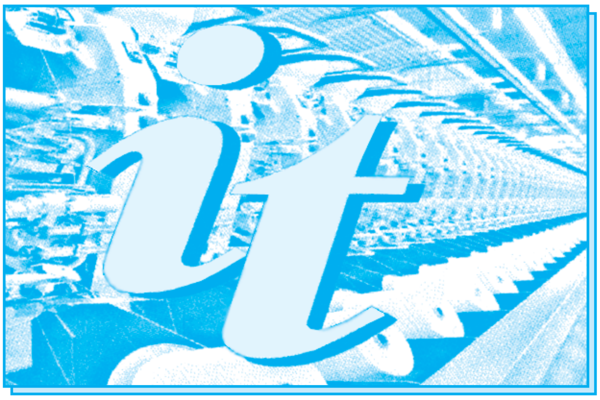

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Effect of different enzymes on mechanical properties of linen fabrics

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REZUMAT – ABSTRACT – INHALTSANGABE

Efectul diferitelor enzime asupra proprietăţilor mecanice ale materialelor din in

În lucrare s-a studiat efectul diferitelor tratamente enzimatice şi a unor combinaţii de tratamente de emoliere şi antişifonare asupra proprietăţilor mecanice ale materialelor din in, folosind sistemul KES. În acest scop, au fost aplicate pe materiale două enzime – o celulază şi o pectinază, prin metoda epuizării. Proprietăţile de emoliere şi antişifonare au fost obţinute prin procedeele de fulardare-uscare-curăţare. Ulterior, folosind sistemul KES-FB, au fost analizate proprietăţile la tracţiune, încovoiere şi forfecare, precum şi unghiurile de revenire din şifonare ale tuturor mostrelor. În general, s-a constatat că enzimele conferă materialelor un tuşeu moale. Ca şi în cazul celulazei, pectinaza a fost utilizată pentru emolierea materialelor, prin hidrolizarea substanţei pectinice, în conformitate cu duritatea fibrei de in. În majoritatea cazurilor, s-a constatat că nu este necesară combinarea enzimelor cu emolienţii, deoarece tuşeul moale poate fi obţinut, cu uşurinţă, doar cu ajutorul celulazelor şi al pectinazelor.

Cuvinte-cheie: in, celulază, pectinază, proprietăţi mecanice, unghi de revenire din şifonare, SEM

Effect of different enzymes on the mechanical properties of linen fabrics

In this work, the effect of different enzymatic treatments and combinations with softening and wrinkle resistance treatments on the mechanical properties of linen fabrics was examined with the KES system. For this purpose, two different enzymes (a cellulase and a pectinase) were applied to the fabrics by the exhaust method. The softening and wrinkle resistance processes were realized according to pad-dry-curing method. Afterwards, the tensile, bending and shearing properties on the KES-FB system and wrinkle recovery angles of all samples were measured. In general, it was found that enzymes are provided to improve soft handle of the fabrics. Like cellulase enzyme, pectinase enzyme was managed to soften the fabrics by hydrolyzing pectin substance related with the hardness of the linen fiber. In most cases, the combination of enzymes with softeners was found not necessary, because soft handle can also be obtained easily just with cellulase and pectinase.

Key-words: linen, cellulase, pectinase, mechanical properties, wrinkle recovery angle, SEM

Der Effekt verschiedener Enzymen auf die mechanischen Eigenschaften der Leinenmaterialien

In der Arbeit wurde der Effekt der verschiedenen enzymatischen Verfahren und einiger Kombinationen von Einweichungs- und Antiknitterbehandlungen auf die mechanischen Eigenschaften der Leinenmaterialien untersucht, indem das KES System verwendet wurde. In diesem Sinn wurden auf den Materialien mit der Nachziehmethode zwei Enzyme angewendet – eine Zellulase und eine Pektinase. Die Einweichungs- und Antiknittereigenschaften wurden durch das Verfahren von Klotzen-Trocknung-Reinigung erhalten. Nachträglich, mit Anwendung des KES-FB Systems, wurden die Eigenschaften bei Zug. Durchbiegung und Scherung, sowie die Erholungswinkel vom Knittern im Falle aller Muster, analysiert. Man hat generell festgestellt, das die Enzyme ein weiches Griff den Materialien verleihen. Sowie im Falle der Zellulase, wurde die Pektinase für die Einweichung der Materialien durch die Hydrolisierung der Pektinsubstanz angewendet, entsprechend mit der Leinenfaserhärte. In meisten Fällen wurde festgestellt, dass die Kombination von Enzymen mit Einweichnungsmittel nicht nötig ist, weil der weiche Griff mit Leichtigkeit nur mit Hilfe von Zellulasen und Pektinasen erhalten werden kann.

Stichwörter: Leinen, Zellulase, Pektinase, mechanische Eigenschaften, Erholungswinkel vom Knittern, SEM

The traditional method in evaluating the fabric quality was the handle judgment of fabric by a subjective method. Professor Sueo Kawabata developed in the 1970's, in collaboration with Hand Evaluation Standardization Committee (HESC), the "Kawabata Evaluation System for Fabric" (KES-FB). KES system was used to make objective measurements of hand properties and measure mechanical and surface properties of the fabrics, such as – tensile, bending, shearing, compression, friction and surface roughness, expressed in sixteen measured or calculated parameters. This objective evaluation system is now quite popular and can be widely applied to the fiber and textile industry [1–3].

Linen is a vegetable fiber obtained from the inside of the woody stalk of the flax plant. The use of linen or flaxen cloth dates back to the European Neolithic people, probably about 10,000 years ago. In comparison with cotton, linen is stronger and longer, but less elastic. This is why linen fabrics feel hard, smooth and crease easily. The main glue substances of the bast fibers are pectins, which enter the composition of all bast connective tissue, even impregnate the walls of the elementary fiber. Increased content of pectin substances results in fiber brittleness, hardness, and poorer separation properties [4, 5]. Another parameter that can affect the linen materials handle and usage properties are also the finishing processes. Hence, finishing processes should be extremely carefully managed for the demanded properties [6]. The softening process is nearly "a must" during the finishing treatments in which the silicone softeners are generally used to improve handle and wrinkle resistance performances of the textile fabrics [7, 8]. Wrinkle resistance treatment is necessary for cellulose-based fabrics, because cellulosic fibers generally crease during use and after washing and drying. For this purpose, several cross-linking agents are available [9, 10].

In our previous work, the effects of different finishing processes were investigated, such as enzymatic, softening and wrinkle resistance on mechanical properties of linen fabrics using the Kawabata Evaluation System. It was found that, among the finishing processes, the biopolishing process is as important as the softening process, with respect to the softness of linen fabrics [11]. In this work, the effect of different enzymes on the mechanical properties of linen fabrics was examined with the KES system.

The use of enzymes in the textile industry has been known and commercially practiced for many years. Cellulase refers to a class of multi-component enzymes

Table 1

ENZYMES USED IN TREATMENTS			
Enzyme	**Structure/Type**	**Optimum application**	**Treatment conditions**
Enzyme *A*	Endo Enriched Engineered Acidic cellulase	*p*H 4.5–5.5 55–60°C	1.5 g/l enzyme *A* *p*H 5 (buffer acid) 55°C; 45 min.
Enzyme *B*	Genetically Modified Acidic Pectinase Enzyme	*p*H 4–6 30–35°C	0.6 g/l enzyme *B* *p*H 5 (buffer acid) 55°C; 45 min.

and named briefly as EC 3.2.1.4 by the International Union of Biochemistry and Molecular Biology (IUBMB). There are three major types of cellulases, which are Endoglucanases, Cellobiohydrolases, Cellobiases. These multi-components act synergistically for the degradation of cellulose. They act specifically on 1,4-β-glycosidic bonds of the cellulose. Cellulase has two domains. One of them is the catalytic domain and the other is the cellulose-binding domain. These two domains linked by a short linker peptide forms the intact bi-modular enzyme [12–16].

Pectinase is a general name of enzymes, which break down pectin, and is named briefly as EC 3.2.1.15 by IUBMB. In the textile industry, acidic and alkaline pectinase enzymes are available. They absorb the pectin and hydrolyze it with their specific three-dimensional structures [17–20].

EXPERIMENTAL PART

All experiments were carried out with bleached 100% linen plain fabric, weighing 156 g/m^2.

The enzymatic treatments of linen fabrics were performed in an Ataç mark laboratory-type exhausting machine (LAB dye HT 10), with 2 different enzymes detailed in table 1. Enzymatic treatments were performed at 55°C, with different commercial enzymes at *p*H 5. The concentrations of enzymes were determined according to the optimum application conditions of the enzyme used. For termination, process temperature was raised to 80°C for 10 minutes. During all treatments, liquor ratio was 1:15.

For the softening process, micro silicone emulsion with a concentration 20 g/l at *p*H 5–6 was impregnated with the pick up 80% and dried at 100°C for 5 minutes. For the wrinkle resistance treatment, modified DMDHEU (45 g/l), $MgCl_2$ (9 g/l, catalyst), at *p*H 4–5 were impregnated with the pick up 80%, dried at 100°C for 5 minutes, and cured at 150°C for 3 minutes. Both the softening and wrinkle resistance processes were realized with Ernstbenz mark laboratory padder for impregnation and Werner Mathis AG mark laboratory stenter for drying and curing. In figure 1, the trial plan is given.

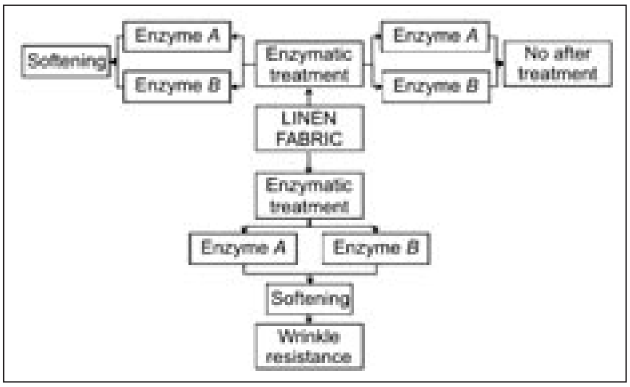


Fig. 1. Trial plan

In order to evaluate the obtained results from all of the samples (size is 20 x 20 cm), the tensile, bending and shearing properties were taken on the KES-FB system. The wrinkle recovery angles (WRA) of the samples were measured according to DIN 53890 standard. WRA° of specimens in warp and weft directions was measured separately and the WRA° (warp + weft) value of specimens was calculated as well.

RESULTS AND DISCUSSIONS

It is known that the finishing processes can affect the mechanical properties of the textile materials. One can easily found many studies about this subject. However important are the finishing processes, such as enzymatic and softening treatments, to improve the handle properties of linen fabrics, yet, the researches on this issue are limited. In this study, the effect of different enzymes and combination with softening/crease resistance processes were investigated on the KES-FB system, in terms of the tensile, bending and shearing

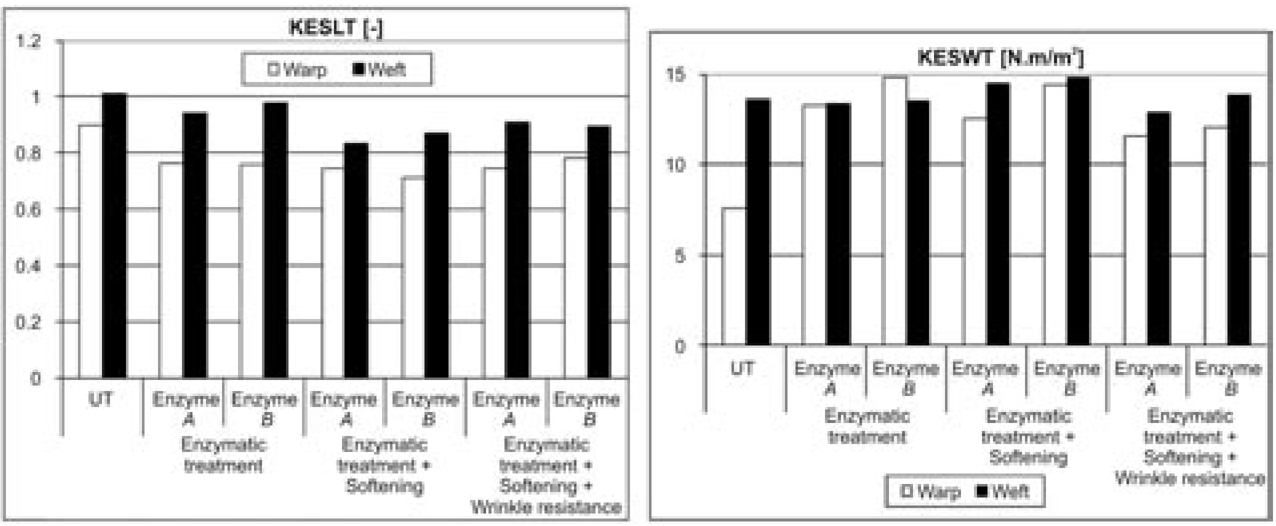


Fig. 2. Linearity in extension and tensile energy of samples

Table 2

BENDING RESULTS OF FABRICS FROM *KES-F* MEASUREMENTS					
Treatment	**Enzyme**	**Bending/warp**		**Bending/weft**	
		B-Mean, x 10^{-4} N · m^2/m	*2HB-Mean, x 10^{-2} N · m^2/m*	*B-Mean, x 10^{-4} N · m^2/m*	*2HB-Mean, x 10^{-2} N · m^2/m*
Untreated	–	0.60	0.37	0.63	0.50
Enzymatic treatment	Enzyme *A*	0.33	0.20	0.61	0.49
	Enzyme *B*	0.32	0.20	0.59	0.38
Enzymatic treatment + + softening	Enzyme *A*	0.36	0.18	0.44	0.24
	Enzyme *B*	0.30	0.13	0.40	0.21
Enzymatic treatment + + softening + wrinkle resistance	Enzyme *A*	0.34	0.17	0.50	0.28
	Enzyme *B*	0.38	0.15	0.53	0.27

properties of fabrics. Kawabata Evaluation System for fabrics is a set of modern instruments employed to measure the fabric's mechanical properties. This system can also be used to evaluate other fabric performances, such as tailorability and fabric softness [21, 22].

Evaluation of tensile properties

Figure 2 and 3 show the change of linearity in extension – *LT*, tensile energy – *WT*, resilience – *RT* and extensibility – *EMT*, of all fabrics.

Linearity in extension of the untreated fabrics decreased dramatically in the warp direction, but also somewhat in the weft direction. The most effective process to minimize the *LT* values is the combination of enzymes with softeners. However, only the enzymatic treatment ensures the reduction in *LT* values, too. For example, with the use of enzyme *B*, the *LT* value decreased from 0.901 of untreated to 0.76, with a 15.6% ratio in the warp direction. In addition, nearly the same tendency could be seen with enzyme *A*. On the other hand, if the enzymes was combined with the softening and wrinkle resistance, *LT* values have shown an increase, when compared with the one only enzymatically treated or enzymatically treated + softened. The tensile energy, *WT*, of the untreated fabrics changed significantly in the warp direction and increased up to 94% if enzyme *B* was used in the enzymatic treatment. Enzyme *A* also ensured an increase, but this increase was lower (74%) than the one obtained with enzyme *B*. Yet, these increases in *WT* values were restricted in combinations with softening and especially with wrinkle resistance treatments.

The tensile resilience, *RT*, fabric recoverability after tensile and tensile elongation, *EMT*, was also examined among the tensile properties. *RT* values of treated fabrics without the wrinkle resistance treatment were decreased in warp and weft direction. This decrease in *RT* was more evident in warp direction. The highest decrease (nearly 30%) was managed with the use of enzyme *B*. The combination with the softening, after the enzymatic process, did not provide any significant advantage. The extensibility of fabrics after the finishing processes was higher in both directions, but especially in the warp direction. The enzymatic treatment raised the *EMT* of fabrics nearly up to 100% in the warp direction; especially with the use of enzyme *B*, this increase was higher than the others (131%) were. Contrary to warp direction, in the weft direction, the enzymatic and softening treatment combination was more important in terms of *EMT* increase. Meanwhile, in the combination of all processes, the *EMT* values of samples started to decrease, because of the wrinkle resistance process, which is thought to be responsible from the hardness of the fabric handle viewpoint.

Evaluation of the bending properties

The bending moment is measured as a sample of fabric is bent through a range of curvatures between 2.5 and –2.5 cm^{-1} at a constant rate of 0.5 cm^{-1}/s. The specimen is put vertically to prevent the effect of

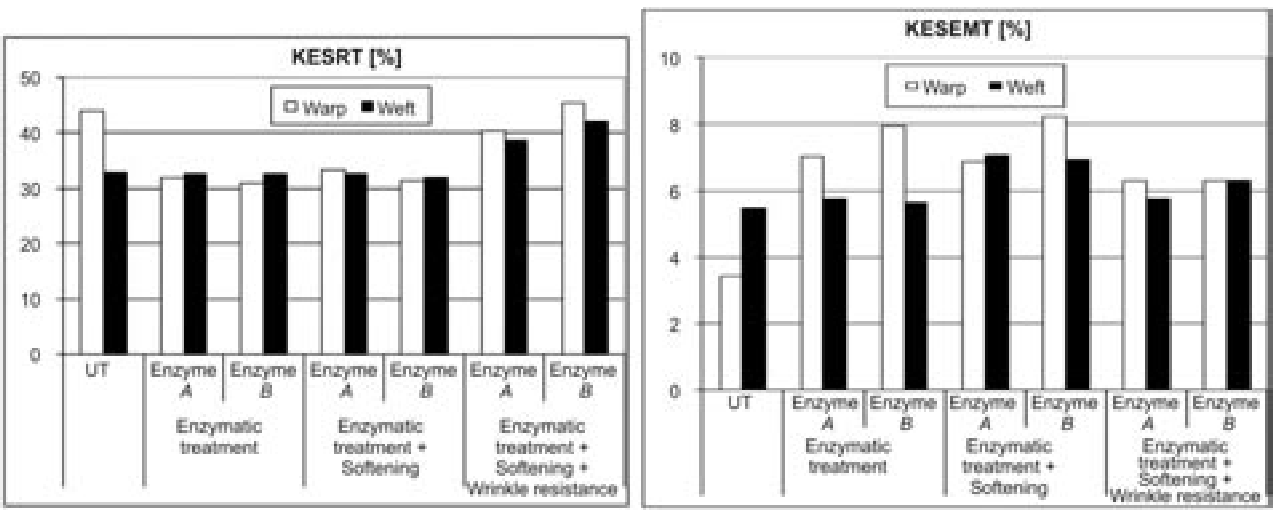


Fig. 3. Resilience and extensibility of samples

Table 3

SHEAR RESULTS OF FABRICS FROM *KES-F* MEASUREMENTS							
Treatment	Enzyme	Shearing/warp			Shearing/weft		
		G-Mean, N/m/deg.	*2HG-Mean,* N/m	*2HG5-Mean,* N/m	*G-Mean,* N/m/deg.	*2HG-Mean,* N/m	*2HG5-Mean,* N/m
Untreated	–	0.37	0.42	1.3	0.32	0.42	1.1
Enzymatic treatment	Enzyme *A*	0.27	0.42	0.88	0.28	0.44	0.98
	Enzyme *B*	0.29	0.37	0.81	0.31	0.39	0.88
Enzymatic treatment + + softening	Enzyme *A*	0.29	0.29	0.61	0.27	0.34	0.61
	Enzyme *B*	0.25	0.29	0.51	0.27	0.34	0.59
Enzymatic treatment + + softening + wrinkle resistance	Enzyme *A*	0.25	0.34	0.59	0.27	0.39	0.69
	Enzyme *B*	0.27	0.39	0.64	0.27	0.32	0.54

gravity. This system measures the forward and backward bending. After the standard measurements, "*B*", the bending rigidity per unit length, and "*2HB*", the moment of hysteresis per unit length, were obtained (table 2).

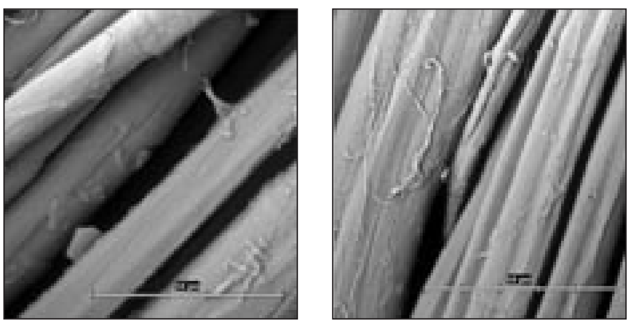
The bending rigidity and the bending hysteresis values of samples were illustrated in table 2. Untreated fabric had the lowest elasticity and so exhibited the highest energy dissipation in one cycle of bending deformation, in both weft and warp directions. Higher *B* value indicates greater stiffness/resistance to bending motions. It is shown that, after the enzymatic treatment, B and 2*HB* values decreased considerably. Among the enzymes, *B* was the most effective enzyme in both fabric direction, which reduced the bending values. The combination of enzymatic and softening treatment was the most effective process. Regarding bending rigidity wrinkle resistant agents, after the enzymatic and softening treatment, these redoubled *B* and 2*HB* values of the samples. Finally, it can be easily noticed that the pectinase enzyme is as efficient as cellulases, in terms of the bending rigidity, and can provide a softness character to fabrics more than tested cellulose enzyme does.

Evaluation of shearing properties

"*G*" is defined as the shear stiffness – shear force per unit length/shear angle. "2*HG*" and "2*HG*5" are hysteresises at 0.5 and 5 degree shear angle, respectively. After the standard measurements, mean values of the "*G*", "2*HG*" and "2*HG*5" should be taken into account. In this work, the mean values of samples shear were given in table 3.

The 0.37 (warp) and 0.32 (weft) values of "*G*" were measured for the untreated fabric. The same tendency for the bending rigidity was observed in the case of the shearing properties. In other words, the enzymatic treatment ensured a decrease in "*G*", also "2*HG*" and "2*HG*5" combination with the softening process improved the shearing properties in view of the soft handle. The fabric treated with enzyme *B* and Softener had the lowest shear stiffness and hysteresis. In this treatment, the shear rigidity reduced nearly 32% and 15% in warp and weft directions, respectively. "2*HG*" and "2*HG*5" values were also reduced significantly in both warp and weft directions. In warp direction, "2*HG*" and "2*HG*5" values reduced nearly by 31% and 60% and, in weft direction, these values reduced nearly by 19% and 46%, respectively. However, only with enzyme *B*, the hysterisis of the shear force in the warp and weft direction decreased nearly by 12% "2*HG*" and 38% "2*HG*5", and 7% "2*HG*" and 20% "2*HG*5", respectively. Finally, shear stiffness and shear hysteresises reduced by enzymes; so, the stiffness of the fabric decreased and fabric softness increased.

Cellulases have been widely used for a long time in the textile industry. They are generally used to modify the surface and properties of cellulosic fabrics for a desired hand or surface effect. It is known that, with the use of cellulase enzyme, the softness and surface appearance of cellulosic textiles improve [11, 16]. In addition, it was reported that the use of pectinolytic and xylanolytic enzymes help in the softening of cellulosic fibers, too [18]. In this study, the effects of cellulases and pectinases and their combination with conventional finishing processes were examined on the handle properties of the linen fabrics. It was found that, like cellulase enzyme, the same and even better effects could be obtained with the use of pectinase (enzyme *B*). In other words, pectinase enzymes made the fabrics soften, by hydrolyzing pectin substance, which is nearly 3.7% of the linen fibers [23]. Both cellulase and pectinase



a *b*

Fig. 4. SEM images of untreated and treated fabrics with enzymes: ***a*** – enzyme *A*; ***b*** – enzyme *B*

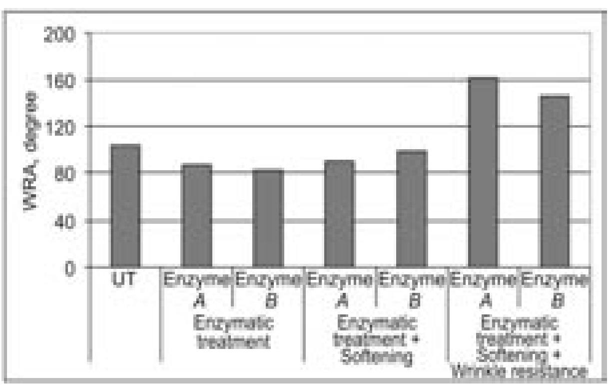


Fig. 5. The wrinkle recovery angles of sample

enzymes scaled the surface of the linen fibers and modified the fibers (fig. 4).

Evaluation of wrinkle recovery angle values

When total (warp + weft) wrinkle recovery angles of treated samples were investigated, it was found that, with a process of enzymes, the wrinkle recovery angle, *WRA*, of the samples decreased slightly, compared to the untreated one (fig. 5). This decrease amounted to nearly 20%, but managing the softening after the enzymatic treatment, the *WRA* of the samples again raised slightly, because silicone based softeners are additive agents and they might have made extra linkages between fibers. On the other hand, when the wrinkle resistance was managed after the enzymatic and softening treatment, unsurprisingly the *WRA* increased significantly.

CONCLUSIONS

This study focused on the effect of different enzymes on the mechanical properties, such as tensile, bending and shearing of linen fabrics. For this aim, the treated samples were examined with the KES system. A cellulase, a pectinase and the combinations with softening and wrinkle resistance processes were investigated. Generally, it was found that enzymes provided to improve the soft handle of the fabrics and, like cellulase enzymes, provoked the hydrolysis of the cellulose macromolecules and removed the fuzz and pills on the surface of the fabric, pectinase enzyme (enzyme *B*) was managed to soften the fabrics by hydrolyzing pectin substance related with the hardness of the linen fiber.

The tensile properties of the samples – *LT* and *RT* – decreased, and *WT* and *EMT* increased after treatments. Both cellulase and pectinase enzymes have nearly the same effect on fabrics tensile properties. Generally, they showed a significant effect on the soft handle of the fabrics.

In terms of the bending properties, *B* and 2*HB* values were investigated and, after the enzymatic treatments, these values were decreased considerably. Higher *B* value indicates greater stiffness/ resistance to bending motions. Among the enzymes, *B* was the most effective enzyme in both fabric directions, which can reduce the bending values.

Lower shear stiffness and shear hysteresis, which are the characteristics of the softened fabric, were also obtained with enzymes; so, the stiffness of the fabric decreased and fabric softness increased. The fabric treated with a combination of enzyme *B* and softener had shown the lowest shear stiffness and shear hysteresis.

As a summary, in most cases the usage of a combination enzymes – softeners is not necessary to obtain a soft handle fabric, because it can also be provided by using easily, just cellulases and pectinases. However, when enzymes and softeners were combined with the wrinkle resistance process, which is an inevitable process in linen finishing, it was observed that the soft handle of the fabrics worsen.

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INDUSTRIA TEXTILĂ ÎN LUME

FIBRE *THERMOCOOL* PENTRU ARTICOLE DE ÎMBRĂCĂMINTE

Prin intermediul rețelei sale de parteneri cu licență în domeniul texturării firelor, producătorul de fibre ***Advansa GmbH***, din Hamm/Germania, oferă un nou produs *ThermoCool Soft'Tech,* obținut prin utilizarea celei mai recente tehnologii de texturare cu jet de aer. Acesta conferă îmbrăcămintei sport de performanță un tușeu moale și plăcut. Bumbacul este adesea selectat pentru articolele sport, datorită tușeului său natural și confortabil. Însă, cu toate acestea, bumbacul poate oferi doar beneficii limitate în ceea ce privește managementul umidității.

Articolele de îmbrăcăminte *ThermoCool* sunt realizate dintr-un amestec unic de fibre, care le asigură o bună capacitate de răcire prin evaporare. Ele sunt proiectate pentru a asigura utilizatorului un nivel optim de umiditate și temperatură. Datorită proprietăților lor unice de termoreglare, temperatura corpului se menține constantă, indiferent dacă temperatura din exterior crește sau scade.

De asemenea, ***Advansa*** a lansat pe piață *Thermo Cool* cu UPF, pentru a oferi o soluție nu numai în ceea ce privește termoreglarea, dar și pentru a conferi o protecție superioară împotriva radiațiilor UV. Există o serie de factori care influențează nivelul de protecție anti UV al materialului, cum ar fi: tipul de fibră, densitatea țesăturii, culoarea, structura, elasticitatea și rezistența acesteia, dar și nivelul de umiditate din țesătură și din mediul ambiental.

Advansa oferă un sistem de protecție anti UV în trei trepte, cu factorul UPF +15, +25 și, respectiv, +40. În funcție de rezultatele obținute, materialelor testate li se atribuie una din cele trei etichete UPF, cu valoarea ce descrie nivelul de protecție asigurat de articolul de îmbrăcăminte.

ThermoCool cu lână merinos

Filatura ***Stöhr AG,*** din Mönchengladbach/Germania, și producătorul de fire ***Wykes International Ltd.***, din Leicester/UK, au dezvoltat fire compozite cu lână merinos, destinate tricotării articolelor de îmbrăcăminte.

Materialul obținut din fibre din poliester ThermoCool în amestec cu lână merinos îmbină proprietățile celor două fibre, respectiv tușeul natural al lânii, cu managementul ridicat al umidității și caracteristicile termoreglatoare ale ThermoCool.

Materialul poate fi utilizat pentru producerea unei îmbrăcăminți funcționale, în care tușeul plăcut, natural și somptuos al lânii se combină cu moliciunea unei fibre copolimerice, special modificată pentru a fi vopsită la temperaturi scăzute.

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Evaluation of physical and mechanical properties of cotton covered polypropylene-core yarns and fabrics

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REZUMAT – ABSTRACT – INHALTSANGABE

Evaluarea proprietăţilor fizice şi mecanice ale firelor cu miez polipropilenic şi înveliş din bumbac şi ale materialelor realizate din acestea

În lucrare sunt analizaţi parametrii fizico-mecanici ai firelor filate cu miez din polipropilenă şi înveliş din bumbac şi ai materialelor realizate din aceste fire. Ţesăturile au fost realizate pe maşini convenţionale de filat cu inele, uşor modificate, din fire filate cu miez şi fire din 100% bumbac, având acelaşi factor de torsiune şi aceeaşi fineţe – în bătătură, şi fire de bumbac – în urzeală. De asemenea, au fost măsurate permeabilitatea la aer, revenirea din şifonare, proprietăţile de tracţiune, rigiditatea la încovoiere, capilaritatea, precum şi transferul termic şi cel de umiditate ale materialelor. S-a observat că, prin utilizarea filamentului polipropilenic ca miez, proprietăţile fizice şi mecanice ale firelor filate cu miez şi, respectiv, ale materialelor au fost optimizate, în comparaţie cu materialele realizate din fire din 100% bumbac. Transferul termic şi cel de umiditate ale materialelor au fost mai mici la materialele realizate din fire filate cu miez.

Cuvinte-cheie: polipropilenă, fir filat cu miez, proprietăţi mecanice, proprietăţi fizice

Evaluation of physical and mechanical properties of cotton covered polypropylene-core yarns and fabrics

In this work, cotton-covered polypropylene core-spun yarns were produced using modification of conventional ring spinning frame. Woven fabrics were prepared using the core-spun and 100% cotton yarns with same count and twist factor as weft and cotton yarns in warp. To study the physical and mechanical parameters of core spun yarns and fabrics the tensile properties, real count and diameters of yarns was evaluated. Besides, the air permeability, crease recovery, tensile properties, bending rigidity, wicking rate and heat and moisture transfer of fabrics were measured. It is observed that using polypropylene filament as core part is an effective parameter on physical and mechanical properties of core-spun yarns and fabrics. Air permeability, crease recovery angle, bending rigidity, wicking rate and tensile properties of core-spun yarn fabrics was increased compare with 100% cotton yarn fabrics. Heat and moisture transfer was reduced in core-spun yarn fabrics.

