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REZUMAT – ABSTRACT – INHALTSANGABE

Detectarea fuselor ce produc bobine defecte pe maşina de filat, cu ajutorul tehnologiei RFID

Dispozitivul de bobinat poate detecta bobinele defecte, în conformitate cu cerinţele controlului calităţii, însă nu poate stabili pe care dintre fusele maşinii de filat s-au realizat acele bobine. Pentru a putea rezolva această problemă, s-au utilizat un asistent digital personal – PDA, şi un program software inclus în acesta, cu ajutorul cărora să se poată identifica fiecare bobină prin numărul de serie a fusului şi codul maşinii de filat, folosind tehnologia de identificare prin radiofrecvenţă – RFID. PDA-ul poate detecta bobina defectă de pe maşina de filat, dar şi fusul pe care s-a realizat aceasta. Prin utilizarea acestei metode s-a rezolvat problema vechiului sistem, care necesita folosirea unui PC, pentru identificarea seriilor fuselor. De asemenea, prin această metodă sunt îmbunătăţite atât mentenanţa maşinii de filat, cât şi calitatea firului filat.

Cuvinte-cheie: RFID, ţeavă, bobină, detectare, maşină de filat, PDA

Tracing defected bobbins back to spindles of spinning frames using RFID technology

The winding device is able to detect the defected bobbins, according to the requirements of quality control; however it cannot deduce on which of the spinning frame's spindles they were produced. In order to solve this problem, a special Personal Digital Assistant (PDA) and an embedded software were used for identifying the individual bobbins associated to the serial number of spindles and the code of the spinning frames, utilizing Radio Frequency Identification (RFID) technology. The PDA could trace the defected bobbin, from the winder to the spindle that produced it. This method solved the problem of the old system, which needed to use a PC in order to manage the serial number of the spindles. It also improved the spinning frame's maintenance and increased the quality of the spun yarn.

Key-words: RFID, spool, bobbin, tracing, spinning frame, PDA

Die Ermittlung der Spindel welche fehlerhafte Spulen auf Spinnmaschinen produzieren, mit Hilfe der RFID-Technologie

Der Spulautomat kann die fehlerhaften Spulen gemäss der Qualitätskontrollnormen herausfinden, aber er kann nicht feststellen auf welcher Spindel der Spinnmaschine diese produziert wurden. Um dieses Problem lösen zu können, wurde in der Arbeit ein Personal Digital Assistent – PDA entwickelt und eine integrierte Software entworfen, für die Identifikation der individuellen Spulen durch die Seriennummer der Spindel und der Code der Spinnmaschine, indem die Technologie für die Identifizierung durch Radiofrequenz (RFID) angewendet wurde. Das PDA kann die fehlerhafte Spule herausfinden, sogleich aber auch die Spindel, auf welche diese produziert wurde. Durch die Anwendung dieser Methode wurde das Problem des alten Systems, welche die Anwendung eines PCs für die Identifizierung der Spindelserie benötigte, gelöst. Gleichzeitig wurde durch diese Methode sowohl die Mentenanz der Spinnmaschine, als die Qualität des Garnes, verbessert.

Schlüsselwörter: RFID, Spindel, Spule, Herausfinden, Spinnmaschine, PDA

According to different requirements of quality control, defected bobbins can be sought out by the winder. But the corresponding spindles which can not be traced will still produce defected bobbins. To solve the problem, Liu et al. [1] put forward a solo bobbin tracing system in which a number is written on the spools before attaching them to the spindles. If experimenters desire to use these spools repeatedly, there are two methods: one is to rewrite the number on the spools after erasing; the other is to arrange the spools according to their number. However, both methods are inconvenient. Liu et al. developed a bobbin tracing system, labeling the top part of spool with the bar code 1-D, but the label was easily damaged and the bar code could not be read when covered by the yarn.

Recently, the RFID technology has been widely used [2]. The working principles, modification and implantation of an existing RFID-tag in extracted human molars were described for forensic identification purposes [3]. By means of Radio Frequency Identification (RFID), Liu [4–6] redesigned a bobbin tracing system based on a PC which enables the quality control of the spindles by means of an electric kind of spool. According to the tests carried out in textile factories, at least two problems needed to be solved in the system:

- During the production, the integrated circuit of the RFID pasted on the surface of spools was easily destroyed by the collision between spools;
- The system needed to use a PC in order to manage the serial number of spindles for each function, which was an inconvenient for the textile factories.

In this research, a new kind of electronic bobbin was designed, where the integrated circuit of the RFID was pasted inside the spools. Two new kinds of Personal Digital Assistant (PDA) were designed for the system's improvement. One can write the information into the data storages of the RFID within the bobbins, and the other can read and print the information received from the RFID of bobbins. Using the new system, experiments of tracing the defected bobbins back to the spindles of the spinning frames were performed and analyzed.

STRUCTURE OF TRACING SYSTEM

The full structure of the tracing system is composed of three parts: electric spool, RFID writer used for spinning frame only, and RFID reader/ printer used for winder only. We will introduce the RFID before introducing the electric spool.

What is RFID?

The RFID, using radio frequency energy to communicate with a reader, is a new technology for automatic identification and for collecting data. It originated from the radio communication techniques, available in the 1980s, later provided with control, identification,

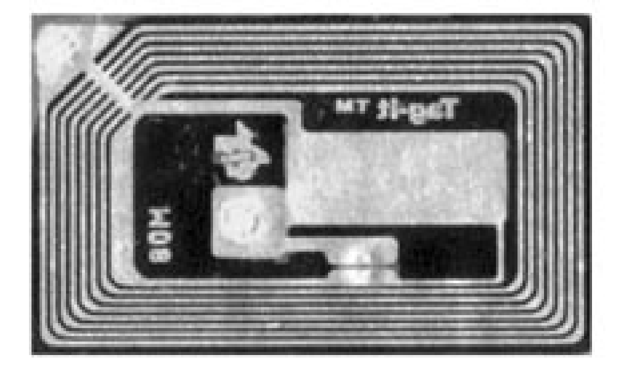

Fig. 1. Typical RFID tag

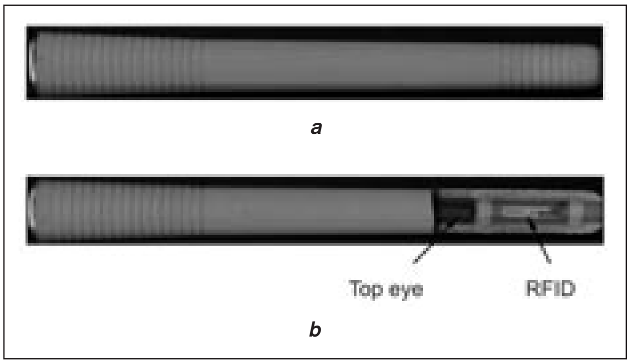

Fig. 2. Cutaway view of the electronic spool:
a – spinning spool; ***b*** – electronic spool

modern computer networking, which gradually matured as a non-contact identification technique. It was successfully applied in the tracing and identification of multi-target applications [7, 8].
Figure 1 shows a typical passive RFID (Texas Instruments Incorporated: ISO15693, 13.56 MHz) used in this application. RFID could store large amounts of data within a small amount of read/write storage space (64 bytes). In this research, 4 bytes were used to store the spinning frames code, and another 4 bytes were used to store the serial number of spindles. The range of codes used in the system can be encoded within 64 bytes, able to store data for an entire textile factory.

Reconstruction of electric spool and electric bobbin using RFID

RFID used to be pasted on the surface of the bobbin. As shown in figure 2, RFID is now installed inside the bobbins. Therefore, the integrated circuit of the RFID will not be destroyed by the collision between two or more spools during production. In the spool, there is a top eye. The RFID is installed between the top eye and the top of the spool and it is about 3–6 cm long. The top eye could prevent the RFID from crashing the spindles. The corresponding spinning spool and spinning bobbin are still called electronic spool and electronic bobbin. The electronic bobbin has stored the serial number of spindles and the code of spinning frames, while the electronic spool has not.

Writer PDA

The writer represents a basic function of tracing system, which could be finished by a PDA device with RFID writer designed for this research, as shown in figure 3. The PDA had integrated an embedded antenna, RFID writer and input/output devices. The flow chart of the writer PDA is shown in figure 4.
After the spools were installed on the spindles of the spinning frame, the serial number of spindles and the code of the spinning frame could be written according to the spindle order, and saved into the data storage of the RFID in the electric spool. In the experiments, when the PDA successfully wrote the data into the RFID, the LED light gave a continual light signal which could be used for confirming that the action of writing was successfully accomplished.

Reader/printer PDA

In the spinning frames, there was only 50 mm left for operating the RFID writer, given the bobbin's diameter was about 20 mm. Therefore, the designed thickness of the writer PDA was of 20 mm, in order to facilitate the operation, as shown in figure 3. However, according to the requirements of experimenter, the data regarding the defected bobbins needed to be printed by RFID printer. Therefore, another PDA functioning as reader/printer system was designed, having a printer attached, on top of RFID reader, as shown in figure 5. The flow chart of the reader/printer PDA is shown in figure 6.
When a defected bobbin was detected by the winder, the RFID reader could read the data stored in the RFID of electric bobbin. After that, the RFID reader translated the data into the serial number of the spindles and the code of spinning frame, and displayed it on the LCD of the RFID reader. In the experiments, when the PDA successfully read the data provided by the RFID, the speaker on the side of the RFID reader gave a

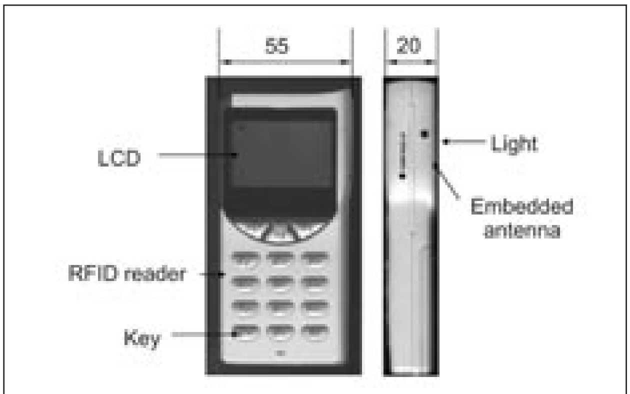

Fig. 3. PDA device of RFID writer

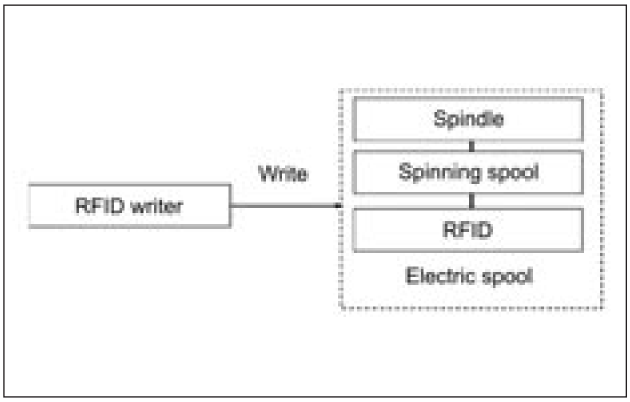

Fig. 4. Flow chart of system structure

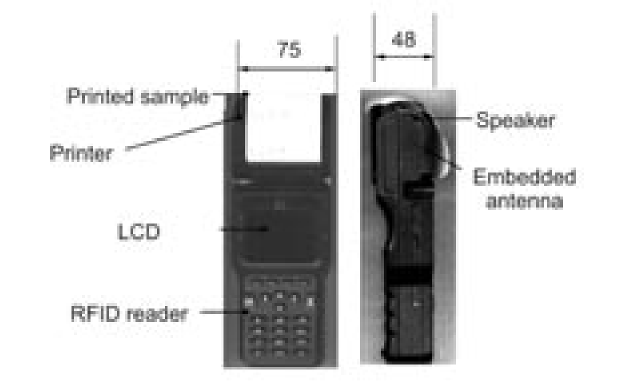

Fig. 5. PDA device of RFID reader/printer

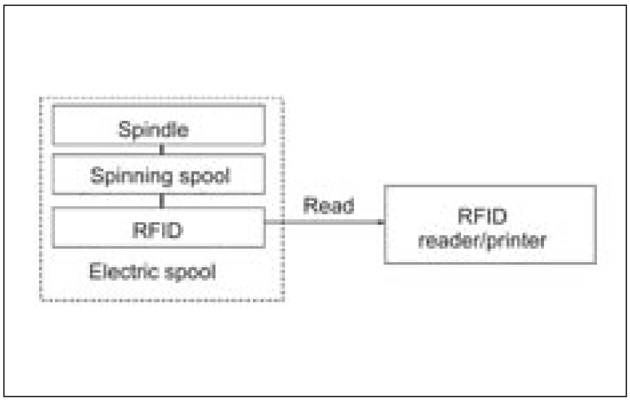

Fig. 6. Flow chart of system structure

continuous sound signal which could be used for confirming that the action of reading was successfully accomplished.

EXPERIMENTAL SETUP

An actual experimental setup of the whole system had been built. Valid experiments of tracing defected bobbins back to the specific spindles of spinning frame (Jingwei Co. /China: FA506) were accomplished on the winder (Savio Co. /Italy: Orion M/L). There were 30 spindles on one-side of the spinning frames.

RESULTS AND DISCUSSIONS

After attaching all electric spools onto the spindles of the spinning frames, the RFID writer wrote the serial number of spindles and the code of the spinning frames, and saved them into the data storage of the RFID, according to the order of the spindles. In the experiment, writing the serial number on 30 electronic spools at once, it took 22 seconds, on average. After the yarn was produced and winded on the electric spool by the spinning frame, the electric spool became an electric bobbin. When defected bobbins were found by the winder, the RFID reader read the serial number of spindles and the code of spinning frames. The experimenter could find the defected spindles of the spinning frames, and maintain the corresponding once. Therefore, the experiments could be simplified in the following four steps:

- attaching the spools to the spinning frames;
- writing the serial number of the spindles and the code of the spinning frames on the electric spool;
- detecting the defected bobbin by winder;
- reading the serial number of spindles and the code of spinning frames, and tracing the spinning frames and spindles etc, and maintaining the corresponding spindle.

By this technique, bobbins from different spindles could be distinguished precisely. Therefore, the usual quality control for each spinning frame was changed into the evaluation for each spindle. This technique could improve yarn quality and gain potential economical profit. Addressing the problematic spindles, improving the maintenance of the spinning frames, as well as increasing the quality of the spun yarn, and so on, could also be accomplished utilizing the system.

The data process of tracing the defected bobbin could only be accomplished by implementing the two PDAs. Therefore, the trouble of the old system, which needed to use a PC in order to manage the serial number of spindles, was solved in this research. As the RFID was installed inside the bobbin, there was no collision between the RFID and spools and bobbins during the manufacturing process. There were also no collisions during the processes of attaching and detaching, between the RFID and spindles, because the RFID was installed outside of top eye of the bobbins. In our experiment, there was no RFID that was destroyed.

CONCLUSIONS

The electric spool and electric bobbin were reconstructed utilizing RFID according to the practical applications from the textile factory. After that, the two PDAs, functioning as reader and writer/printer, used for sharing information about the electric bobbins between spindles and winders, were developed. Then, the tracing system for quality control was developed and discussed. In the experiments, there was no destroying caused by collision between the RFID of reconstructed electronic spool or other. The new system solved the trouble of the old system which needed to use a PC in order to manage the serial number of spindles. The experiments proved that the system was available and robust.

ACKNOWLEDGEMENTS

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CRONICĂ

TEXWORLD 2010

Ediția din septembrie a ***Texworld*** a avut loc la centrul expozițional Le Bourget/Paris și s-a bucurat de participarea a circa 850 de expozanți, peste 150 dintre aceștia fiind din rândul celor specializați în producția de îmbrăcăminte. Un număr din ce în ce mai mare de companii caută să-și verticalizeze producția, în vederea optimizării costurilor, a reducerii timpului de fabricație și a restricționării numărului de colaboratori externi. *„Interesul nostru este acela de a dezvolta acest sector, deoarece este foarte cerut de vizitatorii noștri... Cererea este semnificativă și răspundem acestei nevoi prin deschiderea porților pentru companii specializate în full-packages și în produse de înaltă calitate*" – afirma Michael Scherpe, președinte al Messe France.

Târgul chinezesc pentru comerțul cu textile și îmbrăcăminte – *CTAF*, a reunit aproape o sută de companii textile specializate în producerea de îmbrăcăminte, unele cu tradiții de secole. Scopul acestora este acela de a dezvolta o gamă de produse care să întrunească cerințele piețelor vestice, în ceea ce privește calitatea și stilul. Producători din regiuni precum Beijing, Jiangsu, JueXi sau Zhejiang au oferit broderii fine, mătăsuri sau tricoturi suple, foarte apreciate de actorii din sector.

Numărul expozanților de la CTAF aproape că s-a dublat față de ediția precedentă a Texworld, ceea ce reprezintă o mărturie vie a intențiilor de consolidare a legăturilor economice dintre China și piețele europene. În acest sens, Zhang Tao, reprezentant al Camerei de Comerț și Industrie Textilă din China, afirma: *„Participarea noastră la Texworld reprezintă o oportunitate de intensificare a eforturilor, în perspectiva unei colaborări de lungă durată între expozanții noștri și clienții din Vest. Oferim produse foarte variate, ce întrunesc diversele nevoi ale firmelor și întreprindem ceea ce este necesar pentru a răspunde cel mai bine cererilor clienților noștri, în ceea ce privește calitatea și promptitudinea livrării".*

Consiliul de Dezvoltare Comercială din Hong Kong, *HKTDC*, reunește producători de îmbrăcăminte cu experiență și tradiție îndelungată, care, în prezent, sunt cunoscuți pretutindeni în lume, datorită unor platforme cum este Texworld.

Diversitatea articolelor de îmbrăcăminte a fost asigurată și de companii europene precum *IGL Textil, Piazza Italia, grupul Bestseller, Esprit* etc. *„Participând la Texworld, am putut penetra piețe noi, prin intermediul unor colaborări dezvoltate în cadrul expoziției*" – spunea Frans Bourgeois de la compania belgiană *Mabo Fashion*, specializată în realizarea de cămăși în stil vestic și la prețuri atractive.

Așa cum afirma Murat Ozudogru, director de export al firmei *Ozsim* – producătoare de articole de damă și bărbătești, unii furnizori de articole de îmbrăcăminte au participat pentru prima dată la Texworld, cu scopul de a întâlni parteneri cu care să poată stabili o colaborare pe termen lung.

Firma *Royal Touch* din India, producătoare de accesorii, a prezentat o mare varietate de fulare, eșarfe și pareos din mătase, bumbac sau in, pentru a răspunde oricăror cerințe speciale, solicitate de companiile partenere.

Informații de presă. Messe Frankfurt France, iulie 2010

Algoritmi generalizați de proiectare automată a îmbrăcămintei

MANUELA DIACONU
MARIUS DIACONU
EMILIA VISILEANU
CLAUDIA NICULESCU

ABSTRACT – INHALTSANGABE

Generalized algorithms for computerized apparel design

The development of computerized measurement techniques, particularly by 3D scanning, as well as the mathematical applications, allow the clothing production individualization process to evolve in two directions: sizes systems – with a sufficient number of typo-dimensional variants, thus all bodies could be represented, and design algorithms, with sufficient number of anthropometric parameters, with/without new design rules. The selection of representative dimensional features that describe the body's geometry, and identification of the most suitable design rules, allow the gradual elimination of the body-print correspondence verification, by fitting the product on the body (the classical variant) or by 3D draping (the modern version). The paper presents the basic features of an original type of algorithms, called by the authors generalized algorithms, by means of which basic patterns for any geometric configuration of the body are automatically generated.

Key-words: generalized algorithm, automatic design, 3D scanning, 3D draping, mathematical modeling, individual print

Generalisierte Algorythmen für den automatisierten Bekleidungsentwurf

Die Entwicklung der Messungstechniken im automatisiertem System, insbesondere mit 3D-Bildaufnahme, sowie die Anwendung mathematischer Berechnungen, erlauben den Fortschritt des Individualisierungsprozesses der Bekleidungsproduktion in zwei Richtungen: Grössensysteme, mit einer ausreichenden Nummer von typodimensionellen Varianten, so dass alle Körpertypen vertreten sind und Entwurfsalgorythmen, mit einer ausreichenden Nummer von antropometrischen Parameter, mit/ohne neue Entwurfsregeln. Die Auswahl der dimensionellen Charakteristika, welche vertretend für die Beschreibung der Körpergeometrie sind, sowie die Aussuche der besten Entwurfsregeln, erlauben die stufenweise Eliminierung der „berprüfungsetappe der bereinstimmung Körper-Schnittmuster, durch die Probierung des Produktes auf dem Körper (klassische Variante) oder durch 3D - Drapierung (moderne Variante). Die Arbeit stellt vor die Basischarakteristika eines originellen Algorythmtypes, welche vom Author als generalisierte Algorythmen bezeichnet werden, durch welche automatisch Basisschnittmuster generiert werden, für eine jedwelche geometrische Körperkonfiguration.

Schlüsselwörter: Generalisierte Algorythmen, automatischer Entwurf, 3D-Bildaufnahme, 3D-Drapierung, mathematische Modellierung, Individualisiertes Schnittmuster

Proiectarea individualizată nu mai reprezintă astăzi un concept nou. Noutatea este dată doar de abordarea unor noi metode de proiectare, dezvoltate de cercetători și transpuse de producătorii de software în diverse aplicații, precum: proiectarea semiautomată și automată MTM (made-to-measure); proiectarea 2D și probarea 3D a tiparelor-fișier pe avataruri sau corpuri scanate; proiectarea 2D și probarea 3D în sistem integrat, orice modificare de dimensiune reflectându-se în tiparul 3D; proiectarea 3D pe avatar/model 3D și obținerea ulterioară a desfășuratelor plane. Există câteva sisteme comerciale, care se evidențiază prin rezultate apreciabile, cum ar fi: Browzwear Systems, Scanvec Garment Systems (Optitex), Lectra Systems, Gerber Technology, Tukatech, PatternMaker, CADTERNS etc.

Algoritmii generalizați au fost concepuți în scopul eficientizării producției de îmbrăcăminte individualizată [2], [4]. Aplicarea algoritmilor generalizați implică automatizarea etapei de proiectare.

CARACTERIZAREA ALGORITMILOR GENERALIZAȚI

- *Algoritmii generalizați descriu corpul real corect, „estetic", cu/fără adaosuri de lejeritate.*

Proiectarea în varianta de serie utilizează ca model corpurile tip, obținute în urma prelucrărilor statistice a dimensiunilor prelevate de la un segment de populație. Indicatorii morfologici de caracterizare a formei exterioare a corpului uman (dimensiuni globale, conformație, proporții etc.) reprezintă criterii de clasificare a corpurilor tip, pentru care se elaborează algoritmii de construcție a tiparelor de bază în diverse variante. De cele mai multe ori, acești algoritmi reprezintă modele de proiectare și pentru produselor individualizate, cu deosebirea că numărul de dimensiuni utilizate este mai mare [1], [5]. Acest mod de lucru îmbunătățește, în anumite cazuri, corespondența corp-tipar, dar nu elimină etapele finale de măsurare și verificare a tiparului, respectiv de probare a acestuia pe corp prin drapare 3D, conform celor mai evoluate aplicații de proiectare.

Algoritmii generalizați realizează modelarea matematică a formei exterioare a corpului real [3], [7], astfel încât unele noțiuni – prelucrarea statistică, indicatorul morfologic etc. – își pierd sensul. Practic, se prelevează de pe corpul scanat un set complet de parametri antropometrici, în ideea descrierii complete a corpului indiferent de particularitățile conformaționale [6]. Cu acest set de caracteristici dimensionale 3D se construiesc tipare de bază cu adaosuri de lejeritate „0", care îmbracă corect și armonios corpul, precum o „armură". Aplicând adaosurile de lejeritate corespunzătoare, se obțin tipare pentru diverse siluete de produs.

Caracteristicile utilizate sunt dimensiuni standardizate, prelevate numai între puncte antropometrice ușor identificabile (proeminențe, apofize etc.), cum a fi: perimetre, lungimi, lățimi, diametre, arce și, nu în ultimul rând, adâncimi. Aceste caracteristici pot fi preluate și dintr-un standard antropometric 3D. Pensele care redau forma spațială a produsului de îmbrăcăminte sunt calculate cu precizie. Adâncimile, deosebit de importante în calcularea deschiderilor de pense, se utilizează și pentru dimensionarea unor segmente de bază din tipare. De exemplu, în cazul unui corsaj confecționat din material textil neelastic (fig. 1), algoritmul generalizat introduce ca variantă de proiectare următoarele ecuații de calcul al lățimii feței:

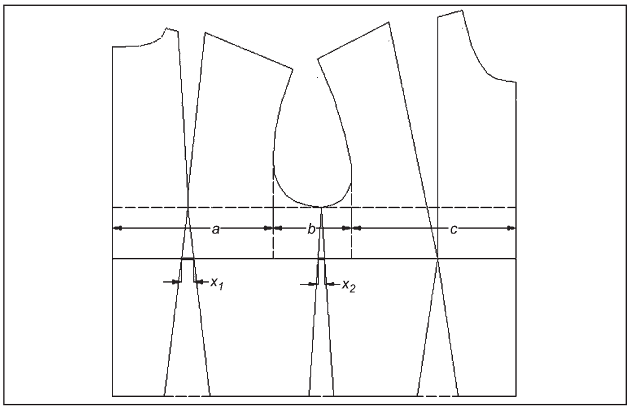

Fig. 1

$$c = 0.5 \cdot P_b + A_x + X_1 + X_2 - (a + b), \quad (1)$$

comparativ cu producția de serie

$$c = 0.5 \cdot P_b + A_x - (a + b) \quad (2)$$

$$X_1 = F(P_b, P_t, X_2, A_0, A_l, A_b, f_1) \quad (3)$$

$$X_2 = F(P_b, P_t, A_l, A_0, Ab, f_1, f_2) \quad (4)$$

în care:

a reprezintă lățimea spatelui;
b – lățimea răscroielii mânecii;
c – lățimea feței;
P_b – al treilea perimetru al bustului;
P_t – perimetrul taliei;
A_0 – prima adâncitură a curburii lombare;
A_l – adâncimea laterală;
A_b – adâncimea bustului;
A_x – adaosul de lejeritate în zona bustului;
f_1, f_2 – factorii ce depind de dimensiunile corpului – lungimea taliei în față, lungimea spatelui până la talie, înălțimea bustului, lungimea spatelui până la diametrul axilo-posterior, poziția omoplatului.

În figura 2 sunt ilustrate prima adâncime a curburii lombare A_0, adâncimea laterală A_1 și adâncimea bustului A_b.

În cazul în care adaosul de bust este A_x = 0, cu siguranță ecuația (1) va dimensiona corect lățimea feței, indiferent de dimensiunea P_b și de particularitățile de conformație a trunchiului. Nu se poate afirma același lucru și în cazul ecuației (2), care este aplicabilă numai corpurilor tip și corpurilor reale cu conformație asemănătoare și cu condiția ca $Ax \neq 0$.

În proiectarea clasică, manipularea adaosurilor de lejeritate acoperă toate inconvenientele legate de particularitățile conformaționale. Din această cauză, tiparele comercializate prezintă adaosuri foarte mari. Algoritmii generalizați lucrează cu un set simplu de adaosuri, care

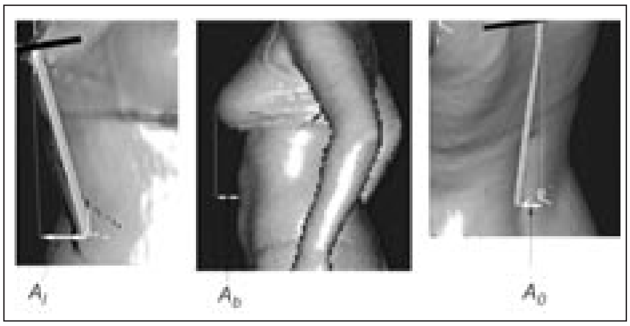

Fig. 2

variază numai în funcție de silueta produsului, fiind independenți de geometria corpului. Cu siguranță, adaosul de lejeritate A_x = 3 cm și chiar mai mic, pentru tiparul unei rochii ajustate, construit cu algoritmul generalizat, este suficient și se regăsește la aceeași valoare în produsul final, indiferent de geometria corpului.

- *Algoritmii generalizați sunt unici.*

Unicitatea este dată de faptul că utilizatorul setează același tip de parametri, indiferent de geometria corpului și obține un tipar unic, destinat corpului investigat. Sistemul este complex, se derulează pe mai multe ramuri și ține cont de o serie de restricții, conform varietății morfologice a corpurilor reale. Cu alte cuvinte, programul analizează automat dimensiunile primite și generează tiparul potrivit corpului. De exemplu, în cazul unei fuste, rutina conține trei ramuri de bază, în funcție de raportul care există între perimetrele zonei inferioare a trunchiului: P_{ab} – perimetrul maxim al abdomenului, preluat la nivelul cel mai proeminent al abdomenului; P_f – perimetrul fesier, preluat la nivelul proeminenței fesiere și $P_ș$ – perimetrul maxim al șoldurilor, preluat la nivelul cel mai proeminent al șoldurilor (fig. 3).

- *Algoritmii generalizați introduc noi reguli de proiectare.*

Curbele de contur, de regulă arce de cerc și parabole, care urmăresc armonios geometria corpului, sunt calculate precis și corespund dimensiunilor corpului. De exemplu, lungimea proiectată a liniei cusăturii laterale între linia taliei și linia șoldurilor este egală cu lungimea măsurată pe corp între aceleași repere.

Curbele de contur prezintă tangente comune în punctele de întâlnire tip curbă-curbă sau curbă-segment de dreaptă, situate pe răscroiala gâtului, răscroiala mânecii, linia taliei, linia de terminație a produsului (figurile 4 și 5).

Pensele de pe linia taliei, pensa de bust, precum și pensa de omoplat sunt calculate precis și se închid perfect, asigurând modelului armonie și verticalitate. De

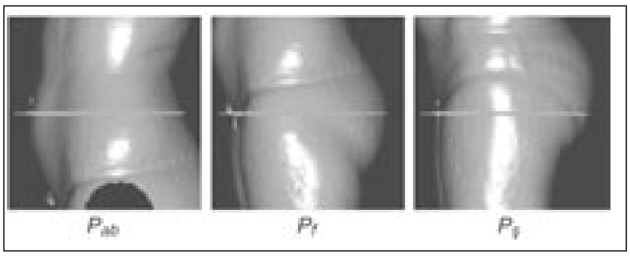

Fig. 3

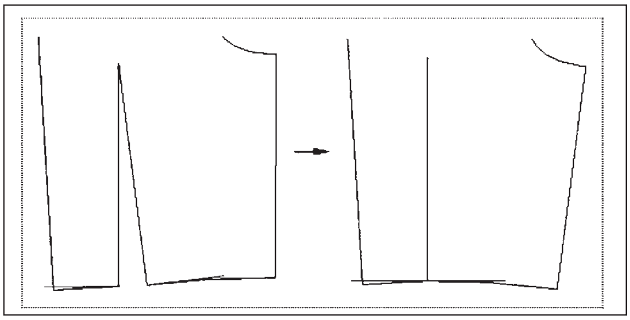

Fig. 4

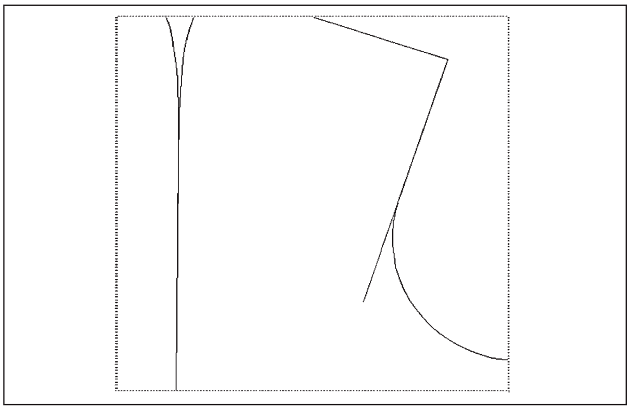

Fig. 5

exemplu, în cazul produsului fustă, axele penselor se dispun radial în așa fel, încât, la îmbrăcarea produsului pe corp, acestea să devină normale la sol.

