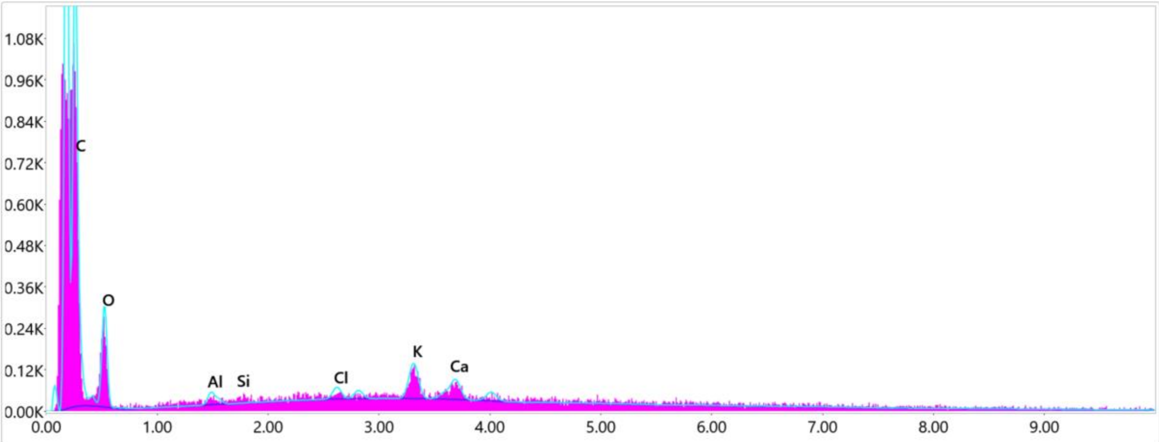

Fig. 4*: The EDX analysis of the GlOH-GA-AC electrode*

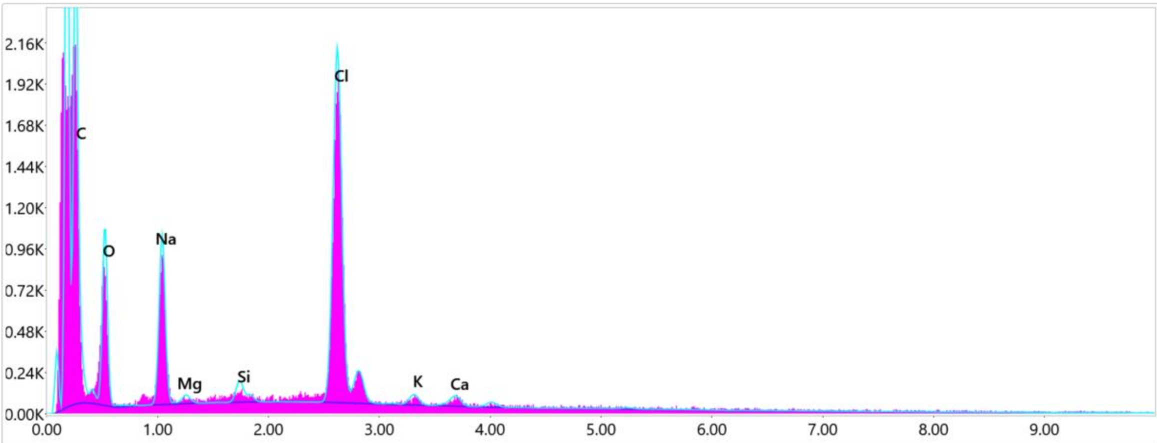

Fig. 5*: The EDX analysis of the GlOH-GA-AC-NaCl electrode*

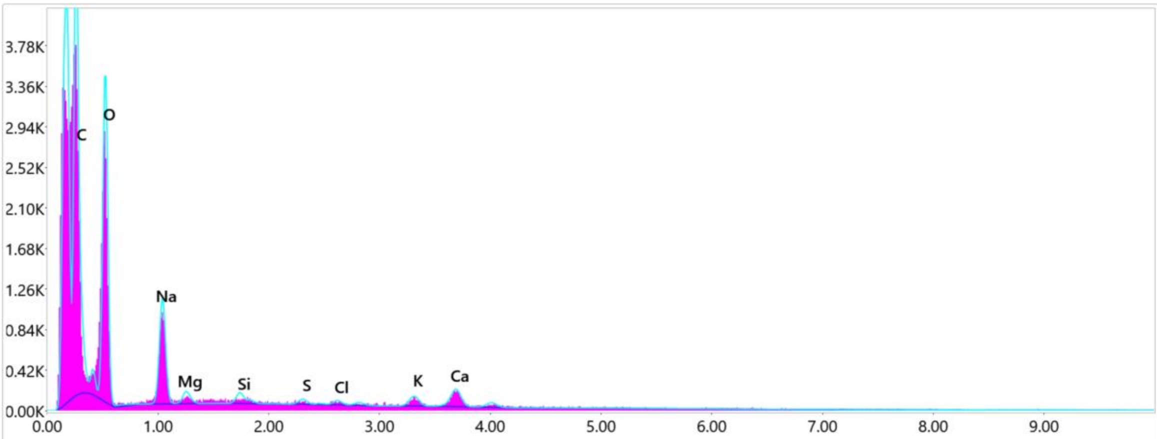

Fig. 6*: The EDX analysis of the GlOH-GA-AC-NaAc electrode*

5. CONCLUSIONS

In this study, we presented seven textile-based electrodes that were obtained by spreading a polymeric AC-based coating on a woven substrate. The electrochemical analysis showed that the electrical conductivities exhibited by the electrodes are situated between $73 \cdot 10^{-4}$ S/m and $244 \cdot 10^{-4}$ S/m and greener salts like ammonium chloride and sodium chloride are good replacements for the toxic 1-butyl-1-methylpyrrolidinium hexafluorophosphate and ammonium hexafluorophosphate because they conduct electricity better than their counterparts in this kind of mixture. The surface characterization of the materials revealed the porous structures of the electrodes, which are due to the adsorption properties of AC. This characteristic is crucial for a material to be used as an electrode, since charge is stored through its pores. Also, the analysis showed that regular shapes lead to an enhanced electrical conductivity if they are combined with porosity. Thus, our findings indicate the potential use of such materials as electrodes for the manufacturing of flexible supercapacitors.

ACKNOWLEDGEMENTS

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ANNALS OF THE UNIVERSITY OF ORADEA
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FUNCTIONAL PROPERTIES OF BAMBOO AND TENCEL UNION FABRICS

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Abstract: *This study delves into the concept of union fabric, a textile innovation that involves weaving two distinct yarns in the warp and weft directions. By merging the unique properties of each yarn, union fabric enables weavers to enhance desirable qualities while minimizing drawbacks, resulting in fabrics with superior functional attributes. This research focuses on the application of union fabrics made from Bamboo and Tencel, highlighting their user-friendly and eco-friendly characteristics. Bamboo fibers are renowned for their natural antibacterial properties, breathability, and sustainability, while Tencel fibers are celebrated for their softness, moisture management, and eco-friendly production processes. When combined in union fabrics, these yarns create textiles that are not only comfortable and gentle on the skin but also highly durable and environmentally friendly. Union fabrics represent an innovative approach in textile manufacturing, offering enhanced functionality and performance by integrating the best attributes of different yarns. The synergy between bamboo and Tencel in union fabrics exemplifies the potential of this technique, providing solutions that are beneficial for everyday use and critical in specialized applications, such as medical textiles. This study underscores the promise of these fabrics in medical textiles, suggesting a promising avenue for the development of advanced and sustainable healthcare materials.*

Keywords: *Union fabric, Textile innovation, Warp and weft, Yarn combination, Functional properties, Bamboo, Tencel, User-friendly, Eco-friendly*

1. INTRODUCTION

Clothing nowadays is no longer a material to be draped over human body for protection from extreme weather conditions. Rather it has many more functions like status symbol, beautifying agent, fitness guide, multitasking device and personality developer in an era of smart clothing. In order to enhance the functional features, introducing new fibres like bamboo and tencel improves the quality and durability of the fabrics produced. Bamboo is an evergreen perennial flowering plant belonging to subfamily Bambusoideae and grass family *Poaceae*. Bamboo fabrics are characterized by good hygroscopicity, excellent permeability, softer to feel, easy to straighten and dye. While Tencel is a brand name of Lyocell fibre, which is regenerated from cellulose extracted from eucalyptus wood pulp. The wood used for the purpose is, which is sustainably grown on farms in Europe, on land which is unsuitable for agriculture. Tencel fibre possesses great strength, excellent moisture management properties, and good absorbency and is gentle when worn next to skin. Tencel is soft, breathable, lightweight and comfortable, exceptionally strong fiber, both wet and dry conditions.

The growing emphasis on eco-friendly products in recent years' merits consideration. Institutions, businesses, and society at large are increasingly directing their focus towards organic agriculture [1].

Bamboo fabrics are more prominent in bathrobes and towels, foot mats, bed clothes, intimate garments, Bamboo T-shirts, sanitary napkins and Bamboo socks and many others [2]. Tencel fabrics are widely used as sports wears, home furnishings, toweling materials and many other areas. Thus, with respect to the properties of both Bamboo and Tencel an attempt was made to study the functional properties of Bamboo and Tencel union fabrics.

2.MATERIAL AND METHODS

2.1. Procurement of raw material

2/20s cotton yarns were procured from KHDC Gadag, Karnataka while Bamboo and Tencel yarns of 20s and 30s counts were procured from Pallava textiles, cotton mill, Mangarangam palayam, Tamil Nadu.

2.2. Design and development of union fabrics

Weaving is the method of fabric production wherein, two sets of yarns are interlaced at right angles to each other. Two types of plain woven union fabrics were produced on a pit loom at Malali Village, Ramapur and Karnataka wherein cotton yarns were used as warp and Bamboo and Tencel yarns were used as weft.

2.3. Cloth stiffness (cm):

Cloth stiffness is the resistance of the fabric to bending. Bending length is the length of the fabric that bends under its own weight to a definite extent. It equals half the length of rectangular stripe of fabric that bends under its own weight to an angle of 41.5°. The test samples were tested as directed in BS test method: 3356-1961. A rectangular strip of fabric, 6 inch × 1 inch was mounted on a horizontal platform in such a way that it hangs like a cantilever and bends downwards. Fabric was cut with help of template and then both template and fabric was placed on the platform with the fabric underneath. Both were pushed forward slowly. The strip of fabric was started to a droop over the edge of the platform and the movement of the templates and the fabric was continued until the tip of the fabric viewed in the mirror cuts both index lines. The bending length was read off from the scale mark opposite a zero line engraved on the side of the platform. Five readings were recorded by using Shirley's stiffness tester [3].

2.4. Cloth crease recovery (Degrees°):

Crease recovery is nothing but allowance of the fabric to recover from the crease. The test samples were tested as directed in IS method: 4681-1968 by using Shirley's crease recovery tester. Samples were cut both warp and weft way from the fabric with a template, 2 inch long by 1 inch wide. It was creased by folding into half and placed under a weight of 2 kg for 5 minutes. The weight was removed and the specimen was transferred to the fabric clamp on the instrument using forceps and was allowed to recover from the crease for 5 minutes. As it recovered the dial of the instrument was rotated to keep the free edges of the specimen in line with the knife edge. At the end of the time period as it was allowed for recovery, usually 1 minute the recovery angle in degrees was read on the engraved scale. Readings were recorded for both warp and weft separately [3].

2.5. Tensile strength (kgf) and elongation (%):

Tensile strength is the ability of the material to resist or rupture induced by eternal force. It is expressed as force per unit cross sectional area of the specimen at the time of maximum load. The specimens were tested as directed in ASTM test method: 12616-1989. The method employed to determine the breaking load and elongation of the material by using the 'raveled strip test' in Unistretch 250 tensile tester.

The fabric sample of 20 cm × 5 cm dimensions was gripped between two clamps of the tensile testing machine in such a manner that the same fabric was gripped by both the clamps and a continuous increasing load was applied longitudinally to the specimen by moving one of the clamps until the specimen ruptured. Values of breaking load of the test specimen were recorded from the indicator of the machine.