Key-words: polypropylene, core-spun yarn, mechanical properties, physical properties

Bewertung der physischen und mechanischen Eigenschaften der Garnen mit Polypropylen-Kern und Baumwollummantelung und der daraus produzierten Materialien

In der Arbeit werden die physisch-mechanischen Parameter der Garne gesponnen mit Polypropylen-Kern und Baumwollummantelung analysiert, sowie der Materialien produziert aus diesen Garnen. Die Gewebe wurden auf leicht modifizierten konventionellen Ringspinnmaschienen realisiert, aus Kerngarnen und Garnen aus 100% Baumwolle mit demselben Drehungsfakor und derselben Feinheit – im Schuss, und Baumwollgarnen – in der Kette. Gleichfalls wurde die Luftpermeabilität, die Knitterholungsfähigkeit, die Zugeigenschaften, die Durchbiegungssteifigkeit, die Kapilarität, sowie der Wärmetransfer und die Materialfeuchtigkeit gemessen. Man hat festgestellt, dass durch Anwendung des Polypropylenischen Filamentes mit Kern, die physischen und mechanischen Eigenschaften der Kerngarnen und der entsprechenden Materialien optimiert wurden, im Vergleich mit den Materialien realisiert aus 100% Baumwollgarnen. Der Wärme- und Feuchtigkeitstransfer der Materialien waren kleiner bei Materialien realisiert aus Kerngarnen.

Stichwörter: Polypropylen, Kerngarnen, mechanische Eigenschaften, physische Eigenschaften

Core spinning is a technique by which fibers are twisted around an existing yarn, either filament or staple spun yarn, to produce a sheath core structure, in which the already formed yarn is the core. The production of core-spun yarns has been done successfully by many spinning systems such as ring, rotor, friction and air-jet. Core-spun yarns have been used to improve the strength, aesthetic, durability and functional properties of fabrics [1]. This relationship offers some unique properties in terms of appearance and performance as well as in dyeing and finishing characteristics. Some researchers such as Balasubramanian, Sawhney and Ruppenicker studied the physical and mechanical properties of core-spun yarns containing polyester and nylon filament yarns as core [2–5]. The properties of cotton blend fabrics from polyester core yarn have been studied by Harper et al. [6]. Ruppenicker et al compared the cotton/polyester core and staple blend yarns and fabrics [3] and structural and physical properties of cotton-covered nylon filament core-spun yarns was studied by Jeddi et al. [7]. The production of core-spun yarns using three strands method on Siro system was carried out by Pourahmad and et. al [8]. If we explore the research which has been done on core-spun yarns, it will be clear that there isn't any research on evaluation the physical and mechanical properties of core-spun yarns containing polypropylene filament yarns as core part. Moreover, Bilayered knitted fabrics with polypropylene inner and cotton outer were seen to provide better comfort, ideal for sportswear [9]. So our aim in this work was to evaluate the physical and mechanical properties of cotton covered polypropylene core yarns and woven fabrics containing these yarns as weft. Core-spun yarns and fabrics were compared with similar yarns and fabrics composed of 100% cotton fiber.

EXPERIMENTAL PART

Materials and methods

To produce 100% cotton and core-spun yarns, the cotton fibers had 4.3 micronair and 28 mm effective length. The count of roving was 0.8 Hank. Polypropylene filaments used as core were 70 dtex (30 f). The breaking tenacity and elongation at break was 30.96 cN/tex and, respectively, 44.92%. The technique that used to produce the cotton-polypropylene filament core-spun yarn is the same as that used by Ruppenicker et. al [3]. A conventional ring spinning frame was

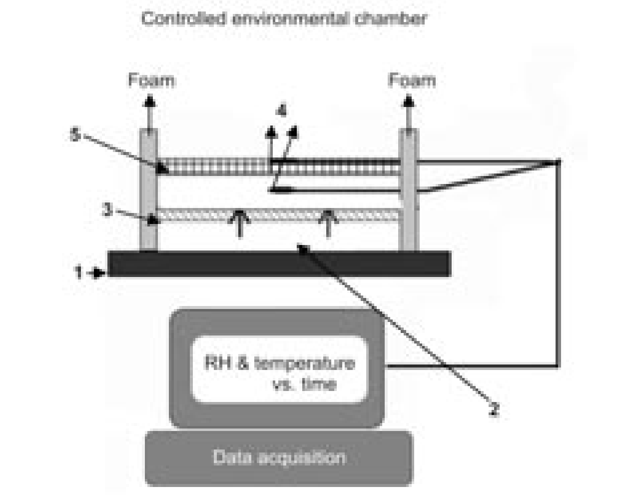

Fig. 1. Schematic design of the instrument for measurement of dynamic moisture and heat transfer [10]:
1 – hot plate; *2* – water container; *3* – membrane (animal skin); *4* – sensors; *5* – fabric

modified to accommodate the packages of filament yarn, tension disc and a ceramic guide to produce the core-spun yarn samples. The filament yarn was fed over-end from the package, through a tension control disc and then inserted behind the top front roll directly in the center of the strand of drafted cotton fibers via a ceramic guide. The yarns were spun in 3.4 and 4 english twist factor. The core-spun yarns were produced without pretension and with 15 g pretension on core part. For all combinations, the nominal count of yarns was 10 Ne. The tensile properties of yarns were measured according to ASTM-D2256 method. Yarn diameter was measured using light microscope based on length wise evaluation based on 50 observations.

The experimental yarns were woven as weft into a construction of 25 ends/cm, 20 wefts/cm, using 100% cotton warp yarns. The count of warp yarns was 20 Ne. The fabrics were tested according to following standard test procedures: crease recovery – ASTM-D1295, bending rigidity – ASTM-D1388, tensile properties – ASTM-D1682, air permeability – ASTM-D737. Dynamic moisture and heat transfer was measured by an apparatus (fig. 1) which is compatible with approximate simulation of skin [10]. This apparatus determine the heat and moisture transfer. This instrument is housed in a controlled environmental chamber. It consists of a sweating guarded hot plate *1* and data acquisition system. The guarded hot plate, maintained at 35°C and used as a heat source, is located in the chamber with ambient conditions (25°C, 65% RH). The diffusion cell consists of a water container *2*, a piece of animal skin *3* for simulating human skin, humidity and temperature sensors *4*.

One side of fabric *5* faces the sweating skin but does not contact it, whereas the other side is exposed to the controlled environment. Five humidity and temperature sensors put on the sample and five humidity and temperature sensors put under the sample. The driving forces for the movement of moisture vapor are the temperature and vapor gradients maintained between the points where the moisture vapor emerges from the simulated skin (37°C, 90% RH) and the ambient environment controlled at 25°C and 65% RH.

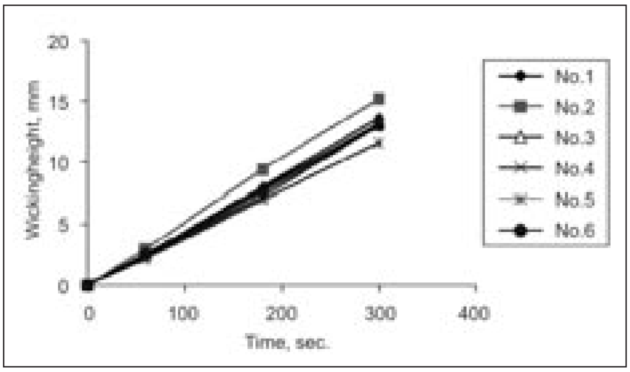

Fig. 2. Wicking behavior of samples

For comparison between different samples, each sample is tested five times for 11 minutes.

The wicking rate was measured by a vertical strip wicking test. One end of a strip (25 mm wide x 254 mm long) was clamped vertically with the dangling end immersed to about 3 mm in distilled water. The wicking height is measured in 1, 3 and 5 minutes intervals. Higher wicking height indicates better water transport ability.

RESULTS AND DISCUSSIONS

Yarns test

The yarn test results including tensile properties, real count and yarn diameter were summarized in table 1. Results indicate that breaking tenacity and elongation at break of core-spun yarns is more than 100% cotton yarns. The better breaking tenacity of core-spun yarn is due to the breaking strength of core part. The statistical evaluation using MINITAB software revealed that there are significant difference between the breaking strength and elongation at break of 100% cotton and core-spun yarns at 95% significant level.

Another side, the core spun yarns produced by 15 g pretension showed more breaking strength and lower breaking elongation. The pretention of core part could cause core part locate in the center of yarn and so contact between sheath fiber and core part will increase. Hence, the fiber slippage is reduced and the breaking strength will improve. This could be the reason for lower elongation at break of core-spun yarns produced by 15 g pretension. Significant increase of the breaking strength and decrease of elongation at break of core-spun yarns produced by 15 g pretension is confirmed by statistical analysis on experimental data.

Fabrics

Wicking test

The wicking behavior of samples has been shown in figure 2. It is clear that the wicking height of core-spun fabrics is slightly higher than 100% cotton yarns. By increasing twist factor, the difference between the wicking height of core-spun yarn and 100% cotton yarn fabrics was decreased. The obtained results show that after 1 minute there is a margin difference between the wicking height of samples, but after 3 minutes the difference is observed. Fabric sample no. 2, produced by core-spun yarn with 15 g pretention and 3.4 twist factor parameters, showed highest wicking height and fabric sample no. 6, i.e. 100% cotton yarn with 4 twist factor, showed the lowest wicking height.

Table 1

COMPARISON OF YARN TEST RESULTS						
Code of sample	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Yarn type	Core-spun	Core-spun	Core-spun	Core-spun	100% cotton	100% cotton
Twist factor, α_e	3.4	3.4	4	4	4	3.4
Pretension, g	0	15	15	0	–	–
Real count, Ne	10.82(6.51)	11.18(7.03)	11.26(8.22)	10.89(6.33)	11.07(7.83)	10.83(10.31)
Yarn diameter, µm	30.82(4.51)	31.65(5.32)	30.82(6.48)	29.99(3.21)	31.65(4.88)	32.48(6.71)
Breaking tenacity, cN/tex	11.24(8.11)	12.23(8.22)	12.60(8.40)	11.76(7.00)	10.76(10.81)	10.41(7.54)
Elongation at break, mm	17.32(16.05)	14.66(11.18)	15.65(13.18)	17.19(15.20)	14.72(13.64)	15.11(16.05)

* The data in parenthesis present the coefficient of variation, *CV* %

Table 2

PHYSICAL AND MECHANICAL PROPERTIES OF FABRICS						
Code of sample	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Fabric thickness, mm	0.43(3.21)	0.43(3.21)	0.45(2.27)	0.45(2.27)	0.46(4.20)	0.46(4.20)
Breaking strength, N	340.18(4.32)	354.70(6.87)	362.35(2.36)	353.47(7.81)	324.99(3.54)	316.84(4.28)
Breaking elongation, mm	12.37(5.12)	12.29(2.01)	13.50(3.38)	14.67(3.16)	12.30(7.16)	13.10(6.34)
Air permeability, ml/cm^2 · sec	52.23(6.71)	51.59(5.32)	53.82(7.64)	57.32(5.16)	45.54(6.28)	39.17(7.85)
Bending rigidity, mg · cm	114.95(3.42)	127.99(6.32)	134.98(5.80)	130.37(6.17)	111.69(3.07)	110.09(4.21)
Crease recovery angle, degree	110(5.08)	110(5.08)	105(6.13)	105(6.13)	100(4.12)	100(4.12)

* The data in parenthesis present the coefficient of variation, *CV* %

Flow of liquid through fabric is through the capillaries inside warp and weft yarns (between the fibers) and the geometry of alveoli on the fabric surface that depends on the weave structure. The size and orientation of the capillaries between the fibers of warp yarns and the size the alveoli would be the same for both these fabrics as they have same warp yarns and woven construction [11]. The core part offers relatively continuous capillaries than sheath fibers, and, hence, the liquid flow is largely decided by the core part in core-spun yarns. Hence the core spun fabrics show higher wicking rate than cotton fabrics. When the pretension of filaments during spinning process is increased, because of the availability of less free lengths to core part, filaments couldn't able to exchange their positions more intensively. Hence, core fabrics no. 2 and no. 3 are exhibiting a higher wicking rate than fabrics 1 and 4. The statistical results show that there isn't significant difference between the wicking height of samples in all three measuring time in 95% significant level.

Crease recovery

Table 2 presents the testing results of fabrics. Results indicate that the crease recovery angle of fabrics made of core-spun yarns as weft is more than 100% cotton fabrics. Significant difference of the crease recovery angle of 100% cotton and core-spun yarn fabrics is confirmed by statistical analysis. There is significant difference between the crease recovery angle of core-spun yarn and 100% cotton fabrics in 95% significant level.

Air permeability

Results of table 2 show that the air permeability of core-spun yarn fabrics is higher than 100% cotton fabrics in different conditions which could be due to the larger diameter of 100% cotton yarn compare with core-spun yarns. Another side, by increasing the pretension up to 15 g, the yarn diameter was increased (table 1) and this is the reason for lower air permeability of fabric produced by these yarns. Increase in yarn diameter results in an increase in fabric cover factor and a decrease of porosity in the fabric. The statistical evaluation shows that there is significant difference between air permeability of core-spun yarn and 100% cotton yarn fabrics in 95% significant level.

Bending test

Bending rigidity values for the core-spun fabrics was higher than those of the 100% cotton yarn. We noted this phenomenon in lower fineness of filaments of core part compare with cotton fiber. The bending rigidity of fiber depends on forth power of fiber diameter [12]. This could be the reason of this trend. It was observed that the fabrics which contain core-spun yarns produced with 15 g pretension, have higher bending rigidity. This difference could probably be attributed to the larger diameter of core-spun yarns produced by 15 g pretension. There is significant difference between the bending rigidity of core-spun yarn and 100% cotton fabrics in 95% significant level.

Tensile properties

Table 2 shows that the tensile properties of core-spun yarn fabrics are higher than cotton fabrics which may be again due to the effect of tensile properties of core part. By increasing the pretension the breaking strength was increased and breaking elongation was decreased. The statistical evaluation shows that there is significant difference between the core-spun yarn and 100% cotton fabrics in 95% significant level in both twist factors.

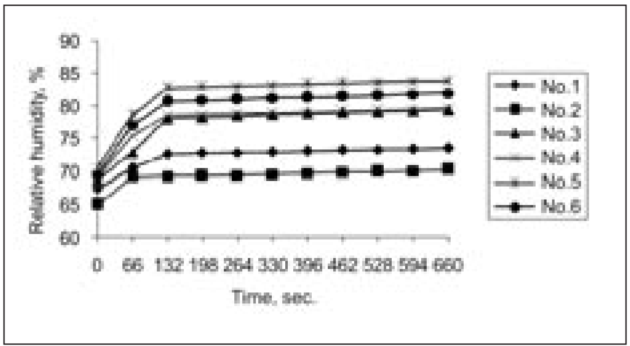

Fig. 3. Moisture transfer behavior of fabrics

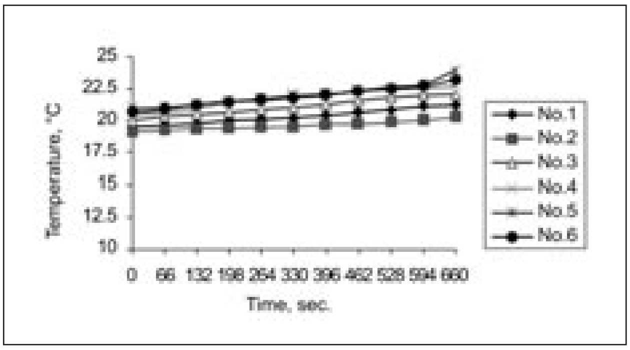

Fig. 4. Heat transfer behavior of fabrics

Dynamic moisture and heat transfer

In figures 3 and 4, the moisture and heat transfer of samples has been shown. Increase in yarn twist decreases the yarn diameter and increases the porosity of fabric. Figure 3 demonstrates the relative humidity of the upper surface of the fabrics versus time. Results show that the moisture transfer of fabrics increases upon an increase in the yarn twist of fabrics. Also, comparing the core spun yarns with different draw ratio shows the yarn with higher pretension on core part has the higher moisture transfer, because of lower diameter of these yarns. Based on the results in figure 3 the moisture transfer of the 100% cotton fabrics is more than that of fabrics which contain core-spun yarns, because of the cotton fibers are hydrophilic and moisture can transfer by void spaces and fibers of fabric. Since the thermal conductivity of air (0.025 W/m · K) is lower than that of the fibers (0.460 W/m · K and 0.170 W/m · K for cotton and PP, respectively), it is expected that the heat transfer through the fabrics to be lower for higher porosity (lower yarn diameter). On the other hand, higher porosity causes higher convection heat transfer and compromising these opposite effects results in higher heat transfer. Therefore, fabrics with higher porosity show the higher heat transfer. The statistical evaluation shows that there is significant difference between the core-spun yarn and 100% cotton fabrics in 95% significant level.

CONCLUSIONS

In this article a study on physical and mechanical properties of cotton covered polypropylene core-spun yarns was presented. The obtained results showed the effectiveness of using the polypropylene as core part in low percentage in physical and mechanical properties of woven fabrics. From this investigation the following results were concluded:

- The breaking strength and breaking elongation of core-spun yarns were higher than 100% cotton yarns. Accordingly, tensile properties of core-spun yarn fabrics were also higher than 100% cotton yarn ones.
- The yarn diameter of core-spun yarns was lower that 100% cotton yarns. Increase of filament pretension and decrease of twist factor increased this parameter.
- The fabric produced by core-spun yarn with 15 g pretension and 3.4 (α_e) english twist factor parameters showed highest wicking height.
- The bending rigidity of woven fabrics by 100% cotton yarns was lower than cotton covered-polypropylene core yarns. This difference was higher, i.e. 9.29% in samples produced by higher value of twist factor.
- The air permeability of core-spun yarn fabrics was higher than 100% cotton yarn fabrics. Woven samples produced by the core-spun yarns with pretension had lower air permeability than samples produced by the core-spun yarns without pretension.
- The crease recovery angle of core-spun yarn fabrics was between 5–10% higher that 100% cotton yarn fabrics.
- Irrespective the usage of polypropylene as a hydrophobic fiber, the heat and moisture transfer didn't show any obvious decrease.

The remarkable properties of cotton covered polypropylene core-spun yarn fabrics can be utilized to produce new products with good properties and lower cost in apparel.

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INDUSTRIA TEXTILĂ ÎN LUME

CLARIANT ŞI-A TRANSFERAT ACTIVITATEA DE PRODUCŢIE DIN EUROPA ÎN ASIA

În cel de-al doilea trimestru al anului 2010, vânzările companiei ***Clariant International AG***, Muttenz/Elveția, producătoare de produse chimice speciale, au crescut cu 18%, ajungând la 1,9 miliarde de franci elvețieni.

Profitul fără taxe și dobânzi a crescut la 211 milioane de franci elvețieni, în comparație cu cei 69 de milioane de franci elvețieni înregistrați cu un an în urmă și cu cei 183 de milioane de franci elvețieni înregistrați în primul trimestru al anului 2010.

Clariant a raportat o creștere a vânzărilor în toate sectoarele și în toate regiunile. Unitățile economice producătoare de pigmenți, aditivi, produse chimice pentru industria de pielărie și preamestecuri au beneficiat cel mai mult de îmbunătățirea mediului economic, creșterile semnalate fiind peste media grupului.

În cadrul diviziei de produse chimice pentru textile, vânzările din trimestrul doi au crescut cu 17%, ajungând la o valoare de 231 de milioane de franci elvețieni, în moneda locală creșterea fiind de 15%. În aceeași măsură a crescut și cererea de produse chimice pentru textile, cu înaltă valoare adăugată, destinate în special industriei de îmbrăcăminte.

Temporar, poziția competitivă a producătorilor europeni de textile s-a îmbunătățit, ca urmare a deprecierii monedei euro. Ca efect, unitatea de producție din Europa a înregistrat cea mai mare creștere a vânzărilor, fiind urmată de unitățile de producție din Asia și America Latină. Piața nord-americană, slab structurată, a înregistrat o recuperare sensibilă, față de nivelurile anterioare foarte scăzute.

Transferul activităților de producție ale companiei Clariant din Europa în Asia va duce la îmbunătățirea competitivității acesteia, pe baza unei dezvoltări durabile a afacerilor în domeniul textilelor.

Conform planului de dezvoltare elaborat de companie, s-a derulat și investiția într-o nouă instalație de etoxilare, în Dayabay/China, încă de la începutul anului 2010.

Cu toate că cererea de produse a rămas solidă până la finele anului, având în vedere faptul că revenirea economiei mondiale a slăbit în ultimul trimestru al anului 2010, iar costurile la materiile prime au crescut, Clariant va continua să-și concentreze atenția asupra generării de lichidități, prin diminuarea costurilor de producție, reducerea nivelului de complexitate al afacerii și chiar printr-o reducere suplimentară a locurilor de muncă.

Melliand International, august 2010, p. 141

Experimental studies of the dimensional properties of single tuck stitch

NADIIA BUKHONKA

REZUMAT – ABSTRACT – INHALTSANGABE

Studiul experimental al proprietăţilor dimensionale ale tricoturilor fang cu ochiuri simple

Lucrarea are ca scop studiul proprietăţilor dimensionale, cum ar fi variaţia desimii tricotului şi parametrii constantelor dimensionale ale diverselor tipuri de tricot fang cu ochiuri simple. Raportul structurilor pe înălţime constă într-o combinaţie de două rânduri de ochiuri: simple şi fang simple, cu diferite raporturi de lăţime ale ochiului, Rb. Materialele sunt realizate pe o maşină de tricotat rectilinie cu clasa de fineţe 10, din fire de semilână de 31 · 2 tex. Toate determinările parametrilor structurali au fost realizate pe materiale supuse la patru cicluri de spălare automată.

Cuvinte-cheie: ochi, fang, proprietăţi dimensionale, raport ochi, desime tricot, constante dimensionale

Experimental studies of the dimensional properties of single tuck stitches

The paper is devoted to the experimentally investigations of the dimensional properties such as fabric density variations and dimensional constants parameters of the nine types single tuck stitches. The structures repeat at height consists of combination of two courses: plain and plain tuck stitches with different stitch repeat at the width, Rb. The fabrics are produced by the flat bed-knitting machine 10 gauge from the 31 · 2 tex half-wool yarn. All measurements of the structures parameters are made on the fabrics after four cycles of washing in a domestic washing machine.

Key-words: stitch, tuck, dimensional properties, stitch repeat, fabric density, dimensional constants

Experimentelle Untersuchung der dimensionellen Eigenschaften der einfachen Fang-Maschen

Der Zweck der Arbeit besteht in der Untersuchung der dimensionellen Eigenschaften, wie Variation der Gewirkdichte und die Parameter der dimensionellen Konstanten unterschiedlicher Typen von Fanggewirken mit einfachen Maschen. Das Verhältinss der Höhenstruktur besteht in einer Kombination von zwei Maschenreihen: eine Glatmasche und eine Fang-Glatmasche, mit unterschiedlichen Breiteverhältnissen der Masche, Rb. Die Materialien werden auf einer Flachwirkmaschine mit der Feinheitsklasse 10 aus Halbwollgarne von 31 · 2 tex produziert. Alle Bestimmungen der strukturellen Parameter wurden auf Materialien hergestellt, welche vier Waschzyklen unterstellt wurden.

Stichwörter: Fang, Masche, dimensionelle Eigenschaften, Maschenverhältniss, Gewirkdichte, dimensionelle Konstanten

The dimensional, physical and mechanical properties of the tuck stitches are determined by basic stitches (interloping), the loop index, the stitch repeat in the width of tuck stitches and other factors.

In the paper [1, 2] studied a geometrical model for single and double lacoste knits. Elliptical shapes for the head of loops (tuck and plain) and general helices for the rest parts, including the arms of the loops, are, used. According to the authors these models can be used as the basis for a computer simulation programmer which gives 3D images and combines the geometry and the mechanics of the fabrics [3]. The geometrical model of a knit-tuck combination and its effect on the plain knitted fabric structure are investigated in the paper [4]. The effect of one tuck stitch using 100 % cotton yarns in a plain knitted fabric was considered.

With increased structural cell stitch length of single jersey, single pique, double pique and honey-comb structures with cotton yarn, and the dimensional properties decreased for all structures, while comfort properties like air permeability and water absorbency increased [4]. Combination order of knit-tuck stitches played an important role in all the properties knit fabrics. The knit-tuck combination showed a higher thickness and weight of 1 m^2 value than plain knit fabrics for both the ring and compact yarn fabrics.

In the paper [6] indicated that the effect of knit structure (1 x 1 plain and 2 x 2 rib, moss stitch, half and full cardigan, half milano and milano rib, lacoste and terry) with of 80% lambswool, 20% polyamide yarn on the properties of the knitted fabrics inspected is highly significant. Tuck stitch fabrics have the lowest resistance to abrasion.

Dimensional properties of single tuck stitches with loop index 2 are investigated in the papers [7, 8]. The density fabrics decrease with increase the loop length in the stitch repeat on the tuck stitch, and the density ratio factor isn't change [9].

The main objective of this research is to analyze the influence of different stitch repeat at the width of tuck stitches on the dimensional properties of single knit structures.

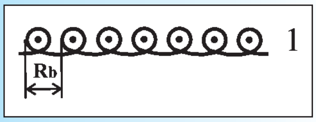
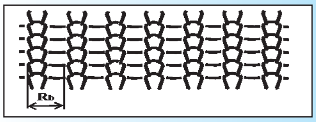
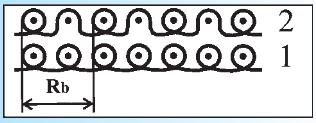
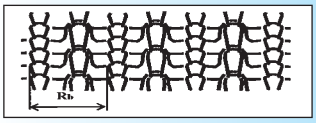
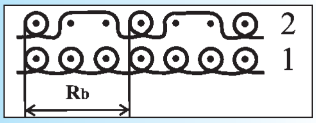
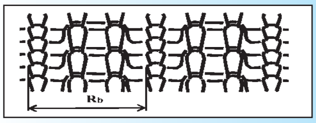
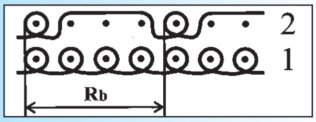
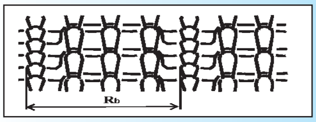
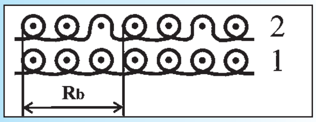
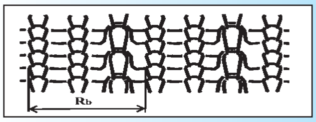
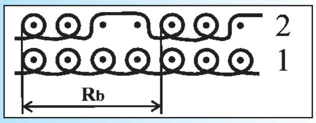
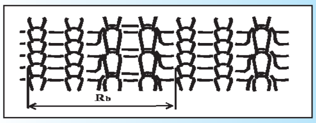
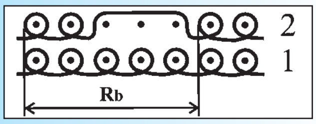
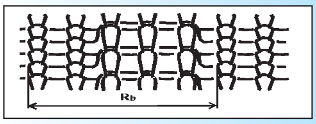
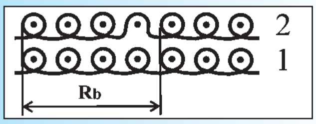
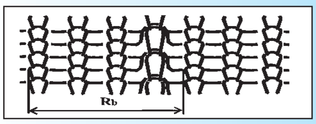
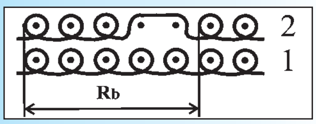
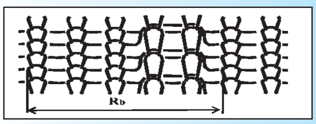
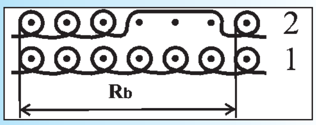
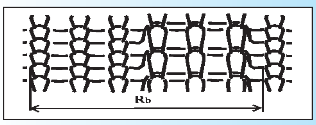
EXPERIMENTAL PART

Preparation of samples

The fabrics were knitted on a 10 gauge *V*-bed flat bed-knitting machine with 200 needles using 31x2 tex half-wool yarns. The stitch cams, yarn tension and take-down are kept constant.

After being knitted, for dry relaxation, the fabrics were for several days laid on the flat surface under a standard atmosphere to facilitate recovery from the stress imposed by knitting. Then the samples imposed to a 4 washing treatment at 30^{o}C in a fully automatic washing machine according to the program to ISO 6330-99 – *Textiles. Domestic washing and drying procedure for textile testing.* After each washing and drying cycle, the fabrics were laid, with minimum stress, on flat surface under a conditional atmosphere for at least 24 hour [9].

Table 1

PHYSICAL AND MECHANICAL PROPERTIES OF FABRICS						
Variants of fabrics	The structure repeat in the height	Graphic representation of single-jersey jacquard	The structure of fabrics	*m*	*n*	*n(m x n)*
1	Plain			1	0	0/1
2	Tuck 1 x 1 Plain			1	1	1/2
3	Tuck 1 x 2 Plain			1	2	2/3
4	Tuck 1 x 3 Plain			1	3	3/4
5	Tuck 2 x 1 Plain			2	1	1/3
6	Tuck 2 x 2 Plain			2	2	2/4
7	Tuck 2 x 3 Plain			2	3	3/5
8	Tuck 3 x 1 Plain			3	1	1/4
9	Tuck 3 x 2 Plain			3	2	2/5
10	Tuck 3 x 3 Plain			3	3	3/6

Measurements of fabrics dimensional properties

Graphical representation and structure the nine type of tuck stitch (variants *2–10*) and plain (variant *1*) knit fabrics are presented in the table 1, where the stitch repeat in the width $R_b = m \times n$ (m – the number of knit loop, m = 1, 2 or 3, n – the number of tuck loop, n = 1, 2 or 3).

After wash relaxation the following dimensional properties of the knitted fabric structure were measured:

- Wales *W* and course *C* per centimeter at 10 different places on every sample;
- The length of yarn of the one loop *l*, in the mm – determined as an average of twenty unrowed courses (plain – l_1, tuck stitch – l_2);
- The weight of 1 m² W_S in the g/m² – determined as an average from the weight of 5 samples, each having an area 200 cm²;
- The thickness *t*, in the mm at 10 different places on every sample.

After measurements the following values of main characteristics were submitted:

- average the length of yarn, l_a, mm

$$l_a = (l_1 + l_2)/2 \quad (1)$$

Table 2

The characteristics	Variants of fabrics									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
W, loops/cm	8.7	7.0	6.4	6.1	7.1	6.8	6.4	7.6	7.2	6.4
C, loops/cm	8.8	7.2	7.5	7.8	6.2	6.7	7.0	5.7	6.2	6.4
S, loops/cm^2	76.0	50.5	47.7	47.6	43.7	45.6	44.8	43.0	44.5	41.0
l_1, mm	6.45	6.34	6.47	6.84	6.15	6.23	6.49	6.24	6.31	6.36
l_2, mm	–	9.97	10.75	15.46	12.21	13.61	14.76	8.41	9.88	11.64
l_a, mm	6.45	8.16	8.61	11.15	9.18	9..92	10.63	7.33	8.10	9.00
W_s, g/m^2	373	382	391	394	383	390	392	382	384	386
l_2/l_1	–	1.57	1.66	2.26	1.99	2.18	2.27	1.35	1.57	1.83
t, mm	0.81	0.86	0.88	0.92	0.89	0.90	0.94	0.90	0.93	0.95
K	12.2	9.7	9.2	7.1	8.6	7.9	7.4	10.8	9.7	8.8
K_w	5.6	5.7	5.5	6.8	6.5	6.7	6.8	5.5	5.8	5.8
K_c	5.7	5.9	6.5	8.7	5.7	6.7	7.4	4.2	5.0	5.8
K_p	1.0	1.0	1.2	1.3	0.9	1.0	1.1	0.8	0.9	1.0
K_s	31.6	33.6	35.4	59.2	36.9	44.9	50.6	23.1	29.2	33.2

- knit constants in course direction, K_c $K_c = C \cdot l_a$ (2)
- knit constants in wale, K_w $K_w = W \cdot l_a$ (3)
- fabric density, *S*, loops/cm^2 $S = C \cdot W$ (4)
- knit density constant, K_s $K_s = K_c \cdot K_w$ (5)
- Poisson's function (the loop shape factor), K_p $K_p = K_c/K_w$ (6)
- fabric tightness, *K* $K = \sqrt{T}/l_a$ (7)

RESULTS AND DISCUSSIONS

Dalidovich [10], Kudrjavin and Salov [11], Spenser [12] indicated that, comparing with plain knit fabric, the tuck loops reduce fabric length and length-wise elasticity, the higher yarn tension on the tuck and held loops causes them to rob yarn from adjacent knitted loops making them smaller and providing greater stability and shape retention. The fabric width is increased because the tuck loops pull the held loops downwards causing them to spread outwards and making extra yarn available for width-wise elasticity.