Consecința firească a generalizării algoritmilor de proiectare este obținerea unor probleme supradimensionate, chiar dacă numărul parametrilor de calcul prelevați de pe modelul 3D al corpului crește semnificativ. De aceea, apare necesitatea formulării unor probleme suplimentare de optimizare matematică cu restricții generale (neliniare) și a soluționării lor, utilizând cele mai ieftine motoare de optimizare disponibile pe piață (Lindo Lingo și ameliorări ale Excel Solver).

Ca interfață grafică cu utilizatorul a fost ales un mediu CAD popular, foarte ieftin, capabil să integreze aplicațiile de optimizare. Deoarece Excel Solver va continua să fie cel mai robust motor de optimizare la un preț modic, s-a optat pentru integrarea Excel (evident, într-un mod invizibil) în cea mai populară clonă AutoCAD, și anume ZwCAD.

CONCLUZII

Soluția problemei privind potrivirea produselor de îmbrăcăminte pe corp, indiferent de configurația morfologică, constă în adoptarea unei proiectări bazate pe regulile „potrivirii perfecte“ și pe implementarea unor algoritmi de proiectare generalizați, care utilizează optimizarea matematică pentru satisfacerea acestor restricții. Deoarece problemele de optimizare matematică nu se pot rezolva decât în mod automat, este necesară generarea automată a tiparelor. Principala proprietate (restrictivă) a acestor tipare constă în aceea că, în principiu, orice modificare ulterioară a construcției de bază, executată prin mijloace tradiționale, afectează potrivirea cu corpul pentru care ele au fost create. Astfel de modificări trebuie realizate după aceleași reguli de potrivire pe corp, efectuate tot prin optimizare matematică. În schimb, se poate aplica orice modelare care nu afectează construcția de bază a tiparului. Metoda de lucru este dezvoltată în cadrul proiectului european EUREKA *„O nouă îmbrăcăminte – CAD pentru modelarea geometrică 2D/3D a confecțiilor“*. Sistemul propus în această lucrare prezintă o serie de avantaje:

- Construiesc, practic instantaneu, tipare dimensionate corect, care îmbracă firesc corpul subiectului – condiția fiind îndeplinită indiferent de varianta morfologică;
- Sunt eliminate operațiilor uzuale de măsurare/verificare care însoțesc obligatoriu proiectarea clasică, etapa de probare a tiparelor pe corp fiind, practic, transferată în etapa de elaborare a algoritmilor generalizați;
- Sarcina utilizatorului constă doar în setarea caracteristicilor de calcul în fereastra de lucru, analiza și proiectarea fiind realizate în cadrul programului.

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Investigating the performance of various relaxation processes on the surface regularity and the dimensional properties of interlock knitted fabric using image processing technique

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REZUMAT – ABSTRACT – INHALTSANGABE

Studierea performanţei diferitelor procese de relaxare asupra uniformităţii de suprafaţă şi a proprietăţilor dimensionale ale tricoturilor interloc, prin utilizarea tehnicii de procesare a imaginii

În lucrare este studiată influenţa diferitelor regimuri de relaxare asupra uniformităţii formei ochiurilor şi a proprietăţilor dimensionale ale tricoturilor interloc din urzeală. Pentru a obţine structuri de tricotare mai stabile şi mai uniforme, tricoturile interloc au fost supuse unor metode complexe de relaxare, mecanică şi chimică, iar apoi s-a evaluat îmbunătăţirea formei ochiurilor prin măsurarea abaterii unghiului de înclinare a ochiurilor faţă de poziţia ideală, pe materiale din diferite tipuri de fire, şi s-a obţinut indicele de neuniformitate a materialului, utilizând metoda convenţională şi cea inteligentă. Rezultatele arată că tratamentul de relaxare chimică în ultrasunete are o influenţă mai mare asupra uniformităţii formei ochiurilor şi a stabilităţii dimensionale a tricoturilor interloc, comparativ cu alte metode de relaxare. De asemenea, după aplicarea acestui tratament, media valorii constante a parametrului dimensional al materialului - Us, este mai apropiată de valoarea ideală. Prin urmare, se recomandă folosirea tratamentului de relaxare chimică în ultrasunete, fiind mai eficient asupra uniformităţii formei ochiurilor şi a proprietăţilor dimensionale ale tricoturilor interloc.

Cuvinte-cheie: tricot interloc, uniformitate de suprafaţă, proprietăţi dimensionale, tratament de relaxare, relaxare chimică în ultrasunete, tehnică de procesare a imaginii

Investigating the performance of various relaxation processes on the surface regularity and the dimensional properties of interlock knitted fabrics using image processing technique

In this study, the effects of various relaxation regimes on stitches shape regularity and dimensional properties of interlock weft-knitted fabrics were investigated. To obtain more regular and stable knitted structure, we applied various mechanical, chemical and complex relaxation methods on interlock knitted fabrics. The improvement rhythm of the stitch shape during various relaxation processes was evaluated by measuring the stitches direction angle deviation from the ideal state, on fabrics obtained from different yarn types, and the index of fabric irregularity was obtained by both the conventional and the intelligent methods. The results show that, the ultrasonic-chemical relaxation treatment has a greater effect on stitches shape uniformity and dimensional stability of interlock knitted fabrics, compared to other relaxation methods. Also, after the above treatment, the average of the fabric's constant dimensional parameter (Us) is closer to an ideal value. Therefore, the utilization of the ultrasonic-chemical relaxation treatment is recommended, due to its effectiveness on the stitches shape regularity and dimensional properties of interlock knitted fabrics.

Key-word: interlock knitted fabric, surface regularity, dimensional properties, relaxation treatment, ultrasonic-chemical relaxation, image processing technique

Untersuchungen der Leistung verschiedener Entspannungssprozesse auf der Oberflächengleichförmigkeit und der dimensionellen Eigenschaften der Interlockware, durch Anwendung der Bildbearbeitung

In der Arbeit wird die Einwirkung der verschiedenen Entspannungsrbedingungen auf der Gleichförmigkeit der Maschenform und der dimenionellen Eigenschaften der Ketten-Interlockware untersucht. Um stabilere und gleichförmigere Wirkwarenstrukturen zu erhalten, wurde die Interlockware einiger komplexen mechanischen und chemischen Entspannungsmethoden ausgesetzt, dann wurde die Verbesserung der Maschenform bewertet, durch die Messung der Abweichung des Neigungswinkels der Maschen im Vergleich zur Idealstellung, auf Materialien aus verschiedenen Fasertypen und es wurde somit der Ungleichförmigkeitsindex des Materials erhalten, indem die konventionelle und die intelligente Methode angewendet wurde. Die Ergebnisse zeigen, dass die Ultraschall-chemische Entspannungsbehandlung einen grösseren Einfluss auf die Gleichförmigkeit der Maschenform und der dimensionellen Stabilität der Interlockware hat, im Vergleich mit anderen Entspannungsmethoden. Gleichsfalls, nach Anwendung dieser Behandlung, ist der Mittelwert des konstanten dimensionellen Parameters der Wirkware – Us, näher einem Idealwert, was in vorherigen Untersuchungen vorgestellt wurde. Deshalb schlagen wir vor die Ultraschall-chemische Entspannungsmethode vor, als neue Entspannungsmethode, welche effizienter für die Gleichförmigkeit der Maschenform als auch für die dimensionellen Eigenschaften der Interlockware ist.

Schlüsserwörter: Interlockware, Oberflächengleichförmigkeit, dimensionelle Eigenschaften, Entspannungsmethoden, Ultraschall-chemische Entspannung, Bildbearbeitungstechnik

Both of the stitches shape uniformity and dimensional stability of weft-knitted fabrics play an important role in the quality of knitted fabrics. Because of their balanced structure, these two properties of interlock weft-knitted fabrics have received comparatively lesser attention than plain or rib weft-knitted fabrics. Munden [1] showed that in fully relaxed knitted-fabric, the loop takes up a fixed geometrical shape. According to this comprehensive study, he defined four non-dimensional parameters or *K*-values in order to determine the dimensional properties of plain knitted fabrics. But to specify the dimensional characteristics of complex knitted structures, various methods of defining the fabric parameters have been utilized. It is obvious that all double-knit structures are made up of repeated, identical structural knit-cells – *SKC*, which are themselves combinations of simple structural knit units. Paying attention to this concept, Knapton et al. [2] modified Munden's *K*-values for complex knitted structures. According to *SKC* definition, in complex knitted fabrics the effective loop length should be the length of the yarn in the smallest repeated unit of the structure, l_u. They also defined the following non-dimensional parameters for complex knitted structures including: Course units per fabric length unit – C_u, wale unit per fabric width – W_u, and the number of *SKC*'s per unit area – S_u. The structural knitted cell in the interlock knitted fabrics consists of four single loops. Therefore the dimensional relations can be defined by the equations (1)–(4).

$$U_c = C_u \times l_u \qquad (1)$$

$$U_w = W_u \times l_u \quad (2)$$

$$U_s = S_u \times l_u \quad (3)$$

$$\frac{U_c}{U_w} = \frac{C_u}{W_u} \quad (4)$$

The forces imposed on the yarn during the knitting process and stitch forming, create some non-uniformity on the stitch shape. Relaxation treatment, by releasing the stitches from the action of these extra forces, brings the stitch shape closer to the fixed geometrical and uniform shape. Stitch shape uniformity and dimensional stability of knitted fabrics can be attained by either mechanical relaxation or chemical treatments. Knapton [3] concluded in a comprehensive empirical study that the dimensional properties of complex structures are not different from those of the simpler structures in relaxation and laundering. On the contrary, once wool fabrics prevented from felting are completely relaxed, the *SKC* appears to take up a fixed configuration, independent of the tightness of construction and presumably the diameter of the yarn. Dimensions are therefore dependent on the structure and length of the yarn in the knitted cell only, and are easily calculable before knitting. Furthermore, if the machines are accurately set by using positive feed, it is unnecessary to measure the l_u in the finished fabric. In another study, Jeddi et al. [4] concluded in a comprehensive experimental analysis that the correct relaxation state for interlock knitted cotton fabrics to reach the maximum shrinkage is the full mechanical relaxation, and for cotton/polyester blended and 100% polyester fabrics is the chemical relaxation treatment. Their empirical results showed that the effect of mechanical relaxation decreases as the percentage of polyester increases. Semnani et. al. [5] proposed an ideal model for plain weft-knitted fabric by using the classic mathematical curves (Strophoid and Folium of Descartes curves) based on the elastic rod model of leaf's theory [6]. According to this model, in fully relax state, the single loop takes up a specific shape that has a factor equal to 1.4002. Jeddi et al. [7] by improving the mentioned ideal model, prepared an ideal model for the interlock structure. They assumed that the loops face in plain and interlock structures are similar. Therefore, this segment of the *SKC* follows the equation of the improved strophoid curve and another segment of *SKC*, the linking portion between the face and back loops, expressed by means of a quadratic equation. Then, they extended this theory to a three-dimensional model. In another study, Jeddi et al. [7] employed ultrasound waves as a new tool to decrease fabrics internal energy in order to improve the performance of relaxation treatments on dimensional stability of weft-knitted fabrics. Ultrasonic waves with frequencies above 20 KHz, which are beyond the human hearing ability, are longitudinal pressure waves. However, by using this novel relaxation method, they could obtain more stable knitted structure, but the average of loop shape factor after this finishing treatment still differed from the ideal value [5]. Therefore, we can conclude that more advanced and suitable relaxation methods should be used in finishing treatments, for the weft-knitted fabrics to acquire a stitch shape closer to an ideal shape.

Computer vision is an accurate tool to evaluate fabric features. It is clear that human inspection vision is time consuming and tiresome, and also depends on human precision. In recent decades many researchers have implemented computer vision in order to improve the inspection method of human vision in textile products. Some workers attempted to utilize the image analysis technique as a real-time inspection tool for fabric quality evaluation. Celik et al. [8], attempted to utilize the image processing technique for determining the angle of spirality in knitted-fabrics. They specifically used the Fast Fourier Transform to cover this matter. They applied the Fast Fourier Transform – *FFT*, to a two-dimensional discrete function and obtain the power spectrum and the logarithmic spectrum of the fabric's image. They also compared their image analysis result with manual inspection result and concluded that the differences between the calculated and measured spirality angles are generally not greater than one degree. In another study, Furferi [9] et al. presented a machine vision tool for on-line detection of the defects on the raw textile fabrics. This tool worked in four stages:

- the image acquisition of the raw fabric;
- the extraction of some critical parameters from the acquired images;
- detection and classification of the most frequent defects by artificial neural network – *ANN*, as a classifier;
- applying the image processing technique to measure the geometric properties of the detected defects.

Ghazi Saeidi et al. [10] developed an on-line computer vision system for knitted fabrics inspection on the circular knitting machine. They considered the performance of this tool on two levels: laboratorial and industrial scale. They also used three different spectral transforms (discrete Fourier transform, the wavelet and the Gabor transforms), and concluded that the Gabor transform method has the highest efficiency value among the three methods.

In all above mentioned studies, the number of faults and their localization were both used to define the quality of the knitted fabric. The probable defects in the knitting process were: broken needles, hole, soil strip or thin and thick-yarn defect etc. But one of the most important faults in the weft-knitted fabric is an irregularity of stitch direction during the knitting process. On the other hand the quality of the non-defective fabric depends on the regularity of the fabric surface which is related to the direction of stitches in the ideal fabric as an almost fully relaxed fabric. In our previous studies [11, 12] we developed a grading method for weft-knitted fabrics, based on stitch deformation in different types of weft-knitted fabrics. We presented a novel definition regarding the knitted fabric quality and defined a fabric irregularity index that determined the deviation of the stitches direction angle from an ideal state [5], by means of image processing techniques on different weft-knitted fabric structures of various yarns. In this study, we used the image analysis method to study the effect of various relaxation processes on fabric regularity and stitch shape. Also we defined a new and more effective relaxation processes in order to obtain the stable form of interlock knitted fabrics, where the angle of stitch direction is near to the ideal angle and therefore the stitch shape close to the ideal shape.

METHODS AND EXPERIMENTS

Sample preparation

In this research various weft-knitted fabric samples were prepared from ring spun yarns with interlock knitted structures and almost equal SKC length to consider the effect of various raw materials and relaxation treatments on the dimensional properties and surface regularity of distorted stitches. The samples were produced without knitting faults such as holes, drop stitches and stripes. Six samples of various yarn types were prepared including cotton ring spun yarn of 20 and 30 Ne, polyester/cotton ring spun yarn (65/35%) of 20 and 30 Ne and polyester/viscose ring spun yarn (65/35%) of 20 and 30 Ne. All samples were produced on a circular knitting machine with positive feed in interlock structure and in similar knitting stiffness with following l_u: 1.49, 1.50, 1.48, 1.51, 1.47 and 1.51 cm. The machine's cylinder diameter is 30, 18 gauge, four cam tracks, and 12 feeders. The machine's yarn input tension was set to 5 g. Four specimens were taken from each knitted fabric, which were produced from different yarn types. Then, each of these samples was subjected to seven different kinds of relaxation regimes (dry, wet, washing, ultrasonic, chemical, detergent-washing, ultrasonic-chemical).

Relaxation process

To consider the effectiveness of various relaxation regimes on knitted fabrics regularity and dimensional properties and for attaining a more suitable relaxation treatment, seven different relaxation processes were defined in three categories. In general, relaxation treatments were divided in two main categories: mechanical and chemical treatment. In mechanical relaxation process, knitted fabrics were subjected to mechanical forces in order to decrease the potential energy of the fabric. In chemical methods, by using chemical processes, such as immersing the fabric in aqueous solutions like ionic detergent baths, attempts have been made to decrease the friction between yarns and to obtain stable knitted structure. In this study, we defined two complex (mechanical-chemical) relaxation processes as the third category, to consider the overall effect of the above mentioned treatments on fabric regularity and dimensional properties and also to attain a more advanced finishing treatment for the weft-knitted fabrics. Therefore each sample was subjected to the following relaxation treatments:

- ***Mechanical relaxation methods:***
  - *Dry relaxation* – the samples were relaxed on a flat surface, at room temperature conditions (25 ± 2°C and RH 65% ± 2) for 24 hours, to release knitted stresses;
  - *Wet relaxation* – the samples were immersed in water bath containing 0.01%, wetting agent at 38°C, for 12 hours and then removed, hydro-extracted gently, and then dried on a flat surface for 24 hours at room temperature;
  - *Washing* – the samples were washed in a domestic washing machine with water containing 0.1% neutral detergent at 50°C, for 35 minutes, then the water drained off; the fabric samples were then removed from the washer, hydro-extracted and dried in tumble drier for 10 minutes and finally the sample was placed on a flat surface for 24 hours at room temperature;
  - *Ultrasonic waves* – fabric samples were placed in an ultrasonic cleaning bath, created by Walter Company, using a frequency of 35 kHz, an intensity wave of 9 W/cm^2, and water temperature of 70°C for 10 minutes relaxation time; the samples were then dried for 24 hours on a flat surface at at room temperature.
- ***Chemical relaxation method:***
  - *Chemical relaxation* – fabric samples were immersed in water bath containing 2 g/l cationic detergent at 50°C for 20 minutes and then removed, hydro-extracted gently, dried on a flat surface for 24 hours at room temperature.
- ***Complex relaxation methods:***
  - *Detergent-washing* – the samples were washed in domestic washing machine with water containing 2 g/l cationic detergents at 50°C, in conditions as described for the washing relaxed state;
  - *Ultrasonic-chemical* – fabric samples were placed in an ultrasonic cleaning bath, created by Walter Company, containing 2 g/l cationic detergent, in conditions as described for the ultrasonic waves process;
  - After each relaxation treatment, fabrics dimensional parameters including course units per fabric unit length – C_u, wale unit per fabric width – W_u, and the number of *SKC*'s per unit area – S_u, of all fabric samples were measured. Also fabric constant parameters were calculated according to Knapton's equations [1]. The average of four measurements of constant dimensional parameter – U_s, is shown in table 1.

MEASURING METHODS FOR STITCH DIRECTION

In the next stage, in order to evaluate stitch formation rhythm during various relaxation processes, we utilized our pervious approach as a new intelligent method for evaluating knitted fabric regularity, based on the image processing technique and Radon transformation analysis, and we also compared the results of this method with the results obtained from the conventional method for determining the stitches direction angle after each relaxation process. Fabric samples were scanned in BMP format of gray scale with a resolution of 1 200 dpi. The scanned images were 200 x 200 mm in size. To detect the stitches direction, the gray scale image of the yarn was converted to an edge-detected form by a differential mask. There are different methods of edge detection in the image processing technique. In one edge-detection method an intensity image is processed and returned as a binary image of the same size, with 1's where the function finds edges and 0's elsewhere.

Table 1

VALUES OF DIMENSIONAL PARAMETER U_s OF INTERLOCK KNITTED FABRICS AT EACH RELAXED STATE								
Yarn type	Yarn count, *Ne*	U_s						
		Dry	Wet	Washing	Ultrasonic	Chemical	Detergent washing	Ultrasonic/ chemical
Cotton	20	144.31	152.01	156.62	171.79	156.26	170.90	175.32
Cotton	30	160.98	167.22	169.16	168.10	166.96	170.11	176.49
Polyester/cotton (65/35%)	20	153.12	157.72	163.61	166.74	165.66	171.29	169.71
Polyester/cotton (65/35%)	30	157.31	162.77	169.11	170.11	169.71	169.54	176.76
Polyester/viscose (65/35%)	20	158.82	163.78	167.30	168.35	166.82	168.01	173.42
Polyester/viscose (65/35%)	30	160.27	165.38	167.77	171.17	169.88	163.96	174.34

According to our previous study we used Canny's method as the most powerful edge-detection method to convert the gray scale image of knitted fabric to an edge-detected form. The Canny's method [13] differs from other edge-detection methods in the fact that it uses two different thresholds (to detect strong and weak edges), and includes the weak edges in the output only if they are connected to strong edges. This method is therefore more likely to detect truly weak edges. A sample of an edge-detected image in dry relaxed state is shown in figure 1. After converting the original image to an edge-detected form, the Radon transformation was used to find the stitches direction. Applying the Radon transform on an image $f(x, y)$ for a given set of angles can be thought of as computing the projection of the image along the given angles. The resulting projection is the sum of the intensities of the pixels in each direction, i.e. a line integral. The result is a new image $R(\rho, \theta)$. This can be mathematically written as the defining equation (5):

$$\rho = \chi \cos\theta + y \sin\theta \tag{5}$$

After which the Radon transform can be written as the equation (6):

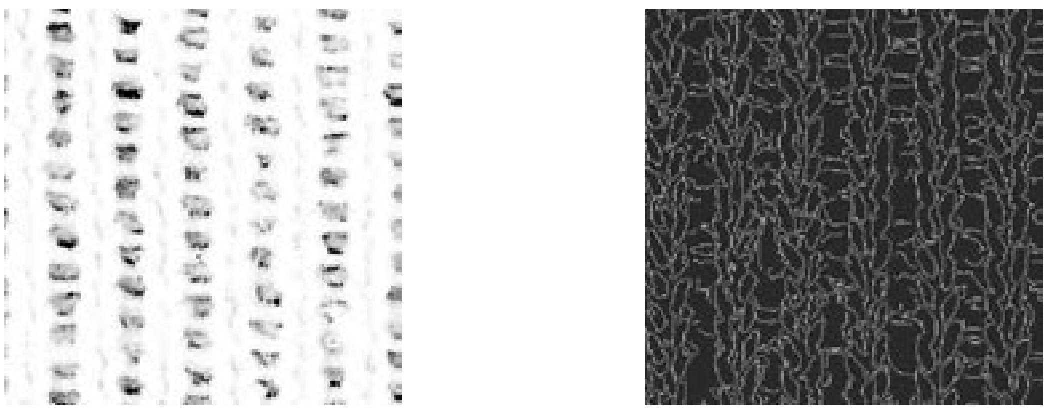
$$R(\rho,\theta) = \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} f(x,y)\delta(\rho - \chi\cos\theta - y\sin\theta)dxdy \tag{6}$$

Where $\sigma(\cdot)$ is the Dirac delta function [14]. According to our previous approach we applied Radon transformation on fabric images in each relaxed state for 180 times in one degree increment. The result will be a matrix *R*, of *n* by 180, where *n* is the length of each column and the number of columns is 180. *R* matrix is an intensity matrix which can be presented as a color map histogram. The plot of high intensity raw of Radon transformation matrix is shown in figure 2. In this plot the maximum value refers to the column number or angle of stitches direction [14]. Because of the Radon transpose of edge image, where the direction of stitches is evaluated in the *x* and *y* axes, the maximum value is repeated after 90 degrees at the mirror point of the first repeat, which is located before 90 degrees. For all fabric images preparations and image analysis to detect stitches direction, the image processing toolbox of MATLAB 7 was applied.

According to Munden's equations, stitch shape factor is represented as the equation (7):

$$tg\alpha = K_r = \frac{cpc}{wpc} = \frac{K_c}{K_w} = \frac{D}{d} \tag{7}$$

Where α_k is the angle between the stitches of consecutive courses in plain knitted structure as shown in figure 3. α_k is located between two stitches in successive order where one of them is located in the first course and the other is located in the second course. *D* and *d* are the height and width of a stitch. As we demonstrated in the previous paper, we assumed that



a *b*

Fig. 1. Cotton 20 Ne interlock knitted fabric ar dry relaxed state:
a – original image of fabric; *b* – enhanced image of fabric as edge-prepared image

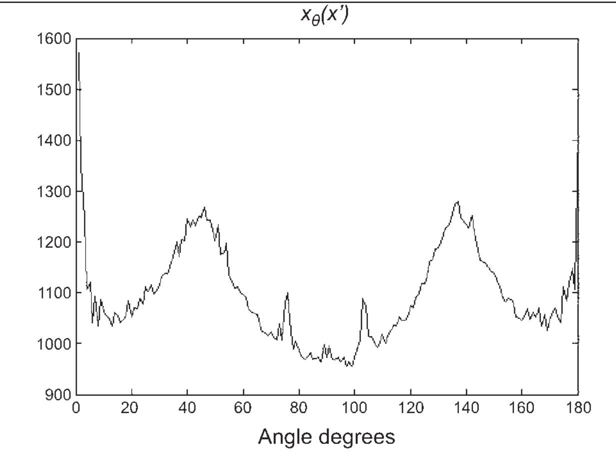


Fig. 2. Plot of high intensity raw of Radon transformation matrix of hot histogram

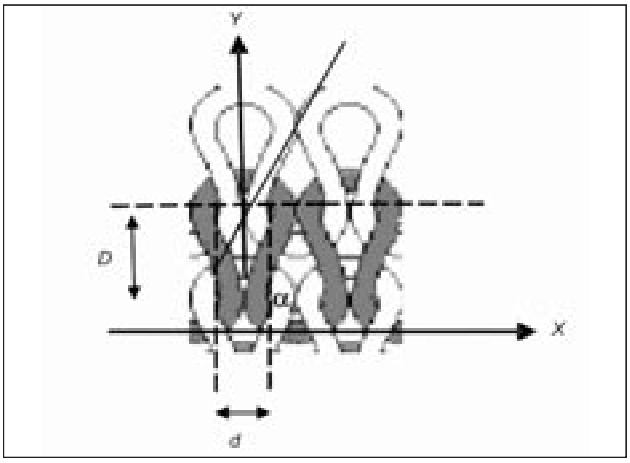


Fig. 3. Model of stitches in ideal knit structure [II]

in fully relaxed state the values of K_c = 6.123 and K_w = = 4.373 from a three-dimensional model [3], thus:

$$tg\alpha_k = \frac{K_c}{K_w} = 1.4002 \quad (8)$$

Then, α_k = 54.5. As we mentioned in previous work [11], it could be assumed that in the fully relaxed fabric the K_r is equal to 1.4002, otherwise the structure would not be fully relaxed and the loops might not be in an ideal state. We can assume that this is true for other similar structures like as interlock knitted fabrics but not rib, milano or cardigan structures. In interlock weft-knitted fabrics as well, by using equation (7) we can calculate the angle between the stitches of consecutive courses or α_k.

To consider the effect of each relaxation processes on interlock knitted fabrics regularity, we calculated the index of irregularity, I_a as our previous work [11] after each relaxation treatment (table 2). Also to compare the results of human vision and computer vision we defined two fabric irregularity indices as equations (9) and (10).

$$I_a = \frac{|54.5 - \alpha_a|}{54.5} \times 100 \quad (9)$$

$$I_r = \frac{|54.5 - \alpha_r|}{54.5} \times 100 \quad (10)$$

Where α_a and α_r are the angles of the stitches direction, calculated manually and by Radon transformation analysis. The results of the above calculations are shown in table 8, for all knitted samples on each relaxed state.

RESULTS AND DISCUSSIONS

In the first part, we attempt to consider, the efficiency of each relaxation processes and yarn type on knitted fabric regularity based on our previous approach. Images of all knitted fabrics on each relaxed state were analyzed by appropriate software, in order to detect the angle between the stitches of consecutive courses, α_r.

In previous studies, it has been proven that this analyzing software can calculate stitches direction irregularities with an error of less than 9%. In the present study, to retest the accuracy of this method, we compared the results of the irregularity index that was calculated manually from equation (9) with the results of the software that calculated equation (10). The results again, showed good agreement between the image analysis method and the manual method. Therefore, because of simplicity and accuracy, this computer vision method is acceptable to inspect the stitches shape irregularity in weft-knitted fabrics.

The statistical analysis by ANOVA test showed that the type of yarn and relaxation regime, together and alone affected fabric regularity and fabric dimensional parameters (table 3, 4). To compare the mean of I_r value of different yarn types and relaxation treatments, Duncan's multiple range tests were performed (table 5,

Table 2

THE RESULTS OF INTERLOCK KNITTED FABRICS ACTUAL IRREGULARITY INDEX I_a ON EACH RELAXED STATE

Yarn type	Yarn count, Ne	I_a						
		Dry	Wet	Washing	Ultrasonic	Chemical	Detergent washing	Ultrasonic/ chemical
Cotton	20	3.59	3.16	2.63	0.88	2.51	1.14	0.18
Cotton	30	4.83	5.27	3.65	1.20	2.98	1.09	0.73
Polyester/cotton (65/35%)	20	2.90	2.19	1.89	1.02	0.69	0.72	0.33
Polyester/cotton (65/35%)	30	3.36	3.01	2.24	1.15	1.03	1.13	0.97
Polyester/viscose (65/35%)	20	2.51	1.91	1.60	0.91	0.85	0.96	0.30
Polyester/viscose (65/35%)	30	3.12	2.51	2.16	1.44	1.73	1.31	0.81

Table 3

TESTS OF BETWEEN-SUBJECTS EFFECTS (DEPENDENT VARIABLE: RADON IRREGULARITY INDEX)					
Source	Type III sum of squares	*df*	Mean square	*F*	Sig.
Corrected model	610.914 *(a)*	41	14.900	74353.033	.000
Intercept	1167.048	1	1167.048	5823592.157	.000
Yarn	138.445	5	27.689	138168.787	.000
Relaxation	424.547	6	70.758	353082.858	.000
Yarn* relaxation	47.922	30	1.597	7971.109	.000
Error	0.025	126	0.000		
Total	1777.987	168			
Corrected total	610.940	167			

a – R Squared = 1.000 (Adjusted R squared = 1.000)

Table 4

TESTS OF BETWEEN-SUBJECTS EFFECTS (DEPENDENT VARIABLE: US)					
Source	Type III sum of squares	*df*	Mean square	*F*	Sig.
Corrected model	7711.465 *(a)*	41	188.085	30.214	.000
Intercept	4625791.818	1	4625791.818	743099.355	.000
Yarn	1126.126	5	225.225	36.181	.000
Relaxation	5094.434	6	849.072	136.397	.000
Yarn* relaxation	1490.905	30	49.697	7.983	.000
Error	784.350	126	6.225		
Total	4634287.633	168			
Corrected total	8495.815	167			

a – R Squared = .908 (Adjusted R squared = .878)

Table 5

RESULTS OF DUNCAN'S[A,B] MULTIPLE RANGE TESTS TO COMPARE THE MEAN OF I_r VALUES FOR DIFFERENT YARN TYPES						
Yarn type	Subset					
	1	*2*	*3*	*4*	*5*	*6*
Polyester/ viscose 20 Ne	1.4679					
Polyester/ cotton 20 Ne		1.9135				
Polyester/ viscose 30 Ne			2.2346			
Polyester/ cotton 30 Ne				2.7261		
Cotton 20 Ne					3.2517	
Cotton 30 Ne						4.2202
Sig.	1.000	1.000	1.000	1.000	1.000	1.000

Table 6

RESULTS OF DUNCAN'S[A,B] MULTIPLE RANGE TESTS TO COMPARE THE MEAN OF I_g VALUES FOR DIFFERENT RELAXATION REGIMES							
Relaxation regime	Subset						
	1	*2*	*3*	*4*	*5*	*6*	*7*
Ultrasonic chemical	0.5274						
Ultrasonic		1.2848					
Detergent-washing			1.6216				
Washing				2.6296			
Chemical					2.7833		
Wet						4.0983	
Dry							5.5046
Sig.	1.000	1.000	1.000	1.000	1.000	1.000	1.000

6). The results of fabric Radon irregularity index in table 7 confirmed that the yarn type has the major effect on fabric regularity. This must be due to the reaction of the yarn to the internal stresses of the fabric and different frictional behavior of the different yarns. Weft-knitted fabric samples of cotton showed greater irregularity in comparison to samples of knitted fabrics from polyester blended yarn. Also the knitted fabric samples of polyester/viscose yarn have better regularity than the knitted fabric samples of polyester/cotton yarn.

The results also showed that by improving the performances of the relaxation treatment, the index of fabric irregularity decreases. The forces imposed on the yarn during the knitting process and stitch forming, led to a certain degree of unevenness in the stitch shape. Relaxation treatment, by releasing the stitches from theses extra forces, brings the stitch shape closer to its fixed geometrical and uniform shape. The stitch shape uniformity increases with the successes that the relaxation treatment has in overcoming the extra forces on the stitch. The obtained results confirmed that, in a fully relaxed state, the stitch takes up the closest to an ideal kind of shape [3]. The results shown in table 3 show the minimum values of irregularity index related to the weft-knitted fabric samples that were subjected to ultrasonic-chemical relaxation treatment.