Elongation is the increase in length of the specimen from its initial length expressed in units of length. The distance that material will extend under a given force is proportional to its original length. Hence elongation is coated as strain or percentage was assessed for the fabrics.

2.6. Cloth drapability (%):

Drape is the ability of the fabric to assume a graceful appearance in us. Fabric drape may be explained as the extent to which a fabric deforms when it is allowed to hung under its own weight. A circular specimen about 10-inch diameter was supported on a circular disc about 5-inch diameter and upper supported area drapes over the edge. On switching the lamp of the drape meter, it gave the shadow of the draped area, which was taken on a paper and was weighed. Similarly draped shadow area of the template and supporting disc was also taken. Drape coefficient is the ratio of the projected area of the draped specimen to its undraped area after deduction of the area of the supporting disc [4], [5].

2.7. Cloth thermal insulation value (Tog):

Thermal resistance is the ability of a material to resist the flow of heat. Thermal resistance is the reciprocal of thermal conductance *i.e.,* lowering its value will raise the heat conduction and vice-versa. The specimens were tested manually. The experiment was carried out by cooling method. In this method, a hot body is wrapped with the fabric and its rate of cooling is measured. The outer surface of the fabric is exposed to the air. The experiment consists in finding the time taken by a hot body covered with the fabric sample without the sample to cool through a particular temperature range under identical atmospheric conditions. The experiment was started when temperature of the water was exactly 48°C. A stop watch was used to find the time taken for the temperature to fall at 38°C.

2.8. Cloth Air permeability ($cm^3/cm^2/sec$)

Air permeability is defined as the volume of air measured in cubic centimeter passed per second through 1 cm^2 of the fabric at a pressure of 1 cm of water. All the samples were tested as directed by ASTM D-737 test method. Air at standard atmosphere was drawn from labrorartry through the test specimen by means of a suction pump, the rate of flow being controlled by means of the pass valve and service valve at the definite pressure. The rate of flow was adjusted until the required pressure drop across the fabric and is indicated on a draught gauge. The rate of flow of air was then recorded by rotameter from the instrument.

2.9. Cloth abrasion resistance (Ratings)

Cloth Abrasion is the rubbing away of component fibres and yarns of the fabric [3]. Abrasion resistance was carried out in **digitized** 'Martindale abrasion tester 'using IS 12673-1989 test method. Fabric specimens of 13.5 cm diameter were cut according to the size of template. The specimens were abraded using zero emery paper and determination of end point was visualized until a hole was formed and number of cycles to create a hole and readings were recorded.

2.10. Visual evaluation of Bamboo and Tencel union fabrics

Visual assessment of the developed fabric was carried out by a panel of textile experts. Weighted average ranking (WAR) was done in order to study the preference of developed union fabrics based on rakings (5-Excellent, 4- Very good, 3-Good, 2- Fair and 1-Poor).

The cost of the yarns and developed bamboo and tencel union fabrics per meter were calculated for comparison of bamboo and tencel union fabrics.

2.11. Statistical analysis

The experimental data obtained from present experiment was subjected to two-way ANOVA using two and three factorial designs using WINDOSTAT software developed by INDOSTAT services.

3. RESULTS AND DISCUSSIONS

Table 1, highlights the physical properties of Cotton, Bamboo and Tencel yarns. It was observed that Cotton yarn obtained maximum **yarn twist** (16.84) compared to Bamboo (3.84) and Tencel (9.24) yarns of 30s counts which is due to the fibre content, the crysatllinity of Cotton fibre which enhances the yarn to twist more, further adding strength. Similar results with respect to twist of Cotton yarns were obtained in a study on Effect of blend ratio on quality characteristics of Bamboo/Cotton blended ring spun yarn by Prakash *et al* [6].

Table 1: *Physical properties of Cotton, Bamboo and Tencel yarns*

Sl.No	Type of Yarn	Yarn parameters							
		Count	Twist	Unevenness (%)	Hairiness (No. of hairs/km)	Count Strength Product	Single yarn Strength (kgf)	Elongation (%)	Lea yarn strength (lbs)
1	Cotton	20	**16.84**	8.0	246	**2954**	**556.5**	4.5	**152.6**
2	Bamboo	20	3.26	8.0	**922**	1540	166.4	**9.1**	78.2
		30	**3.84**	**8.2**	303	1373	132.6	8.4	46.5
3	Tencel	20	4.84	7.6	307	2948	447.4	6.6	143.2
		30	**9.24**	**8.4**	340	2611	287.7	6.1	87.78

Similarly, Bamboo (8.2%) and Tencel (8.4%) yarns of 30s count possessed greatest amount of **unevenness percentage** (Thick, thin places and neps) which may be due to the presence of water in varying amounts or an uneven blend of two or more fibres will alter the relative permittivity (dielectric constant) in parts of the yarn and hence appear as unevenness. The results are on par with the study conducted by Majumdar *et al.* [7] who concluded that, 100 per cent Cotton and Bamboo yarns have comparable yarn unevenness percentage. However, while in case of 30s bamboo yarn, the unevenness percentage was higher than that of 20s bamboo yarn.

Bamboo 20s (922 no of hairs/km) yarn possessed highest **yarn hairiness** and length of hairs ranging from 3mm to 15 mm which may be due to the yarn manufacturing, yarn production techniques. Higher yarn hairiness leads to faulty and poor quality of yarns that affects the thermal insulation and other apparel characterstics. Majumdar *et al.* [7] reported that yarn hairiness of Bamboo was found to be higher than Cotton as Bamboo fibres are longer in length when compared to Cotton fibres.

Likewise, the **count strength product** was also seen higher in Cotton yarn (2954) because yarn count and yarn twist contributes to strength of the yarn which ultimately enhances the count strength product.

Single yarn strength of Cotton yarns (556.5kgf) were found to be maximum when compared to Bamboo and Tencel yarns as the elastic nature of the cellulosic yarns makes them resistant to break when subjected to certain load applied. While **Elongation** was fond to be higher in case of Bamboo 20s yarn (9.1%) compared to other yarns as Bamboo itself possessed good amount of waviness which makes a yarn to take more time to rupture as it lacks the plastic nature.

Lea yarn strength means the amount of pressure required to break a hank of yarn. Cotton yarn hank (152.6lbs) noticed greater lea yarn strength compared to Bamboo and Tencel yarns due to the friction of the pulleys on which the hanks were mounted and also the yarn friction. Yarn friction may alter the fibre constituent of the yarn and also the force at which the yarn initiates to break which depends on the type of instrument used. As the braking elongation of cotton fibres/yarn are expected to reach the rupture point earlier resulting in collapsing the entire yarn structure which makes the yarns unstable to take the load applied.

Table 2: *Loom particulars of Bamboo and Tencel union fabrics*

Sl. No.	Particulars	Union fabrics ($CC/ CB_1/CB_2/CT_1/CT_2$)
1.	Type of loom	Pit loom (Handloom)
2.	Reed width	72’’
3.	Cloth width	36’’
4.	Denting order	2 Threads/dent

Weaving is a technique of fabric construction wherein two sets of yarns *viz.*, warp (lengthwise) and weft (filling) yarns are interlaced at right angle to each other to form a mesh like structure called as a woven fabric. In the present research five different types of union fabrics were woven on a traditional handloom also called as ‘pit loom’ using 2/20s Cotton yarn were used as warp while Bamboo and Tencel yarns of 20s and 30s as weft. One control sample and four union fabrics were woven on a handloom with 72’’ reed width, cloth width of 36’’ with 2 threads/dent denting order (Table 2).

Table 3: *Constructional details of Bamboo and Tencel union fabrics*

Sl. No.	Union fabrics	Direction	Fiber Content	Yarn type	Twist Direction	Threads per inch	Weave
1	Cotton × Cotton	Warp	Cotton	2 Ply	Z	48	Plain
		Weft	Cotton		Z	26	
2	Cotton × Bamboo 20s	Warp	Cotton		Z	51	Plain
		Weft	Bamboo		Z	23	
3	Cotton × Bamboo 30s	Warp	Cotton		Z	50	Plain
		Weft	Bamboo		Z	26	
4	Cotton × Tencel 20s	Warp	Cotton		Z	50	Plain
		Weft	Tencel		Z	23	
5	Cotton × Tencel 30s	Warp	Cotton		Z	50	Plain
		Weft	Tencel		Z	27	

Table 3 explains the constructional details of bamboo and tencel union fabrics wherein Cotton × Cotton (CC), Cotton × Bamboo 20s (CB_1), Cotton × Bamboo 30s (CB_2), Cotton × Tencel 20s (CT_1), Cotton × Tencel 30s (CT_2) 2 ply yarns possessing Z twist were utilized to weave plain woven fabrics on a pit loom following a traditional style of weaving by master weaver in Malali Village, near Hubli.

Table 4. *Cloth stiffness of Bamboo and Tencel union fabrics*

Sl. No.	Union fabrics	Cloth stiffness (cm)	
		Warp	**Weft**
1.	Cotton × Cotton	**4.24**	1.82
2.	Cotton × Bamboo 20s	**5.92**	1.74
3.	Cotton × Bamboo 30s	2.64	**1.86**
4.	Cotton × Tencel 20s	**6.40**	**1.86**
5.	Cotton × Tencel 30s	4.04	**1.92**

ANOVA Table

Factors	S.Em. ±	C.D. (5 %)
A- (Union fabrics)	0.04	0.12
B- (Warp and weft)	0.02	0.07
A × B- (Union fabrics) × (warp and weft)	0.06	0.17

* CD- Critical difference

Table 4, Figure 1 disclose the **cloth stiffness** was slightly higher in union fabrics *viz.*, Cotton × Tencel 20s (6.40 cm) and Cotton × Bamboo 20s (5.92 cm) fabric compared to Cotton × Cotton (4.24 cm) fabric in warp direction which is due to the sizing applied to warp yarns (Cotton yarns) prior to weaving thus imparting stiffness in warp direction. Whereas, due to the variation in the linear densities of the yarns, as tencel obtained greater single yarn strength (table 1) resulted in higher stiffness which means if the fabric is stiffer, thus, it will take greater time to bend against gravity hence Cotton × Tencel fabrics had higher cloth stiffness in weft direction.

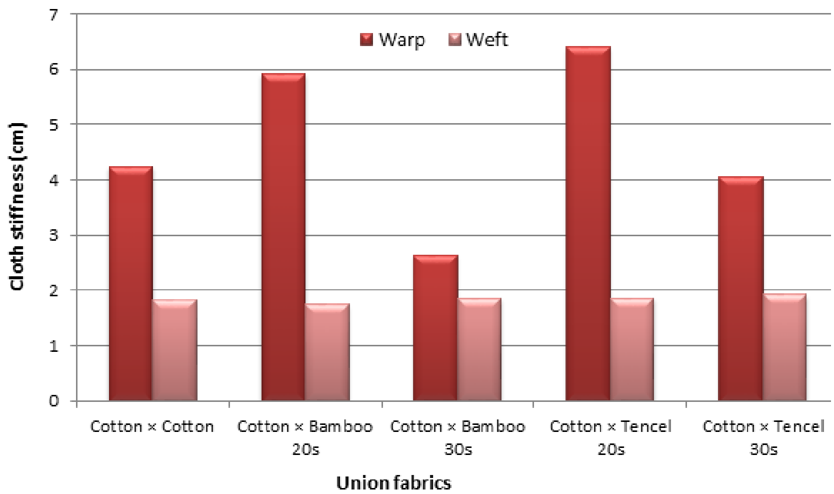

Fig. 1. *Cloth stiffness of Bamboo and Tencel union fabrics*

Rashmi [8] quoted warp way cloth stiffness was signific antly lower than the weft way cloth stiffness as presence of cotton yarns which possessed finer yarn count and more evenness of the yarn.