The width of single tuck stitch knit fabrics is bigger and length is smaller than in plain fabrics produced on the same equal numbers of needles with equal numbers of courses and length of the loop yarn. That could be explained by tendency of tuck loops to unbend what causes that adjacent loops wales draw aside creating the idle between the wales. At the same time the surface of single tuck stitch fabrics decrease and surface density increase compared to the plain knit fabrics [10–12].

The values of dimensional properties of knit fabrics are presented in the table 2. The relations between wales *W* and courses *C* are presented in the figure 1, the fabric density *S* – in the figure 2, and the length of yarn l_1, l_2, l_a – in figure 3.

In the table 3 are presented the change of the characteristics of dimensional properties of tuck stitch knitted structure (variants of fabrics *2–10*) in comparison with the plain knitted fabric (variant *1*).

The structure of tuck stitch fabrics (variants *2–10*) consist of the loops of normal height and held loops, with increased width. So, the wales *W*, courses *C* and fabric density *S* are smaller than the density of plain knitted fabric. The fabric density *S* of tuck stitches are smaller by the 34–46%, than fabric density of plain knit fabric.

With increase the number on knit loops *m* from *1* to *3* at the constant number of held loops *n = const* (*1, 2* or *3*) the wales *W* of tuck stitch (variants *2, 5, 8*, and *3, 6, 9* and *4, 7, 10*) increase linearly, and the courses *C* – linearly decrease (fig. 1). As a consequence the fabric density *S* of these tuck stitch are decrease (fig. 2).

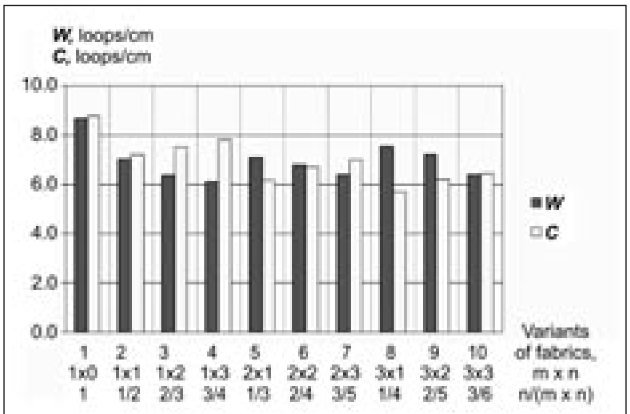


Fig. 1. Diagrams of the wales *W* and courses *C* for knit fabrics

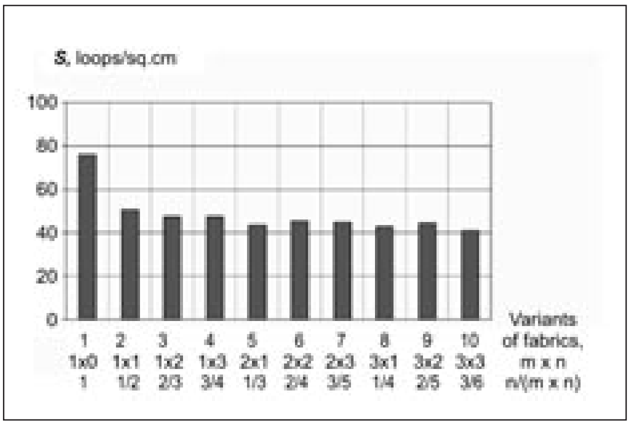


Fig. 2. Diagrams of the fabric density *S* for knit fabrics

Table 3

The characteristics	Variants of fabrics								
	2	3	4	5	6	7	8	9	10
W	–19.3	–26.9	–29.9	–18.4	–21.8	–26.4	–13.2	–17.2	–26.6
C	–18.2	–14.8	–11.4	–30.0	–23.8	–20.5	–35.2	–29.8	–27.0
S	–33.5	–37.3	–37.4	–42.5	–40.0	–41.1	–43.4	–41.5	–46.0
L_1	–1.7	0.3	6.0	–4.7	–3.4	0.6	–3.3	–2.2	–1.4
L_2	54.6	66.7	139.7	89.3	111.0	128.8	30.4	53.3	80.5
l_a	26.4	33.5	72.9	42.3	53.8	64.7	13.6	25.5	39.5
W_s	2.4	4.8	5.6	2.7	4.6	5.1	2.4	2.9	3.5
l_2/l_1	6.2	8.6	13.6	9.9	11.1	16.0	11.1	14.8	17.3
t	–20.9	–25.1	–42.2	–29.7	–35.0	–39.3	–12.0	–20.3	–28.3
K	1.8	–1.8	21.4	16.1	19.6	21.4	–1.8	3.6	3.6
K_w	3.5	14.0	52.6	0	17.5	29.8	–26.3	–12.3	1.8
K_c	2.0	16.8	26.7	–13.9	–2.0	7.9	–25.7	–14.9	–1.0
K_p	6.3	12.0	87.3	16.8	42.1	60.1	–26.9	–7.6	5.1

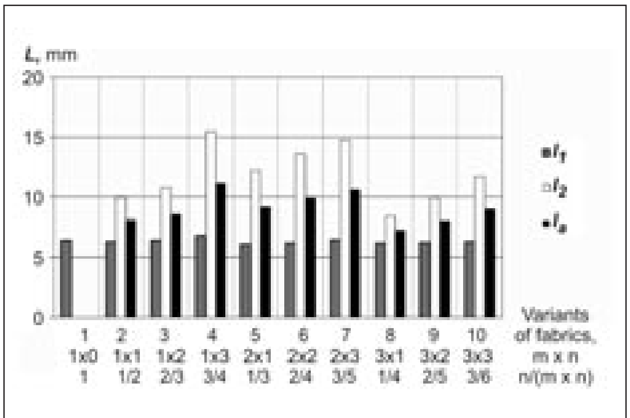


Fig. 3. Diagrams of the length of yarn for fabrics

When the number of knit loops $m = const$ (1, 2 or 3) with increase the number on held loops n from 1 to 3 the wales W of knit fabrics (variants 2–4, and 5–7, and 8–10) are linearly decrease, the courses C – linearly increase (fig. 1), and the fabric density S are decrease (fig. 2).

The length of yarn of plain loops l_1 are depends of stitch repeat in the width $R_b = m \times n$. It is because the change of the knitting yarn tension and take-down for each type fabrics (fig. 3). The length of yarn of tuck stitch l_2 is depends on the number of adjacent needles and take-down tension of fabrics and increase with change of the number of adjacent needles in action from *1* to *3* (table 3).

The weight W_s and thickness t of knitted fabrics depends on the knitting structure, yarn count and dimensional properties of the knitted fabrics (the length of yarn and density). It is clearly seen from tables 2 and 3, that with decrease of the wales W and courses S of knit fabrics (variants *2–10*) the weight W_s are increased by 2–6%, and thickness t – by the 6–17% comparing with plain (variant *1*). With increase the number on held loops n from *1* to *3* for constants number of knit loops $m = const$ (1, 2 or 3) the weight Ws and thickness t of fabrics are linearly increase (table 3).

CONCLUSIONS

The analyses of investigations results about influence of the different stitch repeat in the width of tuck stitches on the dimensional properties of knit structures has demonstrated the importance of the stitch repeat in the width, R_b. The wales W, courses C and fabric density S are depends of the stitch repeat in width of tuck stitches as following:

- with increase the number on knit loops m from *1* to *3* at constants numbers of held loops $n = const$ (1, 2 or 3) the wales W of tuck stitch are increasing linearly, and the courses C and the fabric density S are decrease;
- with increase the number on held loops n from *1* to *3* for constant the number of knit loops $m = const$ (1, 2 or 3) the courses C of tuck stitch *is* linear increase, and the wales W and the fabric density S are decrease.

This effect is attributed to a combination of different number of elements of structure of tuck stitch (plain and tuck loops).

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DOCUMENTARE

Tehnologie chimică

FIBRE CU PROPRIETĂȚI ANTIMURDĂRIRE

Compania ***Schoeller,*** folosind o nouă tehnologie textilă, a dezvoltat un material ce oferă purtătorilor mai multă energie și o creștere a performanței.

Elaborată pentru a crește nivelul oxigenului din sânge, noua tehnologie de la Schoeller, *Energear*, utilizează biomimetismul, pentru a asigura recuperarea energiei radiate de organismul uman.

O matrice minerală integrată în material face ca radiațiile infraroșii din spectrul îndepărtat, radiate de organism, să fie reflectate înapoi de material, către purtător. Potrivit celor afirmate de reprezentanții companiei Schoeller, reflexia FIRs stimulează circulația sângelui și crește nivelul oxigenului din sânge.

Se afirmă că această energie suplimentară are efecte pozitive asupra bunei funcționări a organismului, îmbunătățind performanța, prevenind oboseala prematură și asigurând o mai bună regenerare a acestuia.

În plus, se constată o creștere a puterii de concentrare și a stării de bine. Respirabilitatea este pe deplin garantată, iar încălzirea organismului se face într-un timp mult mai scurt.

Pe parcursul testărilor, s-a constatat că oamenii aflați într-o fază aerobică activă au prezentat o creștere a aportului de aer, la o rată a pulsului cardiac mai mică, ceea ce a dus la o creștere a performanței și la producerea de mai puțin acid lactic.

Compania aplică noua sa tehnologie pentru diverse tipuri de materiale, cu diferite funcționalități, cărora le conferă elasticitate, impermeabilitate sau un management optim al umidității.

Domeniile de utilizare includ îmbrăcămintea pentru sport – ciclism, sporturi montane și de iarnă, dar și echipamentele de lucru, uniformele militare și cele civile.

Au fost elaborate patru tipuri de materiale, și anume:

- *Schoeller WB-400* – un material având o greutate adecvată realizării jachetelor cu înveliș moale;
- *Schoeller WB-formula* – cu o mai mare protecție contra vântului și intemperiilor;
- *Schoeller-dynamic* – cu greutate mică, adecvat pentru confecționarea pantalonilor;
- *Schoeller dryskin* – un material confortabil, ce menține pielea uscată, fiind potrivit realizării de pantaloni și jachete/sacouri.

Sursa: www.schoeller-textiles.com

Research regarding the optimization of flame retardant treatment for cellulose textile materials

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REZUMAT – ABSTRACT – INHALTSANGABE

Cercetări privind optimizarea tratamentului de ignifugare a materialelor textile celulozice

Lucrarea prezintă optimizarea tratamentului de ignifugare a materialelor din 100% bumbac, prin utilizarea agentului de ignifugare de Heraflamm kw 44. Pentru aplicarea tratamentului de ignifugare a fost selectată metoda regresiilor multiple, cu următoarele variabile independente: concentrația agentului de tratare, temperatura de aplicare a tratamentului termic și durata tratării. Utilizând datele obținute în urma testelor la combustie și a acelora la rupere, s-au stabilit parametrii optimi de lucru pentru tratamentul antiflacără cu Heraflamm kw 44.

Cuvinte-cheie: ignifugare, bumbac, compoziție fibroasă, impregnare, tratament termic, urzeală, bătătură

Research regarding the optimization of flame retardant treatment for cellulose textile materials

This paper presents optimization of flame retardant treatment of fabrics of 100% cotton, using Heraflamm kw 44 as flame retardant substance. In order to achieve the flame retardant treatment, we have chosen as research method, multiple regressions, with the following independent variables: treatment substance concentration, heat treatment temperature and treatment duration. Using the data obtained both from combustion tests and fracture tests we were able to reveal the optimal working parameters of flame retardant treatment using Heraflamm kw 44 as fire retardant substance.

Key-words: flame retardant, cotton, fiber composition, impregnation, heat treatment, warp, weft

Forschungen betreff der Optimierung der Flammfestbehandlung der Textilzellulosematerialien

Die Arbeit stellt vor die Optimierung der Flammfestbehandlung der Materialien aus 100% Baumwolle, durch Anwendung des Flammfestmittels Heraflamm kw 44. Für die Anwendung der Flammfestbehandlung wurde die Methode der mehrfachen Regression angewendet, mit folgenden unabhängingen Variablen: Behandlungsmittelkonzentration, Wärmebehandlungstemperatur und Behandlungsdauer. Durch die Benutzung der erhaltenen Daten als Folge der Verbrennungs- und Reissteste, wurden die optimalen Arbeitsparameter für Flammfestbehandlung mit Heraflamm kw 44 ermittelt.

Stichwörter: Flamfestbehandlung, Baumwolle, Faserzusammensetzung, Tränken, Wärmebehandlung, Kette, Schuss

Cellulose textile materials have a wide circulation in the consumer goods industry; they are used for men, women and children's garments as well for the confection of bed linen. The qualities of these materials are well established, therefore, their use is widely extended.

The problem arising, especially for textile fabrics used for night clothing (pajamas, shirts), is that cellulose materials are likely to ignite, their auto-igniting temperature being between 350–400°C compared to wool or polyester that have an auto-igniting temperature around 500°C [1, 2, 3].

Considering these facts it is necessary to apply certain flame retardant treatments, in order to protect materials from ignition or burning.

The aim of this work is to establish the optimal fireproofing parameters for cellulose textile materials using Heraflamm kw 44 as flame retardant substance.

EXPERIMENTAL PART

The fabric used for the study was cotton woven with the following characteristics: fiber composition – 100% cotton, width – 160 ± 3 cm, specific mass 208 ± 10 g/m^2, warp density 225 ± 10 yarns/10 cm, weft density 185 ± 10 yarns/10 cm and Heraflamm 44 kw flame retardant substance, with the following chemical composition (table 1).

Table 1

ENZYMES USED IN TREATMENTS

Elements	Norm., %
Carbon	20.21958
Phosphor	2.008034
Potassium	0.602042
Calcium	0.462699
Chlorine	0.522661
Silicon	0.560064
Oxygen	75.62492

Operating mode

The adopted research method was multiple regressions, with the following independent variables:

- flame retardant substance concentration, x_1 (g/1);
- the curing treatment temperature, x_2 (°C);
- the curing time, x_3 (min.);
- dependent variables the burning time, y_1;
- tensile strength, z_2.

The encoding of the independent variables (flame retardant substance concentration, curing treatment temperature, and curing time) during the entire experiment is mentioned in table 2.

The treatments were performed in the laboratory for textile chemical finish of Faculty of Textiles and Leather Engineering and Industrial Management of Iasi, using a Medsan Lab oven.

Table 2

VALUES OF TECHNOLOGICAL PARAMETERS

Code/real parameter	–1.682	–1	0	+1	1.682
Real concentration, g/l	200	220	250	280	300
Real temperature, °C	130	136	145	154	160
Real time, min.	2	2.8	4	5.2	6

Table 3

No. of tests	x_1 (cod)	x_1 (cod)	x_1 (cod)	x_1 (real)	x_1 (real)	x_3 (real)	y_1 sec.	z_2 R, N
1	–1	–1	–1	220	136	2.8	25	289.2
2	1	–1	–1	280	136	2.8	13	250.8
3	–1	1	–1	220	154	2.8	20	268
4	1	1	–1	280	154	2.8	3	256
5	–1	–1	1	220	136	5.2	27	255.6
6	1	–1	1	280	136	5.2	2	302
7	–1	1	1	220	154	5.2	21	239
8	1	1	1	280	154	5.2	2	235.8
9	–1.682	0	0	200	145	4	27	323,2
10	1.682	0	0	300	145	4	0	350.8
11	0	–1.682	0	250	130	4	25	356.8
12	0	1.682	0	250	160	4	22	224.8
13	0	0	–1.682	250	145	2	26	302.8
14	0	0	1.682	250	145	6	19	264
15	0	0	0	250	145	4	23	340
16	0	0	0	250	145	4	24	350
17	0	0	0	250	145	4	24	349.6
18	0	0	0	250	145	4	23	340.8
19	0	0	0	250	145	4	25	330.8
20	0	0	0	250	145	4	24	341.6

The treatment bath had the following composition:

- Heraflamm kw 44 (x_1);
- Herasim dm 70 (14 g/l) – fixing agent;
- Datasoft CSF (8 g/l) – softener;
- Phosporic acid 85% (18 g/l);
- Teceschneller (3 g/l) – wetting agent.

Flame retardant substance concentration, treatment temperature and duration were applied according to the experimental plan shown in table 3, were the burning tests results, as well as the resulted values for tensile strength were also noted.

The technological flow of the flame retardant process was [4]:

- padding;
- squeezing;
- drying;
- curing;
- washing;
- drying.

After padding, which was performed in the treatment bath at the above mentioned parameters, the squeezing took place, by using the squeeze roller with dryer that works 80% with the aid of an oven at a temperature of 100–110°C followed by curing, the last is influenced by two parameters mentioned in table 3, temperature (x_2) and the duration/time (x_3). The final washing takes place in several stages, the soda ash 10–20/l at 50°C is used first, then a hot water washing at 50–60°C is applied followed by a cold rinse. The second drying takes place, as in the case mentioned above, in an oven at 100–110°C [5, 6].

RESULTS AND DISCUSSIONS

Regression equation of the treatment with Heraflamm kw 44

The flame retardant treatment was assessed by a determining the burnning time according to STAS SR EN ISO 6941, operations performed at the National Research-Development Institute for Textiles and Leather in Bucharest, and the obtained values are present in table 3, marked with y_1. Data processing had as result the obtaining of a regression equation:

$$Y_1 = 24{,}0126 - 8{,}6707\, x_1 - 1{,}9088\, x_2 - 1{,}5193\, x_3 + 0{,}125\, x_1x_2 - 1{,}875\, x_1x_3 + 1{,}125\, x_2x_3 - 4{,}8081\, x_1^2 - 1{,}2731\, x_2^2 - 1{,}6266\, x_3^2$$

Graphic representation of regression equation

The equation was graphically represented establishing burning time curve, according to the three independent variables individually used in the study, and variation curves of this parameter depending on the interactions of pair wise parameters.

Analyzing the influence of the 3 variables

The influence of the three parameters on the burning time is presented in the following figure 1. It has been noticed that along with increasing concentration of treatment substance the burning time decreases, which means the flame-proofing effect increases. This factor significantly influences the fireproofing capacity.

The curing temperature and duration have almost the same influence on the burning time, noticing that along with the increase of their values this index easily increases, followed by a significant improvement of the fireproofing capacity. It is mentioned that at a treatment duration of ≥ 6 minutes the textile material becomes yellow, which means that the curing time has to be

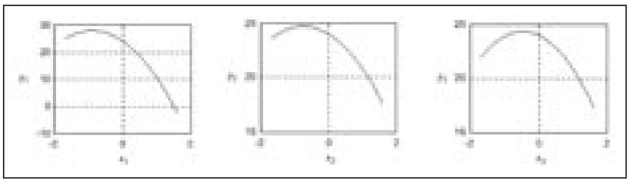

Fig. 1. Burning time variation depending on the three parameters

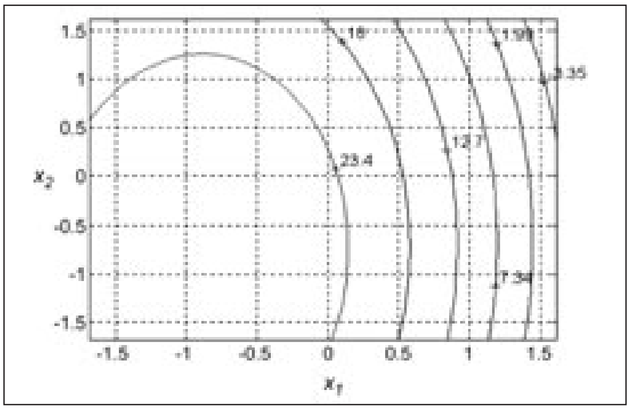

Fig. 2. Graphic representation of burning time variation depending on concentration x_1 and temperature x_2

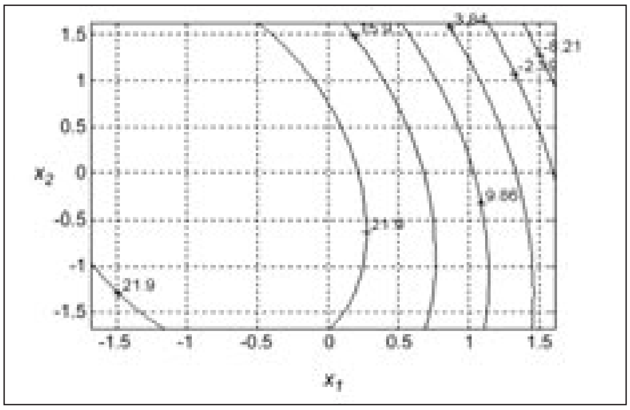

Fig. 3. Graphic representation of burning time variation depending on concentration x_1 and time x_3

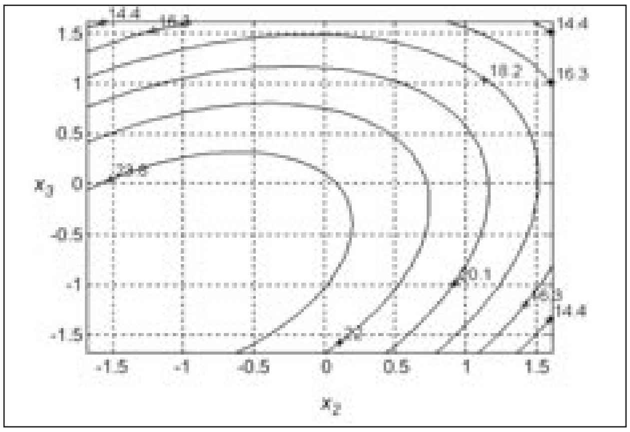

Fig. 4. Graphic representation of time burning variation depending on temperature x_2 and time x_3

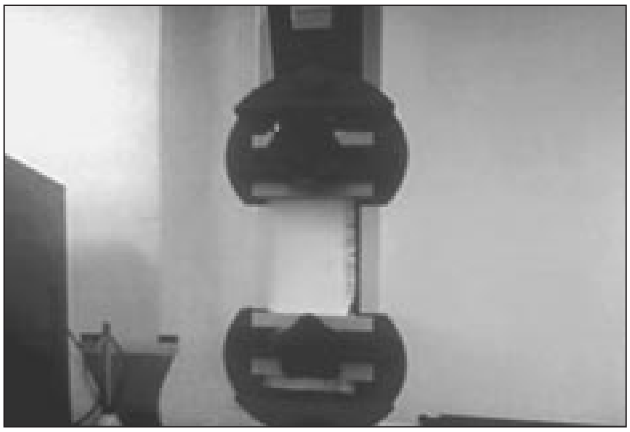

Fig. 5. Dynamometer (H5KT)

smaller than 6 minutes. From the graphics presented above the following optimal values of work parameters can be established in order to achieve maximum resistance to burning:

– concentration of flame retardant substance 290 g/l;
– curing temperature 160°C;
– curing duration 5,2 minute.

The analysis of model, $y_1 = f(x_1, x_2)$

The concomitant influence of concentration of flame retardant substance and the curing temperature on the burning time is presented in figure 2.

Analyzing the curves from the figure 2, it can be noticed that the improvement of fire proofing capacity of cellulose fabrics is achieved along with the increased in the concentration of flame retardant substance and at higher curing temperatures.

The analysis of model, $y_1 = f(x_1, x_3)$

The action of two other parameters, such as the treatment substance's concentration and the treating time, is represented in the following figure 3.

Analyzing the curves from the figure we can notice that for reaching a better fireproofing effect it is necessary to use a higher concentration of the treatment substance and a longer treatment time as well.

The analysis of model, $y_1 = f(x_2, x_2)$

An interesting image of the curves, different from those mentioned previously, is represented by the curves from figure 4, curves which establish how the temperature and time interactions influence the fireproofing effect.

Analyzing the curves it can be noticed that the values of the two parameters, situated in the maximum are of the researched field, do not lead to results favorable for fireproofing.

That is why, for a better fireproofing effect it is necessary to operate either with smaller temperatures and durations, or in the field of the two parameters situated in the maximum are of the researched field.

TENSILE STRENGTH OF THE CELLULOSIC FLAME RETARDANT FABRICS TREATED WITH HERAFLAMM

Considering that each finishing treatment for textiles must ultimatly lead to special results regarding their quality and integral properties, the flame retardant treated materials have also been tested regarding their tensile strength.

The work processes

The tensile test was operated according to STAS SR EN ISO 13934-1 – 1999, using a dynamometer (H5KT), presented in figure 5, with the following parameters: force – 300 N; the distance between clamps – 100 mm; speed – 100 mm/minute. The test results are presented in table 3 with z_2. The samples used for testing have the following size: 50 mm – on

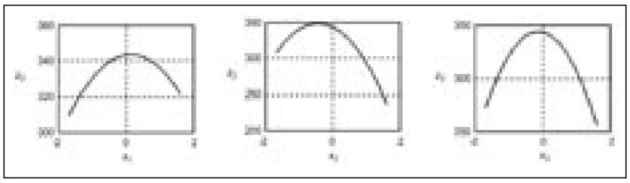

Fig. 6. The variation of tensile strength depending on the three parameters

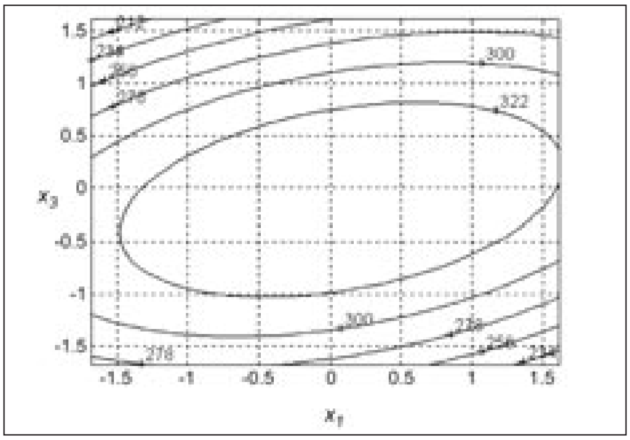

Fig. 8. Graphic representation of tensile strength variation depending on concentration x_1 and time x_3

weft; 200 mm – on warp. Before effectively taking the tensile test, the sample were left for 24 hours at conditioning, in an oven DATA COLOR type, made by SDL ATLAS Company, at 200°C ± 5% and a humidity of 60% ± 5%.

For these case researches has been made on the same experimental program as in the first stage using the method of multiple regression.

EXPERIMENTS, RESULTS AND DISCUSSIONS

Regression equation of treatment with Heraflamm kw 44

The data processing obtain leaded to the following regression equation:

$$Z_2 = 343{,}4476 + 2{,}8721\,x_1 - 23{,}5085\,x_2 - 7{,}0704\,x_3 - 2{,}9000\,x_1x_2 + 11{,}7000\,x_1x_3 - 8{,}3500\,x_2x_3 - 10{,}1482\,x_1^2 - 26{,}4799\,x_2^2 - 29{,}0958\,x_3^2$$

The graphic regression equation representation

The regression equation was graphically represented using variation curves for tensile strength depending on the three parameters individually used in the study and variation curves of this index depending of the pair wise parameter's interactions.

Analyzing the influence of the three variables

Figure 6 presents the influence of the three variables on the tensile strength. From the graphics we can observe that the tensile strength improves along with the increase of the values of the studied parameters, up to values placed in the center of the experimental are (0) for concentration and treatment time, and for temperature to values situated in the interval (–1,0).

If these values – concentration, temperature and treatment duration – are exceeded, the tensile strength

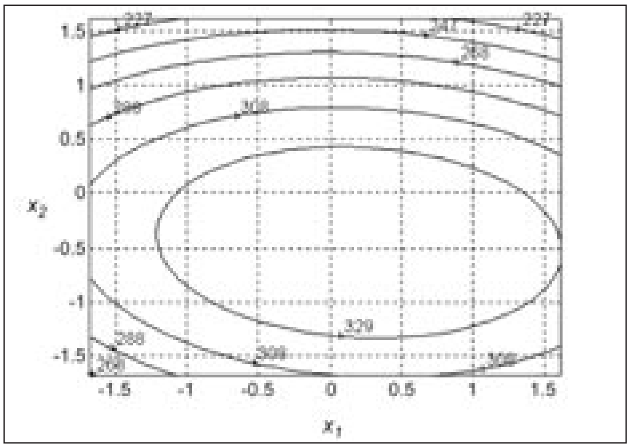

Fig. 7. Graphic representation of tensile strength variation according to concentration x_1 and temperature x_2

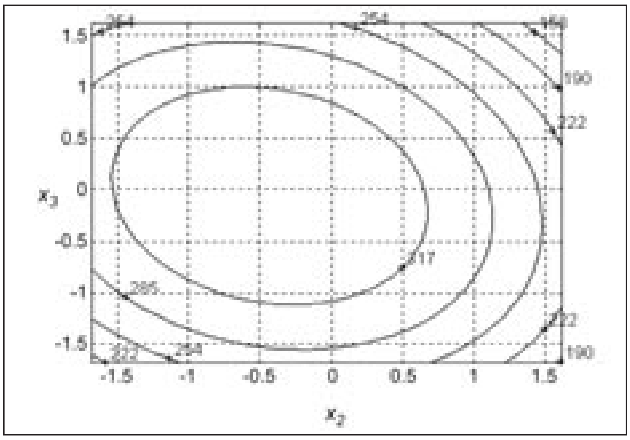

Fig. 9. Graphic representation of tensile strength variation depending on temperature x_2 and time x_3

decreases. We can conclude that the optimal values of work parameters for a maximum tensile strength are:

– concentration of flame retardant substance	220–250 g/l
– curing temperature	145°C
– curing duration	4 minute.

The analysis of model, $z_2 = f\,(x_1, x_2)$

This model is graphically represented in figure 7. The analysis of the graphic, which presents the tensile strength variations depending on concentration and temperature, shows that the maximum values of this index are situated in the (-1, 0) of the experimental field.

The analysis of model, $z_2 = f\,(x_1, x_3)$

The simultaneous influence of concentration of flame retardant substance and the treatment duration is presented in figure 8. Analyzing the figure 8, the graphic representation of tensile strength variation depending on concentration (x_1) and time (x_3), we can observe the maximum values of the index is registered for values situated in the center of the experimental field.

The analysis of model, $z_2 = f\,(x_2, x_3)$

The simultaneous influence of temperature of flame retardant substance and the treatment duration is presented in figure 9. Graphic representation of tensile strength variation depending on temperature and time presents the same conclusions as the representation of variation on concentration and time; the maximum values of these indexes are registered for the central area of the experimental field.

CONCLUSIONS

- The influence of flame retardant substance concentration, temperature and time on the flameproofing of cellulosic materials has been studied;
- The used method research was the method of multiple regression;
- The optimal parameter values of the fireproofing treatment have been established in order to achieve maximum tensile strenghth:
  - concentration of flame retardant substance 260–270 g/l;
  - curing temperature 150°C;
  - curing duration 5 minutes.

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DOCUMENTARE

Tehnologie chimică

TEHNOLOGIE CU PLASMĂ PENTRU FUNCŢIONALIZAREA TEXTILELOR

Producătorul de tricoturi ***Christian Eschler AG,*** din Bühler/Elveţia, în colaborare cu firma textilă ***Grabher Group,*** din Lustenau/Austria, a dezvoltat o nouă generaţie de textile funcţionale. Materialele inovatoare destinate articolelor sport şi de exterior sunt tratate pe baza tehnologiei cu plasmă, asigurându-se astfel o funcţionalizare durabilă şi prietenoasă mediului.

Plasma este creată prin aplicarea de câmpuri electrice asupra gazului pur sau amestecurilor de gaz, într-o cameră de vid. Gazul ionizat produce o reacţie chimică la suprafaţa materialului respectiv. Combinaţia corectă a compoziţiei amestecului de gaz, a frecvenţelor şi fluxului de gaz conduce la modificări sistematice ale suprafeţei materialelor, conferindu-le efecte extrem de durabile de hidrofilizare, hidrofobizare, antimurdărire.

Finisarea textilă clasică, utilizată până în prezent, era bazată pe procese chimice umede. Efectele dorite sunt obţinute, de obicei, cu ajutorul aditivilor şi al peliculelor. Din cauza abraziunii mecanice şi a slabei rezistenţe la spălare, caracterul permanent al acestor efecte este limitat, iar combinarea diverselor proprietăţi este, de asemenea, restricţionată.