In general, ultrasonic cleaning consists of immersing a part of the sample in a suitable liquid medium, agitating

Table 7

THE RESULTS OF INTERLOCK KNITTED FABRICS RADON IRREGULARITY INDEX I_r ON EACH RELAXED STATE								
Yarn type	Yarn count, *Ne*	I_r						
		Dry	Wet	Washing	Ultrasonic	Chemical	Detergent washing	Ultrasonic/ chemical
Cotton	20	6.42	5.14	2.75	0.92	4.59	2.39	0.55
Cotton	30	8.25	6.05	3.85	2.38	5.32	2.75	0.91
Polyester/cotton (65/35%)	20	4.58	3.11	2.20	0.91	1.46	0.91	0.18
Polyester/cotton (65/35%)	30	5.50	3.85	2.75	1.65	2.75	1.83	0.73
Polyester/viscose (65/35%)	20	3.66	2.75	1.83	0.55	0.73	0.55	0.18
Polyester/viscose (65/35%)	30	4.58	3.66	2.38	1.28	1.83	1.28	0.59

Table 8

RESULTS OF DUNCAN'S[A,B] MULTIPLE RANGE TESTS TO COMPARE THE MEAN OF U_s VALUES FOR DIFFERENT YARN TYPES				
Yarn type	Subset			
	1	2	3	4
Cotton 20 Ne	161.1135			
Polyester/cotton 20 Ne		163.9851		
Polyester/viscose 20 Ne			166.6437	
Polyester/viscose 30 Ne			167.5311	167.5311
Polyester/cotton 30 Ne			167.9034	167.9034
Cotton 30 Ne				168.4341
Sig.	1.000	1.000	0.076	0.205

Table 9

RESULTS OF DUNCAN'S[A,B] MULTIPLE RANGE TESTS TO COMPARE THE MEAN OF U_s VALUES FOR DIFFERENT RELAXATION REGIMES					
Relaxation regime	Subset				
	1	2	3	4	5
Dry	155.8990				
Wet		161.4850			
Washing			165.6026		
Chemical			165.8843		
Ultrasonic				168.9984	
Detergent-washing				169.3339	
Ultrasonic-chemical					174.3429
Sig.	1.000	1.000	0.696	0.642	1.000

or sonicating that medium with high-frequency sound (18 to 120 kHz), for a brief interval of time (usually a few minutes), rinsing with clean solvent or water, and drying. The mechanism underlying this process is one in which microscopic bubbles in the liquid medium implode or collapse under the pressure of agitation, to produce shock waves, which impinge on the surface of the sample and, through a scrubbing action, displace or loosen particulate matter from that surface. The process by which these bubbles collapse or implode is known as cavitations. The intensity with which cavitations takes place in a liquid medium varies greatly with the colligate properties of that medium, which include vapor pressure, surface tension, viscosity, and density, as well as any other property that is related to the number of atoms, ions, or molecules in the medium. In ultrasonic cleaning applications, the surface tension and the vapor pressure characteristics of the cleaning fluid play the most significant roles in determining cavitations intensity and, hence, cleaning effectiveness. The energy required to form a cavitations bubble in a liquid is proportional to both surface tension and vapor pressure. Thus, the higher the surface tension of a liquid, the greater will be the energy that is required to produce a cavitations bubble, and, consequently, the greater the shock-wave energy that is produced when the bubble collapses. It is produced with facility when a surface-active agent is added to the liquid. In the same manner, when the vapor pressure of a liquid is low, as is the case with cold water, cavitations is difficult to produce and it becomes less and less difficult as the temperature is increased. Therefore, in the ultrasonic-chemical relaxation method, the role of three factors, bubble formation and collapse (cavitations), heat and detergent, enable the knitted samples to be released of extra forces, more than other relaxation regimes. Therefore, we can express that by using the ultrasonic-chemical relaxation treatment, more uniform interlock knitted structure will be obtain.

In the next stage, the effectiveness of various relaxation processes on the dimensional properties of interlock knitted fabrics, which were produced from different yarn types, was considered. In this stage as well, the statistical analysis by ANOVA test showed that the type of yarn and relaxation regime, together and alone affected the fabric's dimensional parameter (table 4). To compare the mean value of U_s in different yarn types and relaxation treatments, Duncan's multiple range tests were performed again (table 8, 9). It is clear that, knitted fabrics will be out of tensions after wet relaxation rather than the dry one. Specially, in hydrophilic yarns, like cotton and viscose, molecules of water lead to decreasing intermolecular forces in these chains by destroying hydrogen bonds between cellulose molecular chains and, finally, these chains can easily decrease tensions during the knitting and fabrication and determine the fabric to relax while the U_s value increases. For the polyester in the hydrophobic fibers, wet relaxation has not enough effect on removing tensions and reducing fabric energy level. In the washing relaxation treatment, the tumble drying leads to higher shrinkage than in the wet relaxed state. It would appear that this method of fabric drying tends to cause the most dimensional changes in the fabric, due to a combination of constant slow agitation and temperature. This mixture forces the structures to take up their minimum energy state, which causes the most dimensional changes in the loop shape [13]. The results of U_s values in table 1 indicated that, the ultrasonic relaxation treatment has more efficiency on the shrinkage of all knitted fabric samples, than pervious relaxation methods. In this relaxed state, the average of U_s values are closer to the ideal value [7]. We can, therefore, declare that the ultrasonic relaxation treatment is more effective in comparison with other common mechanical relaxation methods, but the average of U_s values after this treatment is still smaller than the theoretical value derived by an ideal interlock structure [7]. It can be concluded that more effective relaxation method should be found for the weft-knitted fabrics to increase their practical U_s value. But the performance of the chemical relaxation process differs for different yarn types. Chemical treatment cause higher shrinkage on the weft-knitted fabric samples of polyester blended yarns than on the 100% cotton ones. In chemical relaxation treatment, detergent helps the water molecules to penetrate the textiles easily, due to the reduction of surface tension. Also it is clear that textile humidity depends on the facile penetration of water molecules into textiles. The second factor will be done by increasing temperature up to 50°C. Increasing the temperature provides larger pores for water molecules and, finally, breakage of internal bonds could be easier. Higher temperature also leads to a faster absorbance of water molecules. But in knitted fabric samples produced from 100% cotton yarns, detergent cause more yarn bulking and also damaged the fibers, therefore the U_s value, decreases. In polyester blended

knitted fabrics, the chemical treatment has been more effective on fabric shrinkage than the washing relaxation process but, there are no significant differences between the ultrasonic and the chemical relaxation treatments for these knitted fabric samples.
In the next attempt to combine the efficiency of laundering and chemical treatment, all knitted fabric samples were subjected to detergent-washing relaxation process. The results in table 1 showed that detergent-washing treatment led to further shrinkage on all samples than the common washing method but, there was no significant change in the U_s value for cotton knitted fabrics than ultrasound relaxed state. Also, in polyester blended knitted fabrics, the detergent-washing treatment makes the same performance as the ultrasonic or chemical relaxation process. The results in table 1 and table 3 indicate that, the ultrasonic-chemical relaxation treatment offered the highest value for the constant dimensional parameter, U_s, in all fabrics. As we mentioned above, in this state the influence of three factors, cavitations, heat and detergent, tend to produce most shrinkage on the all knitted fabrics in comparison to the above methods. The average of U_s value after the ultrasonic-chemical relaxation treatment is closer to the ideal value which derived from the ideal interlock structure [7]. Therefore, we can conclude that, the ultrasonic-chemical relaxation method is a more efficient relaxation treatment on the stitches shape regularity and the dimensional stability of weft-knitted fabrics than common relaxation treatments or ultrasound relaxation method.

CONCLUSIONS

In present study, the attempts have been made to attain a more effective relaxation treatment on the surface regularity and dimensional properties of interlock knitted fabrics. According to pervious definition of knitted fabrics surface regularity [11], the quality of non-defective fabric depends on the regularity of the fabric surface which is related to the direction of stitches in the ideal fabric as an almost fully relaxed fabric. Therefore we used the pervious approach, based on the image processing technique and Radon transformation analyses to investigate the rhythm of stitches shape enhancement during various relaxation processes. The results show that the most regular knitted structure is obtained after the ultrasonic-chemical relaxation treatment. This process is not only a more effective finishing treatment on the dimensional properties of interlock knitted fabrics, but also has a greater effect on the stitch shape enhancment and knitted fabric surface regularity. So we propose the ultrasonic-chemical relaxation treatment as a new relaxation method that is more effective on knitted-fabrics regularity and dimensional stability.

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Spectroscopic studies on the wool surface modifications induced by UV excimer laser irradiation

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REZUMAT – ABSTRACT – INHALTSANGABE

Studii spectroscopice asupra modificărilor de suprafaţă ale lânii, induse de tratamente laser excimer UV

Rezultatele unor investigaţii anterioare au evidenţiat creşterea hidrofiliei suprafeţei ţesăturilor din lână, în urma unui tratament de iradiere cu laser excimer UV, determinând intensificarea proceselor de vopsire şi finisare, datorită modificării suprafeţei fibrelor de lână, în sensul creşterii reactivităţii acestora. În acest studiu, compoziţia chimică a suprafeţelor ţesăturilor din lână considerate model şi a celor iradiate cu laser a fost caracterizată printr-un protocol experimental constând din coasistarea câtorva tehnici spectroscopice, şi anume: spectroscopie FT - IR- ATR, XPS şi colorimetrie prin reflexie. Rezultatele experimentale ale acestor metode au fost analizate în detaliu, iar datele obţinute prin coroborarea acestor tehnici, au fost corelate cu o caracteristică notabilă – capacitatea de umectare, atât a fibrelor netratate, cât şi a celor tratate cu laser UV – folosită la evaluarea prelucrabilităţii din cadrul unor tehnologii textile ulterioare, compatibile unor scopuri industriale.

Cuvinte-cheie: tratament laser, spectroscopie XPS, spectroscopie FTIR-ATR, colorimetrie prin reflexie

Spectroscopic studies on the wool surface modifications induced by UV excimer laser irradiation

Previous investigation results revealed the hydrophilicity improvement of wool textile surfaces after their exposure to an excimer UV laser irradiation treatment. Such an improvement enhances the wool dyeing and finishing processes, fact that might be due to the change of the wool fibers surface into a more reactive one. In this paper, the chemical composition of the control and the laser treated wool surface was characterized by an experimental protocol consisting in FTIR- ATR, XPS and reflection colorimetry. The experimental results are thoroughly discussed. The data obtained by means of these techniques have been correlated with the wettability of both UV laser treated and non-treated fibres, main characteristic used in the evaluation of the processability within some subsequent textile technologies suitable for some industrial purposes.

Key-words: laser treatment, XPS spectroscopy, FTIR-ATR spectroscopy, reflection colorimetry

Spektroskopieuntersuchungen auf die Oberflächenmodifizierungen der Wolle, verursacht von UV- Excimer-Laser Behandlungen

Die Ergebnisse einiger vorherigen Untersuchungen haben das Wachstum der Hydrofilie auf der Oberfläche der Wollgewebe hervorgehoben, als Folge einer Strahlungsbehandlung mit UV-Excimer-Laser, für die Verstärkung der Farb- und Veredlungsprozesse, dank der Modifizierung der Wollfaseroberfläche, im Sinne des Wachstums deren Reaktivität. In dieser Untersuchung wurde die chemische Zusammensetzung der Wollgewebeoberflächen als Muster und Laserbestrahlt durch einen experimentellen Protokoll charakterisiert, welches in der gemeinsamen Benutzung einiger Spektroskopietechniken besteht, und zwar: FT-IR-ATR, XPS und Reflexionskolorimetrie. Die experimentellen Ergebnisse dieser Methoden wurden ausführlich analysiert, und die Daten erhalten durch die Zusammenstellung der Techniken, wurden mit einer wichtigen Eigenschaft korreliert – die Befeuchtungskapazität, sowohl für die unbehandelten als auch für die mit UV-Laser behandelten Faser – welche zur Bewertung der Bearbeitbarkeit im Rahmen einiger zukünftigen industriekompatiblen Textiltechnologien, angewendet wurden.

Schlüsselwörter: Laserbehandlungen, XPS Spektroskopie, FTTR-ATR Spektroskopie, Reflexionskolorimetrie

Previous researches [1, 2] have demonstrated that the laser treatment enhances the thermal-physiological comfort of the woolens, namely an increased hydrophilicity and dyeability are achievable, similarly to other non-conventional treatments [3–5]. In order to initialize the dyeing processes, the fibre requires a treatment with some softening agents. Therefore, a clear correlation is needed between all the effects, between the chemical aqueous treatments and the fibre surface, in order to avoid their removal during subsequent wash cycles; consequently, both physical and chemical sorption is required. This means that, a high level of fibres free movement in the textiles is desirable, for the shape recovery after washing, as well as to avoid shrinkage. Thus, all these processes require the modification of the wool surface properties, both for the subsequent textile applications, and for the optimization of functionalization/thermal-physiological comfort [6–9].
Exposure to a suitable laser can produce surfaces that are more reactive and affect the surface properties, without changing the desirable properties of the bulk material.
There is a competition between surface and bulk, resulting in a thermal-dynamic stabilization at the nano level of the crystalline (polymorphic) structure, while it remains meta-stable in bulk [10].
As a result, the aim of this paper is to investigate the chemical and physical composition of the laser treated wool surface. The understanding of the surface composition can provide more information about the surface properties induced to the laser treated wool.

EXPERIMENTAL PART

Materials and treated samples

Samples of wool fabric were treated using a LPX 200 Excimer 248 nm KrF. The samples were irradiated directly by a laser beam without using focusing lenses. Laser energies, like fluency and number of pulses, were varied from one experiment to another, in order to study their effects upon samples. The laser fluency varied in the range 29–43 mJ/cm^2, and the number of pulses between 0 and 4, the pulse repetition being kept constant at 1 Hz to avoid any possible heat accumulation. During the laser treatment, the control of the sample temperature was very important. Irradiation parameters using a LPX 200 Excimer Laser 248 nm KrF with lens of 100 mm are given in table 1 [1].

Table 1

IRRADIATION PARAMETERS (LPX 200 Excimer Laser, 248 nm KrF with lens of 100 mm)								
HV	Distance from the box, mm	Focal distance, mm	*E*/0.4, mJ	*X*, mm	*Y*, mm	*S*, cm^2	*F*, J/cm^2	Pulses
19	30	90	170.00	1.3	30	0.39	0.435897	4 p
		60	170.00	1.3	30	0.39	0.435897	2 p
19	33	93	170.00	1.5	30	0.45	0.377778	1 p
		60	170.00	1.5	30	0.45	0.377778	4 p
19	35	95	170.00	1.9	30	0.57	0.298246	2 p
		60	170.00	1.9	30	0.57	0.298246	1 p

Table 2

CHARACTERISTIC IR ABSORBANCE WAVE NUMBERS		
Species	Structure	Wave number, cm^{-2}
NH bending	–N–H	1600
Cystine dioxide	$–So_2–S–$	1121
Cystine monoxide	–SO–S–	1071
Cysteic acid	$–SO^{3–}$	1040
S-sulphonate (Bunte salt)	$–S–SO^{3–}$	1022
Carbon-carbon (stretching) single bond	–C–C–	1000

Fourier transform infrared spectroscopy with attenuated total reflectance (FTIR-ATR)

The IR spectra of the wool fabrics were registered with a Perkin Elmer 16PC FTIR spectrometer in ATR reflection mode, using a zinc selenide crystal. An average of 64 scans with a 4 cm^{-1} resolution was used. The characteristic IR absorbance wave numbers are given in table 2 [2, 10].

X-ray photoelectron spectroscopy (XPS) analysis

The information related to the chemical composition and surface microstructure has been obtained by using the X-ray photoelectron spectroscopy (XPS) and FTIR spectroscopy. The XPS analysis was performed with a Kratos Analytical Axis Ultrasystem, equipped with a charge compensation electron flood gun, and an *Al K* α source. The work conditions have been: 14 kV and 25 mA.

The residual pressure in the chamber was of approximately 4 x 10^{-8} Pa. Measurements were made in fixed analyzer transmission and with the analyzer normal to the plane of the sample, at pass energies of 85 eV, for broad scan spectra, and 25 eV, for high-resolution scans of *S(2p)* and *C(1s)* peaks. All peaks have been registered with reference to the major *C(1s)* peak at 285.0 eV (assumed to be proteinaceous/lipid in origin).

The wettability of the studied woolen samples has been assessed by floating a 2 x 2 cm^2 of the material on the surface film of distilled water at room temperature and measuring the time for the water to advance over the upper surface and thoroughly sink the sample. As compared with the Whilhelm test, this method allowed the evaluation of a relationship between the water absorption (wettability) and the micro-structural characteristics.

Reflexion colorimetry

By means of the reflexion colorimetry, using a Spectra Flash 2000 Colorimeter (Datacolor International), with a 2.54 cm aperture, some colorimetric parameters (Berger whiteness and yellowness indices) have been compared for the reference and UV laser treated samples.

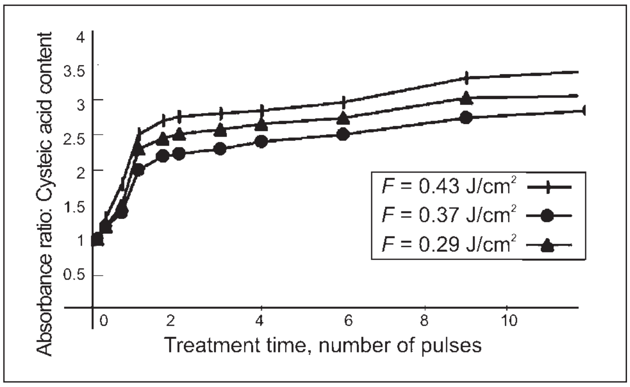

Fig. 1. FTIR-ATR absorbance ratio of the cysteic acid content as a function of the treatment time

RESULTS AND DISCUSSIONS

FTIR-ATR measurement

FTIR-ATR spectroscopy provides the benefits of non-destructive testing, because the amino-acid analysis methods can cause the breakdown of intermediate cystine products during the acid hydrolysis stage [11]. The assignments of the FTIR signal to the functional groups are shown in table 2. There is a depth of 500 nm, that FTIR-ATR technique can analyze, which is good enough for the detection of the chemical components of the wool fibre surface. Therefore, the FTIR-ATR technique is both a qualitative and a quantitative method employed to measure the composition of the wool textile surface.

The absorbance of the selected band wave numbers, i.e. 1600 cm^{-1}, 1121 cm^{-1}, 1071 cm^{-1}, 1040 cm^{-1}, 1 022 cm^{-1}, 1 000 cm^{-1}, was divided by the absorbance of the peptide wave number (Amide III, 1232 cm^{-1}, which was used as an internal reference), and the absorbance ratio was considered in association with the concentration of the surface component. As a result of the cleavage occurring in the disulphide linkage, cysteic acid was formed [12]. The presence of the cysteic acid on the polypeptide chain provides a polar surface for the wool fabric, which in turn helps us improve its wettability [13]. Moreover, the surface barrier of the wool fibre was removed by the cleavage of the disulphide bonds. The absorbance ratio of the cysteic acid as a function of time is shown in figure 1.

Figure 1 clearly reveals that the amount of cysteic acid content increased considerably after the laser treat-

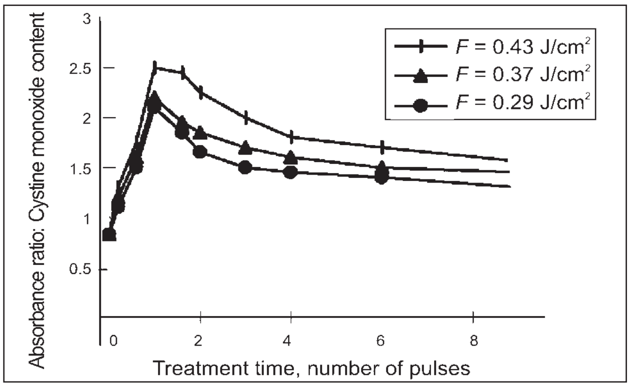

Fig. 2. FTIR-ATR absorbance ratio of the cystine monoxide content as a function of the treatment time

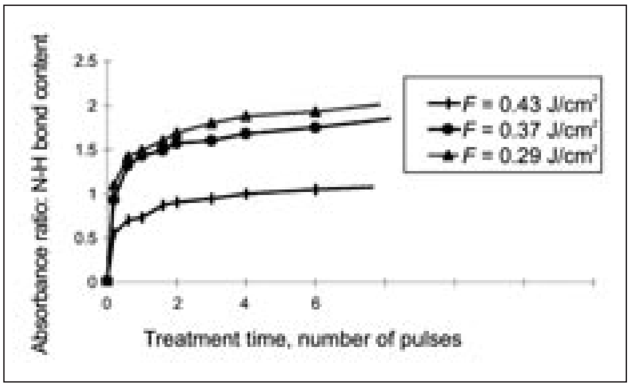

Fig. 3. FTIR-ATR absorbance ratio of the NH bending group as a function of the treatment time

ment. After a rapid initial increase, the cysteic acid content continues to increase gradually throughout the treatment time.

Cysteic acid, as well as other interesting cystine residues to be next studied, is the cystine monoxide and cystine dioxide. According to the scientific literature, both cystine residues were intermediate cystine oxidation products (disulphide, monoxide, dioxide, and sulphonic acid) [14]. Thus, the formation of cystine monoxide and dioxide in wool generates a more reactive substrate, providing a suitable site for introducing agents, such as dyes and softeners, which carry nucleophilic reactive groups [15]. Figure 2 illustrates the variations in the absorbance ratios of cystine monoxide to amide III, as a function of the treatment time. The graph in figure 2 exhibits a pattern, revealing that, after an initial increase, the absorbance ratio decreased gradually over prolonged treatment. The absorbance ratio increased rapidly during the first pulses, but thereafter it started to decrease and reached a nearly constant signal.

It is believed that the cysteic acid was the main oxidation product of the wool fibre. However, the presence of cystine monoxide and cystine dioxide suggests that the cysteic acid is probably formed of these intermediates, as proposed in a previous model [15].

Taking into account the plot patterns found in figures 1 and 2, we can conclude that the laser treatment could generate the same functional groups on the wool fabric surface, but with different concentrations.

The wool fabric itself contained amino groups (-NH2); nevertheless, further introduction of amino groups may have enhanced the absorption of the anionic dye during the dyeing process [16], [17]. Figure 3 shows the variation of the NH concentration, as a function of the treatment time.

Figure 3 shows clearly the absorbance ratio of the N-H bond (NH content) for the laser-treated wool fabrics, as a function of the treatment time. Obviously, in all cases studied, the NH content increased. The more the number of pulses increased, the more the NH content increased, yet, only moderately. By means of the NH content increase, an explanation for the dyeing results can be drawn [16], [17], namely that the laser-treated fibres had a higher percentage of exhaustion at the equilibrium value (% *E* at *Em*), than the untreated fibre. The NH groups induced on the wool fibre surface introduced new dye-sites on the fibre, enhancing the dye absorption ability of the wool fibre. After the laser treatment, the carbon-carbon single bond content on the fibre surface increased (fig. 4).

Figure 4 illustrates the absorbance ratio of the carbon-carbon (stretching) single bond content, which increases after the laser treatment. It may be suggested that the laser treatment enhances the carbon-carbon single bond formation on the wool fibre surface. Properties, such as the hydrophobicity and hidden diffusion (inside-out to the surface), may be the result of these cross-linkages on the fibre surface. On the other hand, the improvements induced by the laser treatment are wettability and, hence, dyeability, fostered by the introduction of the amino groups onto the fibre surface, which causes the wool fibre to become more hydrophilic. The dyeing absorption behavior of the laser-treated wool fibre may be the compromise of these two opposing factors.

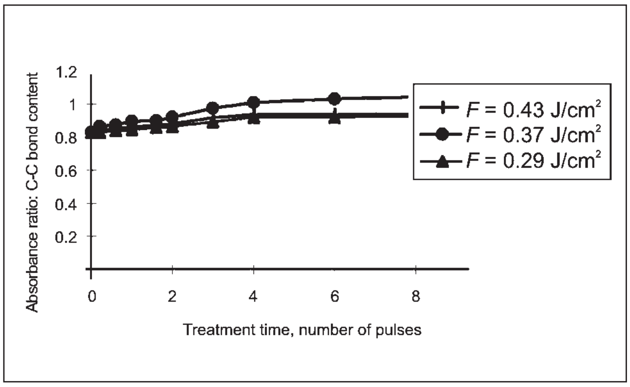

Fig. 4. FTIR-ATR absorbance ratio of the carbon-carbon (stretching) single bond as a function of the treatment time

XPS surface analysis

Table 3 collects and summarizes some micro analytical data on the surface elemental composition of different samples after the laser treatment. An easily noticeable fact is that the carbon content is significantly reduced after the laser treatment. This decrease is probably the consequence of the ablation effect produced by the laser treatment on the wool fibre, resulting in the removal of the fibre surface material. After the ablation process, the inner surface of the wool fibre was exposed, and the chemical effect due to the laser introduced as well a new functional group. The result of those two factors was the contribution in changing the surface composition.

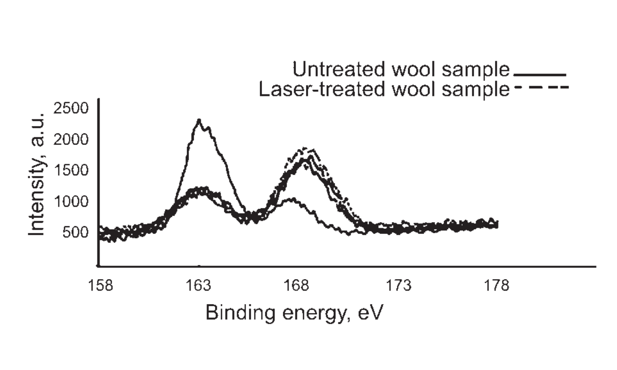

Fig. 5. Sulphur peak (S2p) spectra of wool before and after treatment

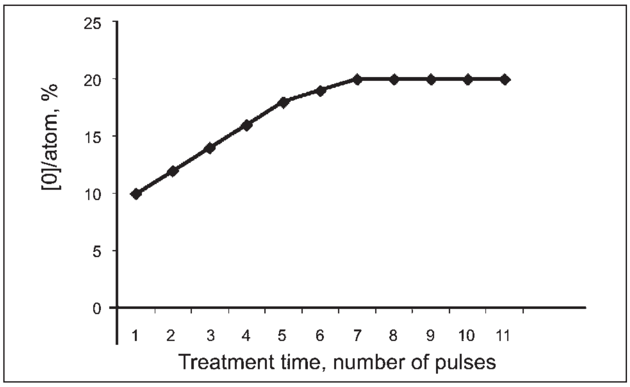

Fig. 6. Relationship between the wool samples wetting time, T_W, and the UV exposure time, T_t, resulting in eqn. (1)

Table 3

ELEMENTAL ANALYSIS (wt. %) AND ATOMIC RATIO OF THE WOOL TREATED WITH UV EXCIMER LASER

	Elemental concentration, wt. %				Atomic ratio	
Sample					*C/N*	*O/C*
Untreated	74.72	8.78	13.55	2.58	8.51	0.18
Laser treated	65.61	8.88	20.16	2.26	7.39	0.31

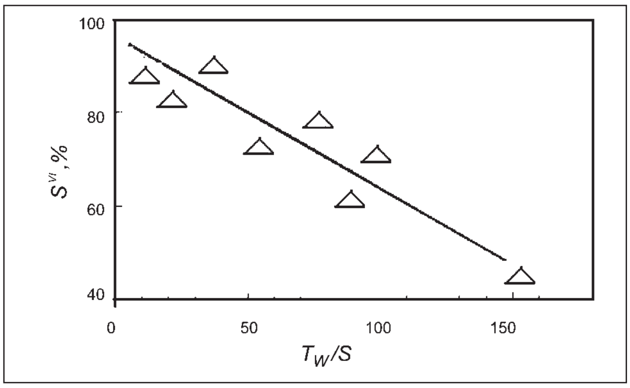

Fig. 7. Relationship between the wetting time, T_W, and the disulfide oxidation (%) leading to eqn. (2)

Scanning electron microscopic images in the previous research [1] have clearly demonstrated that the laser treatment induced a significant surface ablation effect by introducing grooves along the fibre axis. This stage is in agreement with the level of carbon content reduction, as obtained by the XPS analysis. After the laser treatment, the nitrogen content of the wool fibre increased up to various extents. This enhancement of the nitrogen content on the wool fibre reflects an increase of its NH content. Another consequence of the laser treatment was the increased content of oxygen in the wool fibre treated. Therefore, we can deduce that the oxidation occurred during the laser treatment showed the strongest effect. The increased amount of oxygen determines the hydrophilicity improvement of the wool fibre, thus increasing wool wettability. The result was the enhancement of the dye uptake and polymer adhesion during finishing.

After the laser treatment, the sulphur content decreased slightly. This fact is probably the effect of the laser treatment ablation, when the cuticle, containing a large number of disulphide bonds (-S-S-), was removed. In addition, in figure 5, the XPS spectrum shows two broad *S2p* peaks at 163 and 168 eV binding energy values. In the case of the untreated wool fibre, the 163 eV peak intensity was stronger than the 168 eV peak intensity. After the laser treatment, the 168 eV peak intensity is stronger than that of the 163 eV peak. This shift of the S2p peak to higher binding energy is an indicator of the increase in the oxidation state of the sulphur atoms at the fibre surface [17], suggesting the conversion of the cystine residues into cysteic acid residues. It is believed that intermediate oxidation products of cystine may also have been present, since the 168 eV peak is rather broad. The XPS surface analysis can be used to assess the superficial chemical changes (to a depth of about 10 nm) after the laser treatment [18]. The laser treatment showed a decrease in the relative atomic concentration of the carbon and an increase in the relative atomic concentration of the oxygen, suggesting the oxidation of the fatty layer present on the outermost part of the epicuticle.

The excimer UV laser irradiation induced a certain mechanism to the aqueous wetting process of the wool fibers, for which the wetting time is an inverse function of treatment time (fig. 7). This is related to the variation of the wool surface oxidation level in terms of treatment time.

The relationship between the wetting time, *TW*, and the UV exposure time, *Tt*, is expressed by the exponential term:

$$T_W / S = \exp(7.3 - 0.73T_t) \qquad (1)$$

While the relationship between the wetting time T_W and the oxidation of sulphur from the cysteine and cystine surface structures is given in expression (2):

$$T_W / S = (100 - [S^{VI}]) / 0.33 \qquad (2)$$

where:

$[S^{VI}]$ is the % of native sulphur oxidized.

Relationship between the wool samples wetting time, T_W, and the UV exposure time, T_t, resulting in eqn. (1), is presented in figure 6 and relationship between the wetting time, T_W, and the disulfide oxidation (%) leading to eqn. (2) as shown in figure 7.

Reflexion colorimetry

By means of the reflexion spectrophotometry, the degree of discoloration (i.e. the chromatic shift of Berger whiteness and yellowness indices) can be comparable with that of the reference sample (table 4).

Table 4

BERGER WHITENESS AND YELLOWNESS INDEX FOR THE TREATED WOOL FABRICS		
Samples	Berger whiteness	Yellowness index
Reference sample	28.0	21.4
UV treated sample	20.7	24.2

CONCLUSIONS

After the laser surface-modification treatment, significant changes have been noticed in the wool fibre surface properties. The evaluation of the chemical and micro-structural surface modifications of the wool fibre was conducted by an experimental protocol including XPS, FTIR spectroscopy and reflexion colorimetry.

The investigation by means of the FTIR-ATR spectroscopy proved a different modification of the surface composition in the laser-treated wool fibre. The properties of the wool fibre have been influenced by the concentration of the functional groups. This fact has been demonstrated by the study on the functional groups.

XPS study showed the way the laser treatment changes the elemental composition of the wool fibre, that is: nitrogen and oxygen contents were increased, while carbon and sulphur contents were decreased at the surface layer. In addition, a shift of the sulphur peak from 163 eV to 168 eV demonstrated the change in the sulphur state from S^{II} to S^{VI} after different laser treatments.

The surface oxidation level of both the fibres, and the woven material were increased approximately two folds by the UV laser treatment, the precise level being dependent upon the exposure time.

The wetting time of the woven material is an inverse function of the treatment time. This parameter is shown to decrease linearly with the transformation of S^{IV-I} to S^{VI}.

The results of this study supported both the characterization of the surface composition, and the ability to define the effect of the laser treatment on the wool-fibre surface properties. These properties might seriously affect both dyeing, and the finishing processes, such as the shrink proofing treatments.

