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Sumar

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Development of polyester/cellulosic blend woven fabric for better comfort

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REZUMAT – ABSTRACT

Dezvoltarea țesăturilor din amestec poliester/celuloză pentru un confort mai bun

În acest articol, au fost investigate experimental efectele firelor de bătătură asupra proprietăților de confort ale țesăturilor pentru îmbrăcămintea de lucru. În această lucrare de cercetare, nouă fire de bătătură diferite cu aceleași densități liniare şi amestecuri fibroase diferite au fost utilizate pentru realizarea țesăturilor. Rezultatele studiului arată că fibra de bambus are o permeabilitate maximă la aer, iar fibra modal și amestecurile ei au proprietăți de management al umidității mai bune, în grupul G-1, în timp ce fibra 100% PES prezintă o permeabilitate mai mare la aer și un management al umidității în grupul G-2. Atunci când au fost comparate proprietățile de revenire din șifonare ale grupurilor G-1 și G-2, fibrele modal și PES au prezentat proprietăți mai bune de revenire din șifonare datorită lungimii de încovoiere mai mici. Dintre toate cele nouă mostre de țesături, țesătura produsă din modal și bambus în direcția bătăturii a prezentat cele mai bune proprietăți de confort în ceea ce privește permeabilitatea la aer, managementul umidității, rigiditatea și revenirea din șifonare.

Cuvinte-cheie: materiale ale firelor de bătătură, țesături, permeabilitate la aer, managementul umidității, ANOVA, lungime de încovoiere, revenire din șifonare

Development of polyester/cellulosic blend woven fabric for better comfort

In this article, the effects of weft yarn materials on comfort properties of work wear woven fabrics are experimentally investigated. In this research work, nine different filling yarns of the same linear densities with different blend in pure and mix are used for production of woven fabrics. The results of the research show that bamboo has maximum air permeability and modal & its blend exhibit better moisture management properties in group G-1, whereas 100 % PES shows higher air permeability and moisture management in group G-2. When we compare crease recovery properties of group G-1and G-2, modal and PES show better crease recovery due to their low bending length. Among the nine woven fabric samples the fabric produced from modal and bamboo in weft direction exhibited the best comfort properties with respect to air permeability, moisture management, stiffness and crease recovery.

Keywords: weft yarn materials, woven fabrics, air permeability, moisture management, ANOVA, bending length, crease recovery

INTRODUCTION

The word “textile” arises from the texture which means to weave. Barburk and Masajtis stated that woven fabric structures are flat materials used to manufacture garments, technical, decorative and some special products [1]. Lord and Mohamed described that woven fabric is produced by interlacing of warp and weft yarns and are more durable and suitable for garment production due to flexibility in cutting [2]. The coarser fabrics are more durable than finer which may stretch or cause pilling. The flexibility is the basic requirement of woven constructions. There are many materials which are thin and flexible but have poor drape and rough appearance. Sulzer stated that the fibre and yarn flexibility are important properties which affect the flexibility of woven fabrics. M. H Malik *et al*. stated that strength of woven fabric is unique property which makes them distinguished from non-woven and knitted structures [3–4].

All types of fabrics for clothing should possess good comfort and performance. The term comfort is defined as “the absence of unpleasantness or discomfort” or “a neutral state compared to the more active state of pleasure”. A pleasant state of psychological, physiological and physical harmony between human being and environment is known as comfort. Comfort and performance are key parameters for the work wear fabrics and many textile scientists have done work to improve these properties of woven work wear fabrics [5].

Air permeability, water vapor permeability and moisture management are important comfort properties of woven fabrics. Moisture management is ability of fabric to transport, store and disperse off liquid water released from body. It is also defined as controlled movement of water from surface of body to atmosphere through fabrics [6]. The air permeability of the woven fabrics can be controlled during product design by raw material properties (fiber type and blend ratio), yarn characteristics and structural parameters of the woven fabrics [7].

The moisture flow through fabric is the most important factor for physiological comfort. The hydrophilic materials are good moisture absorbers. Tests were conducted by many types of blends of hydrophobic and hydrophilic fibers. It was noted that water permeability increased with the increasing amount of

hydrophilic component in the blend but the adverse effect was that moisture transport decreased with the increase in the hydrophilic groups. The most commonly used blends are polyester/viscose, wool/polyester, and polyester/cotton in garment production [8]. Studies of E-Sema reveal that cellulosic and polyester blended fabrics give better liquid absorption and transport efficiency [9]. Good moisture management means quick absorption and release of moisture, which give better level of comfort. Synthetic fibers like polyester do not attach water and do not get wet giving better release simultaneously. 100% cotton and 100 % polyester both do not give satisfactory moisture management but the blending of both produces satisfactory results of moisture management.
In this research different woven structures are produced by changing the different blends of cellulose material with polyester fiber so that a better blend may be developed for work wear woven fabric in different seasons.