Tehnologia cu plasmă înlătură toate acele dezavantaje, noul proces neavând nicio influenţă negativă asupra tuşeului materialului textil. De asemenea, noua tehnologie utilizează o cantitate minimă de apă şi de substanţe chimice, economiseşte energia şi este lipsită de compuşi fluorocarbonici (PFOA sau PFOS).

Primele articole de îmbrăcăminte, care vor beneficia de această tehnologie, vor fi disponibile consumatorilor finali în vara anului 2012.

Melliand International, august 2010, p. 145

Tensile behavior of textile reinforced flexible composites with notch

ZEXING WANG NANLIANG CHEN

REZUMAT – ABSTRACT – INHALTSANGABE

Comportamentul la tracţiune al compozitelor flexibile, consolidate cu textile şi prevăzute cu crestături

În lucrare sunt studiate efectele tipului şi adâncimii crestăturilor asupra comportamentului la tracţiune al materialelor compozite flexibile, consolidate cu o structură din ţesătură cu legătură tip pânză, supuse la încercări de tracţiune, cu viteză mică de alungire. Sunt analizate curbele tipice de forţă/alungire, obţinute pe aparate de tracţiune uniaxiale, rezistenţa la tracţiune, forţa-limită de propagare a crestăturii şi tenacitatea materialului, în special prin evaluarea influenţei tipului şi adâncimii crestăturii la încercări de tracţiune uniaxiale. Rezultatele arată că proprietăţile materialului compozit flexibil, consolidat cu material textil, depind în mod semnificativ de prezenţa unor crestături. Rezistenţa la tracţiune, forţa-limită de propagare a sfâşierii şi tenacitatea probei cu crestături scad odată cu creşterea lărgimii iniţiale a crestăturii, iar alungirea maximă a epruvetei scade, de asemenea, odată cu creşterea lărgimii iniţiale a crestăturii. S-a stabilit că materialul compozit flexibil, consolidat cu material textil, prezintă o sensibilitate mai mare faţă de o crestătură realizată pe o margine (SEN) şi o mai mică sensibilitate la cea realizată pe două margini (DEN), în comparaţie cu o crestătură centrală (CEN).

Cuvinte-cheie: compozit flexibil, ţesătură cu legătură pânză, sensibilitate la crestături, proprietăţi de tracţiune, tenacitate

Tensile behavior of textile reinforced flexible composites with notch

The effects of notch type and notch depth on the tensile behavior of flexible composite material reinforced with plain woven fabric carcass are experimentally investigated at a low loading speed. The typical force displacement curves under uni-axial tensile loads, the tensile strength, notch propagation threshold force and notch toughness of specimens are analyzed, in particular, by evaluation of the influence of notch depth and notch type under uni-axial tensile loads. The results show that the textile reinforced flexible composite exhibits significant notch sensitivity. The notched tensile strength, notch propagation threshold force and notch toughness decrease with the increase in initial notch depth, and the maximum displacement between jaws supported by a specimen is also decreasing with the initial notch depth. Based on the investigation, it can be also concluded that the textile reinforced flexible composite employed in this study has higher sensitivity to single edge notch (SEN) and lower sensitivity to double edge notch (DEN), compared with the centre notch (CEN).

Key-words: flexible composite, plain woven fabric, notch sensitivity, tensile properties, notch toughness

Zugverhalten der flexiblen, textilverstärkten Verbundwerkstoffe, versehen mit Riffeln

In der Arbeit werden die Effekte des Types und der Tiefe der Riffelung auf das Zugverhalten der flexiblen Verbundwerkstoffe untersucht, welche mit einer Gewebestruktur mit Leinwandbindung verstärkt sind, bei einer stetigen Zugbelastung. Es werden die typischen Dehnungs-Kurven bei uni-axialen Spannungskräften, der Zugwiderstand, die Grenzwertkraft der Riffelausdehung und die Riffelzähigkeit, besonders bei der Einwirkungsbewertung der Riffeltiefe und des Riffeltypes unter uni-axialen Spannungskraft, analysiert. Die Ergebnisse zeigen, dass die Materialeigenschaften des flexiblen, textilverstärkten Verbundwerkstoffes, wesentlich von der Anwesenheit von Riffeln abhängen. Der Zugwiderstand, die Grenzwertkraft der Reissausdehnung und Zähigkeit der Riffelprobe schrumpft mit dem Wachstum der ursprünglichen Riffelbreite. Es wurde festgestellt, dass das flexible, textilvestärkte Verbundwerkstoff, eine grössere Sensibiltät für eine Randriffel (SEN) und eine kleinere Sensibilität für Riffeln auf zwei Rändern aufweist, im Vergleich mit einer Zentralriffel (CEN).

Stichwörter: Flexibles Verbundwerkstoff, Leinwandgewebe, Riffelsensibilität, Zugeigenschaften, Zähigkeit

Textile reinforced flexible composites is a sub-set of textile reinforced composites, which is also called coated and laminated textiles (or fabrics) in the Textile Institute's publication. As a class of engineering materials, the textile reinforced flexible composites consist of a coating substrate and textile carcass, which demonstrate much lager deformation than those of the conventional thermosetting or thermoplastic based composites [1, 2]. Flexible composites reinforced by a textile carcass have become popular nowadays, due to the potential of producing low-cost high quality structures with improved mechanical performance. In recent years, the textile reinforced flexible composites have been used in a variety of applications, among many other fields being listed: civil engineering, architecture and aerospace engineering. Typical examples include membrane roofs and covers, inflatable buildings and pavilions, airships, inflatable furniture, airspace structure etc.

Due to the membranous characteristics of textile reinforced flexible composites, they can be used as the load-bearing components, where they are mainly subjected to tensile load. Since textile reinforced flexible composites show resistance mainly to tension, it is important that the characteristics regarding extension and propagation of cracks, notches and other defects should be studied for industrial application and material preparation [3]. In recent decades, extensive experimental and theoretical researches have been performed on the tensile properties and propagation of cracks and notches in flexible composites reinforced by woven fabric [3–8] and multi-axial no-crimp fabric [9–10], and then the fracture models and energy released rate were also employed to predict failure loads in flexible composites containing cracks [3] and to evaluate the fracture toughness [11]. These experimental investigations were mostly concerned with the tensile behavior of the textile reinforced flexible composites having a centre notch, under uni-axial, bi-axial and even multi-axial tension loading conditions.

However, few researches have been made on the mechanical performance and notch toughness of textile reinforced flexible composites with various sharp notches. The present study is therefore aimed at investigating the tensile behavior and notch toughness of a flexible composite reinforced with woven fabric – with single edge notch (SEN), double edge notch (DEN) and centre notch (CEN) – and also for assessing the tensile behavior and notch toughness with various notch depths for a given notch type.

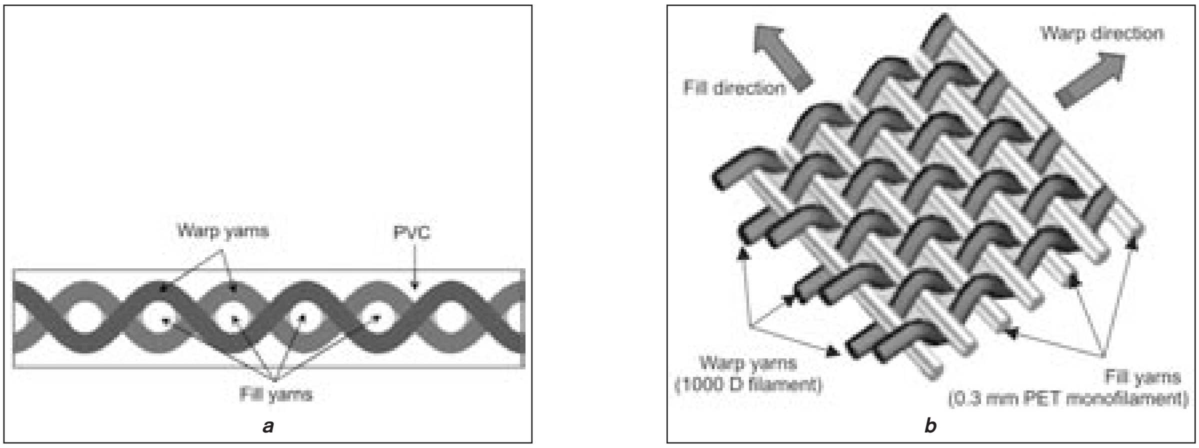

Fig. 1. Schematic representation of:
a – the tested material; ***b*** – fabric geometry

EXPERIMENTAL PART

Experimental material and specimens

The composite material investigated in this study, is used as light-weight textile conveyor belt, being made of plain weave polyester (PET) woven fabrics with Polyvinyl chloride (PVC) coating on both sides. The woven fabric adopted PET filament with a yarn count of 111.11 tex (1,000 denier) in the warp direction and PET monofilament with a diameter of 0.3 mm in the fill direction. The fabric count was 43 warp/inch and 23 fill/inch. The composite weight was 142.00 g/m^2 and thickness 1.42 mm. The construction of the tested material and the geometry of its carcass were illustrated in figure 1. Tensile coupons, single-edge notched (SEN), double-edge notched (DEN) and centre notched (CEN) specimens with geometries and dimensions shown in figure 2 were cut from the flexible composite material parallel to the warp direction. Aluminum plates 0.5 mm in thickness were glued onto both ends of the specimens.

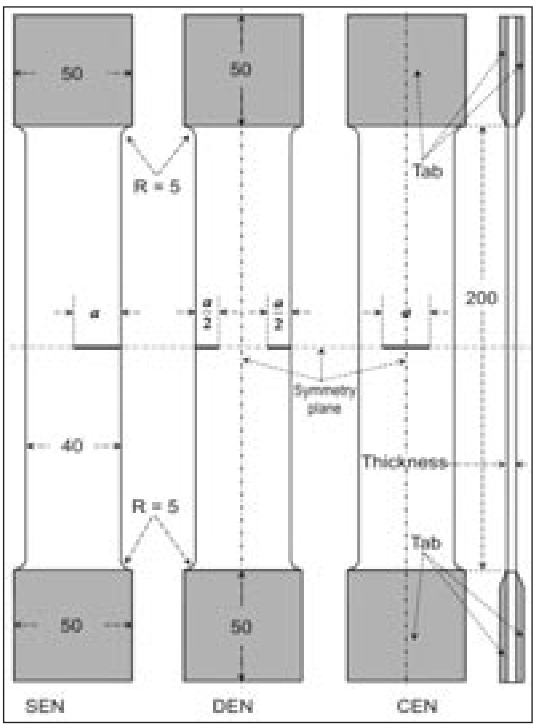

Fig. 2. Dimensions for SEN, DEN and CEN specimens: notch depth, *a* = 5 ~ 20 mm ; all dimensions, in mm

To evaluate the tensile behavior of the textile-reinforced flexible composite with various notch depths, SEN, DEN and CEN specimens were prepared with a notch depth of 5, 10, 15 and 20 mm represented as *W/8, W/4, 3W/8* and *W/2,* with the effective width of the specimen. To ensure an initial sharp notch perpendicular to the loading direction (lengthwise direction), the notch was performed with a lancet, at the symmetry plane (fig. 2).

Mechanical testing

Tensile tests were performed on a uni-axial, servo hydraulic test machine (20 kN), under displacement control, with a nominal laboratory air temperature of 2°C and a relative humidity of 55%. For each specimen tested, the crosshead displacement and corresponding force were recorded; post-testing data analysis was completed to determine the notched tensile strength, notch propagation threshold force and notched toughness. In order to prevent the dynamic effects, a constant crosshead speed of 5 mm/minute was employed for all tests, very low compared to the tensile speed used in conventional tensile tests.

RESULTS AND DISCUSSIONS

Force-displacement response for smooth and notched specimens

The typical force displacement curves for SEN, DEN and CEN specimens with various initial notch depths are shown in figure 3, 4 and 5. The reference curve

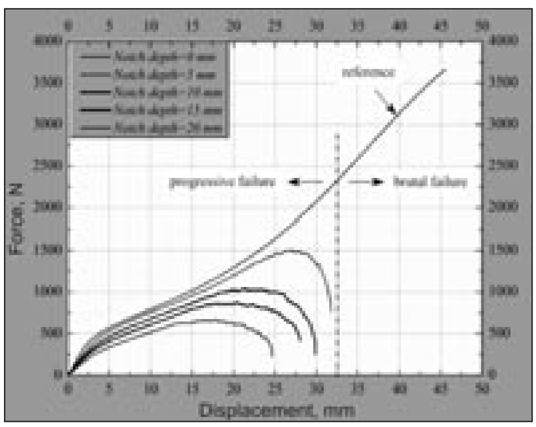

Fig. 3. Tipical force-displacement for SEN specimens with various notch depths

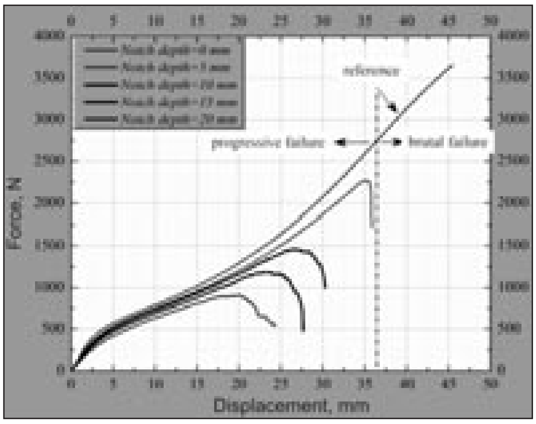

Fig. 4. Tipical force-displacement for DEN specimens with various notch depths

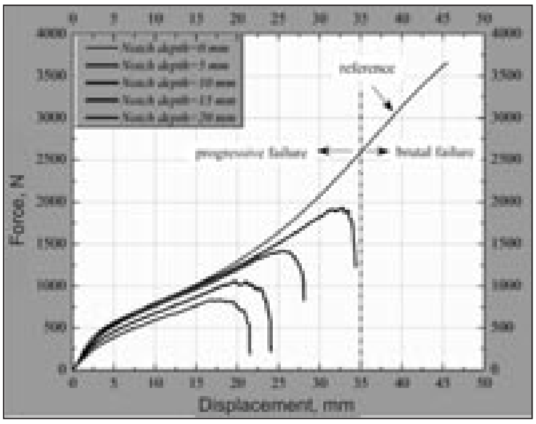

Fig. 5. Tipical force-displacement for CEN specimens with various notch depths

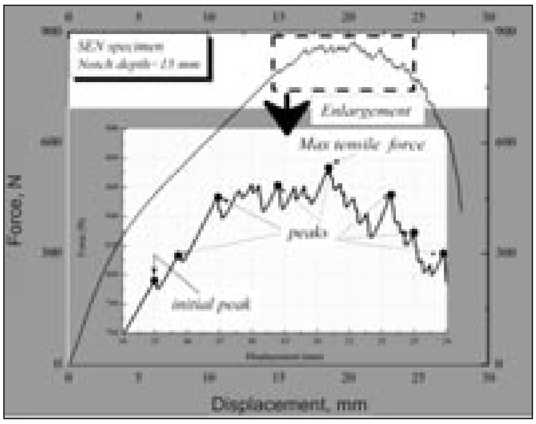

Fig. 6. Tipical force-displacement curve for notched specimen

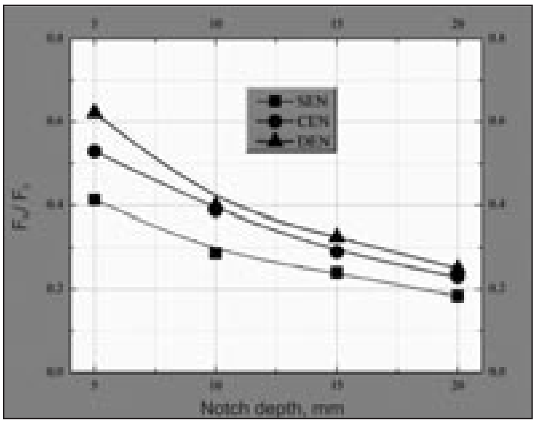

Fig. 7. Variation of notched strength with notch depth

corresponds to the test conducted on smooth specimens (without initial notch).

It can be found that the mechanical behavior of smooth and notched specimens under quasi-static tensile condition is quite different and that the same evolutions are observed in all the force-displacement curves for notched specimens in the case of tension. The mechanical properties for smooth specimens are much higher than those of notched specimens. This is normal, because the notch is present in the flexible composite. The material develops plastic strain as the yield stress is exceeded in the region near the notch tip.

However, for notched specimens, the mechanical properties decrease considerably and this depends on the notch type and notch size. The lowest properties are observed for the SEN specimens, which is furthest placed, when the initial notch depths vary from 5 mm to 20 mm.

According to the initial notch depth, two failure models can be distinguished. For smooth specimens, the failure is described as “brutal”, it occurs suddenly without any propagation. For notched specimens, the failure is described as “progressive”; the initial notch propagates from the side with notch to another side for SEN specimens and, alternately on each side, for DEN and CEN specimens.

By looking at the force-displacement curves, it is clear that there are three aspects involved: one is the elastic-plastic deformation occurring at any given notch type and notch depth, another is the force-displacement curves demonstrating obvious nonlinearity, and the third is the significant notch sensitivity.

Notched tensile strength

As the force applied is increased, yarn rupture and matrix damage occurs in the region near the notch tip, when the force reaches a critical level. The tension corresponding to the load at this moment is called critical strength [3]. The force is also described as “crack propagation threshold force” [4], which indicates the start of the notch propagation. Depending on the notch depth, the force may continue to increase till it reaches the maximum value, namely notched tensile strength. For this class of flexible composites, it is important to determine the value of the threshold force, but it is very difficult to accurately derive in practice the threshold force from the force-displacement [3].

By observing and analyzing the failure process and the force-displacement curves for notched specimens, it can be seen that the notched specimens exhibit several maxima (fig. 6). Peak force is the upper load limit of each peak or the highest load supported before a yarn rupture. The initial peak present in force-displacement curves can be supposed as being caused by matrix damage and yarn rupture near the notch tip, when notch propagation occurs. Based on the results, the threshold force is defined in this study as the force corresponding to the initial peak. The determining method of the threshold force and maximum tensile force is illustrated in figure 6. Compared with the determining

Table 1

COMPARISON OF F_N AND F_N/F_0 FOR SEN, CEN AND DEN SPECIMENS WITH VARIOUS NOTCH DEPTHS (ARITHMETIC MEAN VALUES)										
Notch type	Notch tensile strength, F_N, N					Normalized notch tensile strength, F_N/F_o				
	Notch depth, mm									
	0.00	5.00	10.00	15.00	20.00	0.00	5.00	10.00	15.00	20.00
SEN	3655.26 (F_0)	1508.52	1046.41	874.49	669.85	1.000	0.413	0.286	0.239	0.183
CEN		1934.12	1420.00	1058.55	837.34	1.000	0.529	0.388	0.290	0.229
DEN		2270.88	1459.84	1190.41	912.30	1.000	0.621	0.399	0.326	0.250

Table 2

COMPARISON OF $F_{threshold}$ AND $F_{threshold}/F_0$ FOR SEN, CEN AND DEN SPECIMENS WITH VARIOUS NOTCH DEPTHS (ARITHMETIC MEAN VALUES)										
Notch type	Crack propagation threshold force, $F_{threshold}$, N					Normalized crack propagation threshold force, $F_{threshold}/F_o$				
	Notch depth, mm									
	0.00	5.00	10.00	15.00	20.00	0.00	5.00	10.00	15.00	20.00
SEN	3655.26 (F_0)	1355.17	946.71	797.18	627.54	1.000	0.371	0.259	0.218	0.172
CEN		1907.29	1339.09	1018.42	831.74	1.000	0.522	0.366	0.279	0.228
DEN		2268.49	1435.03	1139.47	823.28	1.000	0.621	0.393	0.312	0.225

method of the threshold force reported by Minami [3], it is more reasonable for the initial peak force to be defined as the threshold force, compared with that of the maximum tension force instead [1]. It should be noted that the value of the maximum tensile force is equal to that of the threshold force, for smooth specimens, which may be attributed to the fact that smooth specimen exhibits a brutal failure model.

The notch tensile strength, *FN* and normalized notch tensile strength F_N/F_0 for SEN, CEN and DEN specimens with various notch depths were listed in table 1, and the crack propagation threshold force $F_{threshold}$ and normalized crack propagation threshold force $F_{threshold}/F_0$ were also listed in table 2.

With regard to the notched specimen, the relation between the notched tensile strength normalized with the tensile strength of smooth specimen and the initial notch depth is illustrated in figure 7, and the relation between the threshold forces normalized with the tensile force of the smooth specimen is also plotted in figure 8. Based on figure 7 and 8, it can be found that all specimens display a decreasing tensile strength and threshold force, while increasing the notch depth. The longer the notch, the lower the tensile strength and threshold force are. The "notched strength"/"notch depth" curves and "threshold force"/"notch depth" curves come closer while increasing the notch depth, but still remain significantly different, when the notch depth varies from 5 to 20 mm. It is also observed that the textile reinforced flexible composite is more sensitive to single edge notch (SEN), than double edge notch (DEN) and centre notch (CEN), for a given notch depth.

Notch toughness

Toughness is an indication of the ability of a material to absorb energy in the process before fracture and is dependent on strength as well as ductility. Usually, the toughness is measured by calculating the area under the stress-strain curves from a tensile test and has units of energy per volume. In this work, the notch toughness is defined as the work done by the force applied; this quantity is mathematically defined as the area under the force/displacement curve, between the origin and the rupture point, and its unit is Joule. To assess the toughness of notched specimens, the notch toughness, E_{notch}, is employed in this study, which indicates the

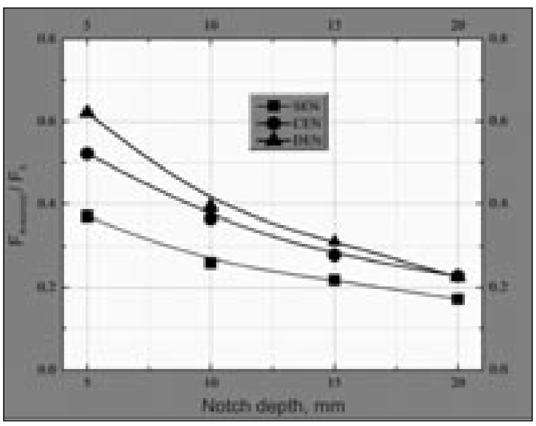

Fig. 8. Evolution of threshold force with notch depth

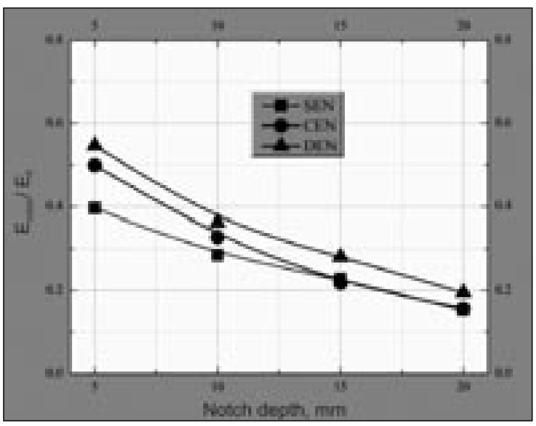

Fig. 9. Evolution of notch toughness depending on notch depth

Table 3

COMPARISON OF E_{notch} AND E_{notch}/E_0 FOR SEN, CEN AND DEN SPECIMENS WITH VARIOUS NOTCH DEPTHS										
Notch type	Notch toughness, E_{notch}, J					Normalized notch toughness, E_{notch}/E_o				
	Notch depth, mm									
	0.00	5.00	10.00	15.00	20.00	0.00	5.00	10.00	15.00	20.00
SEN	767.44 (E_0)	304.03	218.76	175.14	117.13	1.000	0.396	0.285	0.228	0.153
CEN		382.73	251.67	167.25	120.59	1.000	0.499	0.328	0.218	0.157
DEN		419.43	278.44	215.70	149.66	1.000	0.547	0.363	0.281	0.195

Table 4

COMPARISON OF $E_{initiation}$ AND $E_{initiation}/E_0$ FOR SEN, CEN AND DEN SPECIMENS WITH VARIOUS NOTCH DEPTHS										
Notch type	Notch initiation toughness, $E_{initiation}$, J					Normalized notch initiation toughness, $E_{initiation}/E_o$				
	Notch depth, mm									
	0.00	5.00	10.00	15.00	20.00	0.00	5.00	10.00	15.00	20.00
SEN	767.44 (E_0)	179.68	98.71	72.44	50.16	1.000	0.234	0.129	0.094	0.065
CEN		323.13	179.03	113.74	85.05	1.000	0.424	0.233	0.148	0.111
DEN		399.18	210.97	143.32	76.86	1.000	0.520	0.275	0.187	0.100

capacity of a specimen to absorb energy, when a notch is present in a specimen. The notch toughness, E_{notch}, was calculated by the typical force-displacement curves (figure 3–5).

The notch toughness, E_{notch}, and normalized notch toughness, E_{notch}/E_0, for SEN, CEN and DEN specimens with various notch depths, were listed in table 3.

This is graphically illustrated in figure 9, where notch toughness is plotted against the initial notch depth for SEN, DEN and CEN specimens. It is observed that the presence of the notch drastically reduces toughness; this is attributed to the stress concentration present at the notch tip.

To assess the resistance to notch initiation for notched specimens, the notch initiation toughness, $E_{initiation}$, is employed in this study. In the present work, $E_{initiation}$ is calculated by the integrated force-displacement curves between the origin point and the point notch propagation occurred, based on the typical force-displacement curves (figure 3–5). The notch initiation toughness E_{notch} and normalized notch initiation toughness, E_{notch}/E_0, for SEN, CEN and DEN specimens with various notch depths, were listed in table 4.

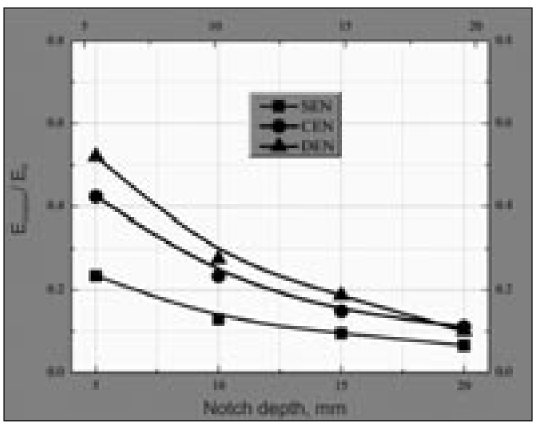

Fig. 8. Evolution of notch initiation toughness with notch depth

Figure 10 shows notch initiation toughness for SEN, DEN and CEN specimens plotted against notch depth. Inspection of figure 10 shows that the values of notch initiation toughness decrease with an increase in notch depth for a given notch type, and the values reduction was also related to notch type.

By observing figure 9 and 10, it can be seen that the flexible composite exhibits a sharp reduction notch toughness and notch initiation toughness, with the increase in notch depth. The effect of notch type on the reduction in notch initiation toughness is more obvious than that in notch toughness, indicating that the flexible composite has significant notch sensitivity, which may be attributed to the presence of stress concentration in the form of edge notch and the reduction in effective width as notch depth increases.

CONCLUSIONS

To experimentally investigate the effect of notch on the mechanical properties of a textile reinforced flexible composite, tests were conducted on SEN, DEN and CEN specimens with various initial notch depth at a very low loading speed. The effect of the notch type and initial notch depth on the tensile strength and toughness were investigated and analyzed. The experimental results show that the flexible composite exhibits distinctly a nonlinear behavior for smooth and notched specimens. The presence of stress concentration in the form of edge notch can reduce the tensile strength and notch propagation threshold force.

To assess the ability of the flexible composite to deform, combined with the tensile strength and displacement, the notch toughness and notch initiation toughness were also employed in this study, and the results revealed as well that the flexible composite demonstrated significant notch sensitivity. The investigation also revealed that high quality textile reinforced flexible composites are required to avoid initial notch, and long initial notch depth should be repaired on time; thus, they have higher toughness and damage tolerance.

In this study, only sharp edge notched specimens with various initial notch depths were investigated. For a further understanding on the effects of notch on the tensile performance, further study should be performed on the effect of shape near the notch tip, e.g. V-shape notch and circular hole in specimens. And, the tensile behavior of asymmetrically notched specimens should also be investigated.

Acknowledgement

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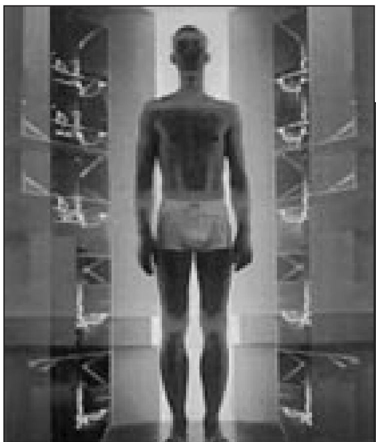
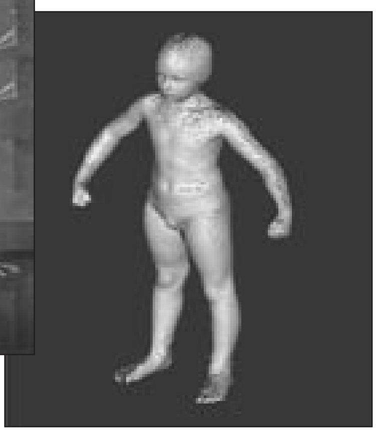
PRIMA ANCHETĂ ANTROPOMETRICĂ A COPIILOR DIN ROMÂNIA

Institutul Național de Cercetare-Dezvoltare pentru Textile și Pielărie, cu sprijinul Ministerului Educației, Cercetării, Tineretului și Sportului efectuează prima ***Anchetă antropometrică a copiilor cu vârsta cuprinsă între 6 și 19 ani.***





Măsurarea paramerilor antropometrici se face prin cea mai nouă tehnologie utilizată la nivel mondial, și anume prin scanarea corpului cu laser optic, 3D VITUS Smart XXL-ANTHROSCAN Pro.

Obiectivul acestei acțiuni îl constituie obținerea unor date antropometrice 3D, atât în scopul elaborării de normative naționale, necesare sectorului de confecții îmbrăcăminte, și al proiectării tehnologice a produselor destinate copiilor – jucării, echipamente pentru sport, dispozitive medicale, mobilier etc., cât și al evaluării stării de sănătate – *greutatea în raport cu vârsta, greutatea în raport cu înălțimea, indicele de masă corporală, circumferința medie a brațului etc.*

Redacția

Comparison of the effect of various pre-settings on the colour yield of polyester dyed with disperse dyes

RIZA ATAV

REZUMAT – ABSTRACT – INHALTSANGABE

Compararea efectelor diferitelor tipuri de fixare preliminară asupra randamentului tinctorial al poliesterului vopsit cu coloranţi de dispersie

În procesul de producţie a materialelor textile realizate din fibre sintetice, cum ar fi poliesterul, se generează solicitări în interiorul structurii fibrei, astfel încât, atunci când materialul este supus unui tratament umed sau termic ulterior, aceasta se va contracta datorită relaxării structurale. Termofixarea este un proces industrial important, deoarece elimină instabilităţile dimensionale. Procesul de termofixare influenţează unele proprietăţi ale fibrei, cum ar fi capacitatea tinctorială. Articolul prezintă rezultatele studiului privind efectele diferitelor tipuri de fixare preliminară (termofixare, fixare cu apă caldă şi fixare cu abur) asupra proprietăţilor de vopsire a fibrelor din poliester cu coloranţi de dispersie. S-a constatat că randamentul tinctorial al mostrelor vopsite după termofixarea uscată, la 180–220°C, este mai mare în comparaţie cu cel al mostrei vopsite netermofixate. În cazul mostrelor care au fost fixate cu apă caldă sau cu abur, randamentul tinctorial scade odată cu creşterea temperaturii. În plus, s-a constatat că tipul de fixare preliminară şi condiţiile de temperatură şi durată au un impact mai mare asupra randamentului tinctorial al coloranţilor cu difuzie slabă-medie.