Table 5: Cloth crease recovery of Bamboo and Tencel union fabrics

Sl. No.	Union fabrics	Cloth crease recovery (degrees)	
		Warp	Weft
1.	Cotton × Cotton	82.40	84.20
2.	Cotton × Bamboo 20s	83.40	**108.20**
3.	Cotton × Bamboo 30s	**85.80**	93.00
4.	Cotton × Tencel 20s	56.40	106.20
5.	Cotton × Tencel 30s	83.60	99.20

ANOVA Table

Factors	S.Em. ±	C.D. (5 %)
A- (Union fabrics)	1.24	3.55
B- (Warp and weft)	0.78	2.24
A × B- (Union fabrics) × (warp and weft)	1.75	5.02

* CD- Critical difference

It is perceived from table 5, fig 2 that, among the fabrics Cotton × Bamboo 30s union fabric (85.80°) had highest **crease recovery angle** when compared to Cotton × Bamboo 20s (83.40°) and Cotton × Tencel 30s (83.60°) union fabric due to the combination of Cotton, Bamboo and Tencel yarns in union fabrics, more unevenness of the yarns, type of weave all alters the crease recovery angle in warp way. Weft way crease recovery was higher in Cotton × Bamboo 20s union fabric (108.20°) when compared to Cotton × Cotton fabric. This may be due to the stiffness of the union fabrics makes them more stiff and pliable than the control sample. The results were on par with the study on value addition to silk floss by Rashmi [8].

Table 6: *Cloth tensile strength and elongation of Bamboo and Tencel union fabrics*

Sl. No.	Union fabrics	Tensile strength (kgf)		Elongation (%)	
		Warp	Weft	Warp	Weft
1.	Cotton × Cotton	**38.00**	25.24	**12.33**	11.51
2.	Cotton × Bamboo 20s	30.02	18.76	9.66	16.76
3.	Cotton × Bamboo 30s	36.72	**27.32**	12.01	8.23
4.	Cotton × Tencel 20s	37.1	21.70	10.44	**17.28**
5.	Cotton × Tencel 30s	34.66	**39.1**	12.10	11.33

ANOVA Table

Factors	S.Em. ±	C.D (5 %)
A- (Union fabrics)	0.22	0.63*
B- (Tensile strength and elongation)	0.14	0.39*
C- (Warp and weft)	0.14	0.39*
A × B - (Union fabrics) × (tensile strength and elongation)	0.31	0.89*
A × C- (Union fabrics) × (warp and weft)	0.31	0.89*
B × C- (Tensile strength and elongation) × (warp and weft)	0.20	0.56*
A × B × C- (Union fabrics) × (tensile strength and elongation) × (warp and weft)	0.44	1.32*

*- CD- Critical difference; Significant at 5 % level of significance

Maximum **tensile strength** was observed in Cotton × Cotton fabric (38kgf) when compared to union fabrics which may be due to the presence of good amount of crysatllinity in the polymer system of both Cotton and Tencel which makes them to withstand the force applied to tear the fabric. However, Cotton × Tencel (39.10 kgf) and Cotton × Bamboo (27.32kgf) 30s union fabric attained highest tensile strength in weft direction may be due to the combination of bamboo and tencel yarns with cotton yarns together influences the cloth tensile strength (Table 6 and Figure 3).

Further, Cotton × Cotton fabric (12.33%) possessed highest **elongation** percentage in warp direction on the other hand, Cotton × Tencel 20s union fabric (17.28%) obtained highest elongation percentage in weft direction which as in case of cotton × cotton fabric both set of yarns are cotton which makes the fabric double times stronger while in case of Cotton × Tencel 20s union fabric both Cotton and Tencel yarn possess high amount of crysatllinity thus making the fabric stronger and sustain more pressure. Similar results were quoted by Rashmi [8] in a study on value addition to silk floss and stated that in general warp way tensile strength of the designed fabric samples depicted higher tenacity.

Table 7: *Cloth drapability of Bamboo and Tencel union fabrics*

Sl. No.	Union fabrics	No of nodes	Drape coefficient (%)
1.	Cotton × Cotton	3	**105.44**
2.	Cotton × Bamboo 20s	3	97.30
3.	Cotton × Bamboo 30s	4	95.24
4.	Cotton × Tencel 20s	4	101.31
5.	Cotton × Tencel 30s	4	**104.11**

ANOVA Table

Factors	S.Em. ±	C.D. (5 %)
A- (Union fabrics)	0.55	1.58*
B- (No of nodes and drape coefficient)	0.35	1.00*
A × B- (Union fabrics) × (no of nodes and drape coefficient)	0.78	2.23*

*- CD- Critical difference; Significant at 5 % level of significance

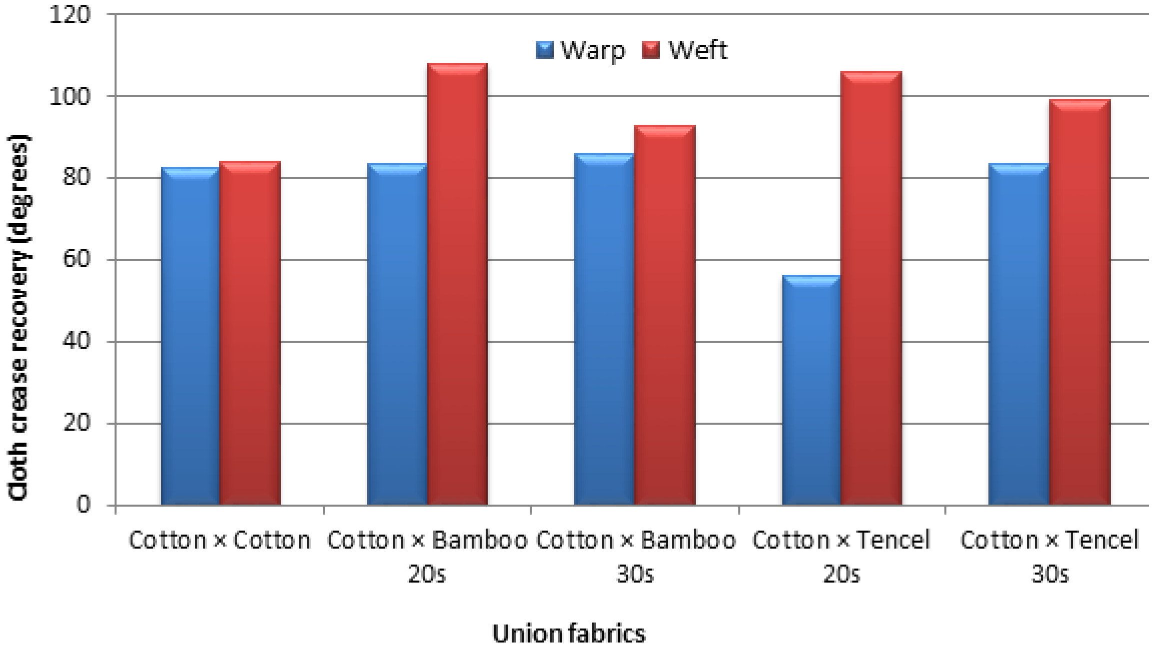

Fig. 2*. Cloth crease recovery of Bamboo and Tencel union fabrics*

Cloth drapability and stiffness are interrelated and are influenced by various properties *viz.*, fabric set ratio, weave, cloth count and cloth thickness. Thus Table 7, Figure 4 illustrates that, cloth drape coefficient was found to be higher in cotton × cotton fabric (105.44%) and cotton × tencel 30s union fabrics (104.11%) which may be because of as cloth stiffness and cloth crease recovery of the fabrics were found to be on par when compare to cotton × bamboo union fabric resulting in higher stiffness ultimately making a fabric stiffer and coarser.

However, irrespective of counts, least cloth drape coefficient was found in cotton × bamboo/tencel union fabrics contributing to lower bending length and cloth thickness, thus making the fabric suppler and soft. Least cloth drape coefficient attributed to low cloth stiffness thus making it soft and pliable, according to Kulkarni *et al.*, [9].

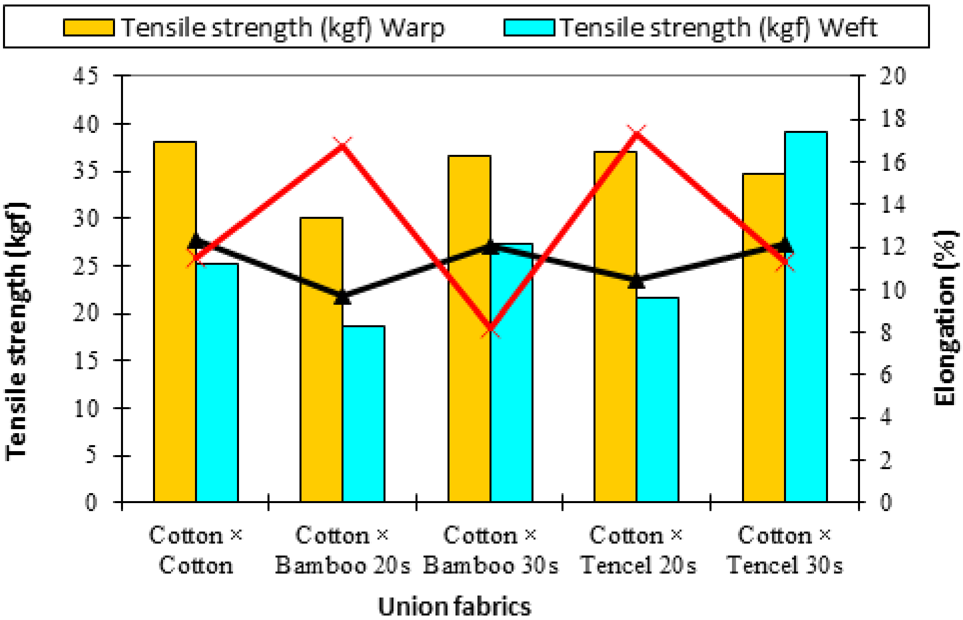

Fig. 3*. Cloth tensile strength and elongation of Bamboo and Tencel union fabrics*