EXPERIMENTAL PART

Material: Polyester/cotton (60:40) blended yarn with 29.53 tex linear density was used for fabric warp and 36.91 tex yarns with different blend ratios and materials were used in weft direction to develop nine different fabric samples. The blend ratio of weft yarns is given in the table 1.
Nine different grey fabric samples with 29.53 tex warp and 36.91 tex weft respectively and 45 ends/cm and 25 picks/cm were woven in 2/1 S-twill design with 160 cm width on Picanol Omni air jet loom using the material given in the table 1.
Method: All samples were produced on air jet Picanol Omni Plus weaving machine in Be Be Jan weaving unit limited Faisalabad. The machine was equipped with the tappet shedding mechanism and running at 1200 meters per minute. The weft was changed for the sample production with different types of nine weft yarn materials as given in the table 1. The fabric samples were produced in controlled atmospheric condition, relative humidity 76 % and temperature 26°C. The de-sizing and bleaching processes were performed in the processing lab in National Textile University Faisalabad.

Table 1

WEFT MATERIALS FOR FABRIC

Sr.#	Sample code	Description
1.	100 % B	100 % bamboo
2.	100 % CC	100 % combed cotton
3.	100 % M	100 % Modal®
4.	100 % P	100 % Polyester
5.	B:C (50:50)	50 % bamboo and 50 % cotton
6.	M:C(70:30)	70 % Modal® and 30 % cotton
7.	PC (52:48)	52 % polyester and 48 % cotton
8.	Hollow P	20 % hollow polyester and 80 % cotton
9.	L:C(55:45)	55 % linen and 45 % cotton

The de-sizing, bleaching and scouring of grey samples were performed according to the chemicals and conditions given in the table 2.
All the processed woven fabric samples were conditioned before testing and characterization. Fabric areal density was determined according to ASTM-3776. Fabric stiffness was determined according to ASTM-BS3356. Fabric thickness was measured according to ASTM-D1777. Fabric air permeability was determined according to ISO 9237 using SDL-Atlas permeability tester. Fabric moisture management properties were determined according to AATCC Test method 195, using SDL-Atlas moisture management tester. Fabric crease recovery was determined according to BS-5690 using crease recovery tester.

RESULTS AND DISCUSSION

The properties of the weft yarn used in different fabric samples are given in the table 3.
The mean value of the physical parameters of the fabric samples are given in the table 4.
All the processed woven fabric were measured for their comfort properties i.e., air permeability, moisture management, fabric stiffness and bending length. The results of each parameter are discussed as follow.

Table 2

CHEMICALS FOR DESIZING AND SETTINGS

Parameters	Units	De-sizing	Scouring	Bleaching
Enzyme De-sizer	ml/l	2	-	-
Wetting agent	g/l	1	2	1
NaOH	g/l	-	-	4
Detergent	g/l	-	2	-
Sequestering agent	g/l	-	-	2
Stablizer	g/l	-	-	2
L:R	-	8:1	-	-
pH	%	6.5	-	10~10.5
Temperature	ºC	50~60	80~90	80~90
Time	Hr.	0.75	1	1

Table 3

WEFT YARN PROPERTIES					
Group	**Material**	**Count (tex)**	**Breaking force (cN)**	**Tenacity (cN/tex)**	**Elongation**
G-1	B:C (50:50)	34.74	455.9	13.12	5.9
	100 % B	36.91	358.9	9.72	10.3
	Modal	36.91	947.4	25.67	10.65
	Hollow P	36.91	637.8	17.28	5.48
	M:C (70:30)	36.91	704.7	19.10	8.5
G-2	100 % CC	34.74	632.2	18.20	5.81
	P:C (52:48)	34.74	755.1	21.74	8.81
	L:C (55:45)	34.74	437.4	12.59	4.01
	100 % P	34.74	772.2	22.23	14.84

Table 4

FABRIC CONSTRUCTIONAL COMMPONENTS						
Group	**Material**	**Fabric width (cm)**	**Fabric weight (g/m^2)**	**Thickness (mm)**	**Warp crimp (%)**	**Weft crimp (%)**
G-1	B:C (50:50)	58.5	244.8	0.51	16.77	6.37
	100 % B	59.25	242.86	0.51	18.7	6.92
	Modal	57.25	242.15	0.51	14.56	8.48
	Hollow P	59.00	241.83	0.51	18.18	6.22
	M:C (70:30)	59.00	241.5	0.50	15.38	7.9
G-2	100 % CC	60.50	234.66	0.50	18.74	6.73
	P:C (52:48)	59.50	233.86	0.48	16.69	6.81
	L:C (55:45)	60.90	233.7	0.49	17.48	7.28
	100 % P	60.25	229.6	0.50	18.26	6.61

Effect of weft material on air permeability

The mean values of air permeability and over all moisture management are listed in the table 5.