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Frequency dependent glass transition behaviour of high performance polyethylene fibers

JUNJIE LIU WEIDONG YU

REZUMAT – ABSTRACT – INHALTSANGABE

Comportamentul fibrelor polietilenice de înaltă performanţă în funcţie de temperatura de tranziţie a sticlei la diferite frecvenţe

Fibrele polietilenice de înaltă performanţă au fost studiate prin metoda de analiză mecanică dinamică. Temperatura de tranziţie a sticlei, exprimată prin factorul de disipare, a fost analizată la diferite frecvenţe – 1, 2, 5, 10 şi 20 Hz. Rezultatele experimentale au arătat că creşterea frecvenţei determină deplasarea vârfului factorului de disipare spre o temperatură mai mare, în timp ce înălţimea vârfului creşte odată cu creşterea frecvenţei. Relaţia dintre temperatura de tranziţie a sticlei şi frecvenţă a fost exprimată prin legea Arrhenius şi legea Vogel-Fulcher. S-a obţinut o corespondenţă mai bună între rezultatele teoretice şi cele experimentale în cazul aplicării legii Vogel-Fulcher, decât în cazul legii Arrhenius. S-a constatat că logaritmul natural al frecvenţei şi cel reciproc al temperaturii pot determina o relaţie nelineară.

Cuvinte-cheie: polietilenă, performanţă, frecvenţă, DMA, relaxare, temperatură de tranziţie, sticlă, legea Vogel-Fulcher

Frequency dependent glass transition behavior of high performance polyethylene fibers

High performance polyethylene fibers have been studied by the dynamic mechanical analysis method. The glass transition temperature based on loss modulus has been analyzed at different frequencies of 1, 2, 5, 10 and 20 Hz. An increase of test frequency will shift the peak of the loss modulus curve to a higher temperature, while a relative level of the peak increases, once with the increase in frequency. Besides, the relation of glass transition temperature and frequency was modeled by the Arrhenius law and the Vogel-Fulcher law. By contrast, a better correspondence between the theoretical and the experimental result was achieved by Vogel-Fulcher law, than by the Arrhenius law. It has been found that the natural logarithm of frequency and the reciprocal of the temperature given by the chosen peak maxima of the loss modulus are more likely to form a nonlinear relationship.

Key-words: polyethylene, performance, frequency, DMA, relaxation, transition temperature, glass, Vogel-Fulcher law

Das Verhalten der Hochleistungs-Polyethylenfaser in Abhängigkeit der Glastransitionstemperatur bei verschiedenen Frequenzen

Die Hochleistungs-Polyethylenfaser wurden durch die mechanisch-dynamische Analysemethode untersucht. Die Glastransitionstemperatur, ausgedruckt durch den Dissipationsfaktor, wurde bei unterschiedlichen Frequenzen -1, 2, 5, 10 und 20 Hz analysiert. Die experimentellen Ergebnisse zeigten, dass das Frequenzwachstum die Verschiebung des Dissipationsfaktormaximums gegen eine höhere Temperatur verursacht, während der Maximumswert zusammen mit dem Frequenzwachstum steigt. Die Beziehung zwischen der Glastransitionstemperatur und der Frequenz wurde durch das Arrhenius-Gesetz und das Vogel-Fulcher-Gesetz ausgedruckt. Es wurde eine bessere Zusammenangehörigkeit zwischen den theoretischen und den experimentellen Ergebnissen im Falle der Anwendung der Vogel-Fulcher-Gesetzes, als im Falle der Arrhenius-Gesetzes erhalten. Es wurde festgestellt, dass das natürliche Logarithmus der Frequenz und der entsprechende Logarithmus der Temperatur eine nicht-lineare Beziehung bestimmen können.

Schlüsselwörter: Polyethylen, Leistung, Frequenz, DMA, Relaxierung, Transitionstemperatur, Glass, Vogel-Fulcher-Gesetz

High-performance polyethylene fibers (HPPE) are high strong, high modulus fibers that are chemically identical to normal high density polyethylene (HDPE), consisting of numerous repeating units of ethylene monomers, but the molecular weight is higher than the commonly used PE grades [1, 2]. Different from aramid and all other high performance fibers, the molecules of polyethylene should be forced by physical treatments to form the straight conformation and orientation in the fiber direction and thus produce a super strong fiber [3]. HPPE fibers are usually produced of ultra high molecular weight polyethylene (UHMW-PE), by the gel-spinning process. For this reason, HPPE fibers are in some case called gel-spun polyethylene fibers.

Up to date, HPPE fibers that are successfully commercially produced include two serials, that is: Dyneema® by DSM in Netherlands and Spectra by Honeywell in USA [4]. The combination of low density and high strength makes commercial HPPE unique products, such as protective bullet armets, cut-resistant gloves and motor helmets, composite ballistic armour, composite reinforcement etc. [5, 6]. Because of technology limitation, the commercial strength values only reach 1/10 of the theoretical maximum values. It is clear that in the construction of the commercial HPPE fibers remain defects, so HPPE fibers should still be investigated for substantial improvements in properties.

As a well accepted thermal analytical tool, dynamic mechanical analysis (DMA) can characterize the visco-elastic response of materials, either as a function of a linear heating rate, or as a function of time at a given temperature [7]. HPPE is a visco-elastic material, with lower glass transition temperature, T_g, and lower melting temperature [8, 9]. The maximum temperature used for HPPE is often set at a certain number of degrees below the T_g. With the temperature changes, the bonds of polymer molecules can break and form. During this process, the mechanical modulus of the polymer showed an obvious relaxation, and the changes in these material properties also showed a frequency-dependent behavior.

In dynamic mechanical experiments, T_g represents the relationship between the mobility of polymer chains and temperature, while the activation energy for glass transition – ΔE_a – represents the relationship between mobility and time scale and could be considered the energy barrier of the glass transition relaxation [10]. Recent experimental results of DMA showed that the peak of loss factor $Tan\delta$ or loss modulus E'' depended on the frequencies used [11, 12].

The glass transition temperature shifts to a higher range with the frequency increase. This frequency-dependent

Table 1

THE BASIC PROPERTIES OF AVAILABLE HIPPE FILAMENT YARNS				
Name and manufacturer	**Linear density,** dtex	**Tenacity,** N/tex	**Tensile modulus,** N/tex	**Elongation to break,** %
Dyneema®SK65, DSM	1.13	3.5	87	3.6

behavior can usually be expressed by Arrhenius equation [13], as shown:

$$f = f_0 \cdot \exp\left(-\frac{\Delta E_a}{RT_g}\right) \quad (1)$$

where:

f_o is the pre-exponential factor;

ΔE_a – the activation energy for glass transition relaxation;

R – the universal gas constant ($8.314 \cdot 10^{-3}$ $kJmol^{-1}$ K^{-1});

T_g – the temperature, K.

The shift of glass transition temperatures can be related to the different frequencies of excitation through:

$$\frac{f_1}{f_2} = \frac{\exp(-\Delta E_a / T_{g1})}{\exp(-\Delta E_a / T_{g2})} \quad (2)$$

where:

f_1 and f_2 are the frequencies leading to corresponding values of the glass transition temperature T_{g1} and T_{g2}. The ratio (f_1/f_2) can be considered as the shift factor for superposition.

$$\ln\left(\frac{f_1}{f_2}\right) = \frac{\Delta E_a}{R}\left(\frac{1}{T_{g2}} - \frac{1}{T_{g1}}\right) \quad (3)$$

Then, the relationship between frequency and glass transition temperature can simply be expressed as:

$$\Delta E_a = -R\left[\frac{d(\ln f)}{d(1/T_g}\right] \quad (4)$$

In the equation above, there is a linear relationship between the natural logarithm of frequency and the reciprocal of the temperature given by the chosen peak maxima of *Tanδ or* E˝, and the slope is equal to $\Delta E_a/R$. For the description of frequency-dependent loss modulus peaks, Yu et al. [14] introduced a frequency-independent static glass transition temperature into Vogel-Fulcher law and achieved more accurate fitting result. According to Saslow's point, Vogel-Fulcher law can also be used to described frequency-dependent glass transition kinetic characteristics [15]. The Vogel-Fulcher law can be expressed as:

$$f = f_0 \cdot \exp\left(-\frac{\Delta E_a}{R(T_g - T_i)}\right) \quad (5)$$

where:

T_i is the ideal glass transition temperature.

From the equation (5), when $(T_g - T_i)$ tend to get smaller, the transition activation energy is smaller, and so the glass transition process should occur easily. To achieve a better result, the key factor of data processing is the choice of the appropriate T_i. The ideal glass transition temperature is proposed based on the available experiment and it is more reliable without the frequency effect.

Vogel-Fulcher law can also be expressed as:

$$\ln f = \ln f_0 - \frac{\Delta E_a}{R}\left(\frac{1}{T_g - T_i}\right) \quad (6)$$

These are plotted as $1/(T_g - T_i)$ vs. ln f for T_g determined from the $E˝$ peaks. The intercept of the regression line in x-axis is ln f_0 and the slope is – (DE_a / R). Thus, ln f and T_g, ln f and $1/(T_g - T_i)$ should be kept in linear relationship.

Multi-frequency study is a powerful tool of determination for the activation energy of the glass transition and for monitoring purposes of crystallization and structural changes of polymer. In this paper, the authors only discuss glass transition relaxation in a limited measurement frequency range; they used a $5^oC \cdot min^{-1}$ constant heating rate.

EXPERIMENTAL PART

Materials used

The testing samples used in the present study were: HPPE (Dyneema® SK65), manufactured by DSM HPF. The basic characteristics of the HPPE fibers are listed in table 1.

Procedure used

Dynamic mechanical measurements were carried out on a Perkin-Elmer DMA 7e system (tensile mode with a free length of 10 mm). All samples were tested over a temperature range from –170 to 125°C, achieved using frequencies of 1, 2, 5, 10, and, respectively, 20 Hz. A directly measured quantity was the loss factor *Tanδ* and complex tensile modulus.

All of the testing samples were conditioned under standard requirements: 25 ± 2°C and 65 ± 3% relative humidity for not less than 24 hours prior to test.

RESULTS AND DISCUSSIONS

In figure 1, a dynamic mechanical spectrum shows three temperature dependencies of *E´, E˝ and Tanδ* in a graph for HPPE fibers. Almost all of the DMA spectra

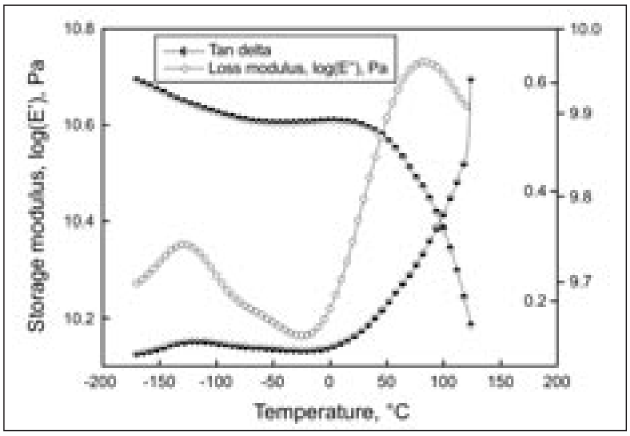

Fig. 1. Supposition of typical plots showing the variation of *E˝, Tanδ* and *E´* with temperature increasing at 1 Hz, for the HPPE fibers

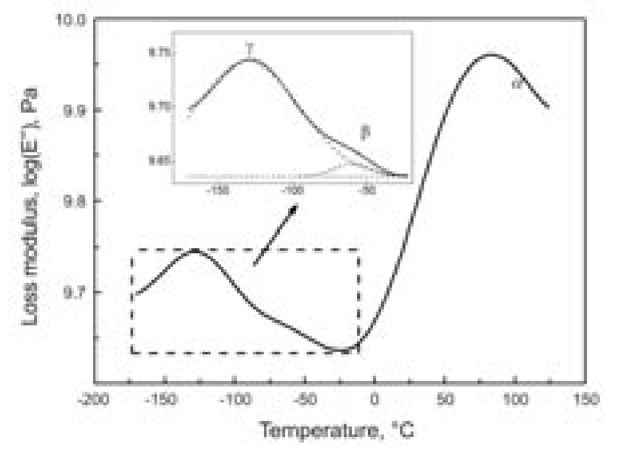

Fig. 2. Temperature dependence of loss modulus E' for HPPE fibers and – in lower temperature – with decomposition into two peaks: γ-peak, β-peak

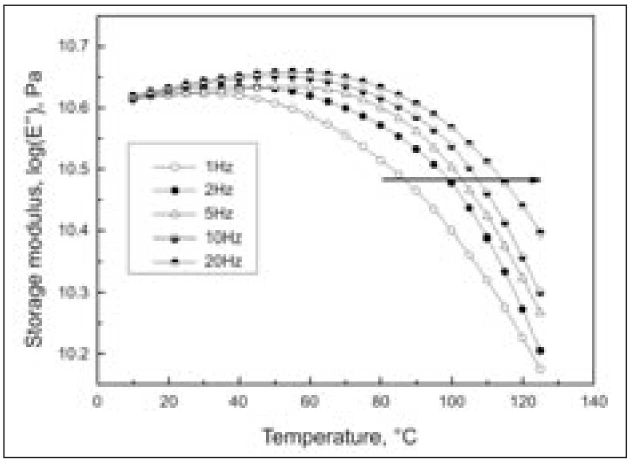

Fig. 3. Effect of the test frequency on the storage modulus, at a 5°C · min^{-1} heating rate, for HPPE fibers

showing the HPPE fibers testing have a similar shape. From the loss modulus curve on the sample presented in figure 1, the T_g of loss modulus is recorded at around 90°C, and an obvious secondary transition, T_γ, is observed in lower temperature, at around 130°C, which appears at the same time on the tan delta curve at around 120°C. The α relaxation corresponds to the crystal fraction in the semi-crystalline HPPE, and the γ relaxation corresponds to the sub-glass transition, assigned to the amorphous state. In the case of β transition of HPPE that is a hardly visible weak, broad relaxation peak exhibits at around 60°C [6]. According to the spectra of transition, the HPPE fibers melting behavior starts at 125°C.

As shown in figure 2, the two relaxations – α and γ – are clearly seen for the test fibers, performed as sharp loss-peaks around the transition temperatures T_g and T_γ. Because the γ-peaks and β-peaks overlap each other and could be detected only as a partial shoulder of γ-peaks, the β-peaks are very weak and almost invisible. The loss modulus spectra in lower temperature have been decomposed into two peaks, γ-peak and β-peak (shown in the local solid rectangle inside figure 2). Otherwise it is difficult to detect the relative transition relaxation peaks.

As we can see from figure 3, the macroscopic quantities introduced here have a tendency to increase once with increasing the frequency. The storage modulus, E', shifts to higher temperatures, without changing the general shape, but the inflexion of storage modulus shifts to higher temperatures, once with increasing the test frequency.

The effect of frequency on the dynamic mechanical response of polymers is well reported. An increase of test frequency will shift the peak of the loss modulus curve to a higher temperature, while a relative level of the peak increase is possible with the increase in frequency, shown in figure 4. This shift results in an apparent shift to higher values of the transition temperatures, T_g, with the increase in frequency. As we can see from table 2, the effects of the frequencies on the glass transition temperature, determined though testing it at a 5°C · min^{-1} constant heating rate. The macroscopic quantities introduced here have a tendency to increase once with increasing frequency. This phenomenon is based on the fundamental relationships between temperature and the frequency of molecular conformational changes in polymers.

The activation energy, ΔE_a, of the glass transition relaxation represents the energy barrier that must be

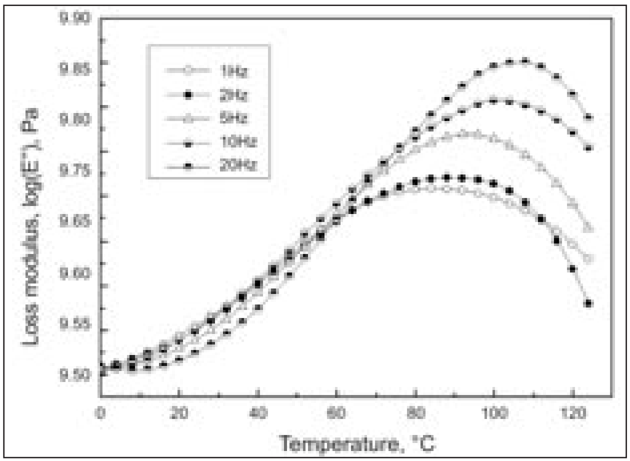

Fig. 4. Effect of an increasing test frequency on the T_g value, based on a E' peak, at a 5°C · min^{-1} heating rate, for the HPPE fibers

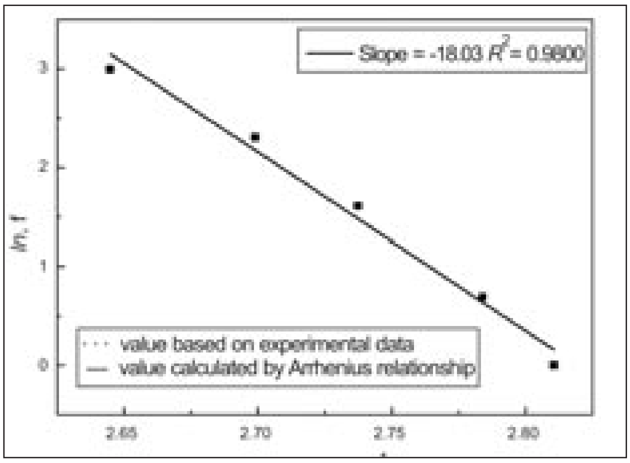

Fig. 5. The relationship between the measurement frequency *f* and T_g, based on the loss modulus peak, with the DMA, for HPPE fibers

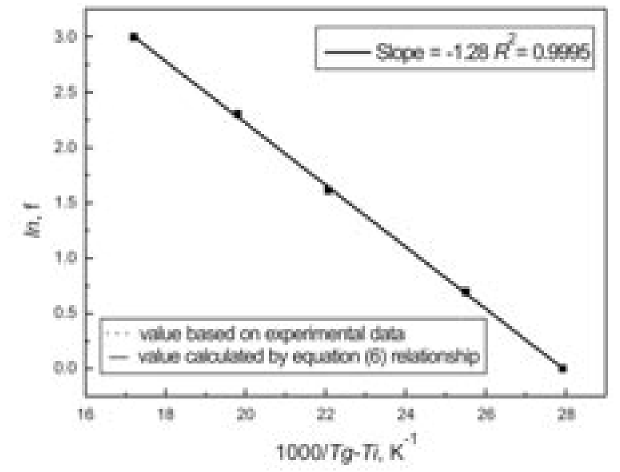

Fig. 6

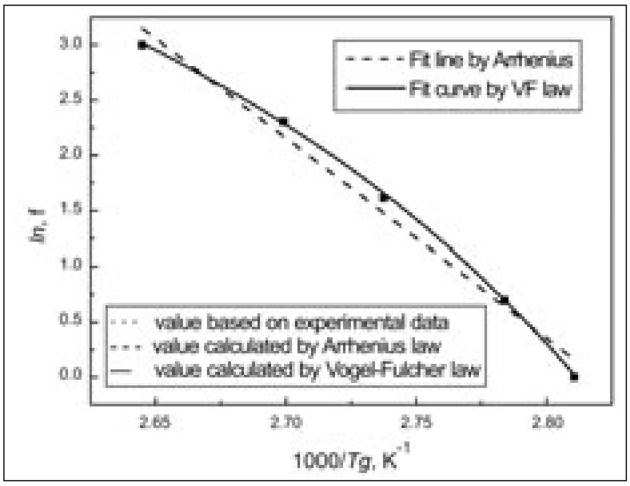

Fig. 7

Table 2

T_g VERSUS FREQUENCY AND 5°C · min^{-1} HEATING RATE, FOR THE HPPE FIBERS

Frequency, *f*, Hz	ln *f*	**T_g (from E''), °C**	$1/T_{E''}$, 10^{-3}K^{-1}
1	0	82.8	2.809
2	0.69	86.2	2.783
5	1.61	92.3	2.737
10	2.30	97.5	2.699
20	3.00	105.1	2.645

overcome for the occurrence of molecular motions causing the transition and can be estimated using DMA testing of a polymer, at different test frequencies. ΔE_a can be computed following the reformulations of Arrhenius relationship and is proportional to the slope of a plot for the natural log of frequency vs. the reciprocal of absolute T_g (K) – see equation (4).
As shown in figure 5 and 6, it is noted that the R^2 values are high, indicating a good level of correlation. The slope of the fitting line is equal to the ratio – ΔE_a and gas constant.
Figure 7 explains the fitting effect of both Arrhenius law and Vogel-Fulcher law. We can see that the latter model is more reliable for fitting the experimental data. It showed that the logarithm of frequency and the reciprocal of glass transition temperature appears like a nonlinear behavior.
In table 3, it is obvious that Vogel-Fulcher presents a higher reliable R^2 of fitting, than the Arrhenius law; the R^2 value is higher by one order of magnitude.

Table 3

PARAMETERS BY FITTING USING ARREHENIUS AND VOGEL-FULCHER LAW

Fitting model	**Activation energies,** Kj/mol	R^2	T_i, K
Arrehenius	152	0.9800	–
Vogel-Fulcher	10.6	0.9995	319.6

CONCLUSIONS

It was found out that the DMA method is a very sensitive and efficient method for the characterization of the relaxation processes. The T_g based on the loss modulus peak is influenced by the test frequency. T_g shifts towards higher temperature, once with the frequencies increasing. At the same time, glass transition peaks tend to become broader, when the testing frequency decreases, that is – the α transition relaxation time extends. In this paper, the frequency-dependent glass transition temperature determined by the peak of the loss modulus curve was modeled by the conventional Arrhenius law and Vogel-Fulcher law. Within a limited range of frequency, the curve modeled by Vogel-Fulcher law showed, by contrast, a better fitting effect, than the Arrhenius law. The relationship that the logarithm of frequency and the reciprocal of glass transition temperature are more likely to form is a nonlinear behavior.

ACKNOWLEDGEMENTS
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DOCUMENTARE

Materii prime

O NOUĂ FIBRĂ IGNIFUGĂ DE LA LENZING

Producătorul de fibre celulozice ***Lenzing***, cu sediul în Austria, a elaborat o nouă variantă a fibrei *Lenzing FR*, în care a fost încorporat un colorant negru, pentru a-i conferi o rezistență sporită la lumină și rezistență la transpirație.

Lenzing FR Blanck este prima și singura fibră celulozică textilă, de culoare neagră, cu proprietăți ignifuge. Ea este destinată diverselor aplicații industriale, în care culorile durabile sunt foarte căutate, cum ar fi îmbrăcămintea de protecție (fig. 1).

Fig. 1

Această fibră conferă tenacitate firului, care, la rândul său, sporește durata de viață a textilelor. Și în ceea ce privește protecția mediului, caracteristicile sunt bune, colorantul fiind injectat direct în masa de filare, fără a fi nevoie de vopsirea prealabilă a masei fibroase sau a firului.

Lenzing FR este o fibră ignifugă lemnoasă, cunoscută pentru proprietățile sale prietenoase pielii. Ea este folosită în diverse aplicații, pentru a oferi o protecție optimă împotriva diferitelor surse de căldură. De asemenea, reprezentanții firmei *Lenzing*, susțin că fibra conferă un bun transport al umidității, reducând riscul de accident vascular cerebral, provocat de căldura mare, care pune în pericol viața.

Compania afirmă că testele efectuate pe diferite materiale ignifuge – inclusiv pe cele din fibre de bumbac 100%, fibre aramidice 100%, amestecuri de fibre aramidice și FR Lenzing, ori amestecuri de bumbac și Modacryl – au evidențiat faptul că, în cazul amestecului de fibre aramidice și fibre Lenzing FR, s-au înregistrat cele mai mari performanțe, de 6 wați, acest lucru reprezentând încă un minut în plus, ceea ce ar putea însemna salvarea unei vieți.

Future Materials, iulie 2010, p. 11

Calculus equations for computer command programs of waxing emulsion warp's load

DANIELA LIUȚE GEORGE CIUBOTARU

REZUMAT – ABSTRACT – INHALTSANGABE

Relații de calcul pentru programe de comandă prin calculator a încărcării urzelilor cu emulsie de ceruire

În lucrare este abordată problema ceruirii urzelilor, din fire tip lână și din amestecuri cu poliester. Concentrația emulsiei de ceruire depuse pe urzeli, care conține agenți de lubrifiere, de emulsionare, de udare și chiar de încleiere, depinde de natura substanțelor componente, de caracteristicile urzelilor și de utilajele folosite. Pe baza unor date experimentale, s-au stabilit, relații pentru calculul masei emulsiei transferate pe urzeală, de pe unitatea de suprafață a cilindrului de ceruire, în funcție de viteza acestuia, în cazul diferitelor valori ale vâscozității emulsiei. Pe baza egalității dintre masa emulsiei transferate de pe cilindru în unitatea de timp și masa emulsiei preluată de urzeală în aceeași unitate de timp, s-au stabilit ecuațiile pentru comanda prin computer a vitezei cilindrului de ceruire, în funcție de principalii parametri constructivi și tehnologici ai procesului de ceruire a urzelilor.

Cuvinte-cheie: urzeli, ceruire, emulsii, relații de calcul, comandă computerizată

Computing relations for the computer controlling programmes of warp load with waxing emulsions

In the paper, the waxing issue is addressed for warps made of wool type and polyester blends yarns. The concentration of the waxing emulsion deposited on the warps, which contains lubricants, emulsifiers, wetting and even sizing agents, depends on the nature of its composing substances, on warp characteristics and machinery used. Based on some experimental data, there were set relations for computing the mass of emulsion transferred onto the warp, from the waxing cylinder surface area, according to its speed and for the various emulsion viscosity values. Considering the equality between the mass of emulsion transferred from the cylinder per time unit and the mass of emulsion taken over by the warp in the same time unit, equations were set for the computer command of the waxing cylinder speed, according to the main constructive and technological parameters of the warps waxing process.

Key-words: warps, waxing, emulsions, computing relations, computing command

Computersteuerprogramme-Rechnungsbeziehungen für die Behandlung der Ketten mit Wachsemulsion

In der Arbeit wird das Problem betreff dem Wachsen der Ketten angesprochen, welche aus Garne Typ Wolle und Polyestergemische bestehen. Die Konzentration der Wachsemulsion für Ketten, welche Agenten für Schmierung, Emulsion, Nässung und sogar Schlichtung enthalten, hängt vom Typ der zusammensetzenden Substanzen, der Eigenschaften der Ketten und der angewendeten Geräte ab. Aufgrund von experimentellen Daten, wurden Beziehungen für die Berechnung der auf der Kette übergetragenen Emulsionsmasse auf der Flächeneinheit des Wachsen-Zylinders festgestellt, in Abhängigkeit dessen Geschwindigkeit und im Falle verschiedener Werte der Emulsionviskosität. Aufgrund der Gleichheit zwischen der Emulsionsmasse übertragen vom Zylinder in der Zeiteinheit und der Emulsionsmasse übergenommen von der Kette in derselben Zeiteinheit, wurden die Gleichungen für die Computersteuerung der Geschwindigkeit des Zylinders für das Wachsen festgesetzt, in Abhängigkeit der grundlegenden konstruktiven und technologischen Parameter des Wachsenprozesses der Ketten.

Schlüsserwörter: Kette, Wachsen, Emulsionen, Rechnungsbeziehungen, Computersteuerung

THEORETICAL CONSIDERATIONS

Warp waxing – also named warp lubrication or even "cold sizing" – is more frequently met at warps of woolen yarns and of polyester blends. The emulsion used for waxing may contain lubrication, emulsifying, wetting and even sizing agents. The concentration of emulsion deposited on warps depends on the nature of the component substances, on warp's characteristics, as well as on the devices employed.

Depending on yarns and warps characteristics, some approximate values of their loading with waxing active substances are already known. For example, I_s = 2–3% – for woolen yarns, I_s = 1–2% – for viscose yarns, I_s = = 1–1.5% – for cotton/polyester yarns, I_s = 2% – for polyester yarns. To attain such values in active substances, the recommended load of warps in waxing emulsion I_{eu} should vary between 5–10%.

Warp load with waxing emulsion supposes warp passing over the waxing roller, which transfers the emulsion taken from the emulsion bath onto the warp (fig. 1). Warp load with emulsion depends on several parameters such as warp speed, respectively waxing roller peripheral speed.

Warp load with waxing emulsion may be calculated with the equation:

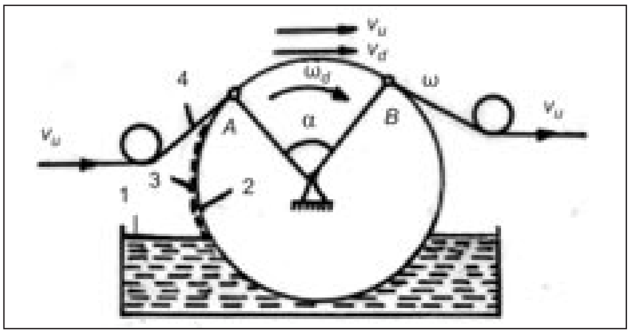

Fig. 1. Scheme of waxing emulsion deposition:
1 – waxing emulsion; *2* – waxing roller; *3* – transferred emulsion; *4* – warp; α – warp contact angle with the waxing roller

$$I_{eu} = \frac{M_{et}}{M_u}100 = \frac{m_{td}Hv_d}{m_uHv_u}100$$
$$I_{eu} = \frac{m_{td}v_d}{m_uv_u}100 \quad (1)$$

where:

I_{eu} is warp load with waxing emulsion, %;
M_{et} – emulsion mass transferred onto the warp by the depositing roller within one minute (flow rate for emulsion transferred), g/min.;
M_u – warp mass passing over the waxing roller within one minute (warp flow rate), g/min.;

m_{td} – emulsion mass transferred onto the warp by each m^2 of the depositing roller, g/m^2;
m_u – warp mass per m^2, g/m^2;
H – warp width, m;
v_d – peripheral speed of the emulsion depositing roller, m/min.;
v_u – warp speed during its passing over the depositing roller, m/min.

The flow of the emulsion supplied by the depositing roller is equal to the flow of the emulsion transferred onto the warp, plus the flow of the returned emulsion not taken over by the warp. The equation takes the form:

$$m_{ea}Hv_d = m_{eu}Hv_u + m_{er}Hv_d \quad (2)$$

or

$$\left(m_{ea} - m_{er}\right)v_d = m_{eu}v_u$$
$$m_{ea} - m_{er} = m_{td} \quad (3)$$

where:
m_{ea} is mass of the emulsion supplied per m^2 of the depositing roller, g/m^2;
m_{eu} – emulsion mass per 1 m^2 of warp, g/m^2;
m_{er} – mass of the returned emulsion per 1 m^2 of the depositing roller, g/m^2.

The difference $m_{ea} - m_{er} = m_{td}$ represents the mass of the emulsion transferred onto the warp per 1 m^2 of the depositing roller. Thus we get:

$$m_{td}v_d = m_{eu}v_u \text{ or } \left(m_{ea} - m_{er}\right)v_d = m_{eu}v_u \quad (4)$$

and

$$m_{td} = \frac{m_{eu}v_u}{v_d} \text{ or } m_{ea} = \frac{m_{eu}v_u}{v_d} + m_{er} \quad (5)$$

The mass of the returned emulsion depends on several elements, such as warp setting, yarns structure, warp contact angle with the waxing roller etc.

In the case of thick warps made of yarns with high pilosity and porosity, the returned emulsion mass $m_{er} = 0$, while in warps with small setting, the returned emulsion mass may attain up to 25–30%. A variation of the returned emulsion coefficient $C_r = 0 \ldots 0.3$ may be noticed, comparatively with the emulsion supplied. The returned emulsion mass may be appreciated as:

$$m_{er} = C_r m_{ea}$$
$$m_{er} = (0 \ldots 0.3)m_{ea} \quad (6)$$

Under these conditions, equation (4) becomes:

$$m_{ea} = \left(1 - C_r\right)v_d = m_{eu}v_u$$

and

$$m_{ea} = \frac{m_{eu}v_u}{\left(1 - C_r\right)v_d} \quad (7)$$

Theoretically, when all waxing emulsion is taken up by the warp ($C_r = 0$), we get:

$$m_{ea} = \frac{m_{eu}v_u}{v_d} \quad (8)$$

The emulsion mass per 1 m^2 of warp is calculated with the equation:

$$m_{eu} = \frac{m_u l_{eu}}{100} \quad (9)$$

The percent loading with waxing emulsion is expressed as a function of both the technologically recommended loading with active substances and the emulsion concentration. Thus, the following equation is applied:

$$l_{eu} = \frac{l_s}{K}100 \quad (10)$$

where:
l_s is technologically recommended load with active substances, %;
K – emulsion concentration in active substances, %.