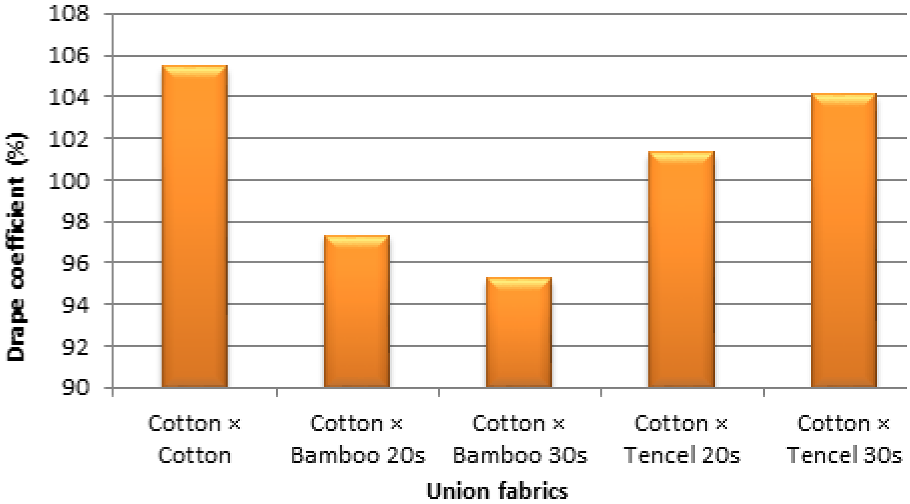

Fig. 4. *Cloth drape ability of Bamboo and Tencel union fabrics*

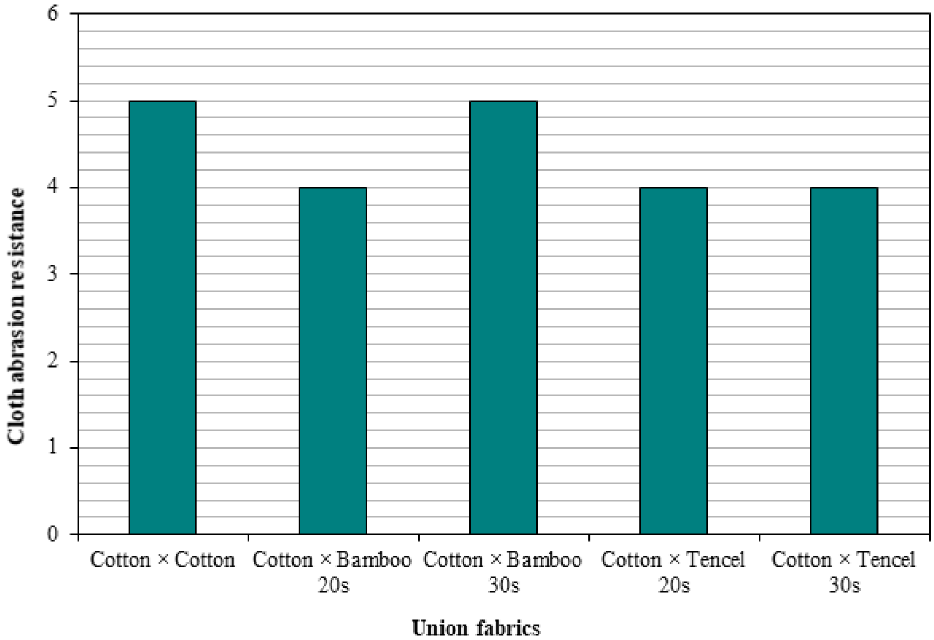

Fig. 5. *Cloth abrasion resistance of Bamboo and Tencel union fabrics*

Table 8. *Cloth abrasion resistance of Bamboo and Tencel union fabrics*

Sl. No.	Union fabrics	Total revolution	Cloth abrasion resistance
1.	Cotton × Cotton	100 Revolutions/ Sample	**5**
2.	Cotton × Bamboo 20s		4
3.	Cotton × Bamboo 30s		**5**
4.	Cotton × Tencel 20s		4
5.	Cotton × Tencel 30s		4

5- No pilling, 4- Slight pilling, 3- Moderate Pilling, 2- Severe pilling, 1- Very severe pilling

Table 8, Figure 5 indicated that, Cotton × Cotton (5) and cotton × bamboo 20s union fabric exhibited no pilling, indicating excellent durability of the fabric thus increasing its life for longer usage. The factors contributing to abrasion resistance are yarn count, cloth count, cloth thickness and the amount of friction between the abradent used and the fabric surface. The results of value addition to silk floss by Rashmi [8] were on par with present research stating that union fabrics with cotton×cotton/silk floss depicted higher abrasion resistance due to the higher percentage of cotton fibre also depends on yarn count, thickness, cloth count and highest contact with abradent and fabric surface.

Table 9. *Cloth thermal insulation value of Bamboo and Tencel union fabrics*

Sl. No.	Union fabrics	Cloth thermal insulation value (tog)
1.	Cotton × Cotton	27.34
2.	Cotton × Bamboo 20s	**29.60**
3.	Cotton × Bamboo 30s	23.84
4.	Cotton × Tencel 20s	27.42
5.	Cotton × Tencel 30s	26.34
S.Em. ±		0.01
C.D. 5 %		0.03*

*- CD- Critical difference; Significant at 5 % level of significance

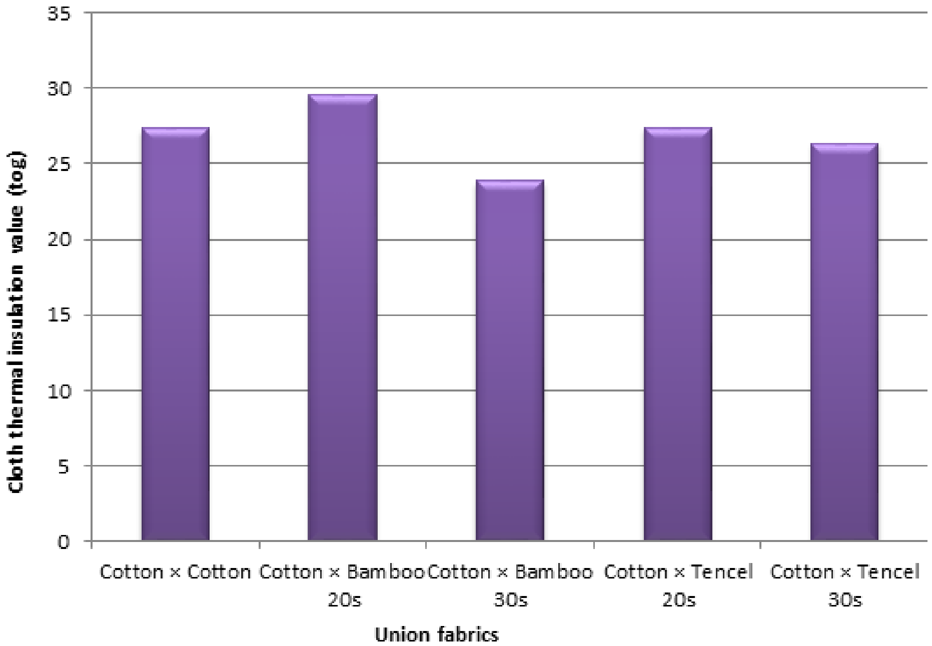

Fig. 6*. Cloth thermal insulation value of Bamboo and Tencel union fabrics*

Table 9, Figure 6 expresses that the **cloth thermal insulation value** depicted higher in cotton × bamboo 20s union fabric (29.60 tog) when compared to the cotton × cotton fabric (27.34 tog) because as cotton is a good conductor of heat, cotton and bamboo both being cellulosic in nature have the tendency to retain heat energy and combining the properties of both cotton and bamboo results in good thermal insulation value of the union fabrics. The results of value addition to silk floss by Rashmi [8] were on par, stating that, maximum thermal insulation value was observed in union fabrics which were due to the combined effect of cotton and silk floss resulting in higher thickness.

Table 10. Cloth air permeability of cotton × bamboo/tencel union fabrics

Sl. No.	Union fabrics	Cloth air permeability ($cm^3/cm^2/sec$)
1.	Cotton × Cotton	58.32
2.	Cotton × Bamboo 20s	43.38
3.	Cotton × Bamboo 30s	**76.26**
4.	Cotton × Tencel 20s	69.28
5.	Cotton × Tencel 30s	**75.28**
S.Em. ±		0.01
C.D. 5 %		0.03*

*- CD- Critical difference; Significant at 5 % level of significance;

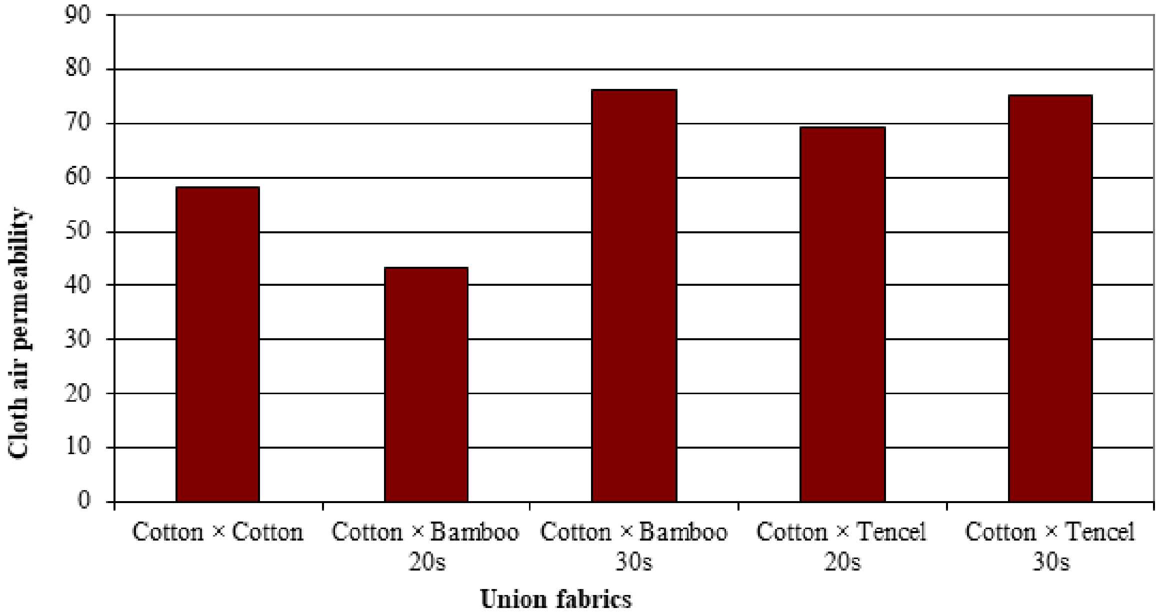

Fig. 7. *Cloth air permeability of cotton × bamboo/tencel union fabrics*

The results presented in Table 10, Fig 7 depicted that, cotton × bamboo 30s (76.26 $cm^3/cm^2/sec$) and cotton × tencel 30s (75.28 $cm^3/cm^2/sec$) union fabrics attained highest **cloth air permeability** which may be due to the count (30s) and compactness of the weave. It can be stated that, higher the yarn count, finer the yarn thus allowing more air to pass through the interstice spaces of the fabrics. Further, loosely woven fabric creates more spaces for air to pass through the fabric structure thereby increasing the air permeability. On the other hand, union fabrics of 20s count were less permeable to air because of the use of coarser yarns and compactly woven fabric structure.

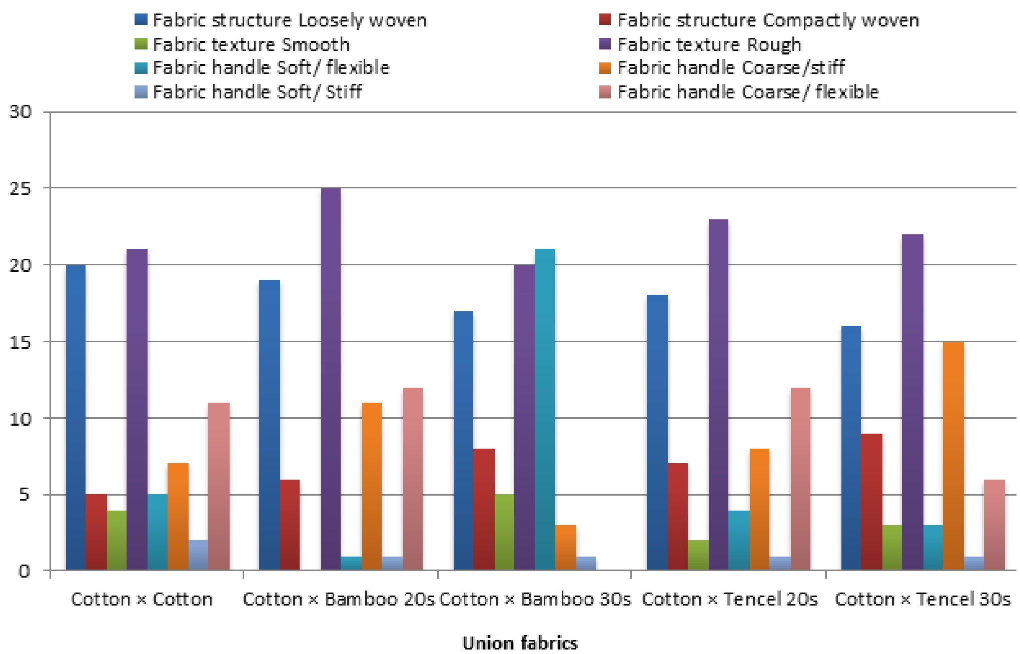

Fig. 8. *Textile expert's opinion on fabric structure and tactile properties of developed union fabrics*

Table 11. *Textile expert's opinion on fabric structure and tactile properties of developed union fabrics*

Sl. No	Samples	Fabric structure		Fabric texture		Fabric handle			
		Loosely woven	Compactly woven	Smooth	Rough	Soft/ flexible	Coarse/stiff	Soft/ Stiff	Coarse/ flexible
1	Cotton × Cotton	**20 (80.00)**	5 (20.00)	4 (16.00)	**21 (84.00)**	5 (20.00)	7 (28.00)	2 (8.00)	11 (44.00)
2	Cotton × Bamboo 20s	19 (76.00)	6 (24.00)	-	**25 (100.00)**	1 (4.00)	11 (44.00)	1 (4.00)	**12 (48.00)**
3	Cotton × Bamboo 30s	17 (68.00)	**8 (32.00)**	**5 (20.00)**	20 (80.00)	**21 (84.00)**	3 (12.00)	1 (4.00)	-
4	Cotton × Tencel 20s	**18 (72.00)**	7 (28.00)	2 (8.00)	23 (92.00)	4 (16.00)	8 (32.00)	1 (4.00)	**12 (48.00)**
5	Cotton × Tencel 30s	16 (64.00)	**9 (36.00)**	3 (12.00)	22 (88.00)	3 (12.00)	**15 (60.00)**	1 (4.00)	6 (24.00)

It was found in Table 11, fig 8 that majority of the respondents opined that, the cotton × cotton fabric (80%) was loosely woven with a rough texture. This may be because of the coarser yarn count and maida starch applied to warp yarns before weft insertion in order to avoid entanglement of yarn and making the yarns to easily pass through the dent. Based on the fabric structure and texture, it was observed that the union fabrics were attributing a soft/flexible, coarse/stiff and coarse/flexible fabric handle property. This may be due to the loom on which the fabric was woven and the different yarn count of bamboo and tencel yarns which also contributes to the fabric handle.