Cuvinte-cheie: poliester, fixare preliminară, colorant de dispersie, randament tinctorial

Comparison of the effects of various pre-settings on the colour yield of polyester dyed with disperse dyes

During textile production with synthetic fibres such as polyesters, stress is generated within fibre structure such that, when the material is subsequently subjected to either wet or heat treatment, it will shrink due to structural relaxation. Heat setting is an important industrial process, since it rids them of their instabilities. The heat setting process also affects fibre properties such as dye ability. This article presents results of a study on the effects of various pre-settings (heat setting, hot water setting and steam setting process) on the dyeing properties of polyester fibres with disperse dyes. It was found that the colour yield of dyed samples after dry heat setting at 180–220°C is higher compared to the unset dyed sample. In the case of samples that have been hot water set or steam set, colour yield decreases by rising setting temperature. Furthermore, it was found that type of pre-setting and its conditions – temperature and time – has higher impact on colour yield of dyes having low-medium diffusion numbers.

Key-words: polyester, pre-setting, disperse dye, colour yield

Vergleich der Wirkung verschiedener Vorfixierungtypen auf die Färbungsleistung mit Dispersionsfarbstoffe im Falle des Polyesters

Im Produktionsprozess der Textilien aus synthetischen Fasern, wie z.B. das Polyester, wird ein Druck im Inneren der Faserstruktur generiert, so dass, im Augenblick der nachträglichen Nass- oder Thermobehandlung, diese wegen der strukturellen Erholung schrumpfen werden. Die Thermofixierung ist ein wichtiges industrielles Prozess, weil somit die Unregelmässigkeiten beseitigt werden. Der Thermofixierungsprozess beeinflusst einige Fasereigenschaften, wie die Färbungsleistung. Dieses Artikel stellt vor die Untersuchungsergebnisse betreff der Wirkungen verschiedener Vorfixierungstypen (Thermofixierung, Warmwasserfixierung, Dampffixierung) auf die Färbungseigenschaften der mit Dispersionsfarbstoffen gefärbten Polyesterfaser. Es wurde festgestellt, dass die Färbungsleistung der Farbmuster nach der trockenen Thermofixierung bei 180–220°C, grösser ist als bei der nicht-thermofixierten Farbmuster. Im Falle der mit heissem Wasser oder Dampf thermofixierten Muster, sinkt die Färbungsleistung mit dem Temperaturwachstum. Mehr, es wurde festgestellt, dass der Thermofixierungtyp, sowie die Temperatur- und Zeitbedingungen einen grösseren Impakt auf die Färbungsleistung der Farbstoffe mit schwach-mittelmässigen Diffusion, aufweisen.

Stichwörter: Polyester, Vorfixierung, Dispersionsfarbstoff, Färbungsleistung

Synthetic fibres are now of great importance to textile production. At present, many clothes are manufactured from pure synthetic yarns or their blends with natural fibres [1]. During textile production with synthetic fibres such as polyesters, stress is generated within fibre structure such that, when the material is subsequently subjected to either wet or heat treatment, it will shrink due to structural relaxation. Consequently, these fibres cannot be used for most textile purposes unless they have been previously subjected to a heat setting process at high temperature, which serves to introduce greatly enhanced dimensional stability to the yarn or fabric [2].

Heat setting is an important industrial process, since it rids them of their instabilities. Heat setting affects such important properties as stress-strain and recovery behavior, dye-uptake, optical properties, and thermal properties. Sometimes improvements in physical properties, particularly mechanical properties, may also be achieved. The structural and morphological changes have been described in terms of changes in crystallinity, crystal size and their size distribution, crystal defects, crystal orientation, the nature of the amorphous phase and its orientation, the coupling of the crystalline and amorphous phases etc.

The conditions of heat treatment depend on the nature of the polymer and the type of fibre. Heating systems applied in industry include dry air contact heating elements, water vapor, liquid baths etc. When swelling media are used, stabilization results from both temperature and solvent induced molecular motions. The stabilization temperature, which is predominantly determined by the nature of the polymer, should be higher than the maximum temperature of application to ensure stability under application conditions, where the kinetic equilibrium can be reached in a reasonably short time [3].

For conventional polyester, polyethylene terephthalate, the heat setting is carried out at 140°C in steam or 190–220°C in dry air. Although heat setting provides dimensional stability to polyester, at the same time it

Table 1

CONDITIONS OF VARIOUS PRE-SETTING TREATMENTS				
Pre-setting method	Temperature, °C	Time		
Dry heat setting	180	10"	20"	30"
	200	10"	20"	30"
	220	10"	20"	30"
Hot water setting	100	10'	20'	30'
	120	10'	20'	30'
	140	10'	20'	30'
Steam setting	102	10'	20'	30'
	130	10'	20'	30'
	160	10'	20'	30'

affects its dyeability, the dye-uptake being influenced by time and temperature of heat setting [2].
PES fibre is perhaps the most-studied fibre as far as heat setting is concerned. Though these extensive studies have enhanced our understanding of process-structure-property relationships, a number of issues still need to be resolved [3]. Some of the literature related to the heat setting of PES fibres is summarized below.
Merian et. al have determined the dependence of saturation limits, rates of diffusion, rates of dyeing, and migration properties of a number of disperse dyes on polyester fibres upon the temperature at which the fibres have been heat-set. The saturation limit and the average diffusion coefficient showed a minimum at a particular heat-setting temperature. The findings suggest that the minimum tinctorial yields obtained at such temperatures are due to increasing transformation of the fibre structure on heat setting and preferential loosening of unset fibre by swelling agents in a heated medium [4].
Radhakrishnan et. al have identified the structural parameters that predominantly influence dye diffusion behaviour in heat-set polyester fibres. Dye diffusion has been shown to depend on two factors: the volume of the accessible region (amorphous region) and the tortuosity of the dye diffusion path. The accessible region represented in terms of the amorphous volume per crystal, and the tortuosity expressed quantitatively by combining the orientation of the amorphous phase and the nature of coupling between the amorphous and the crystalline regions. An integrated model has been proposed by combining these parameters, and has been shown to correlate well with dye uptake in polyester fibres heat-set under slack and taut conditions [5].
Venkatesh et. al heat set nylon 6, nylon 6.6, and polyester (polyethylene terephthalate) filament yarns at different temperatures in oil under a variety of experimental conditions. The effect of time of heat setting, tension on the yarn during heat setting, as well as the effect of the initial tenacity and extension on subsequent changes in the mechanical properties of the heat-set yarns has been studied. The breaking strength, elongation at break and work of rupture has been found to be different for samples heat set while slack and at constant length. From measurements of the shrinkage and the residual shrinkage in boiling water it appears that dimensional stability can be achieved by heat setting even at constant length. Heat setting produces significant improvement in the crease recovery and resiliency of the fibres. Heat setting has also been found to significantly increase the overall crystallinity of the fibres as determined by critical dissolution time and parallel and perpendicular refractive indices. The overall orientation of the polymer chains, as determined from sonic velocity measurements, decreases on heat setting in the slack condition [6].
Recelj et. al examined the effect of stabilization under various conditions (temperature, time and tension) and the treatment of polyester fabric in buffered solution (*p*H 12) prior to high-temperature dyeing, on the migration of oligomers. Based on the results it was established that oligomer migration was affected by temperature, time and the stabilization tension. The greatest reduction in the content of oligomers was in polyester fabric that was stabilized in a restricted state at higher temperatures and longer times (220°C, 600 seconds) [7].
Sardağ et. al subjected 30 tex and 20 tex yarn bobbins consisting of 67% PES-33% viscose to heat-setting at 90°C and 110°C, and under a pressure of 630 mm Hg in order to investigate the effects of heat-setting conditions on the properties of twisted yarns. Both heat-set and unset yarns were dyed. The tensile strength properties (tenacity and elongation at break) of each yarn were measured before heat-setting, after heat-setting and after dyeing. The inner, middle and outer sections of the yarn bobbins were measured with a spectrophotometer to find differences in color. As a result, heat-setting and dyeing processes were found to be effective in the tenacity and elasticity of yarns [8].
This article presents the effects of pre-setting on the colour yield of polyester fibres dyed with various disperse dyes having low, medium and high diffusion numbers.

EXPERIMENTAL PART

Materials used

100% polyester single jersey knitted fabric was used in this study. All the experiments were carried out by using soft mill water.

Presetting of polyester fabric

Fabric samples were pre-set by dry heat setting (thermofixation), hot water setting (hydrofixation) and steam setting. Pre-setting conditions are given in table 1. Dry heat setting and steam setting was carried out by a laboratory scale MATHIS stenter-frame/steamer. For hot water setting, a laboratory scale Thermal HT dyeing machine was used. During heat setting no tension was applied to the samples.

Selection of dyes

Conventional textile dyes are divided into several types according to their chemical structures and dyeing mechanisms. The most frequently used dye in the dyeing processes of polyester is disperse dyes. For that reason, in the present study three commercial disperse dyes were chosen. In order to determine how the effects of various pre-settings on dye-uptake of polyester fibres change towards dye's diffusion abilities, three disperse dyes – Palanil Marine Blue 3GR-CF (C.I. Disperse Blue 79:1), Palanil Dark Blue 3RT (C.I. Disperse Blue 148) and Palanil Yellow 3G

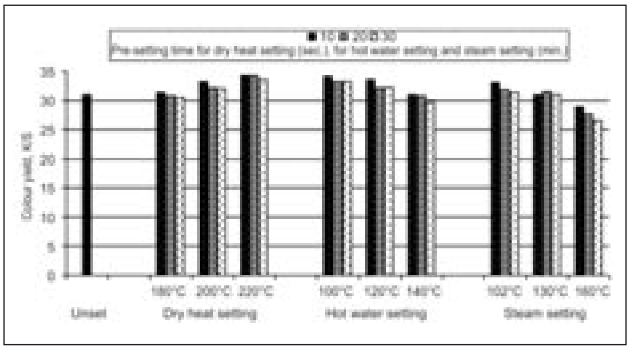


Fig. 1. Effects of various pre-setting on colour yield of C.I. Disperse Blue 79:1 dyeing (Diffusion number: 5)

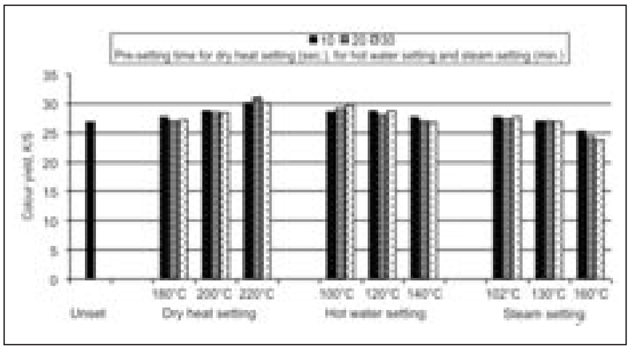


Fig. 2. Effects of various pre-setting on colour yield of C.I. Disperse Blue 148 dyeing (Diffusion number: 7)

(C.I. Disperse Yellow 64) – were used in the experiments. Their diffusion numbers are 5, 7 and, respectively, 9.

Dyeing of polyester fabrics

Fabric samples pre-set with various methods, temperatures, and times and unset samples were dyed in the same bath with a liquor ratio of 1:15 in 2% owf depths with a laboratory scale Thermal HT dyeing machine. In dyeing recipes, acetic acid was used to set the *p*H to 5, and in order to avoid side effects, no further dyeing auxiliaries were used. Dyeing was started at 80°C at after 15 minutes the temperature was raised to 130°C with a heating rate of 1°C/minute and kept at this temperature for 30 minutes. Then temperature was cooled to 70°C with a rate of 1°C/minute and the dyed polyester fabrics were taken out of the dye bath. Fabrics were rinsed, reductive washed (with 5 ml/l NaOH, 3 g/l $Na_2S_2O_4$ at 70°C for 15 minute) and rinsed. The dyed fabrics were then dried at room temperature.

Colour measurements of dyed samples

Colour Yield (*K/S*) values of the samples were measured (at min. reflection wavelength of each dyes) by a Minolta 3600d spectral photometer with D 65/10°.

RESULTS AND DISCUSSIONS

In this study, the effects of pre-setting on dye-uptake behaviour of polyester fabrics and on the colour yield obtained after dyeing were examined. Colour yields of the samples dyed with C.I. Disperse Blue 79:1, C.I. Disperse Blue 148, and C.I. Disperse Yellow 64 are shown in figures 1, 2 and 3.

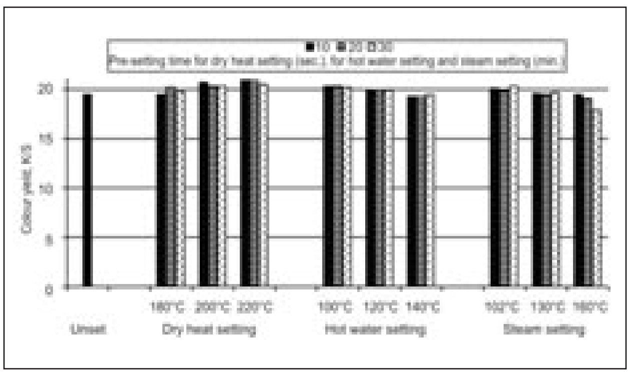


Fig. 3. Effects of various pre-setting on colour yield of C.I. Disperse Yellow 64 dyeing (Diffusion number: 9)

It can be clearly seen from the figures that for the dry heat set samples, the dye-uptake properties increased with rising heat setting temperature (180-220°C). For the effect of time, it can be said that duration of heat setting generally does not significantly affect colour yield except the steam setting at 160°C.
The role played by the structure and morphology of polyester on its dye diffusion behaviour has been well documented. Several attempts have been made to establish qualitative and quantitative correlations between dye diffusion on the one hand, and the structure and morphology of polyester on the other. A common feature observed for annealed polyester in these works is that the dye uptake decreases initially as the annealing temperature increases and shows a minimum at a temperature range of 180–200°C and then increases with rising annealing temperature [5].
Dumbleton and ***Murayama*** suggested that the dye uptake in polyester is controlled by the number of crystals present and the orientation of the amorphous phase. This is based on the fact that the dye diffusion depends on the segmental mobility of the amorphous region, which in turn depends on the order in this region and the number, size and size distribution of the crystallites [5]. In thermofixation processes which are carried out above a temperature which is called as "critical thermofixation temperature", separation starts between crystalline and non-crystalline regions of fibre. Less stabilized small crystallites begin to form more stabilised big crystallites or to attend to the fibrils. This separation gets more evident when thermofixation temperature and tension is increased. According to this theory, during thermofixation processes which are carried out above critical thermofixation temperature, with the increasing of temperature, amount of the small crystallites in the matrix decreases and in lower amounts but big and more stabilized crystallites are formed. As a result "free volume" which dye molecules can pass through increases and hence dye-uptake increases [9]. For samples that have been hot water set, dye uptake decreases by increasing temperature. Furthermore, the effect of hot water setting is not dependent on time.
During fixation processes, energy is needed in order to get over the interactions between macromolecules and to melt the crystallites. In thermal processes (thermofixation) all energy required is supplied from the heat energy, but in hydrothermal processes (hydrofixation) also chemical energy of the water plays role. Chemical

energy of water which has effect on fibres will be same both for low temperature and high temperature hydrofixation conditions. As a result, in hydrofixation processes the effective temperature of fixation process is approximately 35°C higher than the water's temperature [9]. As a result the effective temperature of hydrofixation carried out at 100, 120 and 140°C are approximately 135, 155 and, respectively, 175°C. The reason of these results could be well understood by taking into consideration that the dye uptake of PES fibres decreases initially as the annealing temperature increases and shows a minimum at a temperature range of 180–200°C [5].

In the case of samples that have been steam set, dye-uptake decreases by increasing steaming temperature. Although, the effect of hot water settings at 102°C and 130°C are not dependent on time, colour yields of dyed samples decrease with the increasing steaming time at 160°C. In literature it was stated that the effective temperature of steam setting carried out 10–30 minutes is 35°C higher than steaming temperature [9]. As a result the effective temperature of steaming carried out at 102, 130 and 160°C are approximately 135, 165 and, respectively, 195°C. As mentioned above, by taking into consideration that the dye uptake of PES fibres decreases initially as the annealing temperature increases and shows a minimum at a temperature range of 180–200°C [5], the reason of these results could be understood.

In this study it was found that type of pre-setting and its conditions (temperature and time) has higher impact on colour yield of dyes having low-medium diffusion number. For the dye having high diffusion number, type of pre-setting and its conditions has lower effect. It is thought that dyes having high diffusion numbers are less sensitive for the structural changes of fibres which are caused by pre-setting treatments, because their diffusion ability is high and activation energy for diffusion is low.

CONCLUSIONS

Colour yields of the fabrics pre-set by dry heat setting (thermofixation) increased drastically by rising temperature. Increase colour yields of the dry heat set samples is thought to be occurred due to the formation of bigger and more stabilized crystallites in fibre structure and hence increasing of free volume which allows dye penetration. However colour yields of the fabrics pre-set by steam setting or hot water setting decreased by rising temperature. Generally it can be said that pre-setting time does not have a significant effect on colour yields except steam setting at 160°C.

Pre-setting of the polyester fibres is an important aspect for textile dyers for right-first-time dyeing due to the aforementioned effects on colour yields. The differences between the setting parameters in different times could affect reproducibility. Also, the uniformity of the pre-setting is important in terms of an even dyeing. It was determined that a small difference in temperature leads different sorption characteristics, as a result significantly uneven dyeing would occur.

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Biopolymers from protein wastes used in industry and agriculture

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REZUMAT – ABSTRACT – INHALTSANGABE

Biopolimeri din deşeuri proteice folosiţi în industrie şi agricultură

Lucrarea prezintă un proces inovativ privind degradarea biochimică a deşeurilor de piele gelatină, în vederea obţinerii de biomateriale utilizabile atât în industria textilă şi de încălţăminte, cât şi în agricultură – ca fertilizatori pentru remedierea solurilor degradate şi creşterea plantelor. Procedeul propus presupune tratarea deşeurilor de piele netăbăcită printr-o hidroliză a deşeurilor proteice în mediu enzimatic, obţinându-se un biopolimer proteic care – fie singur, fie în combinaţie cu alţi polimeri (acrilici, maleici, poliacrilamidă, celuloză, amidon etc.) – poate fi utilizat în industrie şi agricultură.

Cuvinte-cheie: biopolimeri, deşeuri proteice, enzime, textile

Biopolymers from protein wastes used in industry and agriculture

The paper presents an innovative process for biochemical degradation of gelatin leather wastes in order to obtain biomaterials which can be used in both textile and footwear industry and in agriculture as fertilizers for remediation of degraded soils and for plant growth. The proposed procedure implies treating untanned leather wastes by a hydrolysis of protein wastes in enzymatic environment, obtaining a protein biopolymer which, either by itself or combined with other polymers (acrylic, maleic, polyacrylamide, cellulose, starch etc.) will be used in the industry and in agriculture.

Key-words: biopolymers, protein wastes, enzymes, textiles

Biopoymere aus proteischen Abfällen mit Anwendung in der Industrie und Landwirtschaft

Die Arbeit stellt vor ein innovatives Prozess für den biochemischen Abbau der Lederabfällen, für die Produzierung von Biomaterialien mit Anwendung in der Textil- und Lederindustrie, sowie in der Landwirtschaft – als Düngemittel für abgenutzte Böden und Pflanzenwachstum. Das vorgestellte Verfahren besteht in der Behandlung der nichtgegerbten Lederabfällen durch eine Hydrolyse der proteischen Abfällen in enzymatischen Mitteln, in dem ein proteisches Biopolymer produziert wird, welches – entweder Einzeln oder in Mischung mit anderen Polymeren (akrylisch, maleisch, polyakrylamidisch, zellulosisch, Stärke) – in der Industrie und in der Landwirtschaft angewendet werden kann.

Stichwörter: Biopolymere, proteische Abfälle, Enzyme, Textilien

The paper presents leather waste recovery from tanneries, identifying methods and technologies for the recovery and recycling of untanned leather waste (gelatin leather). As it is known from technological practice of tanneries, out of 1 000 kg of raw hides (raw material), 250 kg are found in finished leather and the rest of 510 kg are leather wastes (of which 315 kg are untanned leather wastes). Given that, at present, 99% of leather wastes are stored in the landfill and the amount of processed hides in a tannery is about 10 tons/day, the importance of this area can be estimated economically and environmentally.

Pollutant quantities range from one tannery to another, depending on the type of leather processed and the types of processes used. It should be noted that from a ton of raw hide, only 240–250 kg of grain leather are obtained (fig. 1).

Most tanneries and leather product manufacturers have serious problems regarding waste discharge, with possible harmful effects on the ecosystem. Several options can be used to recycle or reuse organic wastes:

- they can be used in the textile industry and in the footwear industry;
- gelatin and glue can be obtained from untanned leather and untanned wastes are processed to obtain meat product packaging;
- fat can be separated and recycled, but this can only be implemented in exceptional cases;
- recovering collagen from trimming wastes (after lime bathing) and split trimmings, have various uses as

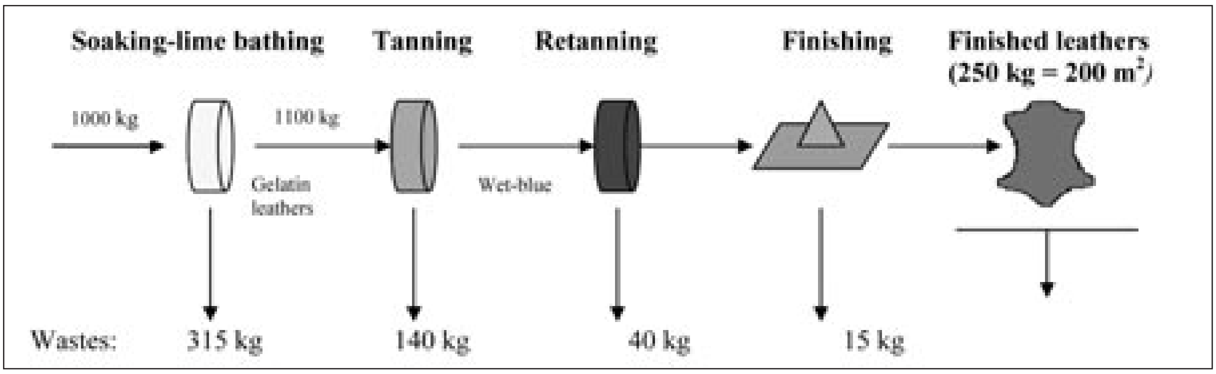

Fig. 1. Balance for a typical process of tanning with basic chromium salts

Note: Data taken from the paper *"Pre-feasibility study for reduction of impact on the environment, caused by the Romanian leather sector"*, elaborated by Italprogetti Engineering S.R.L. – Italy, 2000–2001

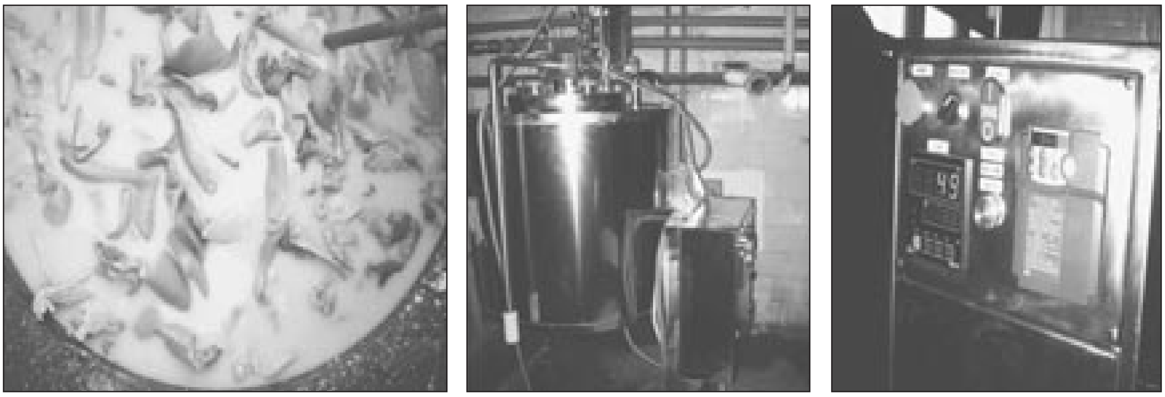

Fig. 2. Protein wastes and equipment for their hydrolysis

additives in bakery and meat processing, in pharmaceutical and cosmetic products, and in rubber products;
- gelatin leather wastes can be used to obtain insoles from leather fibres for footwear;
- recovery of protein (protein hydrolysate) from split trimmings for instance, to turn them into fertilizer.

EXPERIMENTAL PART

Bioproducts based on collagen have applications in a very wide range of areas: medicine, pharmacy, cosmetics, textile industry, food industry, agriculture etc.

Current technologies are mainly destined for untanned leather wastes and generally aim at extracting collagen protein, the basic leather component, in the form of short fibers of dissolved, for the highest yield, which can be used as protein binder, as collagen source in the pharmaceutical and cosmetic industry, in the footwear industry to manufacture insoles obtained from tanned (chrome) leather wastes, or to obtain fertilizers [1].

Global research on leather waste recycling is directed towards obtaining protein compounds, through biochemical treatments with microorganisms/enzymes and obtaining hydrolyzed proteins and protein binders with various uses.

All treatments applied to wastes mainly aim at considerably reducing environmental pollution. For this purpose, untanned leather wastes (fleshing, splitting and gelatin fleshing, as well as proteins from the solution exhausted from lime bathing) are the most suitable for processing in the form of proteins, with various degrees of denaturation and purity.

Biochemical treatment consists in processing gelatin leather wastes with a set of enzymes, co-enzymes and natural breeders with “starter” liquids [2, 3].

The commercial enzyme product is a set of selected microorganisms combined with hydrolytic enzymes (COH), coenzymes and natural enhancers potentiated by starter liquids which catalyze reactions in the decomposition of the entire material, controlling ammonia, hydrogen sulphide exhaustions, mercaptans, specific odours etc. One such product that has been used is made in Switzerland. It contains: 30 000 MWU lipase, 900 unit./g cellulase, 1 200 unit./g amylase and 10 000 unit./g protease. Thus an important control of colibacteria and pathogens is obtained and the fertility of the land it is spread on increases (it eliminates the organic crust). The proposed technological process includes the following operations 4, 8]:
- a quantity of gelatin leather wastes is washed with running water at the temperature of 20–25°C in a drum for 20–30 minutes (because it is highly alkaline);
- then leather wastes are ground with a special grinder (with double blades), obtaining a pasty, homogenous mass – protein biopolymer.

This protein polymer is introduced into an autoclave equipped with heating jacket and agitator and left for 2–3 hours at 80°C.

Then temperature is reduced at 35–40°C and components *A, B* and *C* of an enzymatic product of swiss origin are introduced. It is left for about 1–2 hours and taken out of the autoclave in plastic drums.

The paper also presents the installation of obtaining biocompost-bioreactor, with all facilities necessary to monitor the composting process on the computer [fig. 2].

RESULTS AND DISCUSSIONS

This protean biopolymer can be used in the textile industry and in the footwear industry to manufacture insoles and artificial soles.

Experimenting bioproducts as textile finishing agents has highlighted the fact that the best results regarding hygienic-functional properties are obtained in the case of neutral hydrolysates. Bioproducts based on collagen – vegetable extracts to treat textile materials and furs are efficient and easy to apply in material finishing technologies. There are known compositions of treating wool containing emollient products orienting on the fabric surface, forming a protective layer and spacing the fibres, so that upon friction a sliding friction is caused and the friction of spinning fibres is avoided.

Quaternary ammonium products and derivatives of fatty acids, especially amides endow fabrics with softening properties, but do not ensure superior wear resistance properties, leading to premature disuse of objects made of these fabrics. Wool fibers undergo more or less advanced degradation during processing, depending on the temperature, duration of treatment, *p*H of environment, degradation which is manifested by weight loss and a change in the properties, leading to lack of touch of fabrics and causing great difficulties in the case of spinning painted strips.

Fig. 3. Influence of biocompost on corn plants and wheat:
1, 2 – BAZ 50; *3* – untreated

The purpose of the paper is to expand the assortment range adding a product giving superior properties of surface protection of wool fibers and higher recovery of recyclable materials. The problem that the paper solves is that of establishing reaction conditions, so that leather wastes can be easily hydrolysed and polypeptide residues obtained have a corresponding degree of polymerization to an optimal grafting on the fabric [5, 6]. The product thus obtained is used in textile technology in proportion of 2–5% as auxiliary for protection of natural fibers. The product is used in dyeing and bleaching, avoiding felting, in improving dyeing and touch characteristics of the fiber and it is also used in washing, avoiding loss of substance. Results of research highlight the fact that proteins such as collagen hydrolysate can be used in the textile industry to obtain collagen bioproducts – vegetable extract with insecticide action. Substances in this category are combined with keratins; they create more stable links between their polypeptide chains than disulphide chains and keratins treated in this way are no longer aminolyzed by larvae. Treatment with bioproducts based on collagen and vegetable extracts is done before or after tanning furs. Insecticide properties are established by testing bioproducts on wool and wool-type materials. The higher the bioproduct concentration, the greater the repellant effect (behaviour towards insects: preference or repulsion), the best effect is that of collagen-lavender extract complex.

Recent research made in Central and Eastern Europe have highlighted that in these countries the main degradation processes induced by the human activity is the reduction of soil fertility, crust formation, water and wind erosion, slides and chemical pollution. The compost can be used in the garden as soil enhancer and fertilizer. In addition, it can be used as natural additive and fertilizer for garden mould. In light and sandy soils, compost enhances water retaining capacity, and helps settle nutritive elements. For use in agriculture 5–6.5% dipotassium phosphate is added to the protean biopolymer, contributing to improvement of nutritive properties though the content of phosphorus and potassium. In hard and clayish soils, compost improves the soil structure [4, 7]. Positive effects are a better aeration, and tilling the land is easier. On the other hand, the soil becomes less sensitive to settlement and silting. Compost contains all essential nutritive elements and necessary oligoelements for plant growth. It is applied either at the operation of spraying with herbicides or diluted in the irrigation system or when seeding.

For correct application of products with a role in improving soil structure and developing agricultural crops, soil attributes must be known first of all, and then the specific nutrient requirements of the crop, the role each of these in plant life, the specific interaction of each element in the soil-plant-nutrient level. Depending on the knowledge of these complex interactions and the role of each individual item, the types, doses and times of incorporating soil remediation products are chosen [9]. Field experiments with this compost showed that nitrogen was released into the soil at a low rate; therefore, the compost should be classified as long-term nitrogen fertilizer [10]:

- Application of biocompost (BAZ 50) is recommended in wheat before seeding, so that coronary roots can form in the fall, to stimulate growth of embryonic roots, which are of great importance for wheat plant growth (fig. 3). These roots basically provide wheat transition over winter; they have the main role in absorbing water and nutrients during intensive plant growth. In the twinning large amounts of nutrients are accumulated, which in fall wheat play a central role for resistance to low temperatures and increasing production per unit area.
- Production of wheat recorded in the variant treated with BAZ 50 sample is significantly higher than that obtained from untreated variant.
- The variant to which BAZ 50 was applied in a dose of 10 tons/ha, maize plants had a “significantly” greater height than the untreated variants. Corn production obtained was statistically ensured, recording harvest increases.

CONCLUSIONS

The paper presents an innovative process for biochemical degradation of gelatin leather wastes in order to obtain biomaterials which can be used in both textile and footwear industry and in agriculture as fertilizers for remediation of degraded soils and for plant growth.

The proposed procedure implies treating untanned leather wastes by a hydrolysis of protein wastes in enzymatic environment, obtaining a protein biopolymer which, either by itself or combined with other polymers (polyacrylamide, acrylic, maleic, cellulose, starch etc.) will be used in the industry and in agriculture. For use in agriculture, natural protein sources must be enhanced by adding nutritional elements (P, K, Br etc.), thus resulting complex protein systems/composts used for plant growth and remediation/conditioning of degraded soils. Biofertilizers were field tested, on various soil types (humus, clay, forest reddish brown) and on various vegetable crops administrating quantities between 10–25 tons/ha. As a result of experiences, production increases of 19-39,7% were found.

It can be concluded that as a result of experiments in both industry and agriculture, the obtained protein biopolymers have had very good results.