The warp mass, expressed in g/m^2, is calculated by the equation:

$$m_u = \frac{100 P_u T_t}{1000} = \frac{P_u T_t}{10} \quad (11)$$

where:
P_u is warp setting, yarn/cm;
T_t – yarn fineness, tex.

The emulsion mass per 1 m^2 of warp will be:

$$m_{eu} = \frac{P_u T_t l_u}{10^3}$$

or

$$m_{eu} = \frac{P_u T_t l_u}{10K} \quad (12)$$

To achieve the warp loading with *meu* grams of emulsion per 1 m^2 of warp, the emulsion mass transferred onto the warp per 1 m^2 of depositing roller – m_{td}, respectively the mass of the emulsion supplied by each 1 m^2 of roller – m_{ea}, should be calculated using the equations:

$$m_{td} = \frac{P_u T_t l_s v_u}{10Kv_d}$$
$$m_{eu} = \frac{P_u T_t l_s v_u}{10K(1 - C_r)v_d} \quad (13)$$

or

$$m_{ea} = \frac{m_{td}}{1 - C_r} \quad (14)$$

In the absence of the returned emulsion ($C_r = 0$), the mass of emulsion transferred from each 1 m^2 of depositing roller to the warp, m_{td}, is equal to the mass of emulsion supplied by each 1 m^2 of roller, m_{ea}.

EXPERIMENTAL STUDIES

The emulsion mass on the feeding roller generator depends on the emulsion viscosity and on the position of the generator versus the emulsion level in the tank. The higher the feeding generator is, compared with the emulsion level in the tank, the lower the emulsion layer thickness will be. At the same time, the lower the viscosity, the lower the emulsion reaching the feeding generator will be, because of its more rapid leaking back inside the tank.

The variation of the emulsion mass per surface unit of the feeding roller is determined experimentally. The

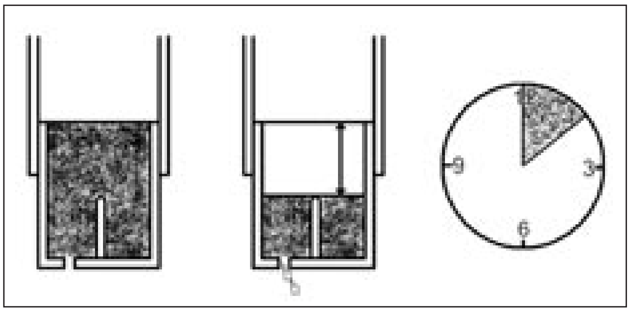

Fig. 2. Pinciple for flow time determination

parameters usually subjected to change are the emulsion viscosity and the peripheral speed of the waxing roller.

The viscosity of the waxing emulsion may be conveniently appreciated with the operation measuring the emulsion flowing time by the special Zell type glass (fig. 2) [Benninger Ben-tronic, Operating Instructions]. For different values of the emulsion viscosity, experimental diagrams of the emulsion mass variation deposited per 1 m^2 of warp may be drawn, as a function of both warp speed and waxing roller speed (fig. 3) [Benninger Ben-tronic, Operating Instructions]. These diagrams are used for settling the waxing roller speed, which can assure a certain loading with emulsion per 1 m^2 of warp, at a certain warp speed.

Warp loading with emulsion is calculated with equation (12). Technologically, the values for m_{eu} and l_{es} are known, which permits calculation of the *meu* value of the waxing emulsion per 1 m^2 of warp. Warp speed at band unwinding v_u (m/min.) is also known. The diagram onto which the waxing roller speed vd will be calculated is a function of the waxing emulsion viscosity. For example, at a 160 m/min. warp speed, a load of 6 g emulsion per 1 m^2 of warp may be attained at a value of v_d = 3.6 m/min. (fig. 4).

The experimental diagrams plotted in figure 4 show that the warp loading with emulsion is not directly proportional to the roller speed v_d, respectively to the $\frac{v_d}{v_u}$ ratio, as shown in equation (1).

Based on equation (5) and on the experimental data from figure 4, the experimental values m_{td} (m_{ea}) have been calculated depending on speed v_d. With these experimental data, there have been plotted the variation curves of the mass transferred per each 1 m^2 of roller – m_{td}, depending on its speed v_d and corresponding to three viscosity values (fig. 3).

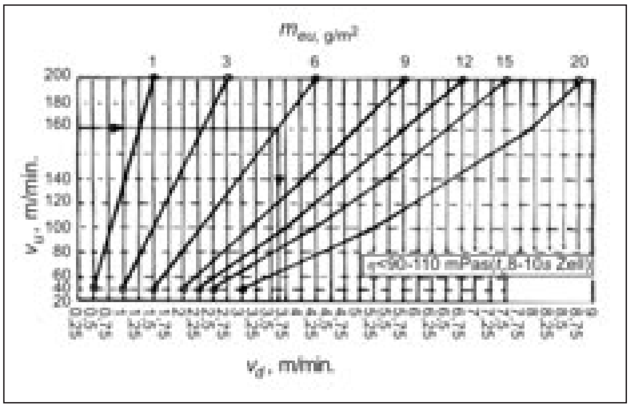

Fig. 4. Speed v_d depending on v_u for attaining different m_{eu} values

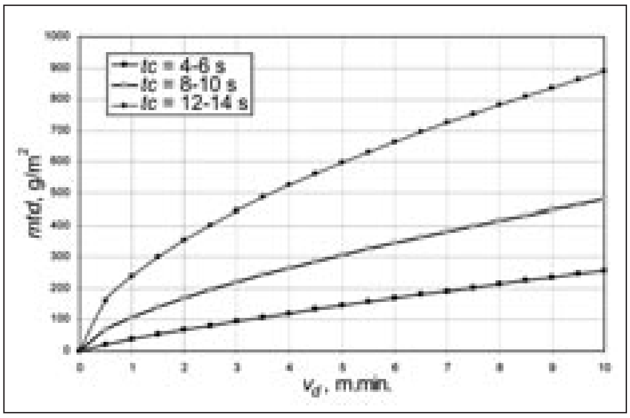

Fig. 3. Mass variation of the emulsion transferred from 1 m^2 of waxing roller

The equations expressing the mass variation m_{td}, as a function of its speed v_d, are of the type $m_{td} = av_d^n$. The concrete equations for the three viscosities studied are:

$$m_{td} = 38.23\, v_d^{0.82} \text{ – for } \eta \text{ with } t_c = 4 – 6 \text{ s Zell} \quad (15)$$

$$m_{td} = 107.67\, v_d^{0.65} \text{ – for } \eta \text{ with } t_c = 8 – 10 \text{ s Zell} \quad (16)$$

$$m_{td} = 237.89\, v_d^{0.57} \text{ – for } \eta \text{ with } t_c = 12 – 14 \text{ s Zell} \quad (17)$$

Knowledge of the variation equations for the mass kinematically transferred from the waxing roller, depending on its speed, at different viscosities, allows the direct calculus of the waxing roller speed, as a function of the warp speed and its characteristics. For this, we use the equations obtained by equalizing the technologically necessary mass m_{td} (equation 13) with the kinematically achieved mass, by the waxing roller, and calculated with one of the relations (15), (16) or (17). For example, for the waxing emulsion with t_c = 4 – 6 s, the equation for *vd* speed calculus is:

$$38.23 v_d^{0.82} = \frac{P_u T_t l_{eu} v_u}{10^3 v_d}$$

or

$$38230 v_d^{1.82} = P_u T_t l_{eu} v_u \quad (18)$$

For waxing emulsions with leaking times t_c = 8 – 10 s and t_c = 12 – 14 s respectively, the specific equations will be used for computing the mass kinematically transferred by the waxing roller m_{td} (m_{ea}), which leads to the equations corresponding to the calculus of speed v_d.

Based on the values known for the warps characteristics, the emulsion load l_{eu} and the warp speed, the speed of the waxing roller, v_d, can be calculated with the equations presented in this paper. Table 1 provides a few examples of speeds, v_d, resulting from these calculations.

Starting from the calculated values of speeds v_d, technological appreciations may be obtained, such as:

– maintaining the same emulsion load, when using increasingly higher viscosities of emulsions, by decreasing the speed v_d of the depositing roller;

Table 1

P_u, yarns/cm	T_t, tex	I_{eu}, %	v_u, m/min.	v_d, m/min., at t_c equal to:		
				4–6 s	8–10 s	12–16 s
10.5	111.11	5	100	14.44	2.78	1.76
19.5	90	6	100	6.13	3.98	2.57
21	20.8 x 2	7	160	4.56	2.86	1.82

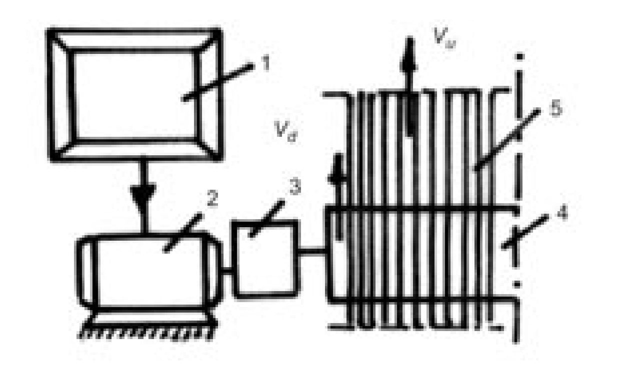

Fig. 5. Kinematic scheme: *1* – the computer connected to the machine; *2* – the motor with variable rotative speed; *3* – mechanical transmission; *4* – waxing roller; *5* – warp

– increasing warp load with waxing emulsion concomitantly with increasing the speed v_d of the depositing roller (if v_u = constant);
– maintaining the same emulsion load, concomitantly with increasing the warp speed v_u, by increasing the speed v_d of the depositing roller.

The calculated values of the speed v_d offer the possibility of being used for the computer-command of warps loading with waxing emulsion, without any other auxiliary nomograms. Thus, computer *1* (fig. 5) will control the rotative speed of motor *2*, which will assure the calculated speed v_d of the depositing roller.
The constant constructive elements introduced in the computer will be:
– the diameter of the depositing roller *4*;
– the mechanical speed ratio between motor *1* and roller *4*.

By means of the computer, there will be also programmed all variation equations for the mass of emulsion transferred from the roller surface unit, as a function of speed v_d, at different pre-established viscosity values.
As constant values for a certain item, there will be introduced into the computer the technological parameters specific to warp and to the waxing emulsion:
– warp setting P_u, yarns/cm;
– yarn fineness T_t, tex;
– the technologically necessary loading with emulsion I_{eu}, %;
– warp speed v_u, m/min.;
– emulsion viscosity, s Zell or other measuring unit.

The computer specific program will calculate the waxing roller speed *vd*, which could be displayed on the monitor, too. At the same time, depending on the fixed kinematic data of the driving device, there will be calculated and computer-programmed the motor rotative speed *2* (fig. 5), which will assure the technologically necessary speed of the waxing roller.
In case the technologically desired values of the emulsion loading were not attained, higher or smaller values of the I_{eu} will be introduced, until reaching the technologically necessary values.

CONCLUSIONS

- Equations used to compute the emulsion mass transferred onto the warp from 1 m^2 of waxing roller have been established, as a function of the warp characteristics, warp loading with emulsion, the $\frac{v_u}{v_d}$ ratio etc.
- Starting from experimental data, there have been established equations for calculating the mass of emulsion transferred onto the warp from 1 m^2 of waxing roller, as a function of its speed, at different emulsion viscosity values.
- The equality between the mass of emulsion transferred from the roller per unit of time and the mass of emulsion taken over by the warp over the same time unit allows the establishment of equations for the computer command of the waxing roller speed, depending on the main constructive and technological parameters of the warp waxing processes.

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Aplicaţii ale structurilor textile auxetice în industrie şi societate

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ABSTRACT – INHALTSANGABE

Applications of auxetic textile structures in the industry and society

The paper presents a series of applications of auxetic textile structures in the economy and social life. In the first part the features of such textile structures are presented, which mainly consist of thickening of a structure when subjected to a longitudinal axial load, unlike the classic case when the structure is thinning. In quantitative terms, such structures are characterized by a negative Poisson ratio. Due to specific properties - high resistance, high absorption of mechanical shock etc., such structures have the most diverse applications, starting with the military field (bulletproof vests and suits) and continuing with the health sector (implanted sutures), the automotive industry etc. The article presents the synthesis of these various applications of such materials.

Key-words: auxetic textile structures, Poisson ratio, applications

Anwendung auxetischer Textilstrukturen in der Industrie und der Gesellschaft

Der Artikel stellt vor eine Reihe von Anwendungen der auxetischen Textilstrukturen in der Wirtschaft und im Gesellschaftsleben. Im ersten Teil werden die Eigenheiten der Textilstrukturen analysiert, welche hauptsächlich eine Verdickungstendenz unter Einwirkung einer längs-axialen Last aufweisen, im Unterschied zum klassischen Fall, wenn eine Verdünnungstendenz vorkommt. Aus quantitativen Sichtpunkt, wird dieses Strukturtyp durch einen negativen Poisson-Koeffizient charakterisiert. Wegen den spezifischen Eigenschaften – hohes Widerstand, hohe Absorption der mechanischen Stösse etc, haben diese Strukturen unterschiedliche Anwendungen, wie z.B.: Militärbereich – kugelsichere Westen und Anzüge, Medizinbereich – Implante, Nähte, Automobilbereich etc. Im Artikel wird eine Synthese der Anwendungen auxetischer Textilmaterialien durchgeführt.

Schlüsselwörter: auxetische Textilstrukturen, Poisson-Koeffizient, Anwendungen

Progresele de ordin tehnologic realizate în ultimii 25 de ani au condus nu numai la rezultate tehnologice deosebite, dar şi la reconsiderări de ordin teoretic, neimaginabile acum 30 de ani. Este suficient să amintim doar două dintre exemplele deosebit de concludente, şi anume metamaterialele şi materialele auxetice.

Metamaterialele reprezintă o categorie de materiale realizate pe cale artificială, caracterizate printr-un coeficient de refracţie negativ.

Materialele auxetice prezintă un coeficient Poisson negativ. Spre deosebire de prima categorie, materialele auxetice se pot găsi şi în natură, însă destul de rar. Important este faptul că ele au proprietatea de a se „umfla“, atunci când sunt supuse unei sarcini de întindere, spre deosebire de cele clasice, care se subţiază.

Trebuie remarcat faptul că materialele auxetice posedă proprietăţi deosebite, cum ar fi: o mare putere de absorbţie a energiei mecanice şi nu numai, o putere mare de disipare a acesteia, o rezistenţă foarte mare în utilizare şi, în acelaşi timp, o masă mult mai mică decât materialele convenţionale, ceea le face deosebit de utile în multe domenii tehnice.

Scopul articolului este acela de a prezenta varietatea aplicaţiilor structurilor textile auxetice în industrie şi societate şi de a sublinia necesitatea continuării cercetărilor ştiinţifice în domeniul proiectării şi realizării unor astfel de structuri.

SCURTĂ PREZENTARE A STRUCTURILOR ELASTICE AUXETICE

Considerând un mediu continuu elastic, o structură elastică auxetică este caracterizată de un coeficient Poisson negativ. Se ştie că, în limitele teoriei clasice a elasticităţii, coeficientul Poisson nu poate lua valori negative, astfel încât toate modelele construite până acum iau drept valori posibile pentru coeficientul Poisson valori pozitive. Speculaţiile de ordin teoretic (în anii ’40) privind posibilitatea existenţei unor materiale caracterizate prin valori negative ale coeficientului Poisson, au devenit reale odată cu realizarea primelor structuri auxetice [1, 2, 3].

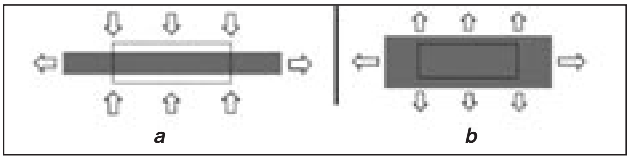

Fig. 1. Comportarea la solicitări de tracţiune:
a – structuri convenţionale; **b** – structuri auxetice

Coeficientul Poisson este definit ca mărime a raportului:

$$\nu = -\frac{\varepsilon_{yy}}{\varepsilon_{xx}} \qquad (1)$$

în care:

ε_{yy}, ε_{xx} reprezintă alungirile longitudinale în sensul axei *Oy*, respectiv *Ox*.

Din punct de vedere matematic, expresia din ecuaţia (1) reprezintă relaţia de calcul şi definire a coeficientului Poisson.

În figura 1 este redată comportarea la efort a unor structuri convenţionale şi auxetice [3]. Se poate observa că, în cazul convenţional, materialul supus unei solicitări de tracţiune longitudinală se subţiază, iar în al doilea caz se „umflă“, respectiv îşi măreşte dimensiunile transversale.

Reprezentarea schematică a comportării la nivel microscopic a unei structuri auxetice este dată în figura 2. Se poate observa că, în stare lichidă legăturile sunt cvasiparalele, însă în stare solidă o parte din ele se comportă ca nişte „bare“, ceea ce duce la starea de cvasiparalelism a lanţului polimeric, cele două lanţuri

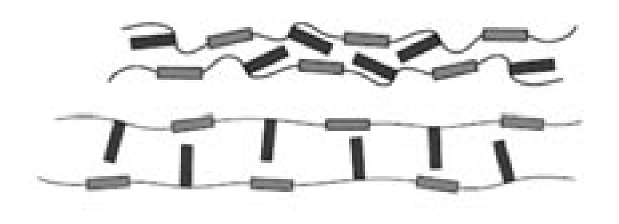

Fig. 2

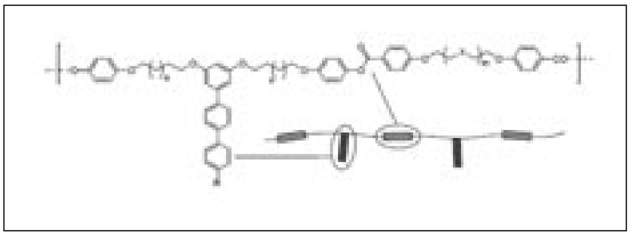

Fig. 3

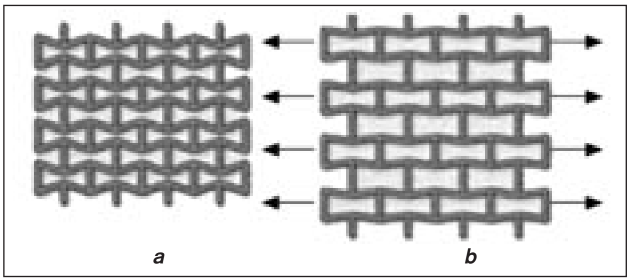

Fig. 4. Comportamentul materialului auxetic de tip fagure:
a – starea inițială netensionată; ***b*** – starea după deformare

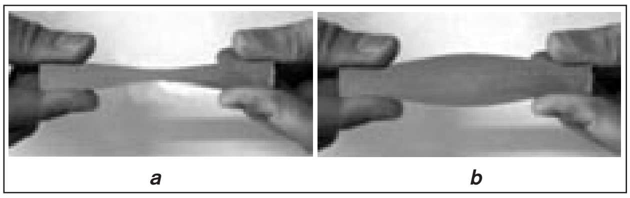

Fig. 5. Comportamentul unui material tricotat:
a – structuri convenționale; ***b*** – structuri auxetice

îndepărtându-se unul de altul și, prin urmare, generând starea de „umflare“. Deși cazul este tratat simplist, în realitate lucrurile se petrec conform unor scheme de „umflare“. Termenul de „umflare“ este utilizat tocmai în ideea eliminării altor termeni, precum cel de dilatare, care are, în acest context, o altă conotație fizică. Pentru a justifica cele expuse, în figura 3 este reprezentată o structură polimerică auxetică [3]. La scară macroscopică, o situație similară se poate observa în cazul materialelor auxetice de tip fagure (fig. 4). În figura 5 este redat comportamentul unei structuri tricotate de tip auxetic, comparativ cu cel al unei structuri convenționale.

APLICAȚII ALE STRUCTURILOR AUXETICE

La baza aplicațiilor structurilor textile auxetice stau proprietățile de bază ale unui material auxetic, respectiv:

- puterea foarte ridicată de absorbție și de disipare a energiei mecanice;
- rezistența sporită;
- masa redusă;
- capacitatea de absorbție sonică și caracteristici abrazive accentuate;
- duritatea ridicată;
- posibilitățile de modificare a porilor sub acțiunea unei tensiuni.

Aplicații în domeniul compozitelor

Armarea compozitelor cu fibre auxetice, pe lângă faptul că sporește caracteristicile de rezistență a compozitului, crește și gradul de funcționalitate a amestecului, datorită proprietăților auxetice specifice (fig. 6). În general, în cazul armării cu fibre neconvenționale, gradul de aderență matrice-structură fibroasă nu este așa de ridicat ca în cazul materialului auxetic, ceea ce, în condiții de solicitare, duce la apariția unor fisuri, care cresc odată cu sporirea intensității sarcinii.

Aplicații în domeniul filtrelor

Materialele auxetice sunt utilizate, de asemenea, în domeniul filtrelor, în primul rând datorită realizării unor țesături sau materiale de tip fagure, cu posibilități de adaptare a porozității și de curățare a porilor cu randament sporit, în urma ancrasării acestora. De exemplu, în cazul filtrelor se poate realiza o mai bună compensare a variației presiunii rezultată în urma procesului de ancrasare. De asemenea, un filtru auxetic – de tip spumă, țesătură sau fagure – prezintă o mare capacitate de deschidere a porilor în ambele direcții, ceea ce sporește adaptabilitatea mărimii porilor în funcție de capacitatea de filtrare a soluțiilor. În figura 7 (http://www.azom.com/Details.asp?ArticleID=168#_Filters), este prezentată schița demonstrativă a funcționalității unui filtru auxetic, comparativ cu cea a unui filtru convențional.

Aplicații în biomedicină

Un prim domeniu de utilizare îl constituie cel al materialelor proteice – implanturi, suturi, țesuturi musculare sau/și ligamente. De asemenea, materialele auxetice

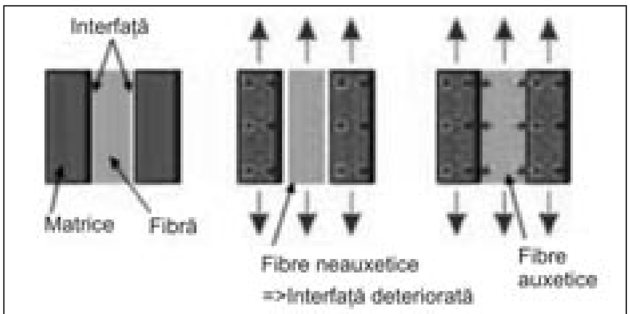

Fig. 6

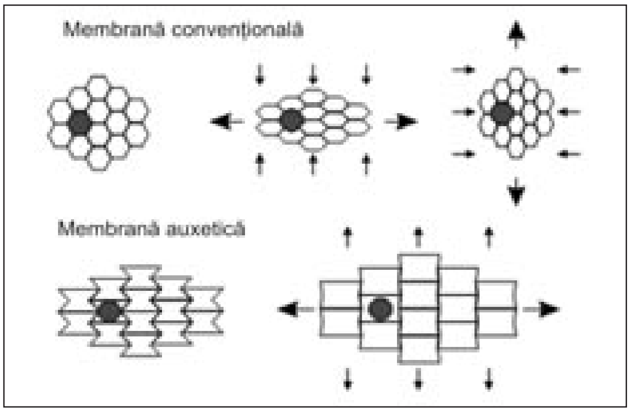

Fig. 7

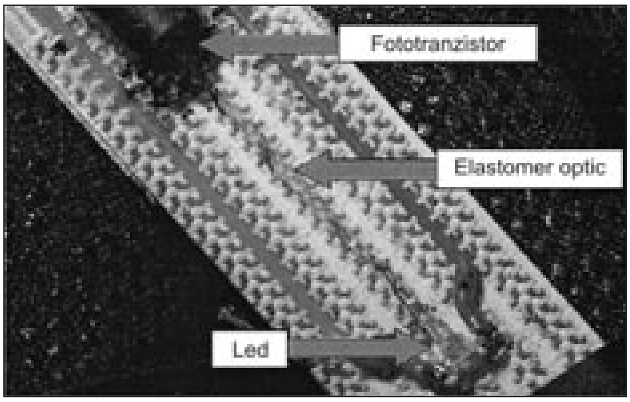

Fig. 8

Fig. 9

Fig. 10

sunt folosite ca dilatator al vaselor de sânge, în timpul intervențiilor chirurgicale cardiace. Tot în biomedicină, aceste materiale pot fi utilizate în mod indirect, în combinație cu alte produse precum senzori electrici și actuatoare. Acest lucru este recomandabil cu atât mai mult cu cât metalele auxetice pot fi utilizate ca straturi de tip sandviș în polimeri piezoelectrici, sau ca tije metalice în elemente ceramice piezoelectrice, încorporate apoi într-o matrice de polimer auxetic. Aceste combinații pot duce la creșterea sensibilității de zece sau o sută de ori, cum se întâmplă în domeniul comunicațiilor.

Aplicații în domeniul comunicațiilor

Un alt domeniu de utilizare a materialelor auxetice îl reprezintă cel al comunicațiilor. Senzorii optici de înaltă fidelitate, cu 600% mai sensibili decât cei convenționali, prezentați în figura 8 (http://www.auxetix.com/), sunt formați dintr-un miez elastomeric, înfășurat într-un strat exterior foarte rezistent, realizat din produse auxetice. Acești senzori pot fi implementați în orice produs textil convențional, pentru a monitoriza parametrii fiziologici ai corpului uman.

Aplicații în domeniul construcțiilor

Materialele auxetice se pot utiliza, de asemenea, la schele și, în principal, în armătura construcțiilor, datorită faptului că structurile metalice auxetice rezistă mult mai bine decât cele metalice clasice, deși au dimensiuni mult mai reduse și sunt mai ușoare. În plus, sunt utilizate pe scară largă ca ferestre de protecție, datorită rezistenței lor extrem de mare, spre deosebire de sticla convențională. Totodată, se pot utiliza ca senzori inteligenți, implantați în structura clădirilor, în scopul monitorizării anumitor riscuri la care pot fi expuse (seisme, incendii etc.).

Aplicații în domeniul automobilelor

Materialele textile auxetice își găsesc aplicabilitatea în realizarea chingilor și a centurilor destinate interioarelor auto – figura 9 (http://www.auxetix.com/). Datorită proprietăților de absorbție a șocurilor și vibrațiilor, ele se pot utiliza în realizarea altor elemente constructive ale automobilului.

Aplicații în domeniul militar

Având în vedere rezistența ridicată și capacitatea deosebită de absorbție a șocurilor, materialele textile auxetice pot fi folosite la fabricarea vestelor antiglonț, a corturilor militare și a echipamentelor de protecție.
Datorită puterii mari de absorbție a energiei mecanice și a șocurilor, dar și de disipare a acestei energii, o realizare aparte o reprezintă țesăturile Zetix, destinate ecranelor de protecție împotriva exploziilor. Rezultatul încercărilor anti-ex, în cazul țesăturilor Zetix, este prezentat în figura 10 (http://gizmodo.com/330343/zetix-blast+proof-fabric-resists-multiple-car-bombs-makes-our-heads-explode).
Țesătura Zetix combină caracteristicile de rezistență cu componente volumice ieftine, toate acestea într-o proporție de 1 la 100, în condițiile menținerii proprietăților de rezistență anti-ex. În plus, eficiența economică ridicată și rentabilitatea rezultă din posibilitatea utilizării de mai multe ori a aceluiași produs, față de materialele convenționale, care devin ineficiente după o singură utilizare.
Un alt avantaj al țesăturii Zetix constă în prețul de cost scăzut, comparativ cu alte produse similare, care sunt realizate din materiale de înaltă performanță, dar costisitoare. Țesătura Zetix utilizează astfel de componente, însă într-un procentaj mai redus. Cercetările recente au evidențiat posibilitatea realizării de țesături auxetice mimetice, respectiv a unor țesături care, sub acțiunea tensiunilor, își pot schimba culoarea.

CONCLUZII

Articolul prezintă date informaționale asupra unui domeniu aproape deloc cunoscut în industria textilă din România. Pe lângă prezentarea elementelor necesare înțelegerii particularităților specifice ale materialelor auxetice, în lucrare sunt sintetizate o parte dintre diversele aplicații ale acestor materiale în industrie și societate.

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DOCUMENTARE

Materii prime

FIRE ULTRAFINE PENTRU SUBSTRATURILE CIRCUITELOR IMPRIMATE

Compania ***AGY*** – important producător de fire și ranforturi din fibră de sticlă, a descoperit un nou domeniu de utilizare a firelor ultrafine, cel al substraturilor circuitelor imprimate (PCB). Firele au fost proiectate pentru a satisface nevoile în creștere de pe piața produselor electronice, axată pe miniaturizare și funcționalitate sporită. *„Deoarece aparatele electronice devin din ce în ce mai mici și includ tot mai multe funcții, complexitatea circuitelor imprimate trebuie să crească. Aceasta implică adăugarea mai multor straturi conductoare, care să nu modifice grosimea plăcii circuitului imprimat. De aceea, materialul utilizat pentru consolidare trebuie să fie foarte subțire, ceea ce necesită fire de sticlă tot mai fine*" – a declarat Scott Northrup, director al departamentului de dezvoltare a afacerilor.

Noile fire vor permite furnizorilor de circuite imprimate realizarea unor laminate mai subțiri, cu un grad ridicat de finețe a stratului și de compactitate a circuitului. Ceea ce le face ultrafine este numărul mic al filamentelor ce alcătuiesc diametrul firului. De exemplu, firul C1200, utilizat în realizarea țesăturii stil 1037, este format din 100 de filamente cu diametrul de 4.5 microni, iar firul BC1500, utilizat în realizarea țesăturii stil 1027, este alcătuit din 100 de filamente cu diametrul de 4 microni. Noul fir BC 3000, în curs de elaborare, va conține doar 50 de filamente cu diametrul de 4 microni. Cele mai fine fire utilizate, până în prezent, la circuitele imprimate, predecesoare ale acestor fire ultrafine, au fost D900 și D450, de cinci microni, care conțineau, de obicei, 100 sau 200 de filamente.

Fig. 1

Pentru obținerea laminatelor placate cu cupru, cu proprietăți dielectrice și de consolidare, s-a folosit un material țesut, din fire ultrafine, laminat cu rășină epoxidică și folie de cupru. Compoziția firului E-Glass (fig. 1) face ca acesta să fie un bun izolator electric, oferind stabilitate termomecanică circuitelor imprimate. Consolidările obținute prin utilizarea materialelor din fibră de sticlă oferă rezultate excelente în ceea ce privește stabilitatea dimensională, astfel că plăcile circuitelor imprimate nu se vor deforma atunci când sunt supuse la presiune și căldură.

Alte aplicații ale firelor ultrafine sunt: cablajele imprimate rigide – pentru o utilizare maximă a spațiului disponibil în interiorul dispozitivelor electronice, circuitele foarte subțiri – care implică un anumit grad de flexibilitate sau curbare, stațiile de bază utilizate în telecomunicații – care necesită plăci cu straturi foarte subțiri și un grad ridicat de funcționalitate etc.

În viitor, aceste fire vor fi folosite pentru satisfacerea nevoii de obținere a unor produse de dimensiuni tot mai mici și cu o mai mare funcționalitate, cum ar fi dispozitivele electronice sofisticate de tipul telefoanelor inteligente.

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The impact of textile products customer retention on the buying decision process

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REZUMAT – ABSTRACT – INHALTSANGABE

Impactul fidelizării consumatorilor de produse textile în procesul decizional de cumpărare

În lucrare sunt definite principalele elemente referitoare la comportamentul de consum, motivațiile și procesul decizional în cazul particular al articolelor vestimentare. S-a avut în vedere identificarea principalelor caracteristici și variabile ale fidelizării, corelate cu procesul decizional de cumpărare, precum și a diferențelor de percepție între mărcile producătorilor și cele ale distribuitorilor, determinarea preferinței pentru o anumită marcă de produse textile, recumpărarea mărcii, disponibilitatea acceptării unui preț mai mare pentru marca preferată, recomandarea produsului, înclinația spre schimbarea mărcii. Astfel, concluziile cercetării nu au vizat numai identificarea unor propuneri privind tehnicile de fidelizare specifice etapei postcumpărare – satisfacția consumatorului, ci și a unor informații importante referitoare la comportamentul postconsum al populației, în ceea ce privește produsele textile.