One way ANOVA was performed in order to determine the statistical significance of weft material on air permeability. P-values and R-Sq values from ANOVA are given in table 6. A P-value of less than 0.05 for any air permeability value indicates that the effect of weft material is statistically significant on that property, with 95% confidence level. R-Sq indicates the percentage change in air permeability that can be described by change in the weft yarn properties. The higher the R-Sq value of a property, the higher is the dependence of that property on the weft yarn material. The analysis of variance (ANOVA) indicates that the weft material has highly significant effect on air permeability of woven structures.

The effect of each weft material on air permeability is shown in the figure 1. All the samples were produced on the same loom with same construction but due to variation in material properties the samples behave differently. If we compare the five samples in group G-1, all of the fabrics samples have almost same fabric weight and thread count, among these samples bamboo has highest value of air permeability due to

Table 5

AIR PERMEABILITY & MOISTURE MANAGEMENT								
Group	**Material**	**Fabric weight (g/m^2)**	**Fiber density (g/cm^3)**	**Yarn density (g/cm^3)**	**Fabric density (g/cm^3)**	**Porosity (%)**	**Air permeability (ml/sec)**	**OMMC**
G-1	B:C (50:50)	244.8	1.45	0.85	0.48	66.85	22.6	0.519
	100 % B	242.86	1.42	0.83	0.45	67.68	30.8	0.507
	Modal	242.15	1.47	0.87	0.47	67.59	27.0	0.565
	Hollow P	241.83	1.46	0.87	0.48	66.96	21.6	0.556
	M:C (70:30)	241.5	1.45	0.87	0.48	66.68	22.6	0.567
G-2	100 % CC	234.66	1.50	0.87	0.46	68.77	28.4	0.557
	P:C (52:48)	233.86	1.46	0.86	0.48	66.72	24.8	0.591
	L:C (55:45)	233.7	1.38	0.86	0.47	67.67	28.8	0.557
	100 % P	229.6	1.44	0.84	0.46	68.10	30.2	0.597

Table 6

ANOVA FOR AIR PEREMEABILITY					
Source	**DF**	**SS**	**MS**	**F**	**P**
Factor	9	1268.82	140.98	122.59	0.000
Error	40	46.00	1.15		
Total	49	1314.82			

* S = 1.072   R-Sq = 96.50%   R-Sq (adj) = 95.71%

Table 7

ANOVA FOR OMMC					
Source	**DF**	**SS**	**MS**	**F**	**P**
Factor	09	0.040939	0.004549	10.36	0.000
Error	40	0.017562	0.000489		
Total	49	0.058501			

* S = 0.02095   R-Sq = 83.98%   R-Sq(adj) = 89.23%

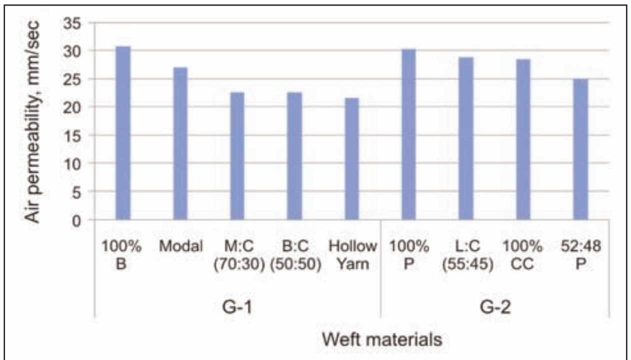

Fig. 1. Effect of weft material on air permeability

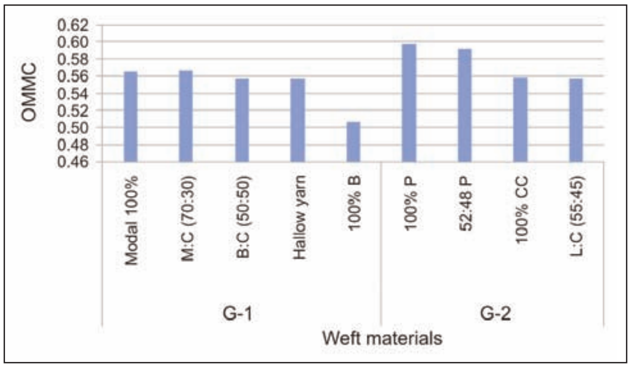

Fig. 2. Effect of weft material on OMMC

its least value of fiber density, yarn density and higher fabric porosity. The bamboo fiber has also specific cross section shape and pores in the inner side so due to air gaps and micro holes the air flow was observed better in this yarn.