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CURSURI DE CALIFICARE DESFĂȘURATE ÎN CADRUL PROIECTULUI *„FORMAREA PROFESIONALĂ ÎN SPRIJINUL INTRODUCERII UNOR METODE INOVATIVE DE ORGANIZARE A MUNCII ÎN SECTORUL CONFECȚII TEXTILE DIN REGIUNEA SUD MUNTENIA“*

Institutul Național de Cercetare-Dezvoltare pentru Textile și Pielărie – București, în calitate de beneficiar, anunță că, în cadrul proiectului POSDRU/35/3.2/G/15718, s-au desfășurat cursuri de calificare pentru 36 de persoane din cadrul grupului țintă „manageri“ și 177 de persoane din cadrul grupului țintă „angajați“, de la 9 firme de confecții, din 4 județe – Argeș, Ialomița, Dâmbovița, Prahova.

Redacția

Experimental investigation on the static and dynamic strength of false twist textured polyester yarns

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REZUMAT – ABSTRACT – INHALTSANGABE

Studiu experimental privind rezistența statică și dinamică a firelor din poliester texturate cu torsiune falsă

Proprietățile mecanice ale firelor reflectă performanța acestora pe parcursul proceselor de prelucrare ulterioară. Pentru estimarea performanței sunt analizate unele proprietăți, cum ar fi rezistența la tracțiune. Însă, aceste proprietăți nu pot indica în totalitate performanța mecanică a firelor în timpul filării și a proceselor de prelucrare ulterioară, fiind indici mecanici statici. Scopul acestui studiu este acela de a realiza o comparație între valorile rezistenței la tracțiune statice și dinamice, pentru firele din poliester texturate cu torsiune falsă și de a studia efectul parametrilor de producție, al ratei laminării și al presiunii jetului asupra valorilor rezistenței firelor. În cadrul experimentului s-au efectuat teste de determinare a rezistenței dinamice, cu ajutorul instrumentului CTT, simulând condițiile de utilizare. Testele de rezistență statică au fost efectuate pe aparatul de testare a tracțiunii Zwick Z010, iar rezultatele obținute au fost evaluate statistic. S-a constatat că rezistența dinamică este cu aproximativ 10,4% mai mică decât rezistența statică, la toate tipurile de fire.

Cuvinte-cheie: rezistență statică, rezistență dinamică, fir texturat cu torsiune falsă, tester CTT

Experimental investigation on the static and dynamic strength of false twist textured polyester yarns

The mechanical properties of the yarns reflect their performance during the subsequent processes. In order to predict their performance, some testing indexes like tensile strength are used. Yet, these parameters cannot completely indicate the mechanical performance of the yarns in the spinning and subsequent processes, since they are static mechanical indexes. The aim of this study is to make a comparison between static and dynamic tensile strength values for the false-twist textured polyester yarns, and to investigate the effect of production parameters, draw ratio and jet pressure on the strength values of the yarns. In the experiment, dynamic tensile tests have been conducted by CTT instrument to simulate the dynamic using conditions. Static tensile tests were measured by Zwick Z010 Universal Tensile Testing Machine and the test results were evaluated statistically. The dynamic strength was found approximately 10.4% lower than the static strength for all types of yarn.

Key-words: static strength, dynamic strength, false twist textured yarn, CTT tester

Experimentelle Untersuchung betreff dem statischen und dynamischen Widerstand der Falschdrahttexturier-Polyestergarne

Die mechanischen Eigenschaften der Garne widerspiegeln deren Leistung während der nachträglichen Bearbeitungsprozesse. Für die Schätzung dieser Leistungen werden einige Eigenschaften analysiert, wie z.B. der Zugwiderstand. Doch, diese Eigenschaften können nicht gänzlich die mechanische Leistung der Garne während des Spinnprozesses und der nachträglichen Bearbeitungsprozesse anzeigen, weil sie statische, mechanische Indikatoren darstellen. Der Zweck dieser Untersuchung ist die Durchführung eines Vergleichs zwischen den Werten der statitischen und dynamischen Zugwiderstände, mit Hilfe eines CTT Instrumentes, indem die Anwendungsbedingungen simuliert werden. Die statischen Widerstandsteste wurden auf dem Zugtestapparat Zwick Z010 durchgeführt und die erhaltenen Ergebnisse wurden statistisch ausgewertet. Es wurde festgestellt, dass der dynamische Widerstand ungefähr 10,4% kleiner als der statische Widerstand bei allen Garntypen ist.

Stichwörter: Statischer Widerstand, Dynamischer Widerstand, Falschdrahttexturiergarn, CTT Tester

Since synthetic yarns do not have the appearance and handling characteristics of natural fibers, certain processes have to be applied to synthetic yarns in order to combine the superior properties of synthetics, like high strength, uniformity and stretch, with the features that are unique to natural fibers. Texturing is one of the processes that give to the synthetic yarns a crimped and bulky structure, a natural appearance, touch, warmth, stretchiness and bulkiness.

The method mostly used among texturing processes is false twist texturing, which is used in thermoplastic filaments. If a stationary multi-filament yarn is held at both ends and twisted in the center by suitable devices, the yarn will receive an equal amount of twist on each side. Although the twist on each side is not zero, the algebraic sum of the twist throughout the yarn is zero. As the false twist device is rotated continuously, a twist is formed in the moving yarn passing from the feed rollers to the twister, but it becomes untwisted due to the reverse twisting effect after the twisting zone. For this reason, this process is called false twist texturing [1].

There are several production parameters which influence the texturing process and the properties of the yarns. The most important parameter is the yarn temperature, which depends on the heater temperatures and the speed of the yarn, as it passes through the heating zone [2, 3].

The draw ratio is the other important production parameter which improves the orientation in the structure. Jet pressure is used in order to improve the quality of entanglements. The texturing speed, changes the duration in which the yarn is in the twisting unit [4, 5]. The ratio of the friction disk surface speed to the yarn speed is usually referred to as *D/Y* ratio.

Barmag M profile false-twist texturing machine is presented in figure 1 [20]. Changes in process parameters affect the mechanical properties of the yarns. De et al. [7] searched the tensile properties of the friction-twisted Nylon 6 texturized yarns. Four different contact times were chosen and for each contact time six heater temperatures were selected. It was found that for each contact time, with increase in heater temperature, the breaking stress of the yarn had decreased, while the breaking strain of the yarn had increased. The breaking stress of the yarn was found to be a function, not only of the strength of the constituent filaments, but also of the degree of dispersion in the differential crimp. The

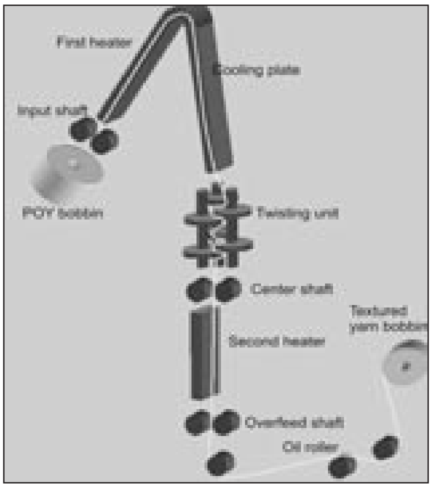

Fig. 1. Barmag M profile false-twist texturing machine

breaking strain of the yarn was observed to be more influenced by the magnitude of the decrimping extension than by that of the post-crimped extension.

Ghosh and Wolhar [8] worked on the influenced of some machine-setting variables on the properties of yarns in the friction-twist-draw-texturing process. For that purpose, they investigated the effects of primary heater temperature, center disc spacing, draw ratio and *D/Y* ratio on the resultant textured yarn properties. A significant interaction effect of primary heater temperature and disc spacing on the yarn dye uptake had been found. In addition, yarn dye uptake had decreased linearly with draw ratio. It was reported that the effects of *D/Y* ratio on the yarn properties are significant.

Sengupta et al. [9] developed a method to characterize the stability of air textured yarns with repeated load testing using an Instron tensile tester. They compared the instability values obtained with other methods with those using this method and assessed the influence of process variables such as overfeed, air pressure, dry and wet texturing, and heat stabilization on the structural integrity of air textured yams with the different methods. They observed that the test method, which uses recovery from a given load as a criterion for yarn instability, provides a more realistic assessment of structural integrity than the method that uses an extension percentage at a given load.

In Kveder et al., study [10], the results of dynamic mechanical testing of five industrially produced partially oriented yarns (POY) and two conventionally spun and drawn PA 6.6 filament yarns are presented, along with some of their structural parameters. Dynamic mechanical spectra of POY samples differ from conventionally spun and drawn yarns across the entire testing temperature range from 20 to 260°C according to their superstructure parameters.

Pal et al. [11] studied the effects of texturing variables – draw ratio, *D/Y* ratio, first heater temperature and heater contact time on tensile properties, crimp characteristics, dye uptake, broken filaments and tight spots – on microfiber polyester yarns. They found that the first heater temperature and draw ratio had significant influence on tensile, crimp and dyeing properties. With increased *D/Y* ratio, broken filaments decreased but tight spots increased. They explained that increased heater temperature improves the crystalline structure of the polyester fiber and increases crimp stability and it was found that a proper selection of *D/Y* ratio gives acceptable levels of broken filaments and tight spots.

Rengasamy et al. [12] stated that, tensile and dimensional properties of air-jet and textured yarns are affected by air pressure, overfeed and different overfeed levels of the core and effect components. It was found that, there was considerable deterioration in the tenacity and modulus of yarns after texturing and yarn breaking extension mostly decreases after texturing. They also explained that yarns textured at higher air pressures have poor strength and low instability.

Karakaş and Dayioğlu [2] investigated the effect of texturing parameters in a false-twist draw-texturing process on the mechanical properties and the structure of polyamide yarns. A high-temperature heater was used in the study. The important effects of texturing temperature and time on the mechanical, crimp and structural parameters were studied. Filament breakage rate was also investigated as a function of the *D/Y* ratio. According to the results, as texturing speed increases, the yarn residence time in the heater decreases and this causes a reduction in crystalline orientation function, crystal size and breaking strength of the yarn. Stabilization of the texturing process is improved, as the *D/Y* ratio increases.

The effect of various material and testing parameters on the static and dynamic failure mechanisms of cotton ring yarns of several counts has been studied by Ishtiaque et al. [13]. The comparison of static and dynamic yarn strength is carried out to assess the over estimation of static yarn strength. This difference in two types of strength can be attributed to the difference in their failure mechanisms and length of yarn over which strength is measured.

Yildirim et al. [6] investigated the effect of *D/Y* ratio and draw ratio on the crimp and tensile properties and percent crystallinity of the false-twist textured yarns. While there was no noticeable change on the percent crystallinity by altering these parameters, tenacity increased and crimp contraction decreased with increasing draw ratio, and crimp stability decreased when the *D/Y* ratio increased. *K/S* value also decreased with increasing draw ratio.

Advanced tensile testing instruments were used within the studies mentioned above in order to measure the mechanical properties of textured yarns, so the detailed information about the static tensile properties can be observed.

A certain length is executed in the measurement of standard yarn static tensile strength. A clamped yarn breaks in its weakest place according to the so-called principle of the weakest link and this strength value is assigned to the whole length. As the test sample is gripped at the two ends and maintain that static state during the testing process and the strength measured by single thread tensile test method is referred to as static yarn strength. Standard evaluation is the result of a measured strength file of the weakest links, while the strength of the other places situated on clamping lengths is not measured. The basic characteristics of distribution (average value, standard deviation and

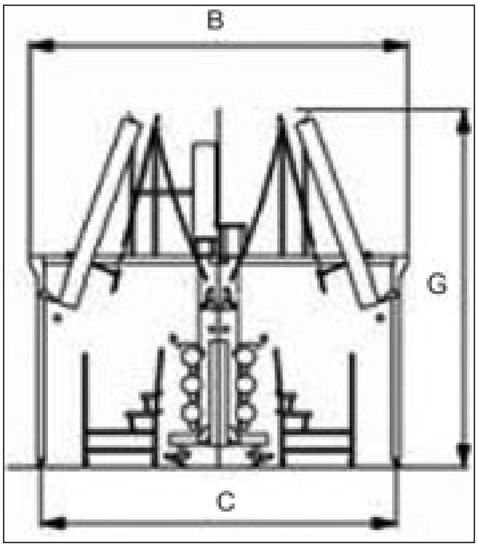

Fig. 2. M configuration for the texturing machines FK6-M1000

coefficient of variation) of the measured values are as a rule calculated but the order of the measured values and the relations between these values and the length of links are not usually examined [14].

Static strength can not accurately predict the running behavior of yarn on subsequent machines. Continuous tensile testing of yarn involves transporting the yarn under constant tension at constant output speed. Thus, in continuous testing mode, every inch or millimeter of yarn is tested to generate true elongation of yarn at specific dynamic tension, the speed condition and tensile characteristics are continuously assessed. The actual manufacturing conditions are simulated by the continuous testing more closely than by the static tensile testing [14, 15–18].

In the subsequent machining process, yarn continually suffers tension and friction and always be in the dynamic status, but not in the static status. Therefore, it is more important to research the mechanical properties of yarns under the dynamic condition [19].

According to the literature review, there is not a comprehensive study including the effects of different process parameters on the static and dynamic tensile properties of false-twist textured polyester yarns, which was aimed in the experiment. The objective of this study is to measure the static and dynamic tensile strength values of the false-twist textured yarns, to make a comparison according to the measured parameters and to investigate the effect of production parameters on the strength values of the yarns.

MATERIALS AND METHOD

In order to investigate the effect of heater temperatures, draw ratio, delivery speed, *D/Y* ratio and jet pressure on the strength values of the yarns, static and dynamic tensile strength tests were conducted by using 14 different false-twist textured polyester yarns in 110/36 denier. Barmag FK6-1000 (M configuration) false twist texturing machine was used for the texturing process. M configuration for the texturing machines is presented in figure 2.

The values of processing parameters used for the tested yarns are given in table 1. Delivery speed is the

Table 1

PROCESS VARIABLES OF THE SELECTED FALSE-TWIST TEXTURED YARNS						
Yarn code	Delivery speed, m/min.	T_1, °C	T_2, °C	*D/Y* ratio	Draw ratio, W_2/W_1	Jet pressure, bar
1	600	190	190	1.90	1.66	3.5
2*	700	190	190	1.90	1.66	3.5
3	800	190	190	1.90	1.66	3.5
4	700	170	190	1.90	1.66	3.5
5	700	210	190	1.90	1.66	3.5
6	700	190	170	1.90	1.66	3.5
7	700	190	210	1.90	1.66	3.5
8	700	190	190	1.70	1.66	3.5
9	700	190	190	2.10	1.66	3.5
10	700	190	190	1.90	1.61	3.5
11	700	190	190	1.90	1.71	3.5
12	700	190	190	1.90	1.66	0
13	700	190	190	1.90	1.66	2.5
14	700	190	190	1.90	1.66	4.5

* The yarn coded 2, was used as the reference yarn for the comparisons

texturing speed, which was selected in three different values. T_1 and T_2 temperatures are the temperatures of the first and the second heater, which were selected as 170°C, 190°C and 210°C. D/Y ratio was selected as 1.70, 1.90 and 2.10. Draw ratio was selected as 1.61, 1.66 and 1.71. Jet pressure, which was changed up to 4.5 bars.

"Disk-type friction texturing" method was used and the ceramic disk material was selected in 9 mm thickness.

In order to measure the static tensile strength properties of the test yarns, a Zwick Z010 Universal Tensile Test Machine was used in the experiment. The static strength values of the yarns were tested according to ISO 2062 by using 250 mm test length and 100 mm/min. test speed. The dynamic yarn strength values were measured by Lawson-Hemphill CTT (Constant Tension Transport) Instrument (fig. 3). The CTT Dynamic Tensile Strength Test is designed to simulate the stress on the yarn during textile manufacturing. Also known as "Weak Spot Test" is used to check the "local" strength of the yarn, if the yarn will survive the dynamic tensions that occur during winding, weaving or spinning.

The device provides constant "Input Tension" on the yarn, as it is running during the test. This is the principle of dynamic yarn testing and it is maintained by the specially designed Tension Arms and the Yarn Drive Mechanism (It maintains Output Roll at constant speed while changing the Input Roll Speed on demand to keep the Input tension constant) [20]. The tension of

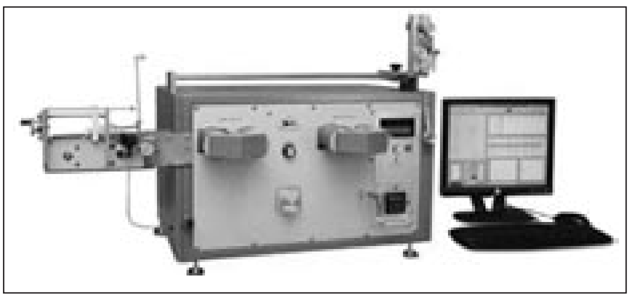

Fig. 3. CTT instrument

Table 2

p VALUES OF VARIANCE ANALYSES						
Tensile strength	Delivery speed	T_1, °C	T_2, °C	*D/Y* ratio	Draw ratio, W_2/W_1	Jet pressure, bar
Static tensile strength	0.025*	0.028*	0.024*	0.007*	0.003*	0.018*
Dynamic tensile strength	0.035-	0.000*	0.002*	0.001*	0.000*	0.000*

* Statistically significant according to α = 0.05

the running yarn is increased step by step during the dynamic strength tests, until the yarn is broken.

The instrument has four tension arms, which could be used in the tension ranges of: 1–10 g, 2–100 g, 10–300 g and 20–700 g. The tension arm, that has the capacity of 20–700 g, was used in the experiment, according to the preliminary tests. The test relative speed was adjusted as 100 m/min. and all the tests were conducted in standard atmosphere conditions (20°C ± 2°C temperature and the relative humidity of 65% ± 4%). The effect of the process variables on the static and dynamic strength was analyzed statistically. Variance analysis and multiple comparisons using Tukey post-hoc tests were done.

RESULTS AND DISCUSSIONS

After the tests, variance analysis was carried out, to determine whether the effects of production parameters on the static and dynamic tensile strength values for the textured poliester yarns are statistically significant. *p* values of the variance analyses are given in table 2.

In order to determine the effect of the process variables on the static and dynamic strength in detail, multiple comparisons were done with using Tukey post-hoc test (table 3). As it can be seen from table 3, the differences between dynamic tensile strength are generally statically significant, rather than differences between the static tensile strength values. Another point is that, for both static and dynamic tensile strength, the differences between the lowest and highest variables are significant.

For all types of tested yarns, the mean dynamic strength value is lower than the mean static strength value of the yarns. The decrease values were calculated as a percentage and given in table 4.

Figure 4 gives the effect of delivery speed on the strength values of the textured yarns. As the delivery speed increases, both static and dynamic strength values of the yarns increase [2]. According to the statistical analyses, the difference between the speed of

Table 3

p VALUES OF MULTIPLE COMPARISONS OF THE PROCESS PARAMETERS			
Parameters	Process variables	Static tensile strength	Dynamic tensile strength
Delivery speed	600–700 m/s	0.514	0.311
	700–800 m/s	0.094	0.219
	600–800 m/s	0.023*	0.029*
T_1	170–190°C	0.037*	0.002*
	190–210°C	0.974	0.004*
	170–210°C	0.048*	0.000*
T_2	170–190°C	0.299	0.047*
	190–210°C	0.151	0.002*
	170–210°C	0.020*	0.039*
D/Y ratio	1.70–1.90	0.055*	0.001*
	1.90–2.10	0.198	0.720
	1.70–2.10	0.006*	0.001*
Draw ratio	1.61–1.66	0.004*	0.000*
	1.66–1.71	0.049*	0.000*
	1.61–1.71	0.000*	0.000*
Jet pressure	0–2.5 bar	0.994	0.097
	0–3.5 bar	0.582	0.005*
	0–4.5 bar	0.020*	0.000*
	2.5–3.5 bar	0.719	0.189
	2.5–4.5 bar	0.029*	0.003*
	3.5–4.5 bar	0.127	0.057

* Statistically significant according to α = 0.05

600 m/min. and 800 m/min. was found statistically significant. This situation may be explained by the change of the duration, in which the yarn is in contact with the heaters. As the process speed increases, the contact duration will decrease and the heat transfer from the heaters to the yarn will decrease too [21]. Therefore, the efficiency of texturing will decrease and both the static and dynamic strength of the yarn will be higher.

This situation may be explained by the number of entanglements per meter, as well. Figure 5 gives the number of entanglements per meter according to the delivery speed, which is obtained from the optical

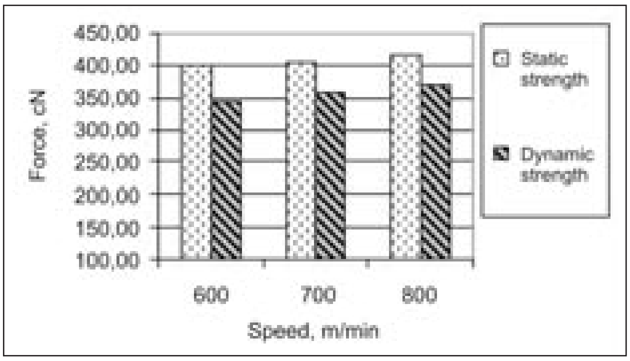

Fig. 4. Effect of delivery speed on strength values of textured yarns: $T_1 = T_2$ = 190°C, *D/Y* = 1.90, draw ratio = 1.66, jet pressure = 3.5

Table 4

DECREASE (%) IN STATIC AND DYNAMIC STRENGTH OF THE TESTED																				
	Delivery speed, m/min.			T_1, °C			T_2, °C			*D/Y* ratio			Draw ratio, W_2/W_1			Jet pressure, bar				Mean value
	600	700	800	170	190	210	170	190	210	1.7	1.9	2.1	1.61	1.66	1.71	0	2.5	3.5	4.5	10.41
Decrease, %	14.17	11.28	10.98	14.87	11.28	5.20	6.38	11.28	16.15	7.40	11.28	9.51	10.65	11.28	7.73	7.28	10.69	11.28	9.09	10.41

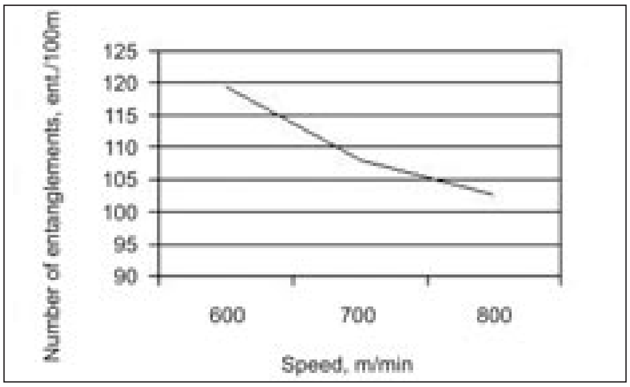

Fig. 5. Number of entanglements per meter vs. delivery speed: $T_1 = T_2 = 190^oC$, $D/Y = 1.90$, draw ratio = 1.66, jet pressure = 3.5

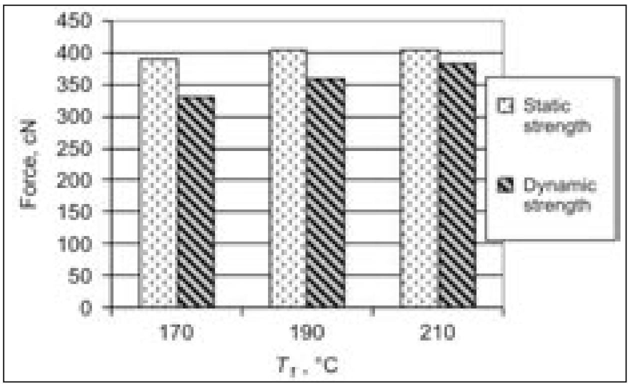

Fig. 6. Effect of first heater (T_1) temperature on strength values of textured yarns: delivery speed = 700 m/min., $T_2 = 190^oC$, $D/Y = 1.90$, draw ratio = 1.66, jet pressure = 3.5

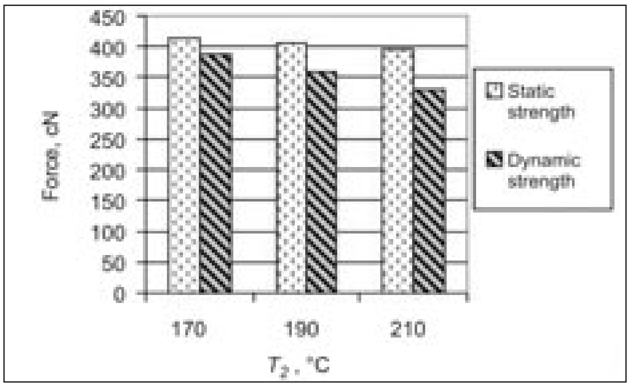

Fig. 7. Effect of second heater temperature (T_2) on strength values of textured yarns: delivery speed = 700 m/min., $T_1 = 190^oC$, $D/Y = 1.90$, draw ratio = 1.66, jet pressure = 3.5

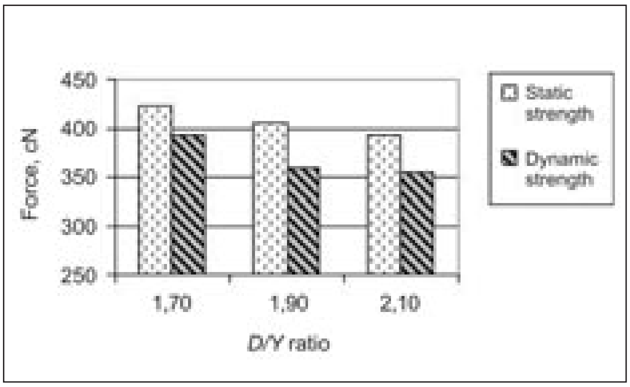

Fig. 8. Effect of D/Y ratio on strength values of textured yarns: delivery speed = 700 m/min., $T_1 = T_2 = 190^oC$, draw ratio = 1.66, jet pressure = 3.5

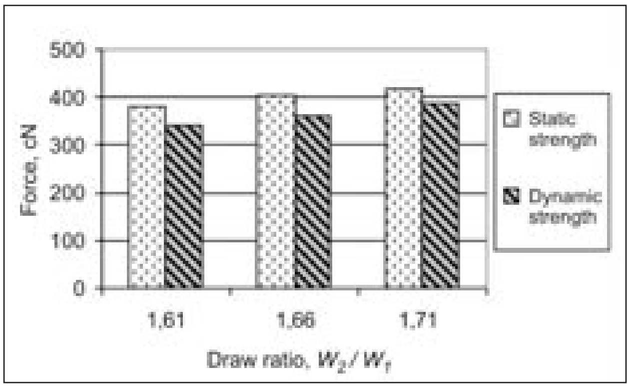

Fig. 9. Effect of draw ratio on strength values of textured yarns: delivery speed = 700 m/min., $T_1 = T_2 = 190^oC$, $D/Y = 1.90$, jet pressure = 3.5

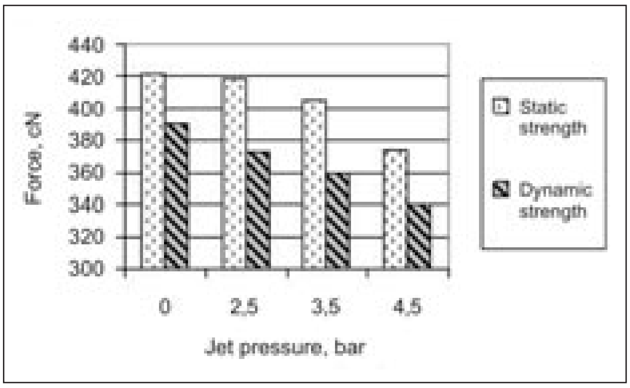

Fig. 10. Effect of jet pressure on strength values of textured yarns: delivery speed = 700 m/min., $T_1 = T_2 = 190^oC$, $D/Y = 1.90$, draw ratio = 1.66

module of CTT instrument. As it can be seen from figure 5, as the delivery speed increases the number of entanglements decreases. Being the entanglements on the yarn causes lower orientation of the filaments. So the higher number of entanglements per meter reduces the static and dynamic strengths of the yarns.

According to figure 6, as the first heater temperature T_1 increases, the strength values of the yarns increases. As the first heater temperature increases, the perfection of packing of the structural units increases, making them more compact [8]. During the texturing process, the orientation and the crystallinity of the fiber increase with the increasing first heater temperature as explained by Pal et al. [11].

As it can be seen in figure 7, the strength values decrease, while the second heater temperature, T_2, increases. As the T_2 temperature increases, some of the entanglements on the yarn structure can be damaged and the bulkiness can be increased [4]. This causes decrease in tenacity of the yarn.

The effect of the *D/Y* ratio on the strength [8] of textured yarns is given on figure 8. *D/Y* ratio directly affects twist level and yarn tension. At a lower *D/Y*, the ratio of disc speed to yarn speed decreases, the yarn is stretched between the false-twisting device and the exit roller. So due to the improvement in orientation and crystal perfection, yarn strength increases [21]. The decrease in tenacity in this study can be attributed to the reduced orientation.

According to figure 9, as the draw ratio value increases, the strength values of the yarns increases, which was explained by earlier studies [6, 8, 11]. As explained by Pal et al. [11] yarn tenacity gradually increases with increasing draw ratio, because molecular orientation increases with increasing draw ratio and first heater temperature.

The effect of jet pressure on strength values of textured yarns is given in figure 10. It can be clearly seen that, strength values decreases, as the jet pressure values increases, being similar with the Cirkin's result [4]. It is also related with the orientation of the filaments, which is lower for the increased pressure values. The yarns of which the orientations are the highest and have the highest static tensile and dynamic tensile strength values were produced by using zero jet pressure.

CONCLUSIONS

Testing of yarn strength is one of the most important parameters to assess the yarn quality and yarn performance during the process. The aim of the research is to determine the effect of production parameters on the static and dynamic strength values of the textured polyester yarns and to compare the strength values under the static and dynamic test conditions. According to the variance analyses tests, the effect of delivery speed, heater temperatures, *D/Y* ratio, draw ratio and jet pressure on the static and dynamic yarn strength are statistically significant. The static and dynamic strength values decrease, as the T_2 temperature, *D/Y* ratio and jet pressure increase. These values increase as the delivery speed, T_1 temperature and draw ratio increase.

Since, every inch or millimeter of yarn is tested in dynamic strength test, to generate true elongation of yarn at specific dynamic tension, in all cases, mean dynamic strength value will be lower than the mean static strengths value of the yarns. In the experiment, the dynamic strength was found approximately 10.4% lower than static strength.

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Modeling tensile strength of woven fabrics made from polyester/cotton blended warp yarns and 100% cotton weft yarns

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REZUMAT – ABSTRACT – INHALTSANGABE

Modelarea rezistenței la tracțiune a materialelor țesute, realizate din fire de urzeală dintr-un amestec de poliester-bumbac și fire de bătătură din 100% bumbac

Scopul acestui studiu a fost acela de a dezvolta modele statistice, bazate pe date empirice, pentru estimarea rezistenței la tracțiune a materialelor țesute, realizate din fire de urzeală dintr-un amestec de poliester-bumbac și fire de bătătură din bumbac. S-a studiat un număr total de 234 de mostre de țesături, având diferite structuri, realizate pe o mașină de țesut cu proiectil, din fire dintr-un amestec de poliester-bumbac, cu finețea de 15, 20 și 25 tex – în urzeală și fire de 20, 25 și 30 tex – în bătătură. Pe baza datelor obținute în urma testării rezistenței la tracțiune, au fost dezvoltate modele de regresie statistică, utilizând software-ul MINITAB. Acuratețea modelelor de predicție a fost determinată prin compararea rezultatelor estimate cu valorile reale ale rezistenței la tracțiune a încă 36 de mostre de material. Compararea valorilor prestabilite ale rezistenței la tracțiune cu cele reale a arătat o foarte mare acuratețe și abilitate a modelelor dezvoltate în estimarea rezistenței la tracțiune a materialelor.

Cuvinte-cheie: fir, material țesut, predicție, rezistență la tracțiune, modele de regresie

Modeling tensile strength of woven fabrics made from polyester/cotton blended warp yarns and 100% cotton weft yarns

This study aimed to develop statistical models, based on the empirical data, for the prediction of the tensile strength of woven fabrics made of polyester/cotton blended yarns in warp and cotton yarn in weft direction. A total number of 234 fabric samples of different constructions were made on a projectile weaving machine by using 15, 20 and 25 tex polyester/cotton blended yarns in warp and 20, 25 and 30 tex yarns in weft direction. Based on the tensile strength test data, statistical regression models were developed by using MINITAB statistical software. The accuracy of the developed prediction models was determined by comparing the predicted results with actual tensile strength values of additional 36 fabric samples. Correlation analysis of the predicted and actual fabric tensile strength values have shown a very strong ability and accuracy of the developed models for the prediction of fabric tensile strength.