Table 12. *Preference of the developed union fabrics by textile experts*

Sl.No	Samples	Bamboo and Tencel union fabrics						
		Excellent	Very good	Good	Fair	Poor	Average	WAR
1	Cotton × Cotton	6 (24.00)	5 (20.00)	7 (28.00)	-	7 (28.00)	3.12	III
2	Cotton × Bamboo 20s	11 (44.00)	-	8 (32.00)	4 (16.00)	2 (8.00)	**3.56**	**II**
3	Cotton × Bamboo 30s	4 (16.00)	12 (48.00)	5 (20.00)	3 (12.00)	1 (4.00)	**3.60**	**I**
4	Cotton × Tencel 20s	2 (8.00)	6 (24.00)	3 (12.00)	11 (44.00)	3 (12.00)	2.72	IV
5	Cotton × Tencel 30s	2 (8.00)	2 (8.00)	2 (8.00)	6 (24.00)	13 (52.00)	1.96	V

5 - Excellent 4 - Very good 3- Good 2- Fair 1- Poor
*Figures in parenthesis indicate percentages *Higher the average values higher the rank

Table 12, Figure 9 depicts the preference of textile experts for cotton union fabrics based on the fabric structure, texture and handle properties. It is noticed cotton × bamboo 30s union fabric was highly preferred as it was woven with coarser cotton yarn thus adding weight and making it more usable.

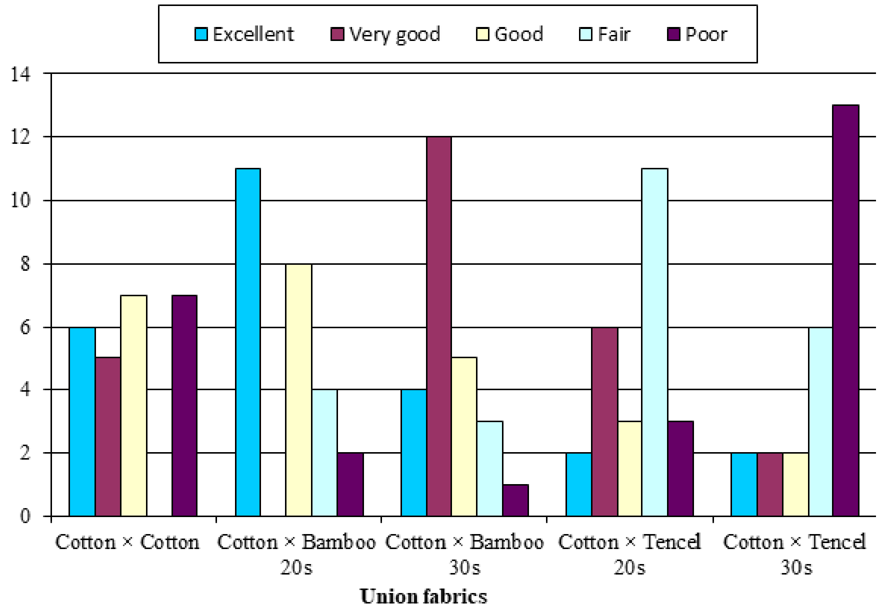

Fig. 9*. Preference of the developed union fabrics by textile experts*

Table 13. *Cost of production of developed union fabrics (Rs./mt)*

Sl. No.	**Particulars**	Cotton × Cotton	**Union fabrics**			
			Cotton × Bamboo 20s	Cotton × Bamboo 30s	Cotton × Tencel 20s	Cotton × Tencel 30s
I. a	Variable Cost (Raw material) Warp	**400.00**				
	Weft	400.00	250.00		280.00	
Total		800.00	650.00		680.00	
b	Pre preparatory process	66.60				
c	Weaving	80.00				
II.	Total cost of production	**946.6**	796.6		826.6	

- Cost of cotton yarn /kg (warp): Rs. 400.00/-
- Cost of bamboo yarn (20s and 30s) kg (weft): Rs. 250.0/-
- Cost of tencel yarn (20s and 30s) /kg (weft): Rs.280.00/-

A perusal of Table 13 indicates that, variable cost of Cotton yarns was found to be higher in cotton × cotton (400.00/-) fabrics in comparison to Bamboo (250.00/-) and Tencel (280.00/-) union fabrics as rate of cotton yarns per kg was higher when compared to Bamboo and Tencel yarns. Total cost of production of one meter of cotton x cotton fabric (946.6/-) was maximum when compared to bamboo and tencel union fabrics as cotton yarns were the costliest yarns among the five types of yarns used in the study.

4.CONCLUSIONS

A union fabric is a textile fabric, which is woven using two different yarns in warp and weft direction to get a new fabric having the properties of both the yarns. Union fabric enables the weavers to combine two different sets of yarns so that good qualities are emphasized and poor qualities are minimized, thereby having the fabrics with better functional properties. Bamboo and Tencel union fabrics being user friendly, ecofriendly is of great use in medical textiles too.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

COMPOUND YARNS FOR LONG HEMP FIBERS VALORIZATION

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Abstract: *Due to the high linear density, low elongation and flexibility, hemp fibers cannot be processed to obtain very thin yarns for value-added destinations. In order to increase the spinnability of these fibers, different processing techniques have been tried. The experiments aimed at the development of compound yarns obtained from hemp fibers blended with modified polypropylene fibers and core from different types of filament yarns: silk, viscose and polyester. Compound yarns combine in an efficient way the advantages of wrapping fibers as well as those of core filaments so that they can lead to obtaining textile materials with high tenacity, resistance to abrasion, reduced shrinkage, color resistance, low pilling and good drapeability. The insertion of filaments into the yarn structure has considerably improved the physical-mechanical properties of compound yarns. The coefficient of variation of the breaking force decreases by 29,6% in the case of the compound yarn with silk filaments core compared with the yarn made of 50% hemp/50% modified polypropylene fibers, and the elongation at break of the compound yarn with silk filaments increases by 30.9% compared to the elongation of the 50% hemp/50% modified polypropylene fibers yarn. This hemp type yarns with a linear density of 50 tex are suitable for use in order to obtain fabrics with a specific appearance of textile materials obtained from 100% hemp, but with a reduced mass per surface unit, thus expanding the field of use of long line wet spun yarns.*

Key words: *hemp, wet spun yarns, modified polypropylene fibers, silk filaments*

1. INTRODUCTION

Ecological considerations have become important factors in the processing of textile products. The fibers obtained from hemp stems, which do not require fertilizers and pesticides for growth, meet these requirements and, as a result, have recently aroused the interest of growers and processors [1,2]. For example, in Europe, the production of hemp plants increased in 2018 compared to 2013 by 70% [2].

Hemp fibers are recyclable, biodegradable, cheap and increasingly available. Mainly due to their very good physico-mechanical properties, such as strength and modulus of elasticity [3], ropes, technical fabrics or reinforcements for polymer composite materials can be obtained from these fibers [4-7].

Hemp fibers also have other qualities, such as the ability to absorb sweat and at the same time confer the feeling of coolness, resistance to wear, shine, dye affinity, qualities that make it usable in the clothing industry as well. Clothing products made from hemp fibers have greater resistance and durability than those made from cotton. In addition, hemp has very good antibacterial properties, exceeding those of other natural fibers, and is hypoallergenic, being suitable for clothing worn by people with sensitive skin [8].

Due to the high linear density, low elongation and flexibility, hemp fibers cannot be processed to obtain very thin yarns with diversified destinations. In order to increase the spinnability of these fibers, different processing techniques have been tried, such as that of processing long hemp fibers blended with other natural and synthetic fibers.

Another technology that can be applied is the one that obtains compound yarns or core-spun yarns with combined properties that capitalize on the advantages of the two categories of fibers. Compound yarns have a central core and a second layer of fibers wrapped around it that are tightly integrated so that the fibers do not slip during further processing [9,10].

Recently, considering various destinations, researchers have realized and analyzed different categories of compound yarns, such as yarns for underwear and socks with a polyester core and wrapping antibacterial fibers, yarns with good elasticity obtained from polyurethane core and wrapping nylon fibers, three-component yarns obtained from cotton/polyester/cashmere or acrylic/Tencel/cotton [9], helical auxetic yarn developed from combination of Kevlar and polypropylene or Kevlar and nylon [11], sewing threads with a polyester core and wrapping cotton fibers [12], compound yarns with a worsted core of mercerized wool [13], and many others.

2. MATERIALS AND METHODS

The experiments, the results of which are presented in this work, aimed at the creation of compound yarns obtained from hemp fibers blended with modified polypropylene fibers and core from different types of filament yarns.

The compound yarns were made by wet spinning the roving obtained from the fibrous blend of 50% hemp / 50% modified polypropylene fibers (MPP) in order to improve the dyeing capacity of the fibers. A filament feeding device was mounted on the wet ring spinning machine which allowed spinning the roving fibrous mixture together with different types of filament yarns. For a first variant of compound yarn, degummed natural silk filaments with doubling 3, with a linear density of 2.3 Tex, a tenacity of 22.1 cN/tex and a relative elongation at break of 16.2% were used as a core. Natural silk has high fineness, high tensile strength, extensibility, smoothness and good dyeability [14]. Although it is perceived as having a high price, in recent years consumption has increased and natural silk fibers have become more accessible.

Considering the fact that the natural silk in the yarn composition could increase its price, making it less attractive, despite its advantages, it was tried to replace it with other less expensive filaments, such as viscose or polyester filament yarns.

The second series of tests was performed with viscose filament core as a replacement for natural silk, with a linear density of 11 tex, a tenacity of 10.8 cN/tex and an elongation at break of 11.6%. Viscose has a shine and can be dyed easily, giving the products comfort, softness and breathability.

The third series of tests was carried out with polyester filament yarn core with a linear density of 8.8 tex, with a tenacity of 34.2 cN/tex, with a relative elongation at break of 24.5% and with a twist of 742 twists per metre. The polyester filaments are resistant, elastic and recover well after being subjected to stress.

Yarn breaking force and elongation were determined according to ISO 2062. To obtain the breaking tenacity of the yarn samples, the value recorded for the breaking force was divided by the linear density of the yarn sample. To determine its value, after breaking, the yarn sample that was loaded between the grips of the tensile testing machine was cut at the edge of the grips and then weighed. The obtained value was divided by the initial gage length of 0.5 m. To carry out the experimental determinations, the devices and equipment from the Department of Engineering and Design of Textile Products were used (Tinius Olsen H5KT tensile testing machine, Optika trinocular microscope, precision analytical balance).