Cuvinte-cheie: marketing, fidelizare, proces decizional de cumpărare, satisfacția consumatorului, strategii de fidelizare

The impact of textile products customer retention on the buying decision process

The study defines the main elements related to consumer behavior, motivations and decision process in the particular case of clothing items. The main characteristics and variables of retention, correlated with the buying decision process, as well as the perception differences between product brands and distributor brands, determining the preference for a certain brand of textile products, brand repurchase, the willingness to accept a higher price for the favorite brand, product recommendation, propensity for changing the brand were considered. Thus, the conclusions of the research were aimed not only at identifying proposals regarding retention techniques characteristic for the post-purchase stage – consume satisfaction, but also at identifying important information regarding the population post-consume behavior, in terms of textile products.

Key-words: marketing, retention, buying decision process, consumer satisfaction, retention strategies

Impakt der Kundentreue bei Textilprodukten im Kaufentscheidungsprozess

Diese Untersuchung definiert die hauptsächlichen Elemente des Kosumverhaltens, der Motivation und des Entscheidungsprozesses im speziellen Fall der Bekleidungsartikel. Es wurden die Identifizierung der Hauptcharakteristiken und – variablen der Kundentreue, korreliert mit dem Kaufentscheidungsprozess, sowie die Wahrnehmungsunterschiede zwischen den Marken der Hersteller und der Lieferanten, Bestimmung des Vorzugs für eine bestimmte Textilproduktmarke, Wiederkauf der Marke, Bereitschaft der Annahme eines grösseren Preises für die vorgezogene Marke, Empfehlung der Marke, Tendenz für Markenwechsel, in Betracht gezogen. Die Schlussfolgerungen der Untersuchung haben nicht nur zur Identifizierung einiger Vorschläge für Kundentreuetechniken spezifisch der Nachkaufsettape – Kundenzufriedenheit, sondern auch der wichtigen Informationen betreff des Postkonsumverhaltens der Bevölkerung, was Textilprodukten anbelangt, geführt.

Schlüsselwörter: Marketing, Kundentreue, Kaufentscheidungsprozess, Kundenzufriedenheit, Kundentreuestrategien

Consumer behavior-related research has been developed in close connection with motivational research, as part of the in-depth study of market phenomena, designed to clarify the mechanism by which demand carriers explicitly express themselves, under the shape of a certain economic behavior, i.e. buying and consuming.

Consumer behavior is the result of a cognitive process, including an array of thought, evaluation and decision sequences. Consumer behavior consists of a series of elements, which manifest themselves through elementary processes: perception, information, attitude, motivation and actual behavior. Motivational research represents an entirely special endeavor within marketing research in general. Thus, it attempts to identify the mechanism associated with these processes, addressing to the requirement for synthesizing information about consumer needs, their dynamics and the effective manifestation of buying and consume decisions.

The retention process for most goods and services implies the deployment of complex resources within an exactly defined timeframe. Adapting a retention strategy will undoubtedly be carried out taking into account the characteristics of the product or service considered.

The identification of the retention strategy contents will take into account a series of general elements also present in other strategic endeavors, as well as a series of specific elements, which present the complete profile of the target consumer and, above all, his behavior and the decision-making environment of his consumption psychology.

The customer retention activity is maybe the most important barometer for the complexity and level of conceptualization, for the organizational marketing strategy itself. No economic entity can evolve in its reference environment, unless it benefits from a coherent strategy for creating and delivering value on its specific market. This very process represents the foundation of the retention strategy. An effective retention strategy cannot be conceived without a profound knowledge of the whole decision process and of the individuals' consumption environment.

The relevance of information is greater for products that satisfy superior needs. This is the category to which the products studied in the present research belong.

In order to evaluate the importance of the consumer's retention, for the textile products, and the present degree of retention for the Romanian consumer, the authors conducted a survey-type quantitative marketing research, gathering information on a subject sample with permanent residence in Bucharest, during the interval 18.05.2009–1.06.2009.

Statistically, the men: women ratio respected the proportion of the statistical population and, as for age groups, most of the interviewed subjects were 18–35 years old (82% of the total sample), because we considered that young, dynamic, high-income persons (56% of the young interviewed subjects declared a household income above 2 500 lei) have better knowledge of retention modalities, are more interested in news, and can be influenced in the choice of retention modalities for the textile products.
Overall, the sample is relatively balanced from the point of view of the socio-demographic and economic structure. Thus, it includes 43.78% men and 56.22% women; 4.47% aged under 20, 36.81% aged between 21 and 25, 45.02% aged between 26 and 35, 11.69% between 36 and 50, and 1.99 over 50 years old. As for income, 1.74% declared an income below 800 lei, 15.92% an income between 801 lei and 1 500 lei, 28.85% an income between 1 501 and 2 500 lei, and 53.48% an income above 2 500 lei. As for the marital status, circa 67.16 % are unmarried, 31.09% married, and a small percentage of 1.74 are widow or divorced. As for education, 1.49% has middle school education, 25.67% high school education, 58.95% university and 13.68% post-university education.
The aim of the research was to study the impact of the textile products customer retention on the buying decision process.
The relevant objectives for the present research are: measuring customer perception about retention (determining the preference for a certain brand of textile products, brand repurchase, the willingness to accept a higher price for the favorite brand, product recommendation, the propensity for changing the brand); identifying the retention and motivation techniques, the attributes which characterize retention, both in terms of certain textile products brands, and for distributor brands (stores); identifying the information sources needed in the buying decision process (namely: the identification of the information source nature, the willingness to inform oneself, the informing process frequency, the number of sources); identifying the modality of choosing products, measuring and identifying the factors influencing the buying decision; the perception of satisfaction and post-decision behavior – regarding consumption.
The research hypothesis were mainly about the fact that retention techniques aimed at textile producer brands can be generally similar to those aimed at distributor brands (stores), that buying behavior is different between sexes, meaning that women consider a series of more diversified sources of information than men during the textile product buying decision process. Furthermore, buying behavior and the feed-back offered to retention techniques is different for age categories, young people (20–35 years old) having generally a greater exposure willingness for promotional messages, on more media channels simultaneously, a greater speed of reacting to organizational initiatives aimed at increasing retention for the textile products.
Recognizing the possibility of further improvement, both in the quality of gathered data, and in the modalities of conducting and conceptualizing the research, we shall briefly present a series of research conclusions, as well as a series of proposals focused on improving the strategic approach of organizations present on the textile product market in our country.
Thus, it was found out that an overwhelming proportion of interviewees declared they are concerned about clothes – 88%, which suggests a characteristic of the urban-metropolitan consumer culture represented by the chosen sample. This conclusion is related to the fact that only 14% of the number of respondents could not specify any textile product brands that enjoy spontaneous notoriety. Among the brands with the greatest spontaneous notoriety are Adidas (11% of the respondents), Zara (10% of the respondents), and Nike (9% of the respondents).
From the point of view of the brand to which consumers are loyal, only 32% of them have a favorite brand, belonging to the same group of brands with high spontaneous notoriety, but in another order: Zara followed by Adidas and Nike.
From the total of those who prefer a brand, only 83 persons (21%) chose the same brand which reveals spontaneous notoriety, 24 persons (6%) chose a different brand from the one holding spontaneous notoriety, 8 persons (2%), although they declared themselves loyal naming a favorite brand, had no answer referring to spontaneous notoriety. This, coupled with the fact that 3% declared to be loyal to a brand, but could not specify what the brand was, leads us to the conclusion that, although the percentage of customers with an attachment to a brand (32% of the total respondents) is not negligible, brand image on the Romanian clothing market is not yet fully crystallized. Brand loyalty has not yet a foundation based on a series of mechanisms with profound implications for the consumer psyche. So, we can say that the consumer is still immature, with an attachment most likely built on promotional advantages constantly offered by producers and/or distributors, and less on a series of more lasting elements, such as the essential brand attributes, identification of consumer profile – brand image etc.
Product brand in relation to the influence of the buying decision was expressed in different ways by the respondents. Thus, in 47% of the cases, this was a guarantee of quality, then 37% of the respondents declared that they perceive brand as an expression of snobbery, not being influenced in the buying decision, followed by 9%, who identify a brand with the producer's original products, and by 7%, who perceive brand as expression of a high price that they cannot afford.
The differences of perception observed between producer and distributor brands show that 73% of the consumers consider there is a difference and 27% that there is no difference. The percentage of respondents who do not see differences between the two brand types supports the conclusion that clothing items producer brands are still not well enough individualized on the Romanian market. This problem offers the possibility of conducting further marketing research, for the in-depth study on what brand image means for the clothes consumer in Romania and which are the attributes identified by this, in relation to consumer

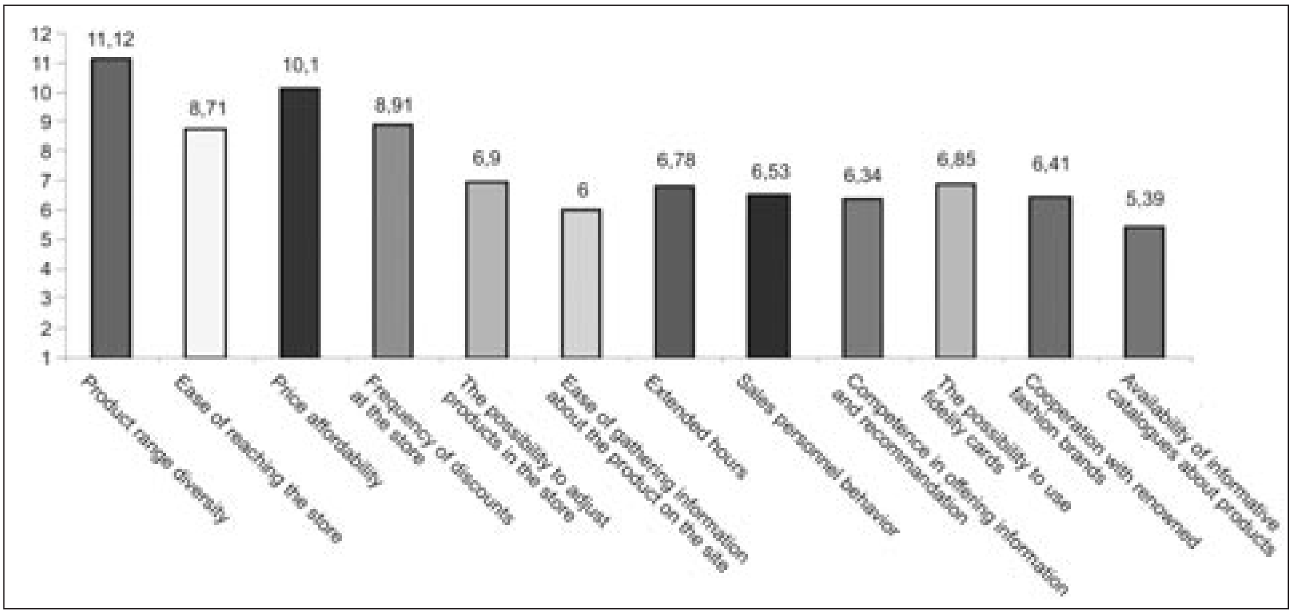

Fig. 1. Average scores for characteristics that determine retention for the clothes stores

type, consume opportunities, socio-demographic categories etc.

A special importance is attributed to conclusions about the retention motivations for producer brands, as well as distributor brands. It was first noticed that motivations were easily mistaken by respondents for attributes, not only of the brand itself, but also of the stores or clothes.

Thus, the attributes most frequently indicated for loyalty to a certain clothing brand were fabric quality (20% of respondents), and the combination of price, quality and comfort (for 19% of respondents). The least important attributes were range diversity, promotions, product promotion or fidelity cards, respectively.

As for distributors (stores) loyalty, the most important attributes were product quality, fabric quality, price and discounts at clothing items. The least important attributes, which can contribute to consumer retention, were offering presents on certain occasions and store location combined with discounts.

Analyzing both categories of information about the attributes that determine people become loyal customers of a clothes brand and about the attributes that determine them become loyal customers of a clothes store, most respondents chose fabric quality and price as the common determining factor for both attribute categories. This was followed by those who believe that product quality alone is the attribute, and then by those who believe that price alone influences their loyalty, both for clothes brands in general, and for a store. The other combinations of characteristics had very small percentages.

This conclusion is interesting for two reasons: on one side the homogeneity of attributes, and on the other side the lack of attributes implying other characteristics of commercial services offered by stores, and not only textile product characteristics themselves.

Thus, it was revealed that consumer perception of their own defining state for the quality of loyal customer is very poorly outlined, the customer having the tendency to borrow easily tangible attributes related only to products for both discussed cases (loyalty to a clothes producer brand or to a distributor brand).

The incapacity to distinguish between motivation and attributes, as well as the nature of the latter (with a higher degree of tangibility – a strong link with the consumption action itself), suggests the lack on the domestic market of consistently applied retention programs, with a large enough scale of addressability to create a powerful awareness among consumers, about – differentiating between brands, creating a strong emotional connection between consumer and brand.

The retention techniques considered important for producer brands were identified in the following order: customer cards, discount and bonus systems, discount coupons inserted in customer magazines, direct-mail, product customization and adjustment, relating a personalized service offer to a customer-oriented product offer, online marketing techniques, customer clubs, telephone marketing. When relating the answers about the retention techniques with the reasons (attributes) that could persuade them to become loyal customers of a clothing brand, it was apparent that fabric quality and the combination of comfort, price and quality were prevalent in most cases.

From the point of view of the defining elements making customers become loyal to a store, the following were apparent: product range diversity; price affordability; frequency of discounts at the store; ease of reaching the store (multiple means of common transportation and parking spots); the possibility to adjust products in the store; the possibility to use fidelity cards; extended hours; sales personnel behavior; cooperation with renowned fashion brands; competence in offering information and recommendation; ease of gathering information about the product on the website; availability of informative catalogues about products. This can be noticed in figure 1, which presents the average scores for each characteristic.

The order of the variables with the greatest influence on the buying decision is the following: product quality

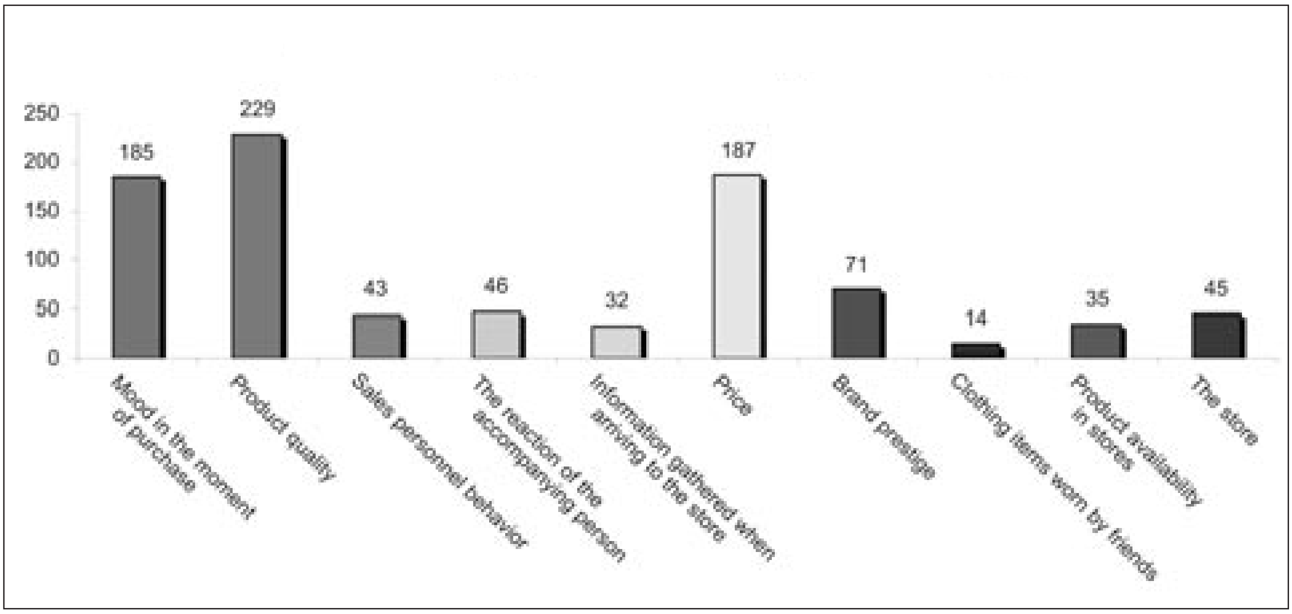

Fig. 2. Defining variables with the greatest influence on the buying decision of a clothing item

(resistance, texture); price; mood in the moment of purchase; brand prestige; the reaction of the accompanying person; the store; sales personnel behavior; product availability in stores; information gathered when arriving to the store (from the store); clothing items worn by friends.

This order of variables is shown in figure 2, which shows how many times each variable was chosen.

A series of conclusions also refer to the information sources considered when shaping the buying decision for clothes: information from stores; popular and specialty magazines; friends and/or family opinion; the site of the favorite company; street advertising (signs, billboards, flyers); promotional materials received by mail.

After evaluating the extent to which information about clothing items is important in the buying decision, the following facts have been revealed: most subjects (40%) do not inform themselves at all before, but buy spontaneously what they like; 33% declared that information helps them, but they are influenced at the same time by the current offers of stores; 22% said that information helps them in a considerable measure to get an opinion before entering the store; and only 4% pointed out that information helps them to a great extent and that they cannot decide without previous information.

After relating the sources of information used with the respondents sex (in order to test one of the research hypotheses), it was found out that women get their information mostly from – popular and specialty magazines, directly from stores, and consider the friends and/or family opinion, while men inform themselves especially from-data obtained directly from the store, when buying a product; use the internet, getting information from the site of the favorite company; and taking into account the friends and/or family opinions.

Furthermore, a statistics based on the sex distribution amount of interviewees revealed that women reported more sources simultaneously than men did (fig. 3).

The strongest correlation was between popular and specialty journals and the respondent sex (using the nonparametric χ^2 test and the contingency coefficient, having both approx. sig. = 0,000), what proves, by the statistic tests once more, that women inform themselves more than men from magazines, while for other sources a correlation with the respondent sex could not be proved. The colected data has been computed with SPSS 13.0 software.

When asked to specify the extent to which the information about clothes is important for the buying decision, the respondents who declared that they do not inform themselves at all and buy spontaneously what they like pointed out that they take mainly into account the information from the store. Besides, those who declared that information helps them, but they are influenced at the same time by the current offer of the store, mentioned the information available in the stores and in the popular and specialty magazines.

Respondents who declared that information helps them to a considerable extent to form an opinion before entering the store mentioned as sources of information the popular and specialty magazines, while those who declared they cannot decide without previous information also mentioned popular and specialty magazines, being, however, the fewest respondents.

According to the χ^2 statistic test and to the contingency coefficient, a strong correlation exists only between the buying decision of a certain clothing item, which relies on magazines as information sources, and the extent to which information about clothes is important in the buying decision and, practically, information from those magazines is considered necessary before going to the store. Taking into account the previous correlation, we may state that most women cannot decide themselves unless they study magazines before going to the store to buy clothes.

Relating the differences of perception in the buying moment and after a certain period of product use, the following conclusions can be drawn: those who inform

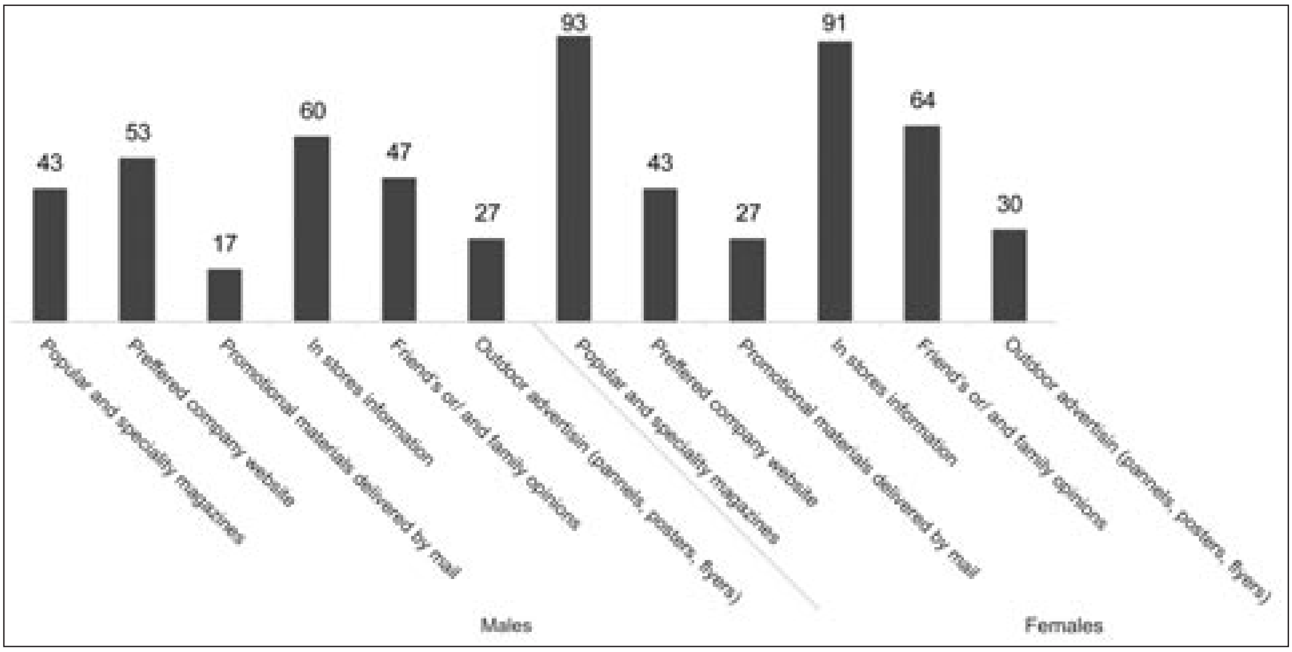

Fig. 3. Sex distribution for informating sources and means

themselves directly from stores have very large and large differences of perception; those who take into account friend and/or family opinion declared themselves indifferent; those who inform themselves from popular and specialty magazines have small and relatively small differences of perception.

Furthermore, the following elements, in their order of importance, were considered as defining respondent satisfaction, closely related to post-consume behavior: comfort, fabric texture, whether the product is in fashion, its durability, other people appreciation, and design (esthetics).

As for testing one of the study's important hypotheses – the willingness of one urban segment, young people (aged between 20 and 35), towards a special interest for retention programs, a more aggressive promotion of clothes and a faster feedback – the research revealed that the age groups more concerned about clothing are: 21–25 years old, 26–35 years old, and the ones under 20. Therefore, the persons preoccupied about the way they look are mainly young. At the same time, they have incomes above 1 500–2 500 lei, and 59% of them are women. As for study group distribution, this is extremely balanced: 89% of the persons with university education are particularly careful about the way they dress, as well as 87% with post-university studies and 85% of those with high school.

The research in its entirety offers a series of important information for quantifying the premises necessary to elaborate a retention strategy for the clothing consumers. These conclusions can be improved by further research, including those of quantitative nature, which should test the concrete impact of each retention technique studied on the target audience.

As previously noticed, a different approach is needed on different consumer segments, from the perspective of their age and sex, women being more sensitive to specialized means of information (magazines), while men rely more on information from the stores. Young people (20–35 years old) are willing to spend more, being generally more concerned with their appearance and more sensitive to promotion efforts, which qualifies them as target for focused promotions, with clear objectives for the distinct positioning of the specific products for their segment. Moreover, the marketing research revealed that young people represent consumers with the highest affinity for brands, considering that they trust brands and those brands represent a guarantee of quality for them. Besides, the segment of women from the same age category (20–35 years old) are willing to pay a higher price for a clothing brand, perceiving this as paying for renown (for the social status provided by the brand). Thus, the segments taken into account are consumers who qualify themselves for retention programs focused on the emotional relation between brand and consumer, long-term relating, aggressive positioning towards the competition.

We believe that a series of qualitative research is called for, to investigate in-depth whether the foundation for the differences in perception between age categories is conditioned by social factors (education, consumer culture) or whether there is a lack of adaptation of the older generation to the diversity of products appeared after 1989.

One of the main conclusions of the research was the insufficient differentiation of brand images in the consumer perception, the necessity for the producers to cooperate with distributors by promoting strategic relationships aimed at conceiving and carrying out retention programs.

Retention programs focused on producer brands can benefit from the current consumer perception (tangible attributes being considered important for loyalty) only by developing partnerships with distributors, in which the product brand image is supplanted by a series of particular elements of the distributor brand.

Clothing items are products requiring relatively complex decision processes, which involve a series of both quantitative and qualitative parameters in the expression of consumer behavior and in subsequently building consumer loyalty. That is why we believe that quantitative research focused on clarifying the aspects about retention should be corroborated with an equally substantial qualitative effort, in order to reveal, in all its complexity, the ever present and, at the same time, dynamic problem of customer retention.

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Optimization models of paraglide manufacturing process

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REZUMAT – ABSTRACT – INHALTSANGABE

Modele de optimizare a procesului de fabricație a parapantelor

Parapanta este un aparat de zbor cu structura principală nerigidă, care necesită – pentru decolare și aterizare – doar efortul fizic al pilotului. Din momentul desprinderii de pe sol și până în momentul aterizării, parapanta se află în continuă mișcare, asupra acesteia acționând o multitudine de forțe. Cunoașterea principiilor care generează mișcarea corpurilor în aer este deosebit de importantă în procesul de proiectare, creând o imagine corectă asupra mișcării de planare a parapantelor. De asemenea, materiale utilizate și tipurile de asamblări influențează modul în care parapantele răspund solicitărilor complexe la care sunt supuse în timpul funcționării. Astfel, pornind de la modelul clasic de asamblare a diferitelor zone se generează modelele de optimizare a caracteristicilor îmbinărilor – desimea cusăturii, finețea aței de cusut și finețea acelor, în concordanță cu cele ale materialelor utilizate – rezistența și alungirea la rupere, permeabilitate la aer.

Cuvinte-cheie: parapantă, proces, parametri, asamblare, optimizare

Optimization models of paraglide manufacturing process

The paraglide is a flying device with a non-rigid main structure, which for take-off and landing needs only the physical effort of the pilot. From take-off to the landing the paraglide is in a continuous movement and a multitude of forces are acting over the canopy. The knowledge of the principles that generate the movement of bodies in air is very important for the design process, because an accurate image can be created on the paraglide soaring movement. Also, the materials and seam type selection affects the way that paraglides can respond to the complex tensions during the flight. Therefore, using the classic way to assemble the different components, optimization models of seam characteristics are generated – stitch setting, sewing thread size and sewing needle size according to the characteristics of the materials used – breaking strength and elongation, air permeability.

Key-words: paraglide, process, parameters, seam, optimization

Optimierungsmodelle des Gleitschirm-Fertigungsprozesses

Der Gleitschirm ist ein Flugapparat mit nicht-starrer Hauptstruktur – welches für Aufstieg und Landung – nur die physische Kraft des Steuers benötigt. Vom Augenblick des Verlassens des Bodens und bis im Augenblick der Landung befindet sich der Gleitschirm in stätiger Bewegung und es wirken darauf mehrfache Kräfte. Die Kenntnis der Prinzipien, welche die Bewegung der Körper in der Luft generieren ist im Enturfsprozess besonders wichtig und es wird somit ein korrektes Bild der Schwebebewegung der Gleitschirme geschafft. Die angewendeten Materialien und die Montagetypen beeinflussen die Art und Weise in der die Gleitschirme der komplexen Belastungen antworten, bei denen sie während der Funktionierung ausgestezt sind. Wenn man vom klassischen Montagemodell der verschiedenen Zonen herausgeht, werden Optimierungsmodelle der Bindungseigenschaften, generiert – Nahtdichte, Nahtfadenfeinheit und Nadelfeinheit, in Übereinstimmung mit denen der angewendeten Materialien – Reiss- und Dehnungswiderstand, Luftpermeabilität.

Schlüsselwörter: Gleitschirm, Prozess, Parameter, Montage, Optimierung

The paraglide (ascensional parachute) is a flying device with a non-rigid main structure, that needs for take-off and landing only the physic effort of the pilot. Initially, paraglide was created for free-time activities and competitions, but now it is used in military and humanitarian purposes like research, seeking, observation on pre-established, hard to access areas for crossing the mined fields without exposure or any radar detection [1].

From ground take-off to the landing the paraglide is in a continuous movement and a multitude of forces are acting over the canopy. The paraglide profile (fig. 1) is maintained in flight by the pressure created inside the cells because of the air speed that enters and stays inside, forming an air cushion with a pressure higher than that of the air fillets on the top and bottom (because of the air flow, the static pressure diminishes and the surface is blowing up) [2].

The knowledge of the principles that generates the movement of bodies in air is very important for the design process, because an accurate image on the paraglide soaring movement can be created. Also, the materials and seam type selection affects the way that paraglides can respond to the complex tensions during the flight. The development of flying device with high

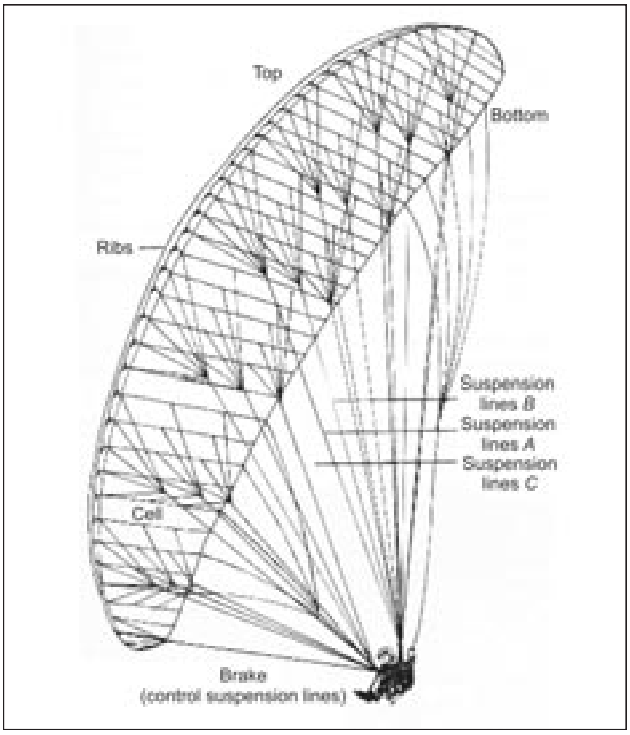
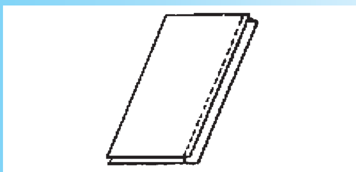
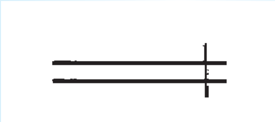
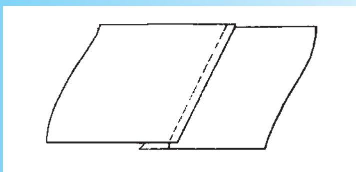
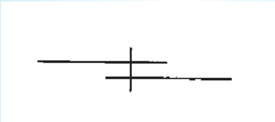
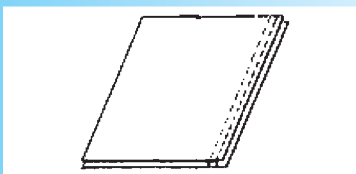
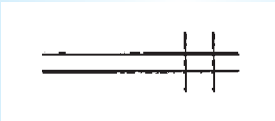


Fig. 1. Paraglide structural elements
Source: Whittall, Noel. *Paragliding. The complete guide.* The Lyons Press, New York, 1995, p. 10

Table 1

VARIANTS STUDIED					
Code	Seam graphic representation		Seam graphic representation		
	Flat		Needle size	Thread size	Stitch setting
B_1		 301-SSa-1 1.01.01	Nac 80	*Nm* 30/3	2.5 stitches/cm
			Nac 90	*Nm* 40/3	3 stitches/cm
			Nac 100	*Nm* 60/3	4 stitches/cm
B_2		 301-LSa-1 2.01.02	Nac 80	*Nm* 30/3	2.5 stitches/cm
			Nac 90	*Nm* 40/3	3 stitches
			Nac 100	*Nm* 60/3	4 stitches/cm
B_3		 301-SSa-2 1.01.02	Nac 80	*Nm* 30/3	2.5 stitches/cm
			Nac 90	*Nm* 40/3	3 stitches/cm
			Nac 100	*Nm* 60/3	4 stitches/cm

performances regarding physical-mechanical, aerodynamic and geometric characteristics is one of the important European research applications [3].