Key-words: yarn, woven fabric, prediction, tensile strength, regression models

Zugwiderstandsmodellierung bei Gewebe mit Kettfäden aus Polyester-Baumwolle und Schussfäden aus 100% Baumwolle

Zweck dieser Untersuchung war die Entwicklung von statistischen Modellen aufgrund von empirischen Daten, für die Prädiktion des Zugwiderstandes der Gewebe mit Kettfäden aus Mischung Polyester-Baumwolle und Schussfäden aus Baumwolle. Es wurde eine Gesamtanzahl von 234 Gewebemuster auf Projektilwebmaschinen gefertigt, mit verschiedenen Strukturen aus Polyester-Baumwolle Mischungsfäden mit der Feinheit mit 15, 20 und 25 tex – in der Kette und Fäden mit 20, 25 und 30 tex im Schuss. Aufgrund der Daten erhalten als Folge der Zugwiderstandsteste, wurden statistische Regressionsmodelle mit Hilfe des Softwares MINITAB entwickelt. Die Genauigkeit der Prädiktion wurde durch den Vergleich der geschätzten Werten mit den reelen Werten des Zugwiderstandes bei 36 Materialmuster bestimmt. Der Vergleich der vorgeschriebenen mit den reelen Zugwiderstandswerte zeigten eine hohe Genauigkeit und Fähigkeit der entwickelten Modellen in der Schätzung des Materialzugwiderstandes.

Stichwörter: Fäden, Gewebe, Prädiktion, Zugwiderstand, Regressionsmodell

All textile fabrics have to conform to certain performance specifications depending upon their intended end use. These performance specifications include, but are not limited to: type of fiber(s) or blend used, yarn count, type of weave, fabric count, fabric weight (in grams/meter^2 or oz/yard^2), fabric tensile strength, etc. Since fabric tensile strength might change during fabric pretreatment, coloration and finishing, depending upon the processing conditions, selection of greige cloth with suitable strength is important in order to meet the strength requirement of the finished fabric, taking into account any strength loss during processing. Similarly, in order to produce a woven fabric of a specified tensile strength, selection of yarns of suitable tensile strength is also very critical. Although yarn strength is one of the key factors in determining the fabric strength, there are many other factors which also play a vital part in determining the final fabric strength, including fabric density and weave design [1, 2].

Although some research has been done in the past for the prediction of tensile behavior of woven fabric using geometric [3–7], mechanical [2, 8–10], energy [11] and statistical models [12], there is currently no simple prediction model based on the empirical data which could be used for the prediction of fabric strength of fabrics containing polyester/cotton yarns in the warp and cotton yarns in the weft direction, keeping into account all necessary factors such as given above.

This study was undertaken to develop regression models for the prediction of tensile strength of woven fabrics, made by using polyester/cotton yarns in warp direction with a blending ratio of 52:48 and cotton yarn in weft direction, using empirical data based on a carefully manufactured range of woven fabrics under controlled conditions.

EXPERIMENTAL PART

Polyester/cotton blended yarns of 15, 20 and 25 tex with a blending ratio of 52:48 while cotton yarns of 20, 25 and 30 tex were spun by ring spinning method using cotton fibres with 27.55 mm span length (2.5%), 13.08 mm span length (50%), 48.98% uniformity index, 4.70 µg/inch micronaire, 87 500 lbs/in^2 fibre bundle strength and 7.2 % trash content, and polyester fibres with 38 mm staple length, 1.2 denier fineness, 6.8 g/tex tenacity, and semi-dull lustre.

Table 1

SPECIFICATIONS OF POLYESTER/COTTON YARNS			
Yarn properties	Values for 15 tex PC	Values for 20 tex PC	Values for 25 tex PC
Breaking force, cN	272.47	391.82	537.936
CV, %	9.45	8.90	8.50
Elongation, %	7.25	7.96	8.19
CV, %	9.85	9.90	10.10
Linear density, tex	14.66	19.77	24.86
CV, %	1.23	1.54	1.25
Unevenness, %	12.59	13.79	12.15
T IPI	956	785	731
Hairiness	5.79	6.16	6.72
Twists per meter	1049.20	841.47	747.97
CV, %	3.22	3.92	3.95

Table 2

SPECIFICATIONS OF COTTON YARNS			
Yarn properties	Values for 20 tex cotton	Values for 25 tex cotton	Values for 30 tex cotton
Breaking force, cN	311.18	402.45	495.36
CV, %	10.90	9.12	8.28
Elongation, %	5.89	6.32	6.84
CV, %	8.32	10.60	7.01
Linear density, tex	20.50	25.41	30.37
CV, %	1.23	2.15	1.35
Unevenness, %	15.46	14.36	12.73
T IPI	1271	1037	513
Hairiness	6.98	7.08	7.40
Twists per meter	999.65	868.73	764.28
CV, %	2.88	3.89	3.57

One hundred cones of yarns of each count were selected randomly from the lot spun and tested for their characteristics after conditioning in standard atmosphere for the 48 hours. Linear density of yarns was determined according to ISO 2060:1994 test method. Tensile properties of yarns were measured by Uster Tensorapid-4 according to ISO 2062:1993 test method. Uster Tester-4 was used to determine *Um*, %, total imperfections (thin places, thick places and neps), and hairiness according to ISO 16549:2004 test method. Semi-automatic twist tester was used to measure the twist per meter in the yarn according to ISO 17202:2002. The specifications of polyester/cotton yarns are given in table 1 and of cotton yarns in table 2.

One hundred and thirty five (135) fabric samples each in plain weave (float length = 1) and twill weave (float length = 3) were woven on projectile weaving machine (P 7150), according to the constructions given in table 3. All warp yarns were sized before weaving with a size percentage of 12.5%, using a sizing recipe containing a mixture of thin boiling starch, PVA (poly vinyl alcohol), acrylic size, and a softener.

All the woven fabric samples were desized by enzymatic method using 2–4% (o.w.f.) Bactasol PHC Liquid desizing enzyme, 3–5 g/l Imerol PCJ Liquid (surfactant), and 0.5-1 g/l Sirrix 2UD Liquid (sequestering agent). All chemicals were provided by Clariant Pakistan Ltd. The desizing of all fabric samples was done

Table 3

FABRIC CONSTRUCTIONS USED IN THIS STUDY									
S. no.	Set 1*	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9
1	15 x 20/ 40 x 40	15 x 25/ 40 x 40	15 x 30/ 40 x 40	20 x 20/ 40 x 40	20 x 25/ 40 x 40	20 x 30/ 40 x 40	25 x 20/ 40 x 40	25 x 25/ 40 x 40	25 x 30/ 40 x 40
2	15 x 20/ 50 x 40	15 x 25/ 50 x 40	15 x 30/ 50 x 40	20 x 20/ 50 x 40	20 x 25/ 50 x 40	20 x 30/ 50 x 40	25 x 20/ 50 x 40	25 x 25/ 50 x 40	25 x 30/ 50 x 40
3	15 x 20/ 50 x 50	15 x 25/ 50 x 50	15 x 30/ 50 x 50	20 x 20/ 50 x 50	20 x 25/ 50 x 50	20 x 30/ 50 x 50	25 x 20/ 50 x 50	25 x 25/ 50 x 50	25 x 30/ 50 x 50
4	15 x 20/ 60 x 40	15 x 25/ 60 x 40	15 x 30/ 60 x 40	20 x 20/ 60 x 40	20 x 25/ 60 x 40	20 x 30/ 60 x 40	25 x 20/ 60 x 40	25 x 25/ 60 x 40	25 x 30/ 60 x 40
5	15 x 20/ 60 x 50	15 x 25/ 60 x 50	15 x 30/ 60 x 50	20 x 20/ 60 x 50	20 x 25/ 60 x 50	20 x 30/ 60 x 50	25 x 20/ 60 x 50	25 x 25/ 60 x 50	25 x 30/ 60 x 50
6	15 x 20/ 60 x 60	15 x 25/ 60 x 60	15 x 30/ 60 x 60	20 x 20/ 60 x 60	20 x 25/ 60 x 60	20 x 30/ 60 x 60	25 x 20/ 60 x 60	25 x 25/ 60 x 60	25 x 30/ 60 x 60
7	15 x 20/ 70 x 40	15 x 25/ 70 x 40	15 x 30/ 70 x 40	20 x 20/ 70 x 40	20 x 25/ 70 x 40	20 x 30/ 70 x 40	25 x 20/ 70 x 40	25 x 25/ 70 x 40	25 x 30/ 70 x 40
8	15 x 20/ 70 x 50	15 x 25/ 70 x 50	15 x 30/ 70 x 50	20 x 20/ 70 x 50	20 x 25/ 70 x 50	20 x 30/ 70 x 50	25 x 20/ 70 x 50	25 x 25/ 70 x 50	25 x 30/ 70 x 50
9	15 x 20/ 70 x 60	15 x 25/ 70 x 60	15 x 30/ 70 x 60	20 x 20/ 70 x 60	20 x 25/ 70 x 60	20 x 30/ 70 x 60	25 x 20/ 70 x 60	25 x 25/ 70 x 60	25 x 30/ 70 x 60
10	15 x 20/ 70 x 70	15 x 25/ 70 x 70	15 x 30/ 70 x 70	20 x 20/ 70 x 70	20 x 25/ 70 x 70	20 x 30/ 70 x 70	25 x 20/ 70 x 70	25 x 25/ 70 x 70	25 x 30/ 70 x 70
11	15 x 20/ 80 x 40	15 x 25/ 80 x 40	15 x 30/ 80 x 40	20 x 20/ 80 x 40	20 x 25/ 80 x 40	20 x 30/ 80 x 40	25 x 20/ 80 x 40	25 x 25/ 80 x 40	25 x 30/ 80 x 40
12	15 x 20/ 80 x 50	15 x 25/ 80 x 50	15 x 30/ 80 x 50	20 x 20/ 80 x 50	20 x 25/ 80 x 50	20 x 30/ 80 x 50	25 x 20/ 80 x 50	25 x 25/ 80 x 50	25 x 30/ 80 x 50
13	15 x 20/ 80 x 60	15 x 25/ 80 x 60	15 x 30/ 80 x 60	20 x 20/ 80 x 60	20 x 25/ 80 x 60	20 x 30/ 80 x 60	25 x 20/ 80 x 60	25 x 25/ 80 x 60	25 x 30/ 80 x 60
14	15 x 20/ 80 x 70	15 x 25/ 80 x 70	15 x 30/ 80 x 70	20 x 20/ 80 x 70	20 x 25/ 80 x 70	20 x 30/ 80 x 70	25 x 20/ 80 x 70	25 x 25/ 80 x 70	25 x 30/ 80 x 70
15	15 x 20/ 80 x 80	15 x 25/ 80 x 80	15 x 30/ 80 x 80	20 x 20/ 80 x 80	20 x 25/ 80 x 80	20 x 30/ 80 x 80	25 x 20/ 80 x 80	25 x 25/ 80 x 80	25 x 30/ 80 x 80

* Fabric constructions are given as: warp linear density x weft linear density/ends x picks (per 25 mm)

Table 4

BEST SUBSETS OF VARIABLES FOR WARP WAY FABRIC STRENGTH MODELS											
S. no.	Variables	R_2	R_2(Adj)	s	C-P	X	YS_{wp}	YS_{wt}	E	P	FL
1	1	50.9	50.7	120.20	2710.2	–	x	–	–	–	–
2	1	50.7	50.5	120.45	2722.2	x	–	–	–	–	–
3	2	94.5	94.5	40.180	99.1	–	x	–	x	–	–
4	2	94.3	94.3	40.911	111.1	x	–	–	x	–	–
5	3	95.5	95.4	36.665	45.2	–	x	–	x	–	x
6	3	95.3	95.2	37.469	57.2	–	x	–	x	x	–
7	4	95.9	95.8	35.129	23.9	–	x	x	x	–	x
8	4	95.8	95.7	35.305	26.4	–	x	–	x	x	x
9	5	96.2	96.1	33.693	5.0	–	x	x	x	x	x
10	5	96.0	95.9	34.550	16.7	x	–	x	x	x	x
11	6	96.2	9610	33.766	7.0	x	x	x	x	x	x

Table 5

ANOVA OF RESPONSE SURFACE REGRESSION FOR WARP-WAY STRENGTH MODEL							
S. no.	Source	DF	Seq SS	Adj SS	Adj MS	F	P
1	Regression	6	6799639	6799639	1133273	IE + 04	0.000
2	Linear	5	6565286	5581889	1116378	IE + 04	0.000
3	Interaction	1	234353	234353	234353	2E + 03	0.000
4	Residual error	227	24481	24481	108		
5	Total	233	6824120				

Table 6

RESPONSE SURFACE REGRESSION COEFFICIENTS FOR WARP-WAY STRENGTH MODEL					
S. no.	Terms	Coefficient	SE coefficient	T	P
1	Constant	422.37	0.9499	444.657	0.000
2	YS_{wp}	132.62	0.9007	147.239	0.000
3	YS_{wt}	13.06	0.8314	15.705	0.000
4	E	169.69	1.2222	138.836	0.000
5	P	17.83	1.2022	14.834	0.000
6	FL	–16.50	0.6789	–24.309	0.000
7	YS_{wp}*E	60.56	1.2990	46.616	0.000

individually on laboratory winch machine at liquor to goods ratio of 15:1, *p*H 6 and temperature 60–90°C. After desizing, fabric samples were rinsed hot and cold and dried at room temperature under shade in order to avoid any possible effect of direct sunlight on the fabric strength. The purpose of desizing was to remove the warp size and its contribution to the fabric tensile strength. The enzymatic method of desizing was used because unlike oxidative or acidic desizing, it does not cause any loss in fabric strength.

After desizing, all the fabric samples were first preconditioned at a temperature of 47°C and relative humidity of 10 to 25% for 4 hours in a hot air oven and then conditioned for 24 hours in standard atmosphere. Then test specimens were prepared and tensile strength was determined both in warp direction and weft direction according to ISO standard test method 13934-1. Calibrated universal strength tester by SDL Atlas UK was used for determining the fabric tensile strength using a gauge length of 200 mm and an extension speed of 100 mm/min. Out of a total number of 270 samples, the data of 234 samples was used for developing the regression prediction models while data of 36 samples (18 of plain weave + 18 of twill weave) was used to check the validity of the developed models.

All statistical analyses were done using MINITAB statistical software.

RESULTS AND DISCUSSIONS

Warp-way fabric strength prediction model

Table 4 is the best subsets regression table for warp-way fabric strength. This table gives eleven different regression models, as given by the MINITAB including different predictor variables among from: *X* – warp count, *Y* – weft count, YS_{wp} – warp yarn strength, in cN, YS_{wt} – weft yarn strength, in cN, *E* – ends/25 mm, *P* – picks/25 mm and *FL* – float length. Model number 9 is the best model with high *R-Sq* and adjusted *R-Sq*, small s, and *C-p* close to the number of predictors contained in the model. Thus model 9 with YS_{wp}, YS_{wt}, *E, P* and *FL* as predictor variables was selected for further analysis using response surface regression. Analysis of variance for response surface regression is given in table 5. *P*-values of 0.000 indicate significant linear and interaction effects of the selected predictor variables on the warp-way fabric strength.

The response surface regression coefficients are given in table 6. *P*-values of 0.000 indicate significant linear effect of warp strength, weft strength, *E, P, FL* and significant interactions of "warp strength*E" at α-level of 0.05. All analysis was done using coded units of the predictor variables as recommended in the MINITAB help files.

The regression equation (1), used to predict the warp-way tensile strength of fabric, obtained from table 6 is represented as follows:

$$FTS_{wp} = 422.37 + 132.62\ YS_{wp} + 13.06\ YS_{wt} + 169.69\ E + 17.83\ P - 16.50\ FL + 60.56\ (YS_{wp}{*}E) \quad (1)$$

where:

FTS_{wp} is fabric tensile strength of in warp direction *N;*

Table 7

BEST SUBSETS OF VARIABLES FOR WEFT-WAY FABRIC STRENGTH MODELS											
S. no.	Variables	R_2	R_2(Adj)	*C-P*	*s*	*X*	YS_{wp}	YS_{wt}	*E*	*P*	*FL*
1	1	71.2	71.0	4193.8	65.587	–	–	–	–	x	–
2	1	25.6	25.3	IE + 04	105.37	–	–	x	–	–	–
3	2	96.7	96.7	273.0	22.119	–	–	x	–	x	–
4	2	71.9	71.7	4076.9	64.840	–	–	–	x	x	–
5	3	97.5	97.5	156.0	19.358	–	–	x	x	x	–
6	3	97.5	97.4	164.0	19.558	–	–	x	–	x	x
7	4	98.2	98.2	47.0	16.340	–	–	x	x	x	x
8	4	97.8	97.7	115.9	18.300	–	x	x	x	x	–
9	5	98.5	98.5	6.9	15.051	–	x	x	x	x	x
10	5	98.5	98.5	8.2	15.091	x	–	x	x	x	x
11	6	98.5	98.5	7.0	15.020	x	x	x	x	x	x

Table 8

ANOVA OF RESPONSE SURFACE REGRESSION FOR WEFT-WAY STRENGTH MODEL							
S. no.	Source	*DF*	*Seq SS*	*Adj SS*	*Adj MS*	*F*	*P*
1	Regression	6	3453038	3463038	575506	2E + 04	0.000
2	Linear	5	3409404	3377719	675544	2E + 04	0.000
3	Interaction	1	43634	43634	43634	1E + 03	0.000
4	Residual error	227	8014	8014	35		
5	Total	233	3461053				

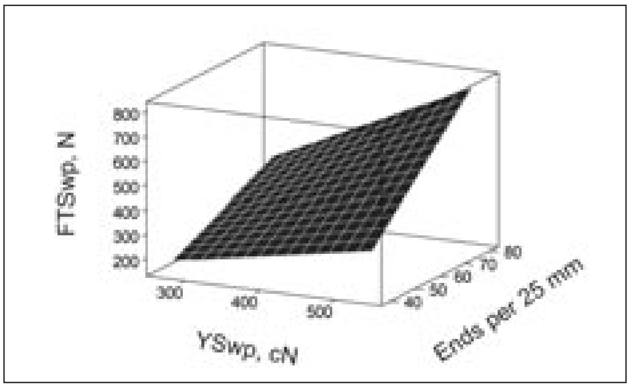

Fig. 1. Response surface plot for warp yarn strength and ends/25 mm interact

YS_{wp} – value of single yarn strength of warp;
YS_{wt} – value of single yarn strength of weft;
E – value of ends/25 mm;
P – value of picks/25 mm;
FL – value of float length.

This equation can be used to calculate the predicted response by putting in the coded values of the predictor variables. Because the coefficients were estimated using coded units, putting uncoded factor values into this equation would generate incorrect predictions about warp strip strength. The following alternative equation obtained from the response surface regression analysis using MINITAB contains the estimated regression coefficient using data in uncoded units. This equation (2) used to calculate the predicted response by directly putting in the uncoded values of warp yarn strength, weft yarn strength, ends/25 mm, picks/25 mm and float length.

$$FTS_{wp} = -4.627 - 0.369\ YS_{wp} + 0.142\ YS_{wt} - 0.759\ E + 0.891\ P - 16.503\ FL + 0.023\ (YS_{wp}{*}E) \quad (2)$$

The FTS_{wp} equation contains an interaction effect of warp yarn strength and ends/25 mm. Response surface plot for this interaction effect is given in figure 1. As can be seen from the figure, the increase in warp strip strength with increase in number of ends/25 mm is much sharper when the strength of individual yarns is higher.

Weft-way fabric strength prediction model

Table 7 is the best subsets regression table for weft-way fabric strip strength. Different regression models including different predictor variables among from: *X* – warp count; *Y* – weft count; YS_{wp} – warp yarn strength, in cN; YS_{wt} – weft yarn strength, in cN; *E* – ends/25 mm; *P* – picks/25 mm and *FL* – float length. Model number 9 seems to be the best model with high *R-Sq* and adjusted *R-Sq*, small *s*, and *C-p*. Hence, Model 9 with YS_{wp}, YS_{wt}, *E, P* and *FL* as predictor variables was selected for further analysis using response surface regression. Analysis of variance for response surface regression is given in table 8. *P*-values of 0.000 indicate significant linear and interaction effects of the selected predictor variables on the weft-way fabric strength.

The response surface regression coefficients are given in table 6. *p*-values of 0.000 indicate significant linear effect of warp strength, weft strength – *E, P, FL,* and

Table 9

RESPONSE SURFACE REGRESSION COEFFICIENTS FOR WARP-WAY STRENGTH MODEL					
S. no.	Terms	Coefficient	*SE* coefficient	*T*	*P*
1	Constant	370.23	0.5435	681.247	0.000
2	YS_{wp}	7.28	0.4753	15.317	0.000
3	YS_{wt}	84.56	0.5435	155.576	0.000
4	*E*	19.27	0.6986	27.571	0.000
5	*P*	148.74	0.6878	216.248	0.000
6	*FL*	–10.34	0.3884	–246.633	0.000
7	YS_{wp}*P	25.74	0.7323	35.155	0.000

Table 10

COMPARISON OF PREDICTED AND ACTUAL VALUES												
S. no.	Plain weave (Float length = 1)						Twill weave (Float length = 3)					
	Warp strip strength			Weft strip strength			Warp strip strength			Weft strip strength		
	Predicted, N	Actual, N	Diff., %	Predicted, N	Actual, N	Diff., %	Predicted, N	Actual, N	Diff., %	Predicted, N	Actual, N	Diff., %
1	339	348	2.6	3.6	314	2.6	224	233	3.8	2.3	219	7.0
2	402	410	1.8	369	353	–4.6	308	3.5	–1.1	287	283	–1.5
3	361	364	0.8	328	317	–3.5	383	392	2.3	362	347	–4.3
4	406	408	0.4	373	389	3.9	318	320	0.5	298	294	–1.2
5	365	346	–5.3	332	345	3.7	393	379	–3.7	372	367	–1.6
6	437	429	–2.0	404	411	1.6	551	559	1.4	531	568	6.5
7	511	480	–6.4	478	451	–5.9	306	307	0.3	285	265	–7.4
8	587	556	–5.5	554	524	–5.6	241	243	1.0	220	231	4.7
9	515	482	–6.7	482	470	–2.5	316	309	–2.2	295	290	–1.6
10	617	625	1.2	584	572	–2.2	474	449	–5.6	454	451	–0.5
11	537	520	–3.2	5.4	485	–3.8	475	509	6.7	454	458	0.7
12	622	625	0.5	589	582	–1.2	484	492	1.5	464	467	0.7
13	665	668	0.5	632	624	–1.2	239	255	6.4	218	228	4.5
14	798	805	0.9	765	749	–2.0	397	392	–1.1	376	361	–4.2
15	687	701	2.0	654	655	0.3	397	411	3.3	377	363	–3.8
16	802	795	–0.9	769	758	–1.5	407	417	2.4	386	372	–3.8
17	691	698	1.1	658	666	1.3	4.8	397	–2.7	387	379	–2.1
18	806	796	–1.3	773	774	0.1	417	407	–2.6	397	389	–2.0

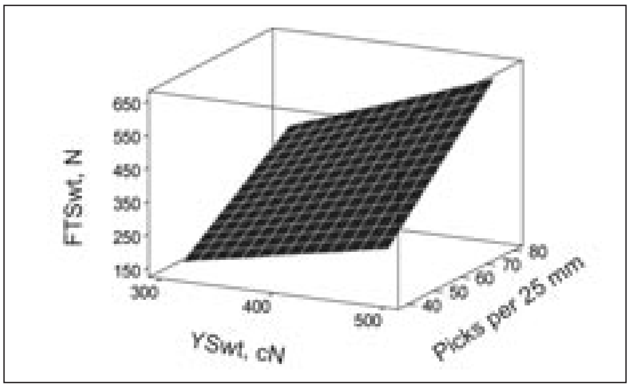

Fig. 2. Response surface plot for weft yarn strength and picks/25 mm interact

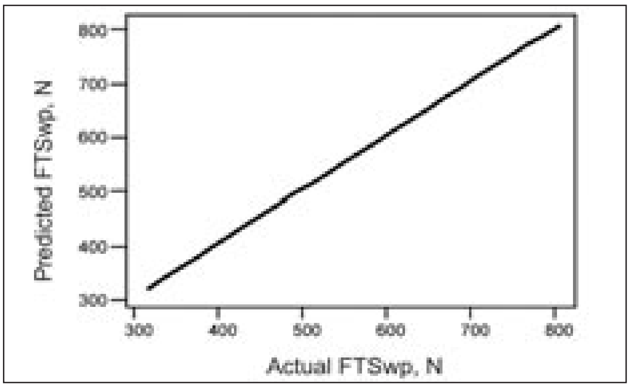

Fig. 3. Fitted line plot for actual and predicted warp wise strength

significant interactions of warp strength*E at α-level of 0.05. All analysis was done using coded units of the predictor variables as recommended in the MINITAB help files.

Response surface regression coefficients are given in table 9. p-values of 0.000 indicate significant linear effect of warp strength, weft strength – E, P, FL and significant interactions of weft strength*P at α-level 0.05. The regression equation (3), used to predict the weft-way tensile strength of fabric, obtained from table 9 is given as follows:

$$FTS_{wt} = 370.23 + 7.28\ YS_{wp} + 84.56\ YS_{wt} + 19.27\ E + 148.34\ P - 10.34\ FL + 25.74\ (YS_{wt}{*}P) \quad (3)$$

where:

FTS_{wt} is fabric tensile strength in weft direction, N;

YS_{wp} – value of single yarn strength of warp;

YS_{wt} – value of single yarn strength of weft;

E – value of ends/25 mm;

P – value of picks/25 mm;

FL – value of float length.

This equation can be used to calculate the predicted response by putting in the coded values of the predictor variables. Because the coefficients were estimated using coded units, putting uncoded values into this equation would generate incorrect predictions about weft strip strength. The following alternative equation obtained from the response surface regression analysis using MINITAB contains the estimated regression coefficient using data in uncoded units. The equation (4) used to calculate the predicted response by directly putting in the uncoded values of warp yarn strength, weft yarn strength, ends/25 mm, picks/25 mm and float length.

$$FTS_{wt} = -167.427 + 0.055\ YS_{wp} + 0.079\ YS_{wt} + 0.963\ E + 1.8\ P - 10.345\ FL + 0.0139\ (YS_{wt}{*}P) \quad (4)$$

The FTS_{wt} equation contains an interaction effect of weft yarn strength and picks/25 mm. Response surface plot for this interaction effect is given in figure 2. As can be seen from the figure 2, the increase in weft strip strength with increase in number of picks/25 mm is

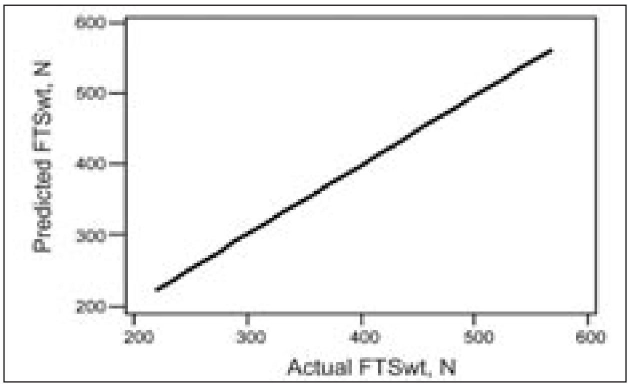

Fig. 4. Fitted line plot between actual and predicted weft wise strength

much sharper when the strength of individual weft yarns is higher.

Validation of prediction models

As mentioned above, out of a total number of 270 samples, the data of 234 samples were used for developing the prediction models while data of 36 samples (18 of plain weave + 18 of twill weave) were used to check the validity of the developed models. A comparison of actual fabric strength values and those predicted by the developed models (FTS_{wp} & FTS_{wt} equations) is given in table 10. Figure 3 gives the fitted line plot between the actual fabric warp strip strength and the warp strip strength predicted by the proposed model. The Pearson correlation between the actual warp strip strength and the predicted warp strip strength was found to be 0.996 with a *p*-value of 0.000 indicating a very strong ability and accuracy of the prediction model. Similarly figure 4 gives the fitted line plot between the actual fabric weft strip strength and the weft strip strength predicted by the proposed model. The Pearson correlation between the actual weft strip strength and the predicted weft strip strength was found to be 0.993 with a *p*-value of 0.000 indicating a very strong ability and accuracy of the prediction model.

CONCLUSIONS

Statistical models were successfully developed for the prediction of fabric strength made from PC yarns in the warp and cotton yarns in the weft direction. The models are based on the real data obtained from 234 carefully developed fabric samples. The prediction ability and accuracy of the developed models was assessed by correlation analysis of the predicted and actual warp and weft fabric strip strength values. The Pearson correlations between the actual and the predicted strength for warp and weft were found to be 0.996 and 0.989, with a *p*-value of 0.000 indicating a very strong ability and accuracy of the prediction models.

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Nanotehnologie

O EVALUARE REALISTĂ ASUPRA VIITORULUI NANOTEHNOLOGIEI

Potrivit ultimului raport al BBC Research-Nanotechnology *“Nanotehnologia: o evaluare realistă a pieței”*, piața globală a nanoproduselor a fost estimată, în 2009, la 11,7 miliarde de dolari, în 2010, la peste 15,7 miliarde de dolari și, în 2015, la aproape 26,7 miliarde de dolari, cu o rată de creștere anuală, în perioada 2010–2015, de 11,1%.
În anul 2009, cele mai importante evoluții în domeniul nanotehnologiei au vizat nanomaterialele, unde va avea loc o creștere de la 9 027,2 milioane de dolari – în 2009, la aproape 19 621,7 milioane de dolari – în 2015, cu o rată de creștere anuală de 14,7%.
Piața globală a nanoechipamentelor/nanoinstrumentelor a fost estimată, în 2009, la 2 613,1 milioane de dolari. Vânzarea acestora va putea atinge, în anul 2015, valoarea de 6 812,5 milioane de dolari, având o rată de creștere anuală de 3,3%.
În domeniul nanodispozitivelor, va avea loc o creștere moderată, de la 31 de milioane de dolari, în anul 2009, la 233,7 milioane de dolari, în 2015, cu o rată de creștere anuală de 45,9%.