The four samples in group G-2 have less fabric weight and low thread density than group G-1. The polyester due to its low fiber density and least fabric weight produces highest value of air permeability due to its uniform circular cross section of fiber. The cotton and linen both have approximately equal porosity and air permeability due the shape of the fibers.

Effect of weft material on moisture management

The moisture management properties of nine samples were tested and the mean of five values for overall moisture management capability in case of each sample are reported in the table 5. The analysis of variance reveals that the effect of weft material on OMMC is statistically significant with 95 % confidence level i.e., P-value < 0.05 in the table 7.

The effect of weft material is shown in the figure 2, it is clear from the figure that the Modal® and its blend with cotton and hollow polyester yarn from group G-1, produced higher OMMC while100 % polyester and its blend with cotton from G-2, produced highest OMMC value. The Modal® fiber has good absorption as well as air permeability so it produced higher overall moisture management properties. The higher OMMC of polyester and its blend might be due to its better wicking properties.

Effect of weft material on bending length

The mean values for fabric bending length are listed in the table 8 with some physical properties like thread density, GSM and crimp. The effect of material on bending length of woven fabric is shown in the figure 3.

It is clear from ANOVA that the weft material has statistically significant effect on bending length in warp and weft direction due to p-value is less than 0.01 with 99 % confidence level as shown in the tables 9 and 10.

If we compare the bending length among the weft materials in group G-1, the hollow polyester yarn shows highest bending length due to the hollow and round cross sectional shape and low yarn elongation % age, while the Modal® and its blend produced less bending length than other materials in this group due to the low fineness of the modal fiber (1.3 dtex) and higher elongation % age, so it has better drape. If we see the group G-2 the first three materials have similar bending length while the 100 % polyester fabric has least bending length due to the solid fiber cross section and also due to very high elongation % age of polyester yarn in this group. More over the polyester fiber is finer (1.2–1.3 den) than others so low bending stiffness than other samples in this group. The linen and 100 % combed cotton fabric show higher bending length that might be due to the

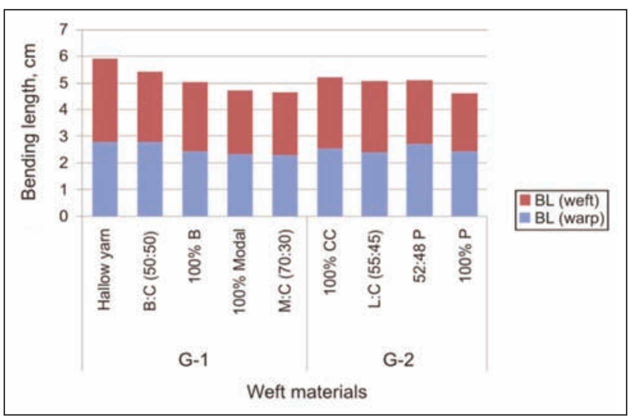

Fig. 3. Effect of weft material on bending length

Table 8

EFFECT OF WEFT MATERIAL ON BENDING LENGTH							
Group	**Material**	**epc/ppc**	**Fabric weight (g/m^2)**	**Crimp %**	**BL warp (cm)**	**BL weft (cm)**	**BL(warp+weft) cm**
G-1	B:C (50:50)	47.5/24.4	244.8	6.37	2.8	2.64	5.44
	100 % B	48.4/24.4	242.86	8.42	2.45	2.59	5.04
	Modal	46.8/24.4	242.15	6.92	2.34	2.39	4.73
	Hollow P	46.4/24.8	241.83	6.22	2.80	3.10	5.90
	M:C (70:30)	46.4/24.8	241.5	7.90	2.33	2.31	4.64
G-2	100 % CC	45.6/24.4	234.66	6.73	2.55	2.66	5.21
	P:C (52:48)	47.2/24.0	233.86	6.81	2.70	2.39	5.09
	L:C (55:45)	47.2/24.4	233.7	7.28	2.40	2.66	5.06
	100 % P	46.0/24.0	229.6	6.61	2.44	2.16	4.60