The connection between the stitch type (stitch step, seam size, stitch setting etc.), the sewing thread type (size, fiber composition, structural characteristics etc.) and the sewing needle type can considerable improve the parachute's flying performances: suspended useful weight, glide ratio, descending speed etc. [4].

The seams used in the paraglide manufacturing process must have similar properties, like elasticity, breaking strength and elongation, air permeability with the materials used for the flying device with textile components, in order to withstand the forces encountered in the use period [5].

Table 2

PHYSICAL-MECHANICAL PROPERTIES OF THE TESTED MATERIALS		
Article	Property	Value
W 9001 fabric	Composition	PA 6.6 100%
	Mass, g/m^2	43
	Breaking strength, daN U B	 40 42
	Breaking elongation, % U B	 28 37
	Tearing strength, daN U B	 5.8 7.2
	Air permeability, l/m^{2}s	0
	Weave type	Rip stop
	Finishing treatment	PU on one side
Coats Gral 30 TKT	Thread size, *Nm*	30/3
	Composition	PES 100%
	Twist	–
	Breaking strength, daN	5.3
	Breaking elongation, %	17–20
Coats Gral 40 TKT	Thread size, *Nm*	40/3
	Composition	PES 100%
	Twist	–
	Breaking strength, daN	4.4
	Breaking elongation, %	17–20
Coats Gral 60 TKT	Thread size, *Nm*	60/3
	Composition	PES 100%
	Twist	–
	Breaking strength, daN	3
	Breaking elongation, %	16–19

EXPERIMENTAL PART

Experimental research was focused on the behavior of the assembled materials using the 301 stitch and different types of seam specific to paraglide manufacture process, with the specification that we used the W9001 fabric, changing the sewing thread size, the sewing needle size and the stitch setting (table 1).

The directions of the seam lines are according to those of the panels and ribs connection in the final product; in this case the seams were cross to the wrap direction.

In the table 2 we will see the technical characteristics of the materials used for paraglide assembly samples.

The samples obtained were tested for breaking strength and elongation and air permeability and the results were compared to those of the materials used for the flying device with textile components.

RESULTS AND CONCLUSIONS

The experimental research led to a large data base that was statistically operated and mathematically modeled. For every characteristic we obtained a great number of results so we developed a data base necessary for the data processing. By using the MathCAD soft we generated the graphics that present the data in a visual format. By using the Cspline and Interp functions we obtained the interpolation of a 2D surface (figures 2–7). Then we generated the 3D graphics were we could observe the breaking strength and air permeability

Table 3

PRELIMINARY DATA FILTERING AND SORTING FOR THE SEAM B_3: 301-SSA-2/1.01.02						
Nac	*Nm*	Setting	Breaking strength, daN	Breaking elongation, %	Air permeability, l/m^{2}s	Efficiency factor, %
80	40/3	3 stitches/cm	25.4	18.5	6	64
100	30/3	4 stitches/cm	24.9	20.7	5.2	62
80	30/3	2.5 stitches/cm	24.3	20.9	1.8	61
100	40/3	4 stitches/cm	24.3	21.3	3.9	61
100	40/3	3 stitches/cm	24	21.9	2.8	60
80	60/3	4 stitches/cm	23.4	20.8	1.6	59
90	40/3	3 stitches/cm	23/4	20.1	8.6	59
80	30/3	4 stitches/cm	22.9	19.9	1.6	57
90	30/3	4 stitches/cm	22.9	21.2	7.5	57
100	30/3	2.5 stitches/cm	22.8	19.8	4.3	57

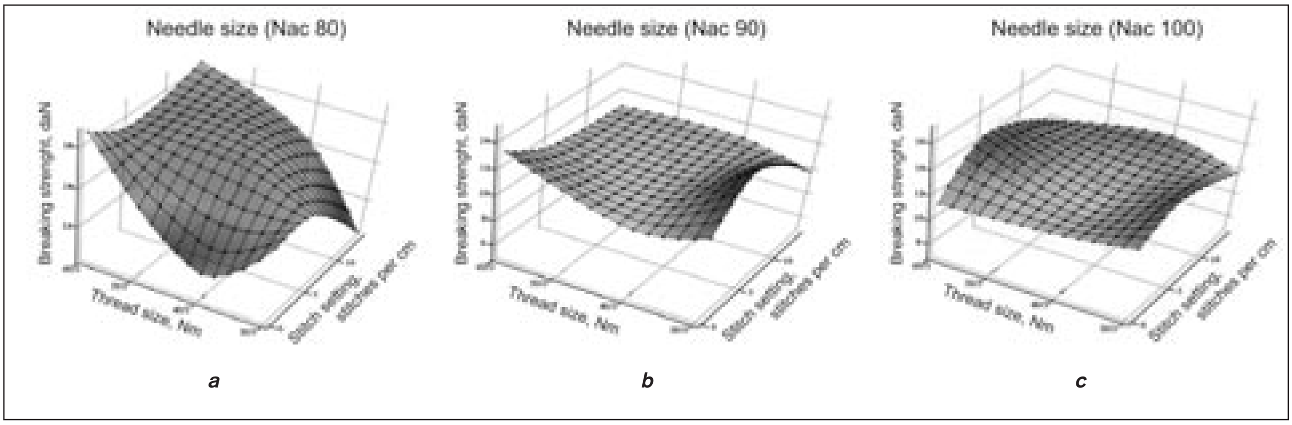


Fig. 2. 3D representation for the breaking strength variation for the seam B_1: 301-SSa-1/1.01.01

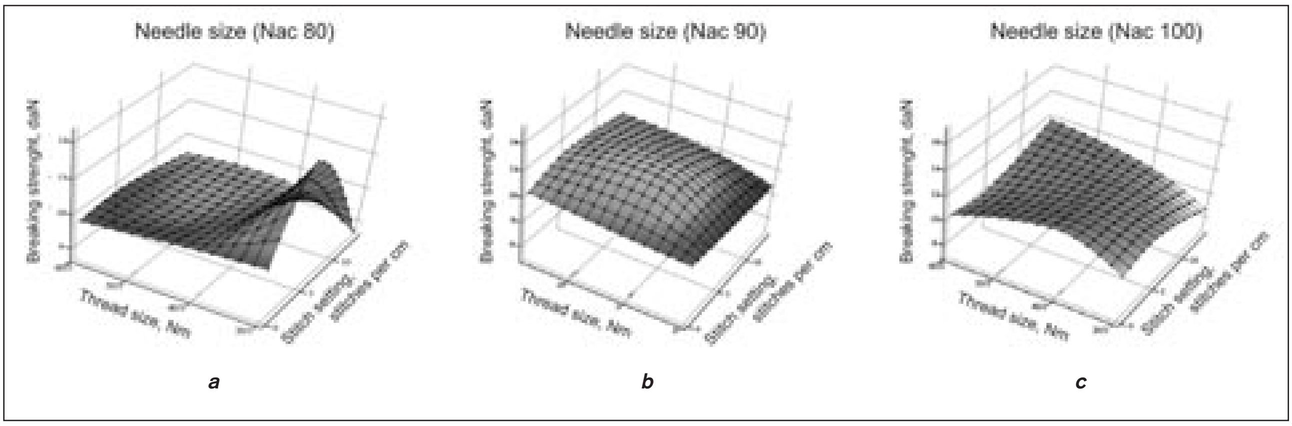


Fig. 3. 3D representation for the breaking strength variation for the seam B_2: 301-LSa-1/2.01.02

variation depending on the stitch setting, thread size and needle size.

The optimization model has three inputs and one output – the optimal values of the decisional variables and of the objective [6]. Therefore, using the classic way to assemble the different parachute elements, optimization models of seam characteristics will be generated according to the characteristics of the materials. In order to assign a relation between the breaking strength of the fabric and of that of the seam we calculated the seam efficiency factor as a ratio between breaking strength of the seam and the breaking strength of the assembled fabric [7].

The objective of the optimization model between the physical-mechanical and functional characteristics of the seam lines and of the parachute materials is the seam breaking strength maximization so that it should be equal to that of the material it joints (the breaking strength 40 daN). The decisional variables are the seam type selected in the study and the restrictions are given by the physical-mechanical characteristics of the W9001 fabric:

- breaking elongation 28%;
- air permeability (the fabric is airproof) 0 l/m^{2}s.

In order to generate these optimization models we sorted and filtered the data base, meaningue to extract

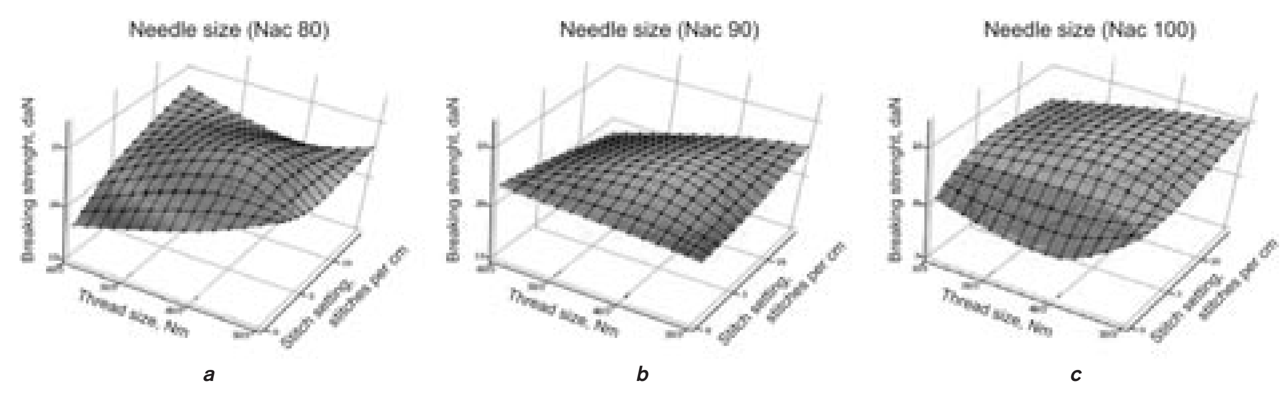


Fig. 4. 3D representation for the breaking strength variation for the seam B_3: 301-SSa-2/1.01.02

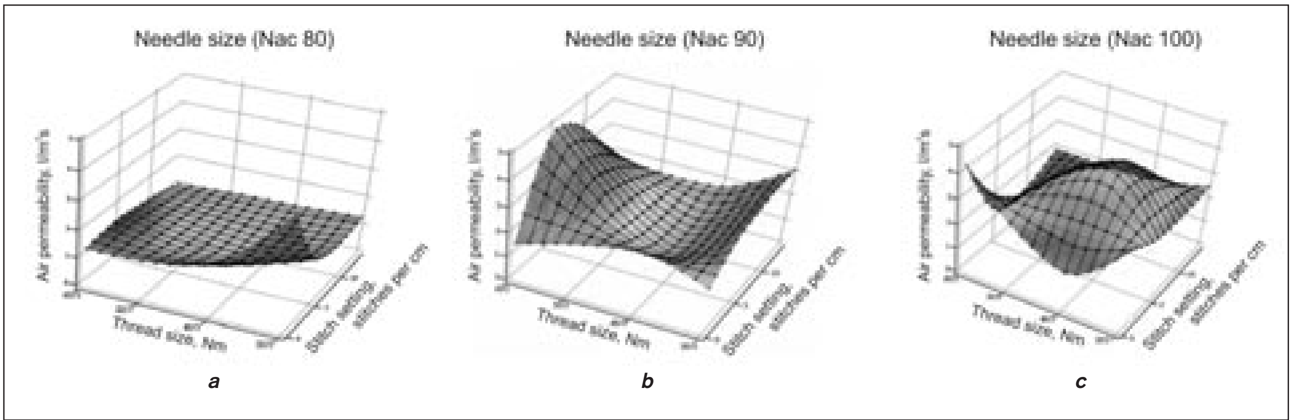


Fig. 5. 3D representation for the air permeability variation for the seam B_1: 301-SSa-1/1.01.01

from the table the results that proved the optimization restrictions, obtaining the optimal assembling solution.

By analyzing figure 2 we observed that for the needle size Nac 80 the breaking strength of the seam B_1: 301-SSa-1/1.01.01, had increased with the sewing thread size increase; for the thread size *Nm* 60/3 and the stitch setting between 2,5–4 stitches/cm, the breaking strength had the highest values. We also observed that the breaking strength had decreased with the needle size increase from Nac 80 to 90 or Nac 100, the highest values had been in the range 10–15 daN.

In the figure 5 we observed that generally the values of the air permeability had fulfilled the conditions assessed by the optimization model. By analyzing figure 5 the result was that the needle size Nac 90 was excluded for manufacture, using the seam B_1: 301-SSa-1/1.01.01, because for the highest values of the breaking strength we obtained air permeability values higher than 2,5 l/m^{2}s. Also, the needle size Nac 100 can be used only with very much restriction: thread size 60/3 and 3 stitches/cm setting.

In conclusion, the optimal solution for the seam B_1: 301-SSa-1/1.01.01 is given by the utilization of the needle size Nac 80, the sewing thread size *Nm* 60/3 and the stitch setting between 2.5–4 stitches/cm with 42% seam efficiency factor.

By analyzing figure 3 we observed that for the seam B_2: 301-LSa-1/2.01.02 we had obtained lower values than in the case of the seam B_1: 301-SSa-1/1.01.01. In figure 3 *a* we observed that for the needle size Nac 80 the breaking strength had decreased with the sewing thread size increase, because it had been affected by the thread breaking strength. In figure 3 *b* we observed that the breaking strength had had the highest values for the thread size *Nm* 40/3 and 3 stitches/cm setting. For the needle size Nac 100, the breaking strength had the highest values for the thread size *Nm* 40/3 and 0/3 and the stitch setting between 2.5–4 stitches/cm (fig. 3 *c*).

By analyzing figure 3 we observed that the air permeability had increased with the sewing thread size increase form *Nm* 30/3 to 60/3, proving the optimization restriction. Also, we can see that for the needle size Nac 80 and 90, for highest values of the breaking strength the air permeability is proving the optimization restriction. Therefore, we can say that between the values of the breaking strength and of the air permeability there is a reverse proportionality.

In conclusion, the optimal solution for the seam B_2: 301-LSa-1/2.01.02 is given by the utilization of the needle size Nac 80, the sewing thread size *Nm* 30/3 and the 3 stitches/cm with 31% seam efficiency factor.

By analyzing figure 4 we can point that for the seam B_3: 301-SSa-2/1.01.02 we obtained higher values than in the case of the seams B_1: 301-SSa-1/1.01.01 and B_2: 301-LSc-2/2.04.03. This fact is justified by the realization of two stitches that increases the breaking

Table 4

FINAL DATA FILTERING AND SORTING FOR THE SEAM B_3: 301-SSA-2/1.01.02						
Nac	*Nm*	Setting	Breaking strength, daN	Breaking elongation, %	Air permeability, l/m^{2}s	Efficiency factor, %
80	30/3	2.5 stitches/cm	24.3	20.9	1.8	61
80	60/3	4 stitches/cm	23.4	20.8	1.6	59
80	30/3	4 stitches/cm	22.9	19.9	1.6	57

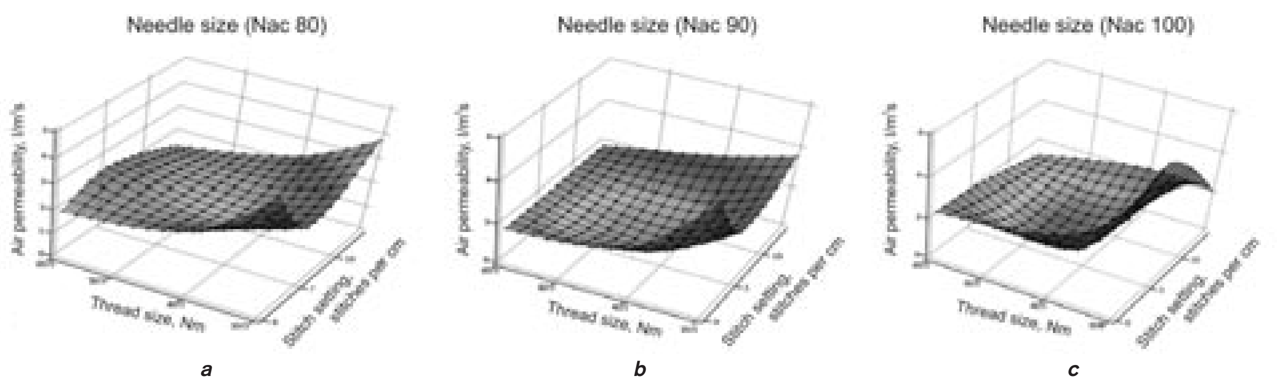


Fig. 6. 3D representation for the air permeability variation for the seam B_2: 301-LSa-1/2.01.02

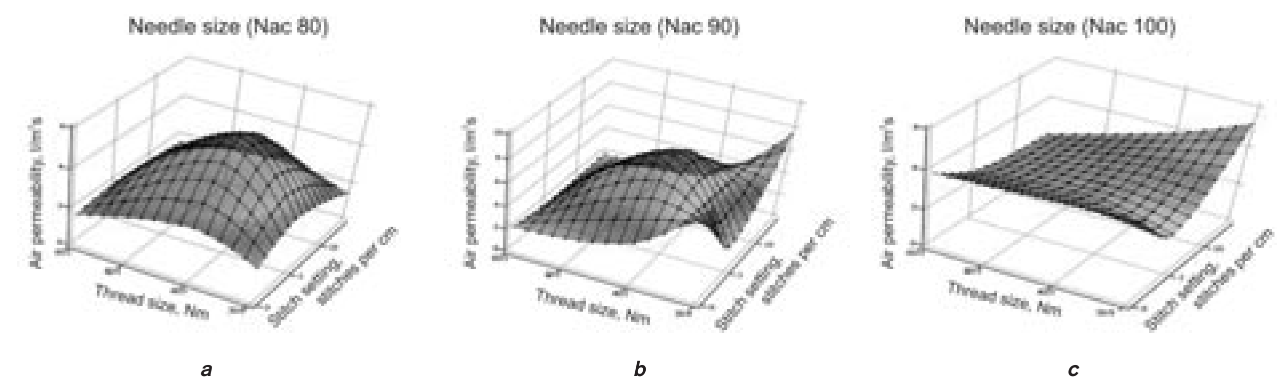


Fig. 7. 3D representation for the air permeability variation for the seam B_3: 301-SSa-2/1.01.02

strength and elongation close to the values of the fabric. From table 3 we can observe that breaking elongation has the highest values simultaneously with the breaking strength. A disadvantage of the two stitches realization is that the values of the air permeability are out of the optimization restriction (fig. 7).

The breaking strength is not influenced by the needle size but is influenced by the thread size and stitch setting, so for *Nm* 30/3 and 40/3 and 3 stitches/cm we have highest values (fig. 4), because of the thread breaking strength influence.

By analyzing figure 4 *a* we can point that the strength domain is beeween 20–25 daN, that is 50% from the fabric strength. In figure 4 *b, c* we observed that the breaking strength poorly influenced by the thread size and stitch setting modification.

The table 4 data lead to the conclusion that the needle sizes Nac 90 and 100 are excluded for manufacture because generally the air permeability is outside of the limits assessed by the optimization restrictions. Therefore, the air permeability is not outside the optimization limits for the needle size Nac 80, the sewing thread size *Nm* 30/3 and the 2,5 stitches/cm and 4 stitches/cm.

Therefore, the optimal solution for the seam B_3: 301-SSa-2/1.01.02 is given by the utilization of the needle size Nac 80, the sewing thread size *Nm* 30/3 and the 2.5 stitches/cm with 61% seam efficiency factor. High value of the seam efficiency factor were obtained by using the sewing thread size *Nm* 60/3 and the 4 stitches/cm setting or the sewing thread size *Nm* 30/3 and the 4 stitches/cm setting.

CONCLUSIONS

After research experiments, these conclusions were reached:

- The flying devices with textile components are the results of evolution, design, testing and over-testing. The optimization of seam characteristics was developed according to the fabric properties also in the assembled area, proprieties that are guaranteed by the fabric producers through technical specification and internal norms.

- The breaking strength is influenced by the sewing thread breaking strength and by the stitch setting.
- The wrong selection of needle and thread according to the fabric can lead to seams that can't respond to the stress during the manufacture process and the utilization period of the flying devices with textile components.
- The mathematic models that led to the assembling process optimization can be adapted to other research variants.

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INDUSTRIA TEXTILĂ ÎN LUME

Dy STAR A LANSAT PRODUCŢIA DE AMIDURĂ DE SODIU

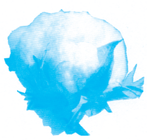
La sfârşitul lunii aprilie 2010, ***DyStar*** a produs primul lot de fulgi de amidură de sodiu, la fabrica din Ludwigshafen. „*Calitatea produsului întruneşte cele mai înalte standarde*“, remarca Andreas-Johann Schmidt – şef al *DyStar Ludwigshafen*.

Amidura de sodiu este un intermediar în sinteza indigoului, care, timp de mai bine de o sută de ani, a fost fabricat la Ludwigshafen.

DyStar a achiziţionat, cu un an în urmă, tehnologiile de formare a amidurii de sodiu, de la *Grupul French Rhodia*. Astfel, a devenit posibilă comercializarea acestui reactiv intermediar, în prezent DyStar putându-şi dezvolta clientela şi în afara industriei textile.

„*Pe lângă deţinerea tehnologiei de top în domeniul producerii de indigo, o parte importantă a producţiei fabricii din Ludwigshafen o va constitui amidura de sodiu, ceea ce-i va spori succesul în viitor şi va ajuta compania DyStar să devină mai independentă faţă de ciclurile comerciale ale industriei textile*“ – afirma Steve Barron, director executiv al *DyStar CEO*.

Informaţii de presă. DyStar, iulie 2010



Effect of warp tension in weaving process on colour obtained in reactive dyeing and fabric shrinkage of cotton

PELIN ÜNAL RIZA ATAV

REZUMAT – ABSTRACT – INHALTSANGABE

Efectul tensionării urzelii în procesul de ţesere asupra culorii obţinute în cazul vopsirii cu coloranţi reactivi şi a contracţiei materialelor din bumbac

Pentru a obţine culoarea dorită, în vopsitorii, se folosesc reţetele de vopsire deja existente. Însă, pentru optimizarea acestor reţete, este necesară cunoaşterea variaţiilor parametrilor structurali şi de producţie ai materialului textil ce urmează a fi vopsit, faţă de materialul de referinţă. În cazul folosirii coloranţilor reactivi, în cadrul studiului s-a analizat modul în care tensionarea urzelii în procesul de ţesere influenţează culoarea. De asemenea, a fost analizată relaţia dintre contracţia materialului şi tensionarea urzelii în procesul de ţesere. Potrivit rezultatelor experimentale, se poate concluziona că tensionarea urzelii în timpul ţeserii nu are un efect semnificativ asupra culorii obţinute prin vopsirea cu coloranţi reactivi, datorită aplicării procesului umed, care determină relaxarea materialului textil. Contracţia materialului pe direcţia urzelii se măreşte odată cu creşterea tensionării, numai în cazul aplicării unui proces umed.

Cuvinte-cheie: tensionarea urzelii, contracţie, culoare, colorant reactiv, vopsire

Effect of warp tension in weaving process on colour obtained in reactive dyeing and fabric shrinkage of cotton

In dyehouses, dye recipes related to the desired colour which exist previously are used for colour matching. It is required to know the variations in structural and production parameters of the fabric to be dyed, compared to the reference fabric. In this study, it was determined how the warp tension during weaving affects colour in reactive dyeing. Fabric shrinkages were also tested and correlated with warp tensions during fabric production. According to the experimental results it can be concluded that the warp tension during weaving does not have a significant effect on colour obtained in reactive dyeing due to the wet processes that cause fabric relaxation. Fabric shrinkages in warp direction increases with the increase in warp tensions, only if performed after a previous wet process.

Key-words: warp tension, shrinkage, colour, reactive dye, dyeing

Einwirkung der Kettenspannung im Webprozess auf der Farbe erhalten beim Reaktivfärben und die Kontraktion der Baumwollmaterialien

Um die gewünschte Farbe zu erhalten, werden in Färbereien schon existierende Farbrezepte angewendet. Für die Optimierung dieser Rezepte ist die Kenntnis der Parameterschwankung der Produktstrukturen des zu färbenden Textilmateials im Vergleich zum Mustermaterial notwendig. Im Rahmen der Untersuchung wurde die Einwirkung der Kettenspannung im Webprozess auf der Farbe beim Reaktivfärben bestimmt. Die Materialkontraktion wurde gleichsfalls getestet und mit der Kettenspannung im Webprozess korreliert. Gemäss den Untersuchungsergebnissen kann man schlussfolgern, dass die Kettenspannung während des Webprozesses keine wesentliche Einwirkung auf die erhaltene Farbe beim Reaktivfärben hat, dank der Anwendung des Nassprozesses, welches eine Relaxierung des Textilmaterials bewikt. Die Materialkontraktion in Kettenrichtung wächst gleichzeitig mit der Kettenspannung, nur nach der Durchführung des ersten Nassprozesses.

Schlüsselwörter: Kettenspannung, Kontraktion, Farbe, Reaktivfarbstoffe, Färbung

As generally known, reactive dyes are the most important dye class used for dyeing and printing of cellulosic fibers and its blends [1]. This dye class has an important usage ratio of 62% in cellulosic dyeing [2]. Although there is not certain data related to the usage of reactive dyes in Turkey, it is estimated that their usage ratio is approximately 70% which is higher than world average [3]. The property which makes reactive dyes different than other dye classes, is their reactive groups which have the ability to form covalent bonds with cellulose macromolecules [4].

In order to obtain and also raise the market share in intensive competition conditions, it is required to obtain desired color from the first time [5]. This is in close relationship with standard material, standard dyeing procedure and standard conditions. Deviation in any of these parameters affects reproducibility negatively [3]. In dyehouses, if there is an order, dye recipes related to the desired color which exist previously are used, or a recipe which is most similar to the desired color is taken and some adjustment is done, according to the experience of the colorist. The main problem in dyehouses is the differences between the structural parameters of the reference fabric of which dyeing recipe is known and the fabric to be dyed [6].

It is required to know the variations in structural and production parameters of the fabric to be dyed compared to reference fabric and make desired adjustments in recipes. These parameters are:

- fabric pattern – plain, twill, sateen;
- fabric construction parameters, such as weft and warp densities;
- fabric production parameters, such as batch difference, warp tension etc.

In this case, the effect of these parameters variations on the color which will be obtained during dyeing should be known, because fabric structure differences would lead to different liquor flow interactions through fabrics. In this case, for example if the dyeing recipe of a loose fabric is applied to a dense fabric, the final colour would be different. It is important to recognise the effects of the fabric structure on the colour effects. In this way, correction of the dyeing recipes on the basis of experience and colour measurement results would enhance right-first-time dyeing [6].

In practice dyeing conditions are rarely constant and this leads to 5–10% inaccurate dyeing of total production [7].

In literature it is stated that, if the cost of right-first-time dyeing is taken as 100, the cost of the production increases by adjustment of the nuance and re-dyeing without stripping 30% and 75% respectively [8]. Faults

Table 1

PROPERTIES OF FABRICS USED IN EXPERIMENTS		
Sample no	Weft density, picks/cm	Warp tension, kN
1	25	0.8
2	25	1
3	25	1.2
4	25	1.4

Table 2

PROPERTIES OF DYES USED IN EXPERIMENTS	
Dye	Remazol Bril. Orange FR
Structure	Monofunctional
Reactive group	Vinyl Sulphone
Reactivity	Medium
Substantivity	High

in dyeing processes generally occur due to the variations in fabric construction, quality and mass; deviations in the liquor ratio, temperature and dyeing *p*H [9]. When dyeing performance of a company which makes dyeing according to the exhaust method and the limitation value of dyeing for ΔE is 1.2 is investigated, it can be seen that 0.3 unit of ΔE comes from dyestuff, but more importantly 0.9 unit of ΔE is based on the differences in the material to be dyed and dyeing conditions [10].

Although the parameters mentioned above would have effect on color, they also may have some effects on fabric shrinkage properties, as commonly known fabrics shrink more or less during wet treatments (such as washing etc.). There are two main reasons for this phenomenon:

- Warp and weft yarns are not completely straight in a fabric due to the interlacing points based on the fabric pattern. In aqueous mediums water molecules enter the amorphous regions of fibers and swell the cross section of fibers and hence yarn. This situation causes the fabric to shrink.
- Fabrics are under tension during weaving and knitting processes. This situation causes inner stress in fibers, yarns and fabrics. During wet treatments fabrics shrink, because the fibers tend to move in direction where they can be relieved of their stress, as a result [11].
- This study aimed to determine how the warp tension during weaving affects colour in reactive dyeing. Fabric shrinkages were also tested and correlated with warp tensions during fabric production.

EXPERIMENTAL PART

Materials used

Plain woven 100% cotton fabrics produced under different warp tensions were used for the purpose of determining the effects of some weaving parameters on fabric dyeability and shrinkage. Table 1 represents the characteristics of the fabrics used. Before dyeing process, all the fabrics were desized and bleached in the same bath under the same conditions in order to obtain white fabrics ready for dyeing.

Dye selection

In order to determine how the warp tension during weaving affects colour in reactive dyeing, Remazol Brilliant Orange FR (C.I. Reactive Orange 82) was used in the experiments. Table 2 represents the properties of the dye used in experiments.

Dyeing procedure

Reactive dyeing was performed with a laboratory scale HT Thermal dyeing machine with a liquor ratio of 1:15. The method used had a temperature rise of 30–60°C. The dyeing process was started with the liquor which contains alkali, salt and dyestuff at 30°C and, after 10 minutes temperature was raised to 60°C with 1°C/minutes temperature rise ratio and then samples were treated for 60 minutes. Dyeing recipes: 2% dye, 50 g/l Na_2SO_4, 13 g/l Soda ash.

After dyeing, samples were rinsed and neutralized 10 minutes at 60°C with 0.5 g/l acetic acid and then rinsed at 80°C for 10 minutes, 95°C for 10 minutes (two times), 80°C for 10 minutes and, respectively, 5 minutes with cold water. All the experiments were carried out by using soft mill water.

Colour measurements

Reflection (*R*, %) and CIELab values of the samples were measured by Minolta 3600d spectral photometer with 10° normal observer and norm light D65.

Colour yields of the dyed samples were calculated by Kubelka Munk equation [12]:

$$K / S = (1 - R)^2 / 2R \quad (3)$$

where:

R is the reflectance at maximum absorption wavelength, nm;

K – the absorption coefficient;

S – the scattering coefficient.

Colour difference was expressed as ΔE using following equation [12]:

$$\Delta E = \left[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2 \right]^{1/2} \quad (4)$$

where:

ΔE is the magnitude of the difference in color;

ΔE^* – the difference between lightness (L^* = 100) and darkness (S^* = 0);

Δa^* – the difference between green ($-a^*$) and red ($+a^*$);

Δb^* – the difference between yellow ($+b^*$) and blue ($-b^*$).

Shrinkage test

Fabric shrinkage tests in warp direction were carried out according to the ISO 6330 standard (washing at 60°C for 70 minutes and drying in drum dryer).

RESULTS AND DISCUSSIONS

Effects of warp tension variation on colour

Table 3 represents L^*, a^*, b^* values and ΔL^*, Δa^*, Δb^* and ΔE values (calculated with reference to the sample woven under warp tension 0.8 kN) of the reactive dyed fabrics considering warp tension variation.