Importanța și riscurile nanotehnologiei

În 2010, un jurnalist respectabil a scris o serie de știri pentru *AOL News*, intitlulate *“Miza nanoteh: știință îndrăzneață, sume mari, riscuri crescute”*, în care critica performanța guvernului S.U.A. în ceea ce privește identificarea și protejarea publicului împotriva așa-numitelor riscuri pentru sănătate impuse de nanotehnologie.
Afirmațiile au fost deosebit de acide, astfel încât *National Nanotechnology Initiative* și *National Nanotechnology Coordination Office* s-au simțit obligate să emită o notă oficială de dezaprobare a celor expuse în articolul AOL News, potrivit căreia autorul este acuzat de o *“perspectivă alarmistă... utilizând exemple nerelevante și... nereușind să contrabalanseze riscurile nanotehnologiei cu beneficiile acesteia”* și de o distragere a atenției asupra cercetării.
Mediul economic și academic, precum și mass-media încearcă să obțină bani din nanotehnologie. Diferite companii producătoare au preluat denumirea „nano“ pentru propriile produse sau procese, chiar dacă nu au de-a face cu nanotehnologiile, în încercarea de a le face să pară mai avansate din punct de vedere tehnologic decât cele ale competitorilor, în scopul creșterii vânzărilor. Unii dintre cercetătorii din mediul academic sunt îngrijorați de faptul că numele sonor „nano“ este utilizat inadecvat, doar cu scopul de a atrage finanțarea cercetării pentru tehnologii și aplicații dubioase, în detrimentul cercetării adevărate.
Pe blogul website-ului *Bespoke Investment Group* se remarca faptul că: *„Cu ani în urmă, în zilele bune ale anilor 2000, investitorii erau purtați de valul unei piețe în dezvoltare, având în vedere perspectiva următorului lucru remarcabil, care a fost nanotehnologia. Dar, s-a produs colapsul din 2007 și nebunia nanotehnologiei pare să fi fost uitată. Ne amintim cu greu ultimul moment în care am citit sau am văzut ceva despre nanotehnologie. Acțiunile legate de nanotech au pierdut și ele interesul investitorilor“.* Drept consecință, produsele și aplicațiile nanotehnologice legitime au început să fie afectate, pe măsură ce finanțarea și piețele au scăzut substanțial.
Raportul *BBC* prezintă o perspectivă realistă asupra domeniului nanotehnologiei și încearcă să ofere o hartă cu repere ale acelor tehnologii și ale aplicațiilor acestora, cu cel mai mare potențial de comercializare în următorii cinci ani.
Pentru ca nanotehnologia să aibă un impact fundamental asupra mai multor sectoare ale economiei din S.U.A., trebuie depășite diferite obstacole tehnice, de marketing și de altă natură. Aceste provocări și diferențe de opinie privind aplicațiile comerciale se reflectă în estimările extrem de divergente privind piețele nano, atât în S.U.A., cât și pe plan mondial.
Estimările privind piața globală a nanotehnologiei arată că, până în 2015, această piață ar putea ajunge la peste 2,4 trilioane de dolari. Diferențele de păreri reflectă nu numai metode și ipoteze analitice diferite, dar și definiții diferite ale pieței nano, de exemplu: chestiunea includerii/neincluderii tehnologiilor vechi de decenii – cum este cazul componentelor de consolidare a cauciucului cu negru de fum și a argintului fotografic, sau problema fundamentării valorii pieței doar pe input-urile nanotehnologiei, față de cazul opus al valorii totale a produselor ce încorporează nanotehnologii.
Din cauza dificultății de cuantificare a pieței nano, unii analiști micșorează dimensiunile acesteia și se concentrează, în schimb, asupra laturii furnizării, și anume asupra dezvoltării de noi tehnologii și aplicații nanoscalare. Acești analiști au avut contribuții valoroase, crescând conștientizarea importanței și interesului pentru nanotehnologii în rândul investitorilor.
Cu toate acestea, activitatea acestor analiști nu oferă suficiente informații pentru a orienta deciziile investiționale individuale sau corporatiste. Investitorii solicită date suplimentare, cum ar fi dimensiunea piețelor specifice, a prețurilor și a competiției, dar și potențialele reglementări.

Obiectivele și scopul studiilor asupra nanotehnologiei

Scopul raportului *BBC* este acela de a oferi informații – atât investitorilor, cât și altor persoane interesate – asupra potențialului comercial al variatelor nanotehnologii și de a completa informațiile de ordin tehnic.
Obiectivele specifice includ identificarea segmentelor pieței nanotehnologice cu cel mai mare potențial comercial, pe termen scurt și mediu (2010–2015), și proiectele de viitor privind cererea de produse din aceste segmente. În scopul estimării probabilității unei comercializări de succes, sunt, de asemenea, evaluate provocările ce trebuiesc depășite, pentru ca fiecare segment să-și realizeze potențialul.

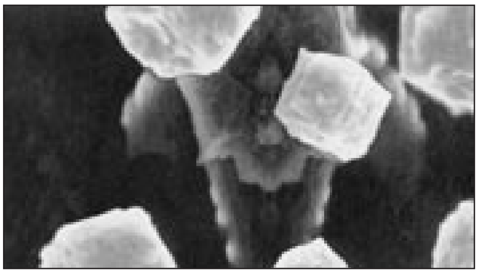


Fig. 1

Raportul este destinat în special antreprenorilor, investitorilor de capital de risc, dar și altor persoane interesate, care doresc să știe unde se va situa piața nanotehnologiei în următorii cinci ani.
Printre persoanele interesate se includ cei din sectorul executiv al marketingului nanotehnologic și oficialii guvernamentali din cadrul *Inițiativei Naționale pentru Nanotehnologie* și din cadrul altor programe la nivel de stat, care promovează dezvoltarea industriei nano.
Studiul acoperă întregul domeniu al nanomaterialelor – nanoparticule, nanotuburi, materiale nanostructurate, respectiv nanocompozite, al nanoinstrumentelor – instrumente nanolitografice și microscoape cu sondă de scanare, și al nanodispozitivelor – nanosenzori și nanoelectronice.
O decizie pragmatică a fost luată în sensul excluderii din raport a anumitor tipuri de materiale și dispozitive, care, din punct de vedere tehnic, nu se potrivesc definiției nanotehnologiei. Aceste excepții includ nanoparticulele de negru de fum – utilizate în ranforsarea anvelopelor și a altor produse din cauciuc, argintul fotografic și nanoparticulele de colorant, carbonul activ – utilizat pentru filtrarea apei. Aceste materiale au fost excluse, deoarece ele au fost utilizate de decenii, cu mult înainte ca acest concept al nanotehnologiei să se fi născut, iar volumul mare al acestora (în special al negrului de fum și al carbonului activ) tind să înghită noile nanomateriale aflate în studiu. Semiconductorii nanoscalari sunt, de asemenea, excluși din studiu, deși sunt incluse instrumentele utilizate pentru crearea lor. Spre deosebire de negrul de fum și carbonul activ, semiconductorii nanoscalari reprezintă o dezvoltare relativ nouă, cu toate că au fost analizați pe larg într-un alt material și, la fel ca negrul de fum și carbonul activ, au tendința de a copleși alte nanotehnologii prin volumul lor total din anii premergători lui 2015.

Metodologie și surse de informare

Proiectarea pieței pentru tehnologiile emergente, cum este cazul majorității aplicațiilor nanotehnologice, al căror potențial comercial nu s-a dovedit încă, reprezintă o sarcină dificilă, ce ne-ar putea ajuta să înțelegem de ce mulți dintre analiști se concentrează mai ales asupra părții legate de furnizarea evaluărilor tehnologice. În pregătirea raportului *BBC,* pentru identificarea aplicațiilor nanotehnologiei ce prezintă cel mai mare potențial comercial și pentru cuantificarea pieței acestor aplicații a fost utilizată o abordare multifazică.
În prima fază a analizei, *BBC Research* a identificat o listă lungă de potențiale aplicații ale nanotehnologiei, inclusiv a acelora aflate încă în stadiul de dezvoltare, stabilind repere față de potențiale industrii cu rol de utilizator final, cum este cazul tehnologiei informației, electronicii, biotehnologiei și îngrijirii sănătății (fig. 1). Prin ancorarea de nanotuburi de carbon cu un singur perete la așa-numitele „nanocuburi“ peliculizate cu aur, s-a dezvoltat un biosenzor ce detectează cu acuratețe nivelul glucozei din sânge. Nanocubul acționează atât ca un tether, cât și ca un fir ultrafin, și se poate utiliza nu numai pentru detectarea cu precizie a glucozei din sânge și a altor tipuri de molecule biologice, ci și în biosenzori destinați cercetării științifice.
În cea de-a doua fază, *BBC* a eliminat acele aplicații ale nanotehnologiei care păreau să aibă slabe șanse de a-și face loc în producția următorilor cinci ani. Acest lucru s-a realizat printr-o trecere în revistă a literaturii de specialitate și prin intervievarea surselor din industrie. Rezultatul celei de-a doua faze s-a concretizat într-o scurtă listă de aplicații și utilizatori finali cu cel mai mare potențial comercial, pe termen scurt și mediu.
Cea de-a treia fază s-a concentrat asupra cuantificării unei potențiale piețe mai mari, pentru fiecare dintre aplicațiile nanotehnologice, prezentate în scurta listă elaborată în faza a doua, și asupra identificării principalelor condiții preliminare ale unui succes comercial. Pentru analiza input-output și elaborarea proiecțiilor, tendințelor și estimărilor privind viitoarea cerere de surse nanoindustriale, au fost utilizate variate metodologii și baze de date.
Andrew McWilliams, autorul acestui raport, este partener al firmei de consultanță pe teme de tehnologie și marketing internațional, cu sediul la Boston, *43rd Parallel.* El este și autorul a numeroase alte studii nanotehnologice de la *BBC Research*, cum ar fi *Nanotechnology: A realistic market assessment,* disponibile pe piață.

***Smart**textiles and Nanotechnology, sept. 2010, p. 12*

Confecții

ÎMBRĂCĂMINTE INTELIGENTĂ PENTRU POLO

Compania ***Cintas Corporation***, cu sediul în S.U.A., a dezvoltat un nou tricou polo, prin utilizarea unui amestec de poliester reciclat și cărbune vegetal ecologic, obținut din coji de nucă de cocos și nanoparticule de bambus. La sfârșitul ciclului său de viață, noul tricou polo, *Full circle eco polo,* prietenos mediului, poate fi reciclat într-un nou material.
Așa cum afirmau repezentanții companiei: *„Noul tricou polo este unul dintre cele mai potrivite articole de îmbrăcăminte disponibile, deoarece reutilizează PET-urile și astfel ajută la economisirea resurselor naturale, la reducerea deșeurilor și la prevenirea încălzirii globale. Pentru agenții economici, aceasta este o oportunitate fantastică de a-și arăta seriozitatea, în sensul combaterii impactului operațiunilor lor asupra mediului“.*
Amestecul din 50% poliester reciclat și 50% cărbune vegetal ecologic face ca materialul să se usuce rapid, eliminând umiditatea. Totodată, aceste componente elimină mirosurile neplăcute, blochează razele ultraviolete și conferă rezistență la șifonare, la mucegai și la căldură.

La sfârșitul ciclului de viață, purtătorul tricoului polo îl poate trimite la adresa indicată pe eticheta de la gât, unde va fi reciclat, iar materia primă obținută va fi redirecționată către alte utilizări. Materialul utilizat pentru realizarea tricoului este certificat bluesign.
Compania Cintas proiectează, produce și implementează programe destinate realizării de uniforme/echipamente și furnizează covorașe personalizate pentru intrare, articole pentru toaletă, produse promoționale, articole de prim ajutor și siguranță, precum și produse și servicii de protecție contra incendiilor și de management al documentelor, pentru aproximativ 800 000 de agenți economici.

Sursa: www.cintas.com

FABRICAN SPRAY-ON – O ALTERNATIVĂ PENTRU ARTICOLELE DE MODĂ

Pentru a realiza o îmbrăcăminte inovatoare, care poate fi spălată și repurtată, se utilizează un material fără cusături, care poate fi spreiat direct pe corp, folosind tehnologia cu aerosoli.
Materialul *Fabrican spray-on* este alcătuit din fibre scurte combinate cu polimeri și un solvent, care distribuie materialul sub formă lichidă și se evaporă, atunci când substanța spreiată ajunge pe o suprafață.
Materialul pulverizabil se poate aplica prin utilizarea unui pistol cu presiune înaltă sau cu ajutorul unui aparat de aerosoli (fig. 1). Textura materialului se poate schimba în funcție de fibrele utilizate – lână, in sau acrilice, și de modul de stratificare a materialului spreiat.
Ideea unui material nețesut, creat instant prin pulverizare, a fost lansată de Dr. Manel Torres, în domeniul articolelor de modă pentru femei, la *Royal College of Art,* din Londra. Cu ajutorul lui Paul Luckham, profesor în tehnologia particulelor la *Imperial College London*, el a brevetat această tehnologie și au înființat împreună, în 2003, compania spin-out *Fabrican Ltd.* Compania intenționează să dezvolte, în colaborare cu parteneri industriali, produse prototip pentru comercializare.
Materialul Fabrican Spray-on va oferi designerilor libertatea de a crea articole de îmbrăcăminte noi, care să elibereze parfumuri, substanțe medicale active sau materiale conductive, permițând purtătorului să-și personalizeze garderoba prin diverse combinații unice, prin adăugarea unor tușeuri individuale. Pe lângă domeniul modei, tehnologia deschide noi perspective, oferind un material pulverizabil oricărui tip de aplicație ce solicită peliculizarea materialului, cum ar fi plasturii și bandajele

Fig. 1

medicale, lavetele igienice, produsele de împrospătare a aerului, tapiseria auto și cea pentru mobilă.
Tehnologia a fost prezentată la *Science & Style,* un eveniment dedicat modei, de la Imperial College London, UK.
Dr. Torres a făcut o demonstrație a performanțelor materialului Fabrican Spray-on, creând articole de îmbrăcăminte direct pe manechine.
În același timp, a expus o colecție de articole haute-couture, pentru primăvara–vara 2011, realizate prin pulverizare.

Sursa: www.fabricanltd.com

Tehnologie chimică

TEHNOLOGIE INOVATOARE DE LIPIRE CU ULTRASUNETE

EvoOrganic este o companie fondată în 2006, care militează pentru un stil de viață ecologic și oferă produse pentru irigarea grădinilor proprietarilor de gospodării, fermierilor și agenților economici. Ea este cunoscută ca fiind firma ce oferă materiale pentru grădină și peisagistică cu irigare încorporată, aflate pe primul loc în lume.

Fig. 1

Prin utilizarea unei tehnologii inovatoare de lipire cu ultrasunete, elaborată de ***Sonobond Ultrasonics***, compania ***EvoOrganic*** a dezvoltat așa-numita țesătură-ploaie, *Rainweave* (fig. 1). Proiectate pentru a reduce cu până la 80% consumul de apă, în comparație cu metodele convenționale, noile materiale pentru grădină, cu irigare încorporată, contribuie și la o creștere îmbunătățită a plantelor.
EvoOrganic a achiziționat modulele 12 SeamMaster de la Sonobond Ultrasonics și a început producția în decembrie 2009. Legat de aceasta, Rick Baker, președinte și CEO al EvoOrganic, afirma: *„Privesc securitatea și rezistența lipirii ca pe un prim avantaj al utilizării tehnologiei Sonobond. Am fost foarte încântat de rezultate. Avem în plan suplimentarea cu încă cel puțin o mașină a unității noastre din S.U.A. și preconizăm utilizarea modulelor SeamMaster și în cadrul extinderii producției peste ocean".*
Materialul Rainweave are o structură de tip sandviș, fiind alcătuit din două straturi – unul superior și unul inferior. Ambele straturi sunt realizate din polipropilenă și sunt prevăzute – la mijloc – cu o bandă de irigare cu picătura.
Modulele Sonobond, de la SeamMaster (fig. 2), sunt utilizate pentru sigilarea și canelarea materialului, pe

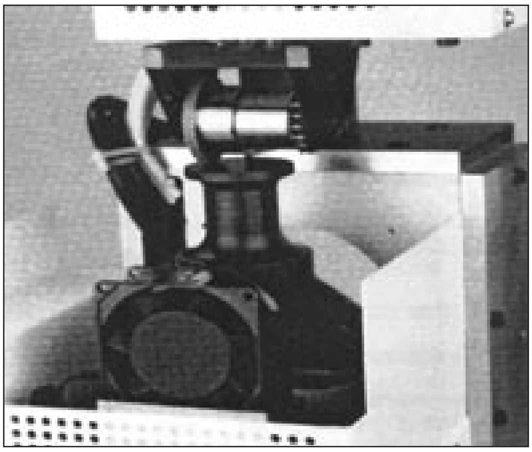


Fig. 2

parcursul procesului de asamblare. Unele unități realizează sigilarea din jurul benzii de irigare cu picătura și lipesc cele două straturi împreună, în timp ce altele realizează canelarea materialului în funcție de lățimile dorite.
Modulele SeamMaster utilizează un sistem rotativ acționat de un motor, împreună cu o roată turnantă cu model, care asigură o operare continuă, fără fir, adezivi sau alte produse. Cu alte cuvinte, este eliminată destrămarea sau deșirarea cusăturilor sau a marginilor lipite.

Sursa: www.evoorganic.com

DEFLEXION – UN MATERIAL DE PROTECȚIE ANTIIMPACT

Dow Corning a elaborat un nou material destinat articolelor de îmbrăcăminte sport, echipamentelor de protecție și încălțămintei. Tehnologia brevetată *Deflexion,* de protecție la impact, se bazează pe materiale din silicon, cu bune caracteristici de respirabilitate și flexibilitate. Spre deosebire de sistemele tip armură, rigide și voluminoase, noile materiale asigură nu numai o foarte bună protecție la impact, ci și libertate de mișcare, controlul temperaturii și un confort ridicat în purtare.
Tehnologia Deflexion este astfel proiectată încât să ofere posibilitatea ca materialele textile să fie confecționate fără a fi necesară inserarea unei căptușeli incomode (fig. 1).
Tehnologia poate fi aplicată, de asemenea, pentru dispozitivele medicale, echipamentele individuale de protecție și bagaje.

Fig. 1

Sunt disponibile două prototipuri de *Deflexion*, și anume: textile tridimensionale S-Range (Gama *S* – de la *spacer*), special proiectate pentru articolele de îmbrăcăminte purtate perioade îndelungate, destinate aplicațiilor medicale sau sport, și textile termoplastice TP-Range (Gama *TP* – de la *thermoplastic*), create pentru aplicații sport și accesorii sport de armare corporală, dar și pentru huse sau mânecuțe de protecție destinate electronicelor și echipamentelor sensibile, de exemplu laptopuri, telefoane mobile și camere foto-video.

Sursa: www.dowcorning.com/deflexion

VOPSIREA MATERIALELOR TEXTILE CU DIOXID DE CARBON

Noul proces de vopsire fără apă, elaborat de compania olandeză ***DyeCoo Textile Systems***, va fi implementat, pentru prima dată, de către ***Grupul Yeh***. Deoarece realizează pionieratul acestui nou proces revoluționar, Grupul Yeh are drepturi exclusive, brandingul materialelor astfel realizate purtând denumirea de *DryDye fabrics*, adică materiale cu vopsire uscată.
Compania consideră că eliminarea procesului ce utilizează apă și produse chimice va reprezenta o reală și importantă evoluție în procesul de vopsire din industria textilă. În medie, este necesară o cantitate de 100–150 de litri de apă pentru prelucrarea unui singur kilogram de material textil, apa fiind utilizată ca solvent în cadrul multor procese de pretratare și finisare, cum ar fi spălarea, spălarea pentru degresare, albirea și vopsirea. Deficitul de apă și creșterea conștientizării importanței problemelor de mediu reprezintă preocupări mondiale, ce conduc la o creștere acută a prețurilor legate de consumul de apă și de deversarea apelor uzate.
Noul proces de vopsire a materialelor textile nu utilizează apă, ci doar dioxid de carbon reciclat. Potrivit afirmațiilor Grupului Yeh, materialele cu vopsire uscată *DryDye fabrics* vor prezenta aceiași calitate a vopsirii, ca și cea a materialelor vopsite în mod convențional.
Pe instalația realizată de Grupul Yeh pot fi vopsite loturi de material de 100–125 kg, cu o lățime de 60–80 inci.
Compania ***DyeCoo,*** fondată în 2007, și-a propus realizarea unui nou prototip al instalației, pe care să se poată vopsi loturi de până la 200 kg. Dezvoltarea sistemului s-a efectuat inițial la compania mamă a ***DyeCoo – FeyeCon Development and Implementation BV*** – specializată în aplicații industriale, cum ar fi extracțiile chimice pentru produse farmaceutice. Expertiza tehnică în domeniul vopsirii textile a fost oferită de către partenerii ***Stork Prints*** și ***Universitatea Delft.***
Fluidele supercritice sunt gaze foarte comprimate cu proprietăți unice, atât de lichid, cât și de gaz, ceea ce le conferă avantaje deosebite în procesul de prelucrare textilă. CO_2 supercritic poate acționa atât ca solvent, cât și ca dizolvant, ceea ce reprezintă o calitate ideală pentru procesul de vopsire textilă. Fluidele supercritice prezintă coeficienți de difuzie mai mari și vâscozități mai mici decât lichidele, dar și absența unei tensiuni de suprafață, permițând astfel o mai bună penetrare a materialelor.
Cele trei faze principale ale materiei, la temperaturi și presiuni normale, sunt gazoasă, lichidă și solidă. Moleculele dintr-un solid sunt foarte strâns ordonate, astfel

încât forțele dintre ele le mențin în forma prestabilită. Atunci când energia crește, aceste forțe sunt depășite și substanța se transformă în lichid, iar dacă crește și mai mult se transformă în gaz. Atunci când atât temperatura, cât și presiunea ajung să fie suficient de mari, faza lichidă și, respectiv, cea gazoasă devin nedefinite, această fază fiind numită fluid critic. Înlocuirea apei cu CO_2 ar putea prezenta avantaje majore pentru vopsitorii, în ceea ce privește protecția mediului. Alimentarea cu apă reprezintă o problemă în multe părți ale lumii, iar apa reziduală și tratarea acesteia reprezintă o povară atât din punct de vedere economic, cât și al mediului. De asemenea, pentru ca vopsirea să fie eficientă, vopsitorii utilizează mari cantități de energie pentru încălzirea apei la temperaturile necesare acestui proces.

Există și alte proiecte de cercetare a posibilităților de vopsire cu CO_2, dar niciunul dintre acestea nu a condus la crearea unui sistem care să facă față solicitărilor de pe piață.

***Smart**textiles & Nanotechnology, sept. 2010, p. 10*

PRODUSE ENZIMATICE PENTRU FINISAREA LA TEMPERATURI SCĂZUTE

Biotouch XC300 a fost dezvoltată de furnizorul de produse enzimatice ***AB Enzymes OY***, din Rajamäki/ Finlanda, pentru biofinisarea articolelor de îmbrăcăminte la temperaturi scăzute și valori neutre ale *p*H-ului. Caracteristicile produsului au ca rezultat economii de energie și facilități mai mari pentru finisorii de îmbrăcăminte, prin eliminarea costurilor pentru încălzirea apei și reglarea valorilor *p*H-ului.

Ecostone CZYME 50 a fost special dezvoltată pentru finisarea denimului la temperaturi scăzute, în scopul creării unui efect de gri, în pas cu tendințele modei, și a unui contrast puternic, cu pierderi minime ale rezistenței și modificării culorii. Ecostone CZYME 50 reprezintă alegerea perfectă pentru finisarea modernă a denimului, oferind rezultate bune, atât în cazul mașinilor de spălat industriale cu tambur longitudinal, cât și în cazul celor cu încărcare frontală.

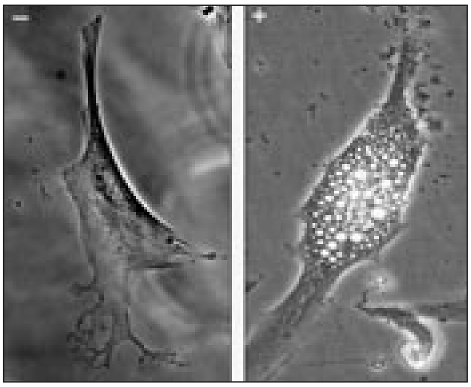
Melliand International, august 2010, p. 147

Diverse

STUDII PRIVIND RISCURILE FUMATULUI ASUPRA SĂNĂTĂȚII COPIILOR

Institutul Hohenstein a efectuat un studiu privitor la riscurile „fumatului la mâna a treia". Termenul se referă la transferul de nicotină din fumul de țigară, care nu este inhalat nici de fumătorii activi, nici de cei pasivi, ci este depus pe suprafețe, perne/căptușeli, covoare, perdele sau îmbrăcăminte. Concentrațiile substanțelor toxice depuse sunt cu mult mai mari decât cele din atmosfera în care se fumează și pot fi din nou eliberate, de exemplu în contact cu pielea. De fapt, doar cca 30% din fum este inhalat, restul de 70% fiind eliberat în atmosferă.

Cercetătorii de la *Institutul de Igienă și Biotehnologie* (IHB) din cadrul *Institutului Hohenstein* au studiat riscul potențial al „fumatului la mâna a treia" asupra sănătății noilor născuți și copiilor mici. S-a utilizat un model dermic 3D, ale cărui compoziție, structură și proprietăți imită pielea bebelușilor și a copiilor mici. Pentru a simula efectele fumatului la mâna a treia, un tricou a fost impregnat cu nicotină, principalul ingredient toxic al țigărilor, la fel ca în cazul în care s-ar fi fumat o țigară pe balcon. Pentru a putea verifica cantitatea de toxine, s-a utilizat o nicotină marcată radioactiv. Textilele impregnate cu fum au fost plasate pe pielea de bebeluș și s-a urmărit penetrarea nicotinei în piele. Rezultatele obținute au arătat, pentru prima dată, faptul că nicotina neurotoxică nu numai că este eliberată din îmbrăcăminte prin transpirație, astfel încât poate fi detectată în toate straturile dermice ale bebelușului, dar este, de asemenea, transportată prin piele către straturile țesuturilor mai profunde. Pentru a realiza o comparație, oamenii de știință au repetat experimentele, utilizând piele donată de adulți și au descoperit că rezultatele sunt aceleași.



a b

Fig. 1. Influența „fumatului la mâna a treia" asupra celulelor dermice: ***a*** – celulă dermică sănătoasă, fără expunere la fumul de țigară; ***b*** – celulă dermică afectată de expunerea la fumul de țigară, cu formare de vacuole, clar vizibile

Pentru a studia efectele dăunătoare asupra organismului ale nicotinei și ale celorlalte toxine din fumul de țigară, care au penetrat pielea, a fost investigat gradul în care sunt eliberate toxinele dintr-un material textil supus fumului de țigară și modul în care reacționează culturile de piele și de celule nervoase la amestecul de fum și transpirație. Rezultatele experimentului au arătat faptul că toxinele din fumul de țigară, care s-au dizolvat în transpirație, au provocat daune majore celulelor dermice: unele dintre acestea și-au schimbat forma, iar altele, acolo unde concentrația de fum a fost mare, chiar au murit (fig. 1). În mod similar, celulele nervoase, care sunt active mai ales pe parcursul primelor etape ale dezvoltării, au prezentat modificări clare și nu au mai fost capabile să interacționeze.

„Părinții ar trebui să fie conștienți de faptul că propria lor îmbrăcăminte poate transmite toxine din fumul de țigară... Căutăm, în prezent, pelicule textile ce ar putea neutraliza toxinele din fumul de țigară, putând astfel reduce pericolul fumatului la mâna a treia. Cu toate acestea, este necesară continuarea cercetărilor în acest sens" – afirma prof. Dirk Höfer, director al Institutului de Igienă și Biotehnologie din cadrul Institutului Hohenstein.

Oamenii de știință de la Hohenstein depun, în prezent, toate eforturile în vederea descoperirii unei soluții la această problemă. Prin colaborarea cu parteneri experimentați din industrie este posibil ca ei să atingă acest obiectiv destul de repede. „Modelul tip piele de bebeluș“, utilizat acum de către oamenii de știință de la Hohenstein, oferă un sistem de măsurare versatil, în special în ceea ce privește crearea unei îmbrăcăminți prietenoase pentru copii mici și bebeluși, care să fie purtată în contact direct cu pielea.

Informații de presă. Hohenstein Textile Testing Institute GmbH & Co. KG, 22 sept. 2010

NOI FIRE DE CARBON

O companie israeliană a elaborat o nouă tehnologie de producere a firelor de carbon la scară industrială, printr-un proces de formare a filamentelor de carbon din „fum elastic“. *Plasan Sasa*, cu sediul la Kibbutz Sasa – Israel, a anunțat înființarea companiei ***TorTech***, care va produce noi fire din nanotuburi de carbon, pentru consolidarea vestelor de protecție și a sistemelor compozite pentru vehicule.

TorTech Nano Fibres este o societate mixtă, deținută de *Plasan* și *Universitatea din Cambridge*, împreună cu compania *Q-Flo* – din Marea Britanie.

„*Noi credem că nanotuburile de carbon ale companiei Q-lui Flo au potențialul de a revoluționa industria de apărare printr-o nouă gamă de materiale ușoare, flexibile și foarte puternice... Prin TorTech, ne propunem să producem fire pe bază de nanotuburi de carbon, care pot fi țesute pentru a obține cel mai puternic material artificial care există. Expertiza Plasan va permite apoi proiectarea și producerea unei noi game de veste de protecție și carcase pentru vehicule*“ – a declarat Dan Ziv, CEO Plasan Group.

Este pentru prima dată când tehnologia va fi redimensionată pentru producția industrială. Profesorul Alan Windle și Dr. Martin Pick, care au lucrat cu Q-Flo, în 2004, au dezvoltat un proces care răsucește fibra din „fumul elastic“ format din nanotuburi de carbon plutitoare. Fumul este creat prin creșterea nanotuburilor de carbon pe catalizatori mici plutitori de fier în interiorul unui reactor. Nanotuburile plutitoare se prind unul de altul și formează un fum, din care se poate obține o fibră continuă, folosind o mașină special proiectată de Q-Flo. În timp ce valorile rezistenței axiale și ale rigidității se situează în același interval ca și cele ale fibrelor de carbon convenționale, valorile tenacității depășesc de trei ori pe cele ale kevlarului. În același timp, greutatea noilor fibre este mai mică. Natura lor asemănătoare cu cea a firului face ca ele să poată fi țesute cu succes într-o matrice compozită pe bază de rășini.

Smart*textiles and nanotechnology, ianuarie 2011, p. 12*

BENZI ȚESUTE DE LA *AUTOLIV*

Ca răspuns la creșterea rapidă a producției de autovehicule din Asia, compania a început construcția unei fabrici de centuri de siguranță în Mysore, lângă Bangalore. În prezent, cele mai multe curele pentru centurile de siguranță sunt importate de la fabrica ***Autoliv***, din China. În Asia, cererea de centuri de siguranță a crescut atât de brusc în ultimii ani, încât este nevoie urgentă de o cantitate mult mai mare.

În curând, Autoliv va produce, anual, peste o jumătate de miliard de metri de benzi țesute, o cantitate suficientă pentru a face înconjurul lumii de cinci ori.

Fabrica de curele pentru centurile de siguranță din Mysore va avea o capacitate de producție de 100 de milioane de metri de centuri. Inițial, va avea 65 de angajați, dar se va ajunge la 180 de angajați, atunci când toate investițiile în mașini de țesut automate vor fi finalizate. În faza inițială, vor fi investiți circa 10 milioane de dolari, ceea ce include și costurile pentru amplasare.

Centurile țesute reprezintă o componentă importantă în sistemul centurilor de siguranță, de aceea trebuie să posede o rezistență ridicată, o anumită alungire, pentru a preveni producerea efectului de „bandă de cauciuc“ și să asigure o fricțiune redusă, pentru a preveni răsucirea, oferind astfel confort și siguranță purtătorilor.

Prin punerea în funcțiune a noii fabrici, Autoliv va crește capacitatea de producere a centurilor de siguranță, la nivel mondial, cu 20%.

În prezent, aceasta are cinci fabrici, amplasate în Olanda, România, Canada, China și Brazilia. Reprezentanții Autoliv susțin că, în fabricile proprii, se produc centuri de siguranță care acoperă peste 40% din producția anuală globală.

Potrivit unor estimări, producția de vehicule ușoare, din India, s-a dublat în ultimii cinci ani, ajungând la 2,4 milioane – în 2009, față de 1,2 milioane – în anul 2004. Este de așteptat ca, în următorii cinci ani, producția acestor vehicule să se dubleze din nou, ajungând la 5 milioane, până în 2014.

Smart*textiles and nanotechnology, ianuarie 2011, p. 7*

TEHNOLOGII *AGION* PENTRU CONTROLUL MIROSULUI

Compania ***Agion Technologies*** a obținut *Brevetul SUA 7 754 625* pentru controlul mirosului în tratarea țesăturilor albe și a celor deschise la culoare și asigurarea stabilității culorii pe termen lung și a durabilității spălării. Tehnologia elaborată conferă eficacitate și performanță în procesul de tratare, fără a afecta drapajul ori tușeul materialului.

„Obținerea acestui brevet confirmă faptul că tehnologiile noastre textile sunt unice, în comparație cu alte soluții, și oferă beneficii reale, tangibile producătorilor, distribuitorilor și brandurilor de îmbrăcăminte, care le încorporează în produsele lor... tratamentele Agion efectuate pe materiale textile fac ca albul să pară mai strălucitor, chiar și după spălări multiple și o durată mare de utilizare, acest lucru neputând fi realizat de nicio altă companie care utilizează tratamente pe bază de argint“ – a declarat Paul Ford – CEO Agion Technologies.

Tehnologiile *Agion* pot fi încorporate în diverse tipuri de îmbrăcăminte – articolele vestimentare pentru sport, lenjerie, articole de încălțăminte și o mare varietate de uniforme. Compania *Agion Technologies* a încheiat parteneriate cu branduri din alte industrii, cu scopul de a oferi soluții personalizate pentru o mare varietate de textile medicale, articole de consum și textile industriale.

Sursa: www.agion-tech.com

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