Table 9

ANOVA FOR WARP BENDING LENGTH					
Source	**DF**	**SS**	**MS**	**F**	**P**
Factor	09	2.05077	0.22786	30.54	0.000
Error	40	0.29848	0.00746		
Total	49				

* S = 0.08638 R-Sq = 87.29% R-Sq(adj) = 84.44%

Table 10

ANOVA FOR WEFT BENDING LENGTH					
Source	**DF**	**SS**	**MS**	**F**	**P**
Factor	9	2.93074	0.32564	129.43	0.000
Error	40	0.10064	0.00252		
Total	49	3.03138			

* S = 0.05016 R-Sq = 96.68% R-Sq(adj) = 95.93%

Table 11

EFFECT OF WEFT MATERIAL ON CREASE RECOVERY							
Group	**Material**	**epc /ppc**	**Fabric weight (g/m^2)**	**Weft elongation (%)**	**CR warp (deg)**	**CR weft (deg)**	**CR (warp+weft) (deg)**
G-1	B:C (50:50)	47.5/24.4	244.8	5.90	77.50	69.00	147
	100 % B	48.4/24.4	242.86	10.3	86.00	96.00	182
	Modal	46.8/24.4	242.15	10.65	91.00	102.5	193.5
	Hollow P	46.4/24.8	241.83	5.48	71.5	82.00	153.5
	M:C (70:30)	46.4/24.8	241.5	8.50	74.0	98.50	172.5
G-2	100 % CC	45.6/24.4	234.66	5.81	72.0	89.00	161.00
	P:C (52:48)	47.2/24.0	233.86	8.81	89.83	95.66	185.0
	L:C (55:45)	47.2/24.4	233.7	4.01	99.33	71.00	170.0
	100 % P	46.0/24.0	229.6	14.84	86.00	112.5	199.0

coarser fiber, their higher modulus and profiled cross sectional shape and low elongation % age.

Effect of weft material on crease recovery

The mean values for fabric crease recovery are listed in the table 11 with some physical properties like thread density, fabric weight and crimp. The effect of weft material on crease recovery of woven fabric specimen is shown in the figure 4.

The analysis of variance reveals that the effect of weft material on crease recovery is statistically significant with 95 % confidence level (P-value < 0.05, table 12).

It is evident from the figure 4 that the fabric woven with Modal® yarn produced higher crease recovery in group G-1 due to the highest elongation of Modal® yarn while B:C (50:50) and hollow polyester have least crease recovery due to low elongation of these yarns. The polyester and the its blend produced best crease recovery among all materials and among their group G-2 due to their better elongation % age while

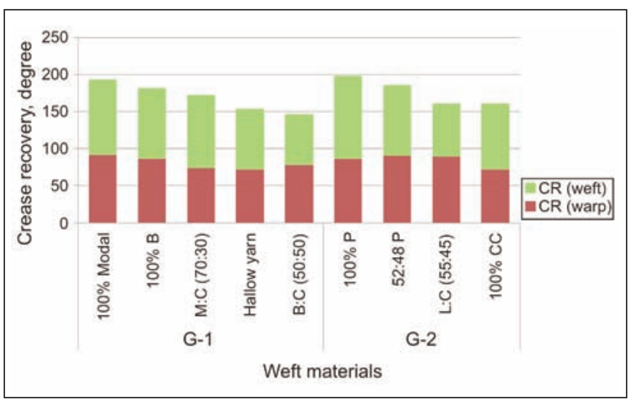

Fig. 4. Effect of weft material on crease recovery

Table 12

ANOVA FOR FABRIC CREASE RECOVERY					
Source	**DF**	**SS**	**MS**	**F**	**P**
Factor	8	6200	775	6.04	0.000
Error	36	4619	128		
Total	44	10819			

* S = 11.33 R-Sq = 84.30% R-Sq(adj) = 87.81%

the cotton and linen both have less crease recovery due to low elongation % age as shown in the table 3.

CONCLUSION

Fabric comprising 100 % bamboo yarn in weft direction among group G-1 produced better air flow due to specific cross sectional shape, air gaps and micro holes. All samples in group G-2 have less fabric weight and low thread density than group G-1. The fabrics comprising polyester yarn in weft give highest value of air permeability due to uniform circular cross section of fiber and low fiber density.

Fabric comprising Modal® and its blend with cotton from group G-1, produced higher OMMC while100 % polyester and its blend with cotton from