3. RESULTS AND DISCUSSION

The three categories of yarns tested were analyzed compared to a classic spun yarn, coreless, made of 50% hemp/50% MPP. In Fig. 1, the longitudinal aspect of this thread can be seen. In the case of compound yarn, the core filament is not visible because the staple fibers of hemp and MPP migrate around the core filament during spinning.

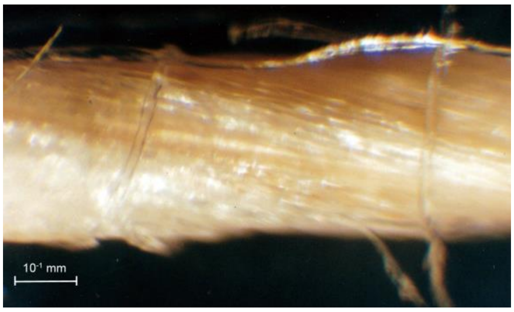

Fig. 1*: Longitudinal morphology of a 50% hemp 50% MPP spun yarn (x150 magnification)*

In Fig. 2, some tensile characteristics of the yarn obtained from 50% hemp/50% MPP and the core yarn obtained by spinning the roving from 50% hemp/50% MPP, together with three filaments of degummed silk, are presented.

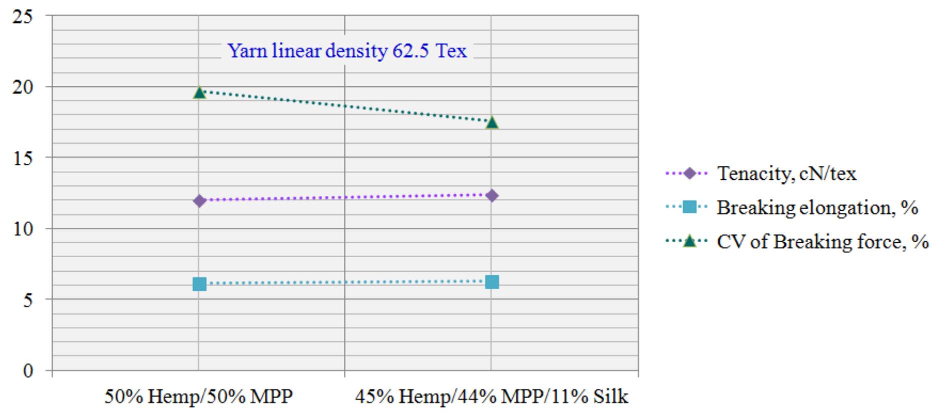

Fig. 2*: Comparison between the tensile characteristics of the yarn obtained from 50% hemp/50% MPP and the compound yarn with silk filaments*

Analyzing the characteristics presented in Fig. 2, it can be found that:

- the breaking tenacity of the compound yarn with silk filaments increases slightly by 3.4% compared to that of the 50% hemp/50% MPP yarn;

- the coefficient of variation of the breaking force decreases from the value of 19.7% for the yarn made of 50% hemp/50% MPP, to the value of 17.6% for the yarn with silk filaments core, i.e. by 10.7%, which constitutes a major improvement to this feature;
- the elongation at break of the compound yarn with silk filaments increases by 2.9% compared to the elongation of the 50% hemp/50% MPP yarn.

The number of yarn breaks recorded when machine processing the silk filaments together with the hemp/MPP blend was lower than that observed when spinning the yarn from 100% hemp. Since through these experiments it was aimed to lower the limit of the linear density of hemp-type yarns that are currently being produced, attempts were made to obtain 50 tex compound yarn with a core of silk filaments.

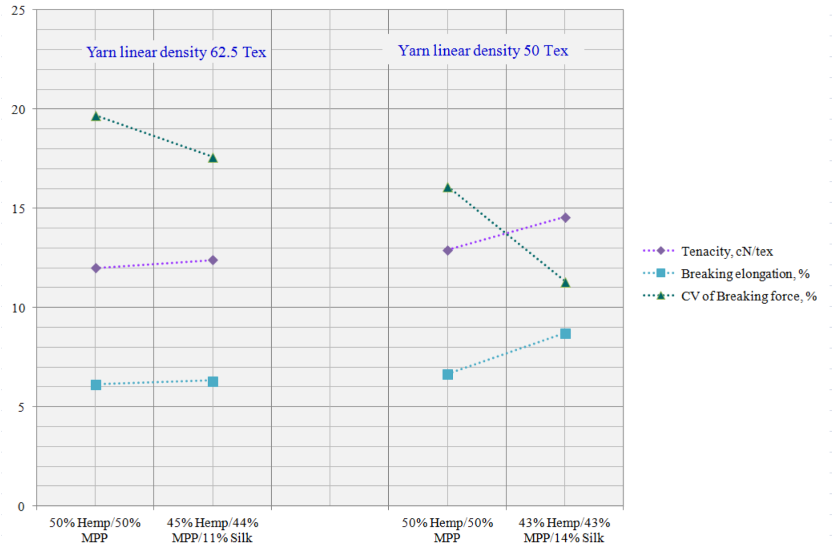

***Fig. 3**: Comparison between the tensile characteristics of the compound yarns with different values of linear density obtained from hemp/MPP/silk filaments*

Analyzing the graphs presented in Fig. 3, it can be seen that all the tensional characteristics have kept their increasing or decreasing tendencies, and these tendencies are much more obvious in the case of the thinner yarn. Thus, in the case of the yarn with linear density of 50 tex, the breaking tenacity of the compound yarn with silk filaments increases by 12.7% compared to that of the 50% hemp/50% MPP yarn, the coefficient of variation of the breaking force decreases by 29,6% in the case of the compound yarn with silk filaments core compared with the yarn made of 50% hemp/50% MPP, and the elongation at break of the compound yarn with silk filaments increases by 30.9% compared to the elongation of the 50% hemp/50% MPP yarn.

Analyzing comparatively the tensional characteristics of the yarns shown in Fig. 4, it can be found that the tenacity values, if the core is made of viscose and polyester filaments, are lower by 24.1% and by 11.7%, respectively, than those of the yarn that has natural silk in the composition, although the polyester filament yarn, analyzed individually, has a higher tenacity than natural silk filaments. There is a difference between the percentages of silk and polyester filaments in the mass of composite yarns. Since the percentage of silk core filament in the compound yarn mass is lower compared to the polyester core, it can cause more winding of the strong hemp and MPP fibers than in the case of the polyester core, thus resulting in a higher strength value of the compound yarn with silk core. In addition, the fact that the polyester filaments are twisted appears to negatively influence the processing of the fibers and the characteristics of the compound yarn. If the twisting direction of the compound yarn is the same as the twisting direction of the polyester filaments, during spinning, an over-twisting of the polyester filaments may occur, which leads to a weakening of the resistance, and if the twisting directions are different, a de-torsion of it occurs, which causes the decrease of his resistance.

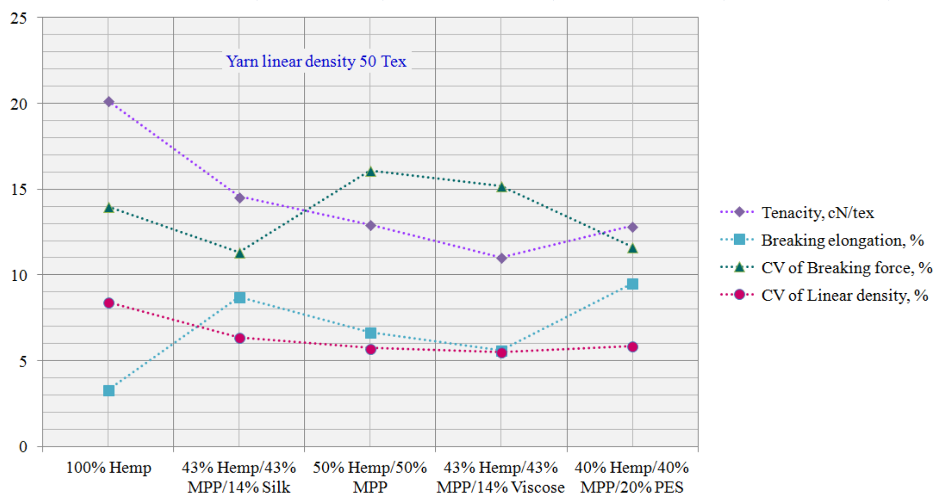

***Fig.** 4: Comparison between the tensile characteristics of the compound yarns obtained from hemp/MPP/silk filaments, hemp/MPP/viscose, hemp/MPP/polyester*

As shown in Fig. 4, the elongation at break of hemp/MPP/viscose yarn is 35.5% lower than that of hemp/MPP/natural silk yarn and 40.9% lower than that of hemp/MPP/polyester yarn but all are much higher than the breaking elongation of 100% hemp yarn. The most spectacular increase, by 187%, of the elongation at break is recorded in the case of the yarn with a polyester filament yarn core.

For the compound yarn that has viscose in its composition, the coefficient of variation of the breaking force is higher than the coefficient of variation of the other compound yarns analyzed. These data make the yarn with viscose filament yarn core to be considered less advantageous compared to the other yarns containing natural silk or polyester.

Comparing the previously analyzed yarns and the yarn resulting from spinning the hemp/modified polypropylene roving, it was found that the tenacity of the polyester core yarn is close to that of the 50% hemp/50% MPP yarn. The tenacity of hemp/MPP/natural silk yarn is 11.2% higher than that of the bicomponent yarn. Also, the elongation at break increases by 23.6% by introducing natural silk into the yarn and decreases by 15.6% by the presence of viscose in the yarn.

Regarding the coefficients of variation of the linear density of the yarns, no relevant changes were found in them by introducing the filamentary yarn core into the yarn.

4. CONCLUSIONS

The presence of the filament in the compound hemp type yarns makes it possible to obtain yarns considered thin for flax and hemp industry, yarns with good physical-mechanical characteristics and with greatly improved elongations. As for the elongation values, they approach or even exceed those of semi-combed wool yarns, of the same fineness, which represents a gain for yarns that have hemp in the composition.

Hemp type yarns with a linear density of 50 tex are suitable for use in order to obtain fabrics with a specific appearance of flax or hemp type fabrics, but with reduced mass per surface unit.

Their main advantage, however, remains the fact that they can constitute an alternative in the range of new threads that respond to the constant innovation required by the change in aesthetic aspect of clothing products.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

DEVELOPMENT OF WASH-DURABLE ANTIMICROBIAL POLYESTER/COTTON FABRICS BY IMPREGNATION WITH ZINC-OXIDE NANOPARTICLES

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Abstract: *Polyester fabrics, frequently utilized in healthcare and sportswear settings, exhibit susceptibility to microbial contamination. This is due to their inherent structural attributes coupled with diverse environmental factors such as humidity and temperature fluctuations. This vulnerability presents notable hygiene and health concerns. To address these issues prompted by healthcare considerations, and the need to design more diverse products, the development of multifunctional antimicrobial polyester/cotton fabrics was accomplished in this work through the impregnation of zinc oxide (ZnO nanoparticles using an aqueous heat attachment method. The fabrics used in this study were polyester/cotton blends. The fabrics were characterized using X-ray Diffraction, and Digital Microscope to determine the chemical composition, morphology, and crystallinity. The antimicrobial performance of the fabric against Escherichia coli, using zone of inhibition (ZOI) test. The fabrics also underwent a wash test to determine the durability of nanoparticle coating. The impregnation with ZnO nanoparticles did not alter the visual appearance of the fabric, as the light gray shade of the ZnO nanoparticles integrated with the fabric's appearance. The coated fabrics demonstrated effectiveness against E. coli achieving a ZOI of 8 mm while no ZOI was observed for the uncoated fabric. After undergoing multiple washing cycles, the fabric exhibited minimal decrease in antimicrobial activity after the first 10 cycles and the performance did not change for 20 and 30 cycles. The ZOI of the ZnO-coated fabrics were 5, 4, and 4 mm after 10, 20 and 30 washing cycles, respectively. Notably, the immobilization of ZnO nanoparticles yielded a robust polyester textile, with elevated antibacterial activity and preserved the fabric's original color and morphology.*

Key words*:* Antimicrobial; Polyester fabric; Zinc oxide; Nanoparticle; Impregnation; *Escherichia coli*

1. INTRODUCTION

Textile materials are susceptible to microbial contamination due to their inherent structural characteristics, compounded by various environmental factors such as humidity and temperature.