Δa^* and Δb^* values calculated with reference to the sample woven under warp tension of 0.8 kN show that

Table 3

EFFECTS ON WARP TENSION VARIATION ON THE CIELAB VALUES OF REACTIVE DYED FABRICS							
Warp tension, kN	L^*	a^*	b^*	ΔL^*	Δa^*	Δb^*	ΔE
0.8	55.64	55.12	43.44	Std.	Std.	Std.	Std.
1	55.81	54.93	43.41	–0.17	0.19	0.03	0.26
1.2	55.64	55.18	43.25	0	–0.06	0.19	0.20
1.4	55.56	54.84	42.94	0.08	0.28	0.5	0.58

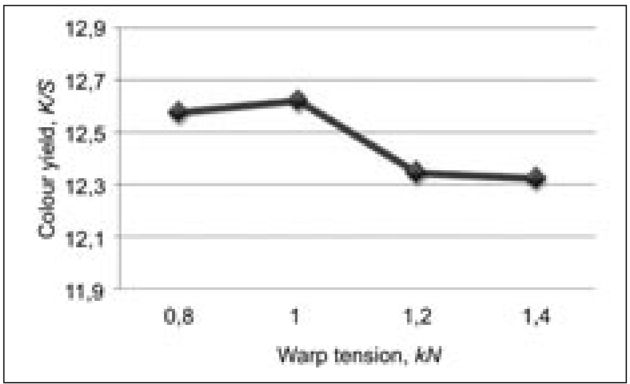


Fig. 1. Effects of warp tension variation on colour yield, *K/S*

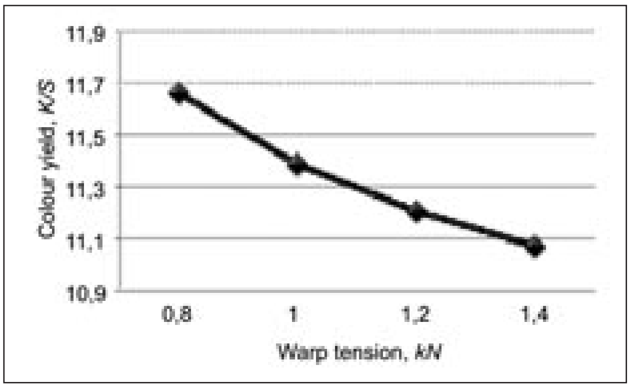


Fig. 2. Effects of warp tension variation on colour yield, *K/S*, of un-pretreated fabrics

increase in warp tension does not have a significant effect on the colour shade of the reactive dyed fabrics. Furthermore, by the increase of warp tension, there is also no significant change in the L^* values of the samples. As a result, the total colour difference values were low. If acceptable maximum ΔE value is considered as 1, change in warp tension does not affect the colour obtained during dyeing.

Color yield results of dyed samples are given in figure 1. When figure 1 is examined, it can be understood that warp tension variation also does not affect the colour yield. The reason is thought to be the maximum relaxation of the fabrics during desizing and bleaching treatments carried out before dyeing, which were produced under different warp tensions. In this way, inner stress differences due to the various warp tensions during weaving are eliminated. In order to prove this claim, samples were also dyed without making pretreatments (desizing and bleaching). In other words, dyeing was the first wet treatment performed for woven fabrics.

Colour yield (*K/S*) values of dyed samples are given in figure 2. As can be seen from figure 2, colour yield of dyed samples decreases with the increase of warp tension during weaving. The reason is thought to be the fabric shrinkage. When fabric shrinks, fabric structure becomes tighter which causes an increase in the values of weft density. For this reason dye-uptake decreases and hence colour yield values reduce. Table 4 represents the results of variance analysis for the effect of warp tension on *K/S* values. The effect of warp tension on the difference between the mean values of *K/S* is statistically significant.

Table 5 represents L^*, a^*, b^* values and ΔL^*, Δa^*, Δb^* and ΔE values (calculated with reference to the sample woven under warp tension 0.8 kN) of the un-pretreated reactive dyed fabrics considering warp tension variation.

Table 4

ANALYSIS OF VARIANCE FOR THE EFFECT OF WARP TENSION ON *K/S* VALUES					
Source	*DF*	Adj. *SS*	Adj. *MS*	*F*	*P*
Warp tension	3	0.59 722	0.19 907	14.87	0.001*
Error	8	0.10 707	0.01 338		
Total	11				

R^2 (adj.) = 0.79
* means significant according to a = 0.05

Table 5

EFFECTS ON WARP TENSION VARIATION ON THE CIELAB VALUES OF UN-PRETREATED REACTIVE DYED FABRICS							
Warp tension, kN	L^*	a^*	b^*	ΔL^*	Δa^*	Δb^*	ΔE
0.8	54.87	52.27	42.77	Std.	Std.	Std.	Std.
1	54.98	51.92	42.83	–0.11	0.35	–0.06	0.37
1.2	55.18	51.86	42.97	–0.31	0.41	–0.21	0.55
1.4	55.30	51.53	43.61	–0.43	0.74	–0.84	1.20

Table 6

ANALYSIS OF VARIANCE FOR THE EFFECT OF WARP TENSION ON FABRIC SHRINKAGE IN WARP DIRECTION					
Source	***DF***	**Adj. *SS***	**Adj. *MS***	***F***	***P***
Warp tension	3	5.3 958	1.7 986	17.27	0.001*
Error	8	0.8 333	0.1 042		
Total	11				

R^2 (adj.) = 0.82
* means significant according to *a* = 0.05

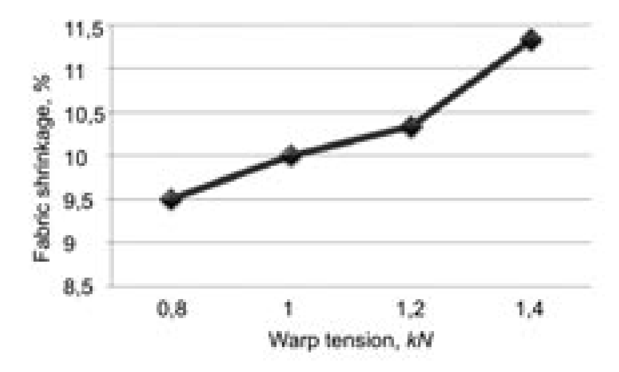


Fig. 3. Effects of warp tension variation on fabric shrinkage in warp direction

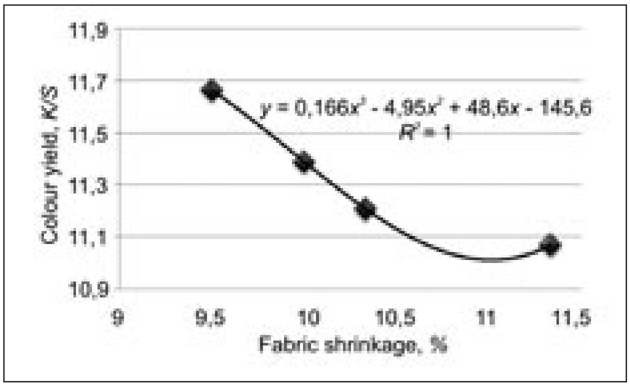


Fig. 4. Relationship between fabric shrinkage and colour yield

From table 5, it can be concluded that although increase in warp tension changes colour, the differences are acceptable for warp tensions 1 and 1.2 kN, but when warp tension is increased from 0.8 to 1.4, colour changes are not in the acceptable range.

Effects of warp tension variation on fabric shrinkage

Effects of warp tension variation on fabric shrinkage in the warp direction can be seen from figure 3. As it can be noticed, fabric shrinkage increases with the increase of warp tension during dyeing. If warp tension during weaving increases, inner stress in fibers, yarns and fabrics also increases, as a result, and as mentioned above, during wet treatments fabrics shrink [11]. Table 6 shows the results of variance analysis for the effect of warp tension on fabric shrinkage values in warp direction. The effect of warp tension on the difference between the mean values of fabric shrinkage in warp direction is statistically significant.

Either the fabric shrinkage increases or the colour yield values decrease with the increase of warp tension in the first wet process, the relation between the fabric shrinkage and colour yield results were investigated. Figure 4 shows the relation between these two parameters. There is a high correlation between the fabric shrinkage in the warp direction and colour yield results (regression coefficient is 1).

CONCLUSIONS

In dyehouses, dye recipes related to the desired colour which existed previously, are used for colour matching. The differences between the structural parameters of the reference fabric for which dyeing recipe is known and the fabric to be dyed, causes problems during colour matching. It is required to know the variations in structural and production parameters (construction, weft and warp density, warp tension etc.) of the fabric to be dyed compared to the reference fabric and make desired adjustments in the recipes. These parameters can also affect fabric shrinkage.

In this study, it was determined how the warp tension during weaving affects colour in reactive dyeing. Fabric shrinkages were also tested and correlated with warp tensions during fabric production. According to the experimental results it can be concluded that warp tension has a significant effect on the colour yield values of the fabrics if and only if the dyeing process is performed as a first wet treatment. If dyeing is performed after desizing and bleaching, as normally done, the effects of warp tension difference is not found to be significant. Furthermore, the un-pretreated fabric shrinkage increases and the colour yield values decrease with the increase of warp tension in the first wet process which means a high correlation between the results of fabric shrinkage and colour yield.

In view of these observations, it is obvious that production parameter such as warp tension of the woven fabric will not affect the color of dyeing performed after wet pre-treatments. However, it should be taken into consideration that high warp tensions in weaving process will increase fabric shrinkage during wet treatments.

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DOCUMENTARE

Materii prime

FIBRE DIN PET CU NANOADITIVI

Ultima descoperire a companiei japoneze ***Sumitomo Metal Mining*** o reprezintă o fibră care poate absorbi rapid căldura și o poate reține. Fibra este realizată din PET, în care sunt dispersate microparticule de compuși de cesiu, tungsten și oxigen.

Compusul cu absorbție de căldură este transparent, iar proprietățile conferite fibrei sunt păstrate corespunzător, chiar și în cazul expunerii materialului textil la condiții climatice nefavorabile.

Compania produce un fir multifilamentar, ce poate fi tăiat pentru realizarea de fibre scurte, care, la rândul lor, pot fi utilizate la producerea firelor filate. Din acestea, a fost creat chiar și un tricot.

Pentru realizarea fibrelor originale, compania folosește un amestec de microparticule din compuși cu toluen și un dispersant. Toluenul este apoi îndepărtat, înainte ca, în dispersia de microparticule, să fie încorporate granulele de rășină PET.

În urma extrudării acestei mixturi, se eliberează fasciculele formate din fulgi și granule de PET, rezultând un amestec preliminar care încorporează compusul. Pentru a crea firul multifilamentar, în această compoziție a fost adăugat un alt amestec de PET, în care, înainte de filarea din topitură, nu a fost încorporat niciun alt compus.

Compania a depus mai multe cereri de brevete pentru procesul de fabricație a acestor fibre, inclusiv Brevetul US 2008/0308775 și Brevetul European 1 847 635.

Smarttextiles and nanotechnology, iulie 2010, p. 11

Tricotaje

PROTEZE ARTERIALE TRICOTATE

Tricotarea din urzeală este tehnologia de bază, utilizată de compania ***Vascutek Terumo*** – din Marea Britanie, în producerea protezelor vasculare, folosite în tratamentul bolilor cardiovasculare.

Inițial, majoritatea protezelor erau realizate prin tricotate, deoarece erau mai ușor de manevrat.

În prezent, la arterele majore care pornesc de la inimă sunt folosite protezele țesute, deoarece sunt mai puțin permeabile și mai rezistente la dilatare.

Având în vedere faptul că, în chirurgia cardiovasculară, există cerințe variate, sunt utilizate atât proteze vasculare tricotate, cât și țesute, raportul acestora fiind, în prezent, de aproximativ 50:50. Pentru ambele tipuri, se folosește un fir texturat din 100% poliester, de 44 dtex x 27, caracterizat printr-o porozitate scăzută și o rezistență mare la rupere. Protezele cântăresc 30 g. Protezele vasculare tricotate se dilată într-o anumită măsură. Compania a dezvoltat o proteză tricotată, foarte subțire, cu o dilatare redusă, *VP1200plus* (fig. 1). Aceasta se aseamănă cu proteza țesută, fiind foarte rezistentă și având o dilatare foarte redusă. Structura

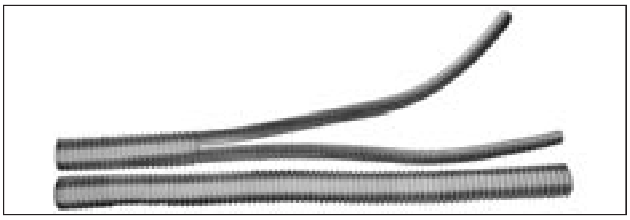

Fig. 1

tricotată este destul de complicată, ea fiind folosită atunci când chirurgii au nevoie de o proteză moale, cu o dilatare redusă.

Pentru sporirea productivității și reducerea numărului de ruperi, mașinile de țesut cu ace de la firma *Jakob Müller* au fost optimizate, fiind dezvoltată o tehnologie de producere a unui tub bifurcat. Se utilizează 64 sau 30 de ace și patru moduri de poziționare a lor. În același scop, acele se schimbă la fiecare 6–7 săptămâni.

Compania *Vascutek* este dotată cu mașini de tricotat din urzeală, cu două fonturi, de la firma *Karl Mayer.* Acestea au fost modificate, inclusiv în ceea ce privește adaptarea electronică. Acestea trebuie să funcționeze cu o toleranță de ± 2%. Procesul de fabricare se desfășoară într-un mediu curat, iar prelucrarea ulterioară, cum ar fi îndoirea tuburilor, se realizează în camere curate, unde personalul poartă măști, mănuși, articole pentru acoperirea capului, costume și papuci medicinali. Înainte de expediere, produsele sunt sterilizate.

Future Materials, iulie 2010, p. 26

Tehnologie chimică

TEHNOLOGII ANTIMICROBIENE DE TRATARE A TEXTILELOR MEDICALE

Tehnologiile antimicrobiene încorporate în materialele textile și în suprafețele dure reprezintă o strategie utilă pentru menținerea curățeniei în unitățile de îngrijire a sănătății. Indiferent dacă acestea se aplică în domeniul covoarelor, al tapițeriei, al măștilor de față, al așternuturilor pentru pat, al draperiilor, al uniformelor, ori pentru îngrijirea rănilor, ori picături pentru ochii bebelușilor etc., beneficiul este incontestabil.

Tehnologia antimicrobiană cu ioni de argint este preferată de către producătorii de textile destinate îngrijirii sănătății. Argintul este un agent antimicrobian extrem de eficient, întâlnit în stare naturală și lipsit de toxicitate. Materialele textile tratate cu ioni de argint își mențin efectul antimicrobian chiar și după un număr ridicat de spălări industriale.

Ionii de argint pot fi încorporați în fibre sau utilizați la finisare. O serie de finisaje ale materialelor textile, bazate pe ioni argint, au obținut certificările ecologice *Bluesign* și *Cradle-to-Cradle.* De exemplu, Fosshield de la ***Foss Manufacturing*** folosește tehnologia antimicrobiană brevetată *Agion*, de încorporare a ionilor de argint direct în fibră, în timpul procesului de prelucrare (fig. 1). Datorită eliberării controlate a ionilor de argint, aceste fibre sunt durabile și oferă protecție antimicrobiană pe toată durata de viață a produsului. În

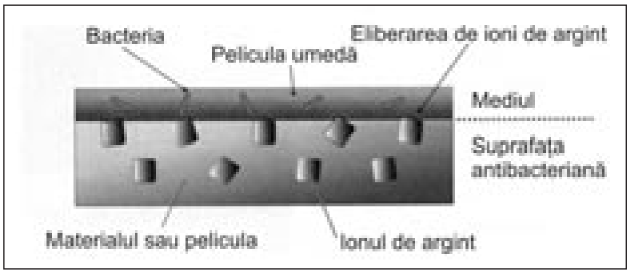

Fig. 1

prezent, tehnologiile cu *Agion Active* depășesc cu mult granița caracteristicilor antimicrobiene, la acestea adăugându-se și cele de eliminare a mirosurilor neplăcute, fapt ce contribuie la confortul personalului activ din domeniul îngrijirii sănătății, care lucrează în condiții de stres și interacționează zilnic cu pacienții.

Datorită caracteristicilor ecologice, combinate cu o excepțională durabilitate și rezistență naturală la atacul bacteriilor și al microorganismelor, fibrele *Foss* sunt utilizate la realizarea produselor cu protecție antimicrobiană, la acoperirea pardoselilor și tapițarea mobilierului din saloanele și sălile de așteptare ale unităților de îngrijire a sănătății.

Un domeniu-cheie continuă să fie cel al nețesutelor cu protecție antimicrobiană. De exemplu, compania ***Nexera*** a dezvoltat o mască pentru față, reutilizabilă, folosită în cazul pandemiilor. Noi tehnici de îngrijire avansată, în domenii precum îngrijirea rănilor, sunt în creștere, pe măsură ce spitalele renunță la folosirea textilelor tradiționale.

Alte domenii de aplicații sunt: articole de unică folosință sau articole utilizate exclusiv în medii sterile, uniforme, perii, îmbrăcăminte și încălțăminte medicinală, draperii separatoare din saloanele pacienților, așternuturi pentru pat, saltele etc.

Încorporarea protecției antimicrobiene în aceste produse oferă o soluționare funcțională a problemelor legate de curățenie, care se află în fruntea listei de priorități de pe piața medicală.

International Fiber Journal, iunie 2010, p. 32

LIANT BIOPOLIMERIC DE JOASĂ DENSITATE UTILIZAT ÎN IZOLAȚIA RIGIDĂ

Firma britanică ***Second Nature***, producătoare de articole din lână marca *Thermafleece,* a fost lansat pe piață un nou material, *Edenbloc35,* ce oferă o izolație rigidă naturală, de joasă densitate, pentru diferite structuri interne – pereți, căpriori și profile din lemn. Această tehnologie unică, brevetată, combină performanțele termice excelente cu permeabilitatea la vapori și respirabilitatea conferită de fibrele naturale. Prin utilizarea unui sistem de fixare pe bază de biopolimeri naturali, în locul componentelor sintetice, s-a obținut o reducere substanțială a impactului asupra mediului și o utilizare eficientă a energiei. Un alt avantaj al sistemului pe bază de lianți naturali îl constituie faptul că acesta poate fi reutilizat în condiții de siguranță.

Fibrele proteice din plăcile *Edenbloc35* absorb și rețin poluanții din aer, inclusiv formaldehidele, contribuind astfel la controlul nivelului de poluare a aerului din interior și la menținerea unui mediu sănătos. Totodată, aceste fibre sunt, în mod natural, mult mai rezistente la ardere, de aceea tratamentele de ignifugare necesită concentrații mai mici ale produselor folosite.

Plăcile *Edenbloc35,* produse la ***Cumbria***/Marea Britanie, nu contribuie doar la economii considerabile în ceea ce privește energia, ci și la reducerea emisiilor de CO_2, blocând o cantitate a acestora de aproape de două ori mai mare decât propria greutate și oferind un dublu beneficiu în cazul schimbărilor climatice.

Ele pot avea multiple aplicații, cum ar fi: sistemele de capitonare uscată, izolarea zidurilor, îmbunătățirea

structurilor existente, izolant între profilele distanțiere, în sau între căpriori, umplerea cadrelor din lemn etc.
În plus, datorită faptului că Edenbloc35 captează umezeala, performanțele termice nu sunt afectate semnificativ de fluctuațiile de umiditate și temperatură.
„*Este important ca firme precum Second Nature să contribuie la ridicarea standardelor privitoare la calitatea, inovația și performanța izolațiilor naturale... Cu Edenbloc35, dorim să îmbunătățim brandul Thermafleece și să facem ca materialele naturale pentru izolații să se bucure de o acceptare unanimă, iar performanțele și beneficiile lor durabile să dobândească o recunoaștere mai largă*" – afirma directorul comercial al companiei, domnul Mark Lynn.

Smarttextiles, aprilie 2010, p. 12

CRONICĂ

OPTIMISMUL PLUTEŞTE ÎN AER

Desfășurat în perioada 18–20 mai, în Atlanta/Georgia, ***Techtextil North America*** a emanat o atmosferă de încredere pe toată durata desfășurării, ce și-a găsit ecou în rândurile expozanților și a participanților. Dintre firmele participante la această manifestare, s-au remarcat:

- ***RadiciSpandex Corporation*** – sucursala din S.U.A. a Grupului italian Radici, care a prezentat cea mai nouă soluție personalizată de fibre spandex, într-o gamă variată de finețe, destinate scutecelor de unică folosință.
- ***American & Efird, Inc.*** – cu sediul în Mount Holly/ Carolina de Nord, care a prezentat o mare varietate de ață de cusut tehnică și pentru îmbrăcăminte, ori încălțăminte, cum ar fi: *Anefil Dry* – un tip de ață fără miez, destinată încălțămintei GoreTex, ambalajelor pentru componente electronice, genților/geamantanelor și corturilor; *ața de cusut SS-110* (fig. 1), din fire aramidice/oțel, de înaltă performanță, cu proprietăți de control static și FR, ideală pentru aplicații termice și compozite speciale; *fire tehnice consolidate cu aer*, netede ori torsionate, vopsite sau naturale, împreună cu o gamă largă de alte fire modificate, inclusiv aramidice, destinate industriei de materiale înguste; *Camel* – un fir gonflabil, cu caracteristici deosebite de absorbție a umidității, realizat din fibre de poliacrilat și destinat aplicațiilor tehnice.
- ***Saunders Thread Company*** – cu sediul în Gastonia/Carolina de Nord, care a expus o gamă completă de ață de cusut cu filament continuu, din nailon, poliester, polipropilenă, Vectran, Nomex și Kevlar, pentru aplicații speciale, precum și fire filate din Nomex, Kevlar și amestecuri, ața *Tenara* cu PTFE expandat, precum și alte tipuri de fire și de ață, antistatice și conductive. Saunders este producător exclusiv al aței paraaramidice *Spun Gold,* destinată coaserii tapițeriei și a așternuturilor ignifuge pentru pat.

Fig. 1

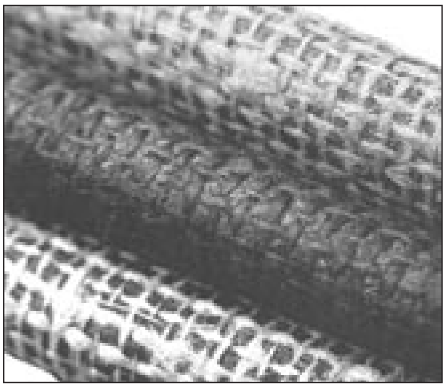

Fig. 2

- ***Glen Raven Technical Fabrics, LLC*** – lider mondial în domeniul materialelor de protecție termică de înaltă performanță, care a prezentat țesătura *GlenGuard FR* de 4.5–6.4oz., realizată dintr-un amestec de Kermel/modacril FR/fibre de carbon antistatice și destinată unor domenii de aplicații în care sunt posibile incendii instantanee și incendii de arc voltaic, și tricotul *GlenGuard Hi-Vis,* de 6.5oz, realizat dintr-un amestec de modacril FR/Kevlar.
- ***King Tech Industries*** – care a prezentat materiale reflectorizante imprimate, cum este KTTEX, ce întrunesc cerințele noului standard ANSI/ISEA 107-2010, imprimeul reflectorizant ocupând acel minimum specificat de 50% din zona reflectorizantă a umărului.
- ***SNS Nano Fiber Technology, LLC*** – care a expus materialele nețesutele nanostructurate *Nanosan,* alcătuite din particule superabsorbante, ce au fost adăugate nanofibrelor, pentru a crea o viitoare generație de produse absorbante de unică folosință, destinate îngrijirii rănilor, igienei personale, filtrării etc.
- ***Rentex Mills*** – care a prezentat o nouă structură de tricot din urzeală, realizată dintr-un amestec de 56% fibră Eco Circle și 44% poliester PBT și destinată unor domenii precum ciclismul, triatlonul, vâslitul și înotul.
- ***Vulcana, LLC*** – care a prezentat *rubbRe* – un material nețesut cu folie de cauciuc, prietenos mediului, produs din anvelope reciclate, într-o mare varietate de culori și grosimi, utilizat pentru tapițerie, tapet, mobilier de exterior, prelate, steaguri și bannere,

genți și geamantane, respectiv accesorii pentru birou și locuință, și *fuzun* – un material din *rubbRe* liat pe 100% pânză de sac din cânepă (fig. 2).

- ***Leigh Fibers*** – care a expus noul material *Safe Leigh FR*, realizat din fibre aramidice reciclate, generate din jachete de pompieri uzate. Noua fibră poate fi folosită în amestec cu alte fibre, pentru a întruni standardele ASTM ale unor aplicații speciale. Aplicațiile curente includ căptușeala pentru somiere și sectorul auto.

Future Materials, iulie 2010, p. 8

INDUSTRIA TEXTILĂ ÎN LUME

EVOLUŢIA CONSUMULUI DE FIBRE LA NIVEL MONDIAL ÎN ANII 2009–2010

Consumul de fibre, la nivel mondial, a crescut cu 4,2%, ajungând la 70,5 milioane de tone. Consumul de fibre artificiale a crescut cu 4,0%, ajungând la 44,1 milioane de tone, iar cel de fibre naturale cu 4,5%, ajungând la 26,4 milioane de tone. La o populație globală de 6,8 miliarde, consumul mediu pe cap de locuitor este de 10,4 kg.

Luând în considerare faptul că rata medie anuală de creștere pe termen lung este de 3,4%, diferența față de cererea din ultimii doi ani ajunge la 15 milioane de tone. Deoarece îmbrăcămintea cu prețuri mici a fost disponibilă în întreaga lume – după aderarea Chinei la OMC, la sfârșitul anului 2001 – rata medie anuală de creștere, pe termen scurt, a ajuns chiar la 5,2%. Această rată anuală de creștere ar putea duce la un deficit al cererii, în ultimii doi ani, de 19 milioane de tone.

Producția de fibre

- ***Fibrele de bumbac.*** Producția mondială de bumbac din acest sezon este de așteptat să scadă cu 4,8%, ajungând la 22,3 milioane de tone, fiind cel de-al cincilea sezon de declin consecutiv. În schimb, consumul global este proiectat să crească cu 5,4%, ajungând la 25,2 milioane de tone. Aprobarea culturilor modificate genetic a avut ca rezultat creșterea producției de bumbac. Producția din sezonul curent a revenit la trendul pe termen lung, datorită randamentelor mai mici cu 3,5%/ hectar, în sezonul actual.
- ***Fibrele de lână.*** Producția mondială de lână a scăzut, în 2009, cu 7,4%, ajungând la 1,1 milioane de tone și marcând cel de-al șaptelea an de declin din ultimul deceniu. Producția de confecții din lână a scăzut cu 8%, ajungând la 552 de mii de tone, iar cea de textile de interior cu 6%, ajungând la 547 de mii de tone. Aproape jumătate din producția mondială provine din Australia, China și Noua Zeelandă.
- ***Fibrele celulozice.*** Piața fibrelor celulozice a crescut cu 7,7%, ajungând la 3,8 milioane de tone. Datorită cererii crescânde de textile nețesute și de produse ignifuge, producția de fibre scurte din viscoză a crescut cu 11,4%, ajungând 2,7 milioane de tone. Un consum peste medie s-a constatat în China și India, ca urmare a creșterii veniturilor provenite din bunurile de uz casnic.
- ***Fibrele sintetice.*** Producția totală de fibre sintetice a crescut cu până la 3,7%, ajungând la 40,3 milioane de tone. Producția de fibre de poliester a crescut cu 5,3%, iar cea de fibre acrilice cu 4,4%. Pe de altă parte, producția de fibre din polipropilenă a scăzut cu 6,5%, iar cea de poliamidă cu 1,4%.

– *Fibrele de poliester.* S-a constatat o creștere a producției de fire PES cu 6,7%, respectiv 18,2 milioane de tone, într-un număr mic de țări asiatice, precum China, India, Malaezia și Vietnam, în timp ce în emisfera de vest s-au raportat scăderi importante. Acest lucru a ridicat cota de piață asiatică la circa 97%. În anul 2009, în China volumul de producție a crescut cu 22%, ajungând la 550 de mii de tone, în India cu 15%/ 860 de mii de tone, în Taiwan cu 13%/ 570 de mii de tone și în Coreea de Sud cu 5%/ 516 mii de tone. În Europa, producția a scăzut cu 14%, ajungând sub 600 de mii de tone. În timp ce în Turcia activitatea de producție a fost stabilă, în Europa de Vest a scăzut cu 23%, ajungând la 268 de mii de tone, iar în CIS cu 18%/ 82 de mii de tone. În America, producția a scăzut cu 15%, ajungând la 725 000 de tone.

– *Fibrele de poliamidă.* Producția de fibre poliamidice a scăzut cu 1,4%, ajungând la 3,5 milioane de tone, în 2009.

– *Fibrele de polipropilenă.* Producția globală de fibre polipropilenice a scăzut cu 6,5%, ajungând la 2,6 milioane de tone. În timp ce aplicațiile fibrelor scurte au crescut cu 3,5%, ajungând la 1,1 milioane de tone, producția de fire filamentare a scăzut cu 12,7%, ajungând la 1,5 milioane de tone.

– *Fibrele acrilice.* În 2009, producția mondială de fibre acrilice a crescut cu 4,4%, ajungând la 1,9 milioane de tone.

– *Fibrele de carbon.* În urma crizei financiare, producția a scăzut cu 15%, ajungând la cca 33 000 de tone, deoarece aproape fiecare domeniu de utilizare finală, din sectoare precum cel industrial, aerospațial și al sporturilor, a suferit o diminuare a activității de prelucrare, exceptând sectorul energiei eoliene, unde – potrivit Consiliului Global pentru Energie Eoliană – s-a înregistrat, în 2009, o creștere de 31% a puterii instalațiilor de energie eoliană, respectiv 158 de GW.

– *Fibrele aramidice.* Producția anului anterior a fost de 64 000 de tone, fiind furnizată în principal de DuPont și Teijin. Consumul de fibre para-aramidice, în special al celor destinate anvelopelor și materialelor de consolidare a cauciucului, a început anul cu o evoluție lineară, din cauza declinului din sectorul de automobile, însă s-a revitalizat pe parcursul anului. Tendințele de creștere în domeniul fibrelor aramidice – care oferă o multitudine de oportunități unor domenii precum cel al aeronavelor, al echipamentelor de protecție, al automobilelor și anvelopelor, al ingineriei civile și geotextilelor, dar și al aplicațiilor balistice, al materialelor de consolidare și al celor rezistente la temperaturi înalte și la tăiere – au fost umbrite de un anunț, făcut în aprilie 2010, privind crearea unui substitut al acestor fibre pentru domeniul echipamentelor de protecție. Un colectiv internațional de cercetători, din Elveția, China și S.U.A., a elaborat un studiu inedit privind un material din carbură de bor, flexibil, ușor și rezistent, considerat a ocupa locul al treilea în privința rezistenței și care deschide calea unor oportunități fără precedent.

Producția de fire

În 2009, producția globală de fire a crescut cu 4,0%, ajungând la 61,8 milioane de tone. În timp ce producția de fire pentru covoare (cu excepția celor poliesterice) a scăzut cu 13,4%, ajungând la 1,7 milioane de tone, cea de fire industriale cu 6,9%, ajungând la 2,4 milioane de tone, producția de fire filamentare a crescut cu 6,4%, ajungând la 20,7 milioane de tone. Producția de fire scurte a crescut cu 5,1%, ajungând la 32,9 milioane de tone, iar cea de fire lungi s-a menținut la un nivel scăzut, de 4,1 milioane de tone. Piața mondială de fire este dominată de China, urmată de India, S.U.A., Taiwan și Coreea de Sud.

Producția mondială de fire *Spandex* a fost și ea influențată în mod negativ de consumul în scădere al textilelor. Producția anului trecut a scăzut cu cca 6%, ajungând la 330 000 de tone, ceea ce s-ar traduce printr-un procentaj global al consumului de cca 57%. Cu toate acestea, proiectele derulate de China, aflate în stadiul de planificare sau construcție, adaugă capacității de producție existente o valoare de cca 60 000 de tone. În cele două Americi și în Europa, producția de Spandex a avut, la început o evoluție lentă, dar s-a îmbunătățit în cel de-al doilea și cel de-al treilea trimestru, cu cca 80%. Încetinirea activității din amontele lanțului, în cel de-al patrulea trimestru, a fost o consecință a redistribuirii mărfii.

Producția de netesute

În cadrul industriei de materiale nețesute, unele sectoare, cum ar fi cel de igienă personală – inclusiv produsele de incontinență pentru adulți, produsele de igienă feminină și scutecele pentru bebeluși – și cel al articolelor medicale nu au fost afectate de criza economică. În schimb, în alte sectoare – precum cea a autorismelor, construcțiilor și textilelor de casă, s-a înregistrat o scădere a volumului de producție.

International Fiber Journal, iunie 2010, p. 4;
Oerlikon Textile International Business

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