The presence and growth of harmful bacteria can lead to several detrimental effects on textiles, including the generation of unpleasant odors, the formation of stains and discoloration, a decline in the mechanical strength of the fabric, and an increased likelihood of contamination for end-users. Consequently, it becomes imperative to employ antimicrobial treatments on textile materials to mitigate the proliferation of bacteria during their use [1, 2].

The textile industry benefits from many uses of the characteristics of nanoparticles, which covers a wide range of applications. The use of different kinds of nanoparticles in the textile industry has been successful in a number of ways. Creating desired textile characteristics, modifying the physical, chemical, and biological characteristics of textiles, and engineering, synthesizing, and changing conventional materials and processes to create newer, better materials, devices, systems, and structures are just a few examples. Deposition of effective and appropriate nanoparticles on the surface of textiles is one of the primary methods for achieving the mentioned attribute [3, 4].

Zinc oxide (ZnO) nanoparticles have gained significant interest due to their stability in diverse environmental conditions and the ability to be produced at low temperatures. ZnO particles have demonstrated antimicrobial effects against both Gram-positive and Gram-negative bacteria, including antibacterial activity against bacterial spores. These nanoparticles are generally considered safe for human use, being non-toxic, biocompatible, and regarded as biosafe [5, 6]. The size of ZnO Nanoparticles (NPs) was determined to be the most relevant parameter when considering antimicrobial activity. Smaller nanoparticles are more harmful to microbes [7].

To ensure the effectiveness of nanoparticle coatings on polyester materials, it is crucial that these coatings exhibit strong adhesion to the fabric's surface. This adhesion is necessary because polyester materials experience both dry and wet friction, undergo wet washing, and may be subjected to dry cleaning during their usage. Furthermore, it's essential that these modified fabrics retain their antimicrobial properties even after multiple washing cycles, maintaining resilience even after 20 rounds of washing [8].

The objective of this study was to examine the antimicrobial effectiveness of polyester fabrics coated with ZnO nanoparticles against Gram-negative bacteria (*E. coli*) and assess the effect of multiple washing cycles on robustness of the fabrics.

2. MATERIALS AND METHODS

2.1. Materials

Zinc acetate, sodium hydroxide, acetone, and ethanol were obtained from DLA Chemical Reagent Co. Ltd., Nairobi, Kenya. They were used to synthesize ZnO nanopowder and the impregnation process. These reagents were of analytical reagent quality and were employed without any additional purification steps. Deionized water, purchased from Eldo Chemical Reagent Co. Ltd., Eldoret, Kenya, was utilized in all synthesis and treatments. The fabric (65% polyester, 35% cotton) was sourced from the Rivatex Eldoret, Kenya.

2.2. Synthesis of ZnO nanopowder

The method of Wang et al. [9] was employed with some modifications. Initially, 6.23 grams of zinc acetate, 6 ml of deionized water and 80 ml of absolute ethanol were mixed and subjected to magnetic stirring for half an hour. The resulting solution was allowed to age at room temperature until it transformed into a gel. Following this, the gel mixture underwent a drying and calcination process. The calcination process was carried out at temperatures of 450° C, 480° C, 500° C, 550° C, and 600° C, respectively. The duration of calcination was varied (1 hour, 1.5 hours, 2 hours, 2.5 hours, and 3 hours). These sequential steps ultimately yielded the ZnO nanopowder.

2.3. Preparation of the polyester fabric and impregnation of ZnO

Aqueous heat attachment method by Abdel-Wahab et al and Sudrajat [10, 11] were used with modifications. The fabric was washed with detergent at 80°C for 30 minutes and rinsed thoroughly with a substantial amount of water to completely remove the detergent. Subsequently, the PFW was immersed in a 3.75 g/L NaOH solution at 100° C for 20 minutes, then rinsed repeatedly with water and dried at 80° C. Next, the cleaned PFW was immersed in a ZnO suspension at 80° C for 2 hours, with stirring at 200 rpm, and then subjected to 5 minutes of sonication to eliminate any released nanoparticles. This process was repeated three times. The coated PFW was subsequently cured at 150° C for 30 minutes. Finally, the resulting ZnO/PFW was immersed in water at 80° C for 30 minutes to remove loosely attached particles, followed by drying at 80° C for 24 hours and storage in desiccators for use.

2.4. Fabric Characterization

The surface morphology of the coated polyester was determined using a Digital microscope (MSX-500 Di viewer). The chemical composition and the structure of the coated fabrics were determined using X-ray Diffraction (Model: Smartlab X-Ray Diffractometer).

2.5. Washing of coated fabrics

The experiment involved placing three pieces of coated fabric (each measuring 50x50 mm^2) that had undergone impregnation treatment into a wash bottle containing 250 ml of distilled water at a temperature of 40° C. Along with this, three drops of a standard detergent (Sapnol uses for the evaluation of textiles at Rivatex Ltd) and ten steel balls with a diameter of 5 mm were added to the bottle. The mixture was thermally stabilized at 40° C. The washing process was carried out by agitating the bottle at 42 revolutions per minute (rpm) for duration of 30 minutes using a Launder-paramount machine [12].

After the initial washing, the first fabric underwent two rinsing cycles, each lasting 3 minutes, using distilled water. Subsequently, all the fabrics were air-dried in a dark environment at room temperature. This entire procedure was repeated twice more for the second and third fabrics to complete a total of 20 and 30 wash cycles, respectively.

2.6. Antimicrobial Test

To evaluate the antimicrobial properties of polyester/cotton fabric coated with ZnO nanoparticles, a series of washing cycles (10, 20, and 30 cycles) were conducted. The antimicrobial effectiveness of this fabric against Escherichia coli was assessed through a zone of inhibition (ZOI) test [13, 14]. This experiment utilized five Petri dishes, each filled with nutrient media and *E. coli* [15]. The first dish functioned as a control, containing uncoated fabric. The second dish contained the coated fabric without any additional treatment, while the remaining three Petri dishes held the fabric after undergoing 10, 20, and 30 washing cycles, respectively. This experiment was conducted in triplicate, and following a 24-hour incubation period, the results were analyzed.

3. RESULTS AND DISCUSSIONS

3.1. Fabric Characterization

Fig.1 shows the microscope (MSX-500 Di viewer) image for coated polyester/cotton with ZnO (a) and uncoated polyester/cotton (b). The microscope photos showed that there is no significant change on the fabric morphology and the impregnation with ZnO nanoparticles did not alter the fabric's color, as the light gray shade of the ZnO nanoparticles integrated with the fabric's appearance.

The X-ray diffraction (XRD) patterns of various fabric samples are presented in Fig.2 In all samples, distinct peaks characteristic of polyester/cotton (65/35%) composition were evident. In the case of the uncoated fabric, specific peaks at 2θ = 25.5 and 34.5 were identified, corresponding to crystallographic planes (101) and (002), respectively[16]. Additionally, a series of notable diffraction peaks within the 20 to 40° range were attributed to the semicrystalline nature of polyester fibers [17]. Furthermore, reflection peaks at 2θ = 16.4 and 22.4, indicative of (101) and (002) planes, were attributed to the presence of cotton fibers. On the other hand, for the coated fabric, a set of characteristic peaks at 2θ = 34.5, 36.5, 36.2, 47.4, 62.8, and 68.2 were observed, corresponding to (002), (101), (102), (103), and (112), respectively. These values aligned with the standard card JCPDS 36-1451, confirming the presence of hexagonal wurtzite ZnO phase [18]. These findings suggest the successful deposition of ZnO onto the surface of the polyester/cotton fabric under the specified conditions.

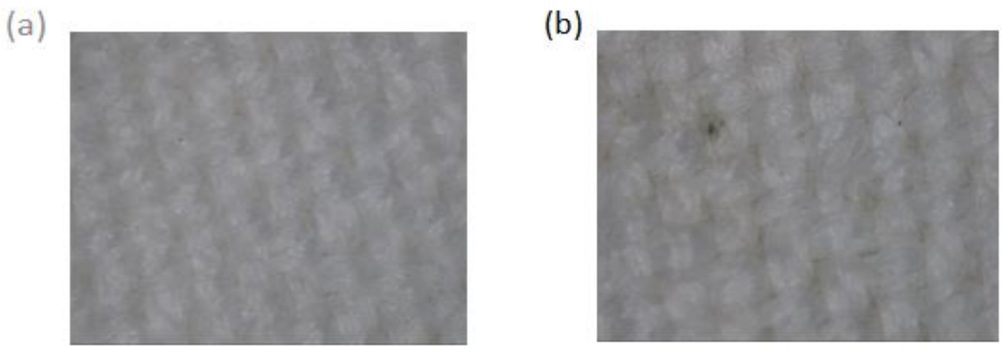

Fig.1. *Microscope (MSX-500 Di viewer) for coated polyester with ZnO (a) and uncoated polyester (b)*

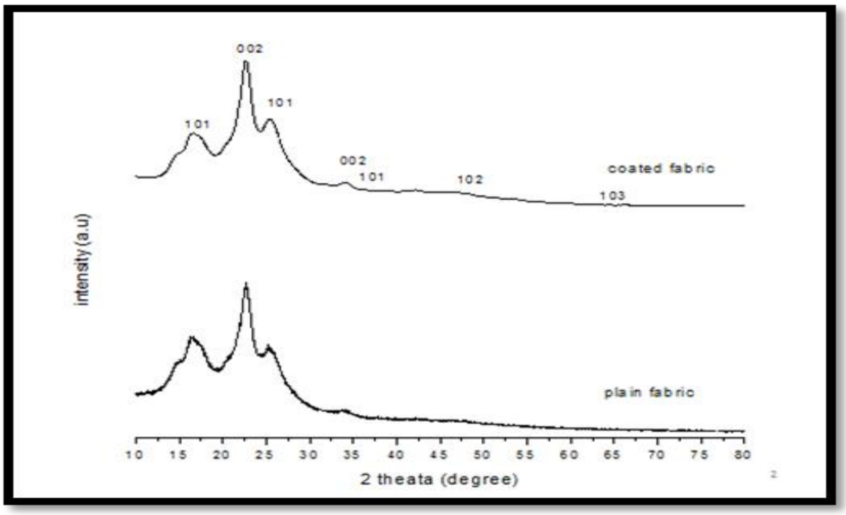

Fig.2 *X-ray diffractometer (XRD) patterns for coated polyester with ZnO and uncoated polyester*

3.2. Antimicrobial Test

The outcomes of the zone of inhibition (ZOI) test for uncoated and coated membranes against *E. coli* as shown in Fig.3. It was observed that there were no inhibition zones around the uncoated fabric as expected. In contrast, distinct zones of inhibition were evident around the ZnO coated fabrics. There was a slight reduction in antimicrobial activity after the initial 10 cycles, and this performance remained consistent through the subsequent 20 and 30 cycles. This demonstrated that the impregnation of the ZnO on the polyester/cotton was effective and could withstand friction and mechanical forces which agree with the literature studies [8].

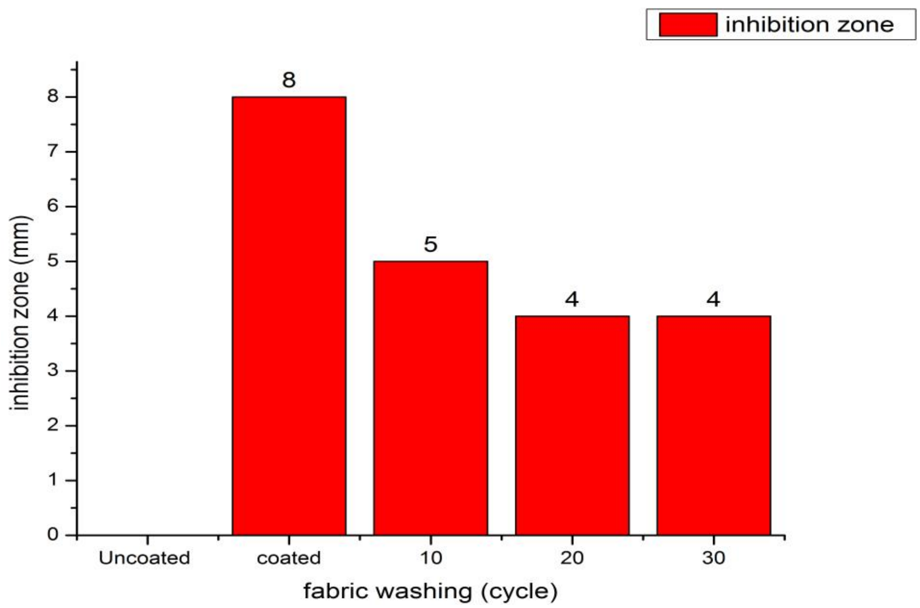

Fig.3. *Inhibition zones around the coated, uncoated and washed fabric fabric*

4. CONCLUSIONS

In this study, ZnO nanopowder was successfully synthesized and applied to polyester/cotton fabric using an aqueous heat attachment method. The antimicrobial efficacy of the coated fabric was investigated against *Escherichia coli*, initially and after multiple wash cycles, through zone of inhibition (ZOI) tests. The findings indicated that the coated membranes demonstrated remarkable antimicrobial ability even after 30 washing cycles. More studies can be done to assess broader antimicrobial activity against gram-positive bacteria and fungi.

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ANNALS OF THE UNIVERSITY OF ORADEA
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USING REVERSE ENGINEERING TECHNIQUES IN WEAR IDENTIFICATION OF THE NEEDLE PLATE OF SEWING MACHINE

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Abstract: *Reverse engineering techniques were employed in this study to determine the wear of needle plates of sewing machines. The wear of such components used in the sewing process of textile products has the effect of bending them. Due to this phenomenon, the sewing needles hit the edges of the hole of the needle plates that leads to their break. As a result of this process the needle plate wears out. The wear of needle plates is manifested by the formation of micro-irregularities on the contour of the hole on the needle plate. Reverse engineering techniques allow to determine the size of the micro-irregularities that comes out on the contour of the hole on the needle plate. In order to apply reverse engineering techniques to establish the degree of wear of a needle plate, the plate was scanned using the Shining 3D scanner and the points cloud of the needle plate were obtained. The points cloud was then transferred to the ShiningForm XOR redesign software, which allows making sections throughout the needle plate. The section where the micro-irregularities have the maximum size was determined, and through the facilities offered by the ShiningForm XOR software the value of the micro-irregularities related to the state of wear of the needle plates was established.*

Key words: *reverse engineering, sewing machines, needle plate, scanning, wear.*

1. INTRODUCTION

Deterioration of various machine components is mainly caused by their wear, which is considered as a response of machines that can conduct to the maintenance activities for these parts [1]. Therefore, wear can negatively influence the textile machine effectiveness and its detection may have a great impact of their productivity. The extant literature presents different methods that can be used for wear identification [2, 3]. In this paper, we propose an approach that is based on reverse engineering, a process involving techniques such as digitization and redesign of the machine parts [4]. Reverse engineering have been used in various applications in the textile industry. For example, reverse engineering techniques were used to design a textile machine yarns pass, which was manufactured after its redesign using selective laser sintering [5]. Employing reverse engineering techniques, the complex 3D geometry of a jacket product was developed in reference [6]. The complex geometric shape of a presser foot base part of a sewing machine was also developed using the reverse engineering method, which was then manufactured with the Inspire 200 3D printer [7].

In the case of sewing machine, as the sewing needles wear they bend and hit the needle plate. As a result of hitting the needle plate, micro-irregularities are created on the contour of the channel of the needle plate. The occurrence of these micro-irregularities has the effect of breaking the sewing thread and the appearance of a defect on the sewing surface of the products. Using reverse engineering techniques allows to determine the size of the micro-irregularities that appear on this contour and, thus, its wear state. This information can be next used for planning maintenance activities, employing either a statistical approach [8] or a predictive strategy [9].

2. MATERIALS AND METHODS

Figure 1 depicts the wear identification approach of a worn needle plate for sewing machines. This approach was based on the Shining 3D Scanner and the ShiningForm XOR software for product redesign. The needle plate is scanned using the Shining 3D scanner, and the ShiningForm XOR software allows the determination of the wear state of the needle plate by measuring the micro-irregularities that appear on edge of its hole.

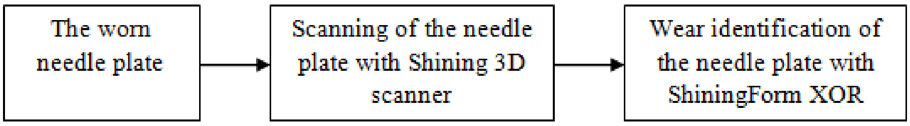


Fig. 1*: Wear identification of a needle plate [7]*

3. RESULTS

After positioning the needle plate on the scanning table, 15 scans were acquired for different positions of the needle plate using the Shining 3D scanner. Next, these scans were superposed to obtain the points cloud of the needle plate (Fig.2), which was saved into a "*.rge" format as E1015_Mesh_15.rge.

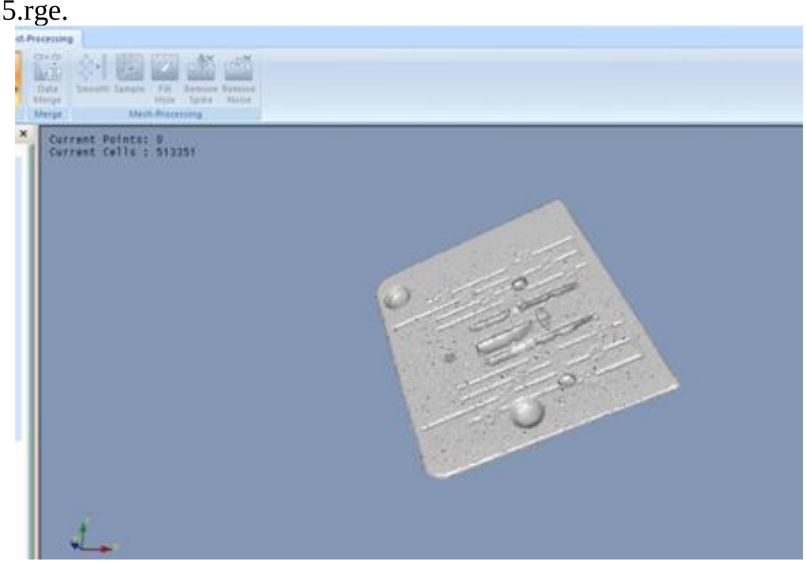
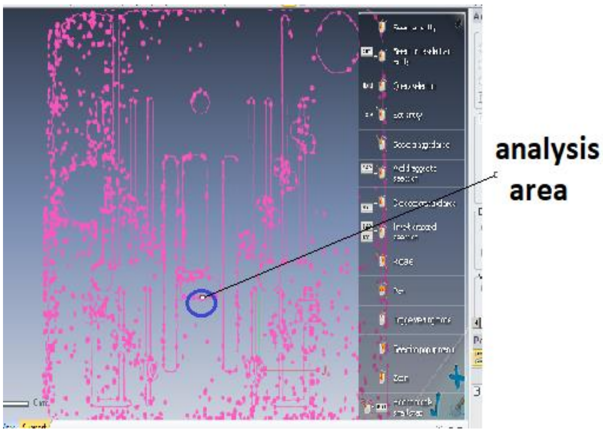
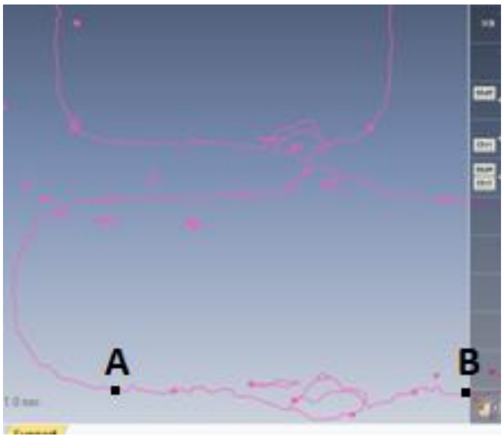


Fig. 2*: The points cloud of the needle plate*

Then, the file E1015_Mesh_15.rge was imported into the ShiningForm XOR software. Using the Mesh Sketch Setup command of the ShiningForm XOR software, sketches were made to identify the size of the micro-irregularities of the hole of the needle plate. Figure 3.a shows the sketch of needle plate that corresponds to the largest micro-irregularity, while figure 3.b illustrates the enlarged area of wear of the needle plate. The micro-irregularities that appear on the AB contour will cause the breaking of the sewing thread, so this contour will be next analyzed to determine the wear of the needle plate.



a)



b)

Fig. 3*: The sketch containing the analysis area of needle plate wear using ShiningForm XOR software*

A horizontal line was drawn for the AB contour in the resulted sketch, corresponding to the line of the hole of the needle plate for the state when the plate is new (continuous blue line in figure 4). A horizontal line was also drawn corresponding to the size of the micro-irregularity of the needle plate for the state when it is used (dotted blue line in figure 4).

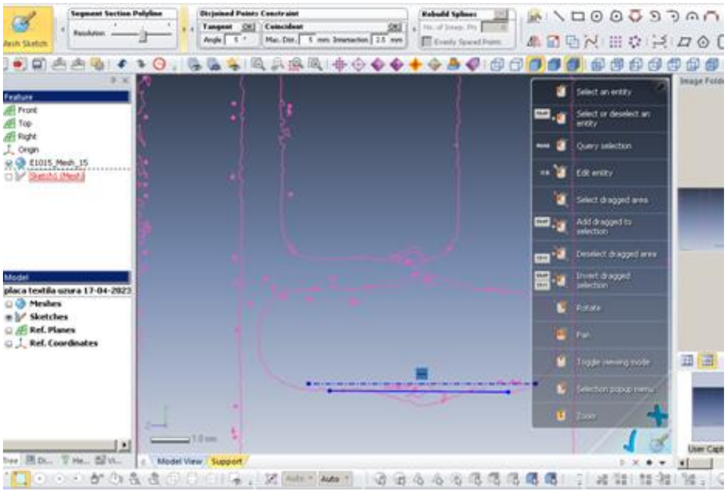


Fig. 4*: Drawing the horizontal lines that define the new and the used state, respectively of the analyzed contour of the needle plates*

The ShiningForm XOR software allows the determination of micro-irregularity dimensions for the wear condition of needle plate. According to figure 5, the value of micro-irregularity for the state of the wear of analyzed needle plate is 0.2658 mm.

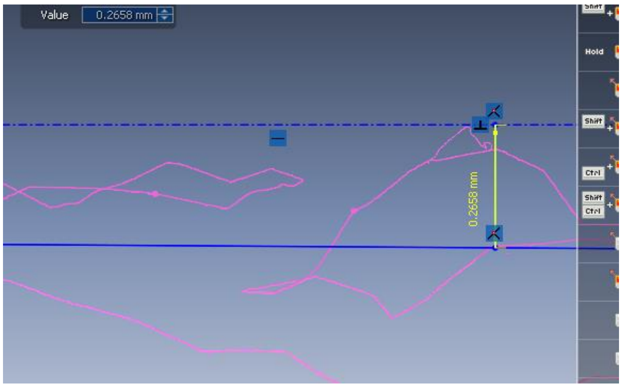


Fig. 5*: Determining the value of the micro-irregularity of the wear condition of needle plate*

4. CONCLUSIONS

This paper presents the application of reverse engineering techniques to determine the wear of sewing machine components. The case study illustrates the employment of such techniques to establish the wear condition of needle plates. Once the values of the micro-irregularities for the state of wear of needle plates are known, it is possible to determine the moment of their replacement, so that the sewing thread does not break because of the needle plates wear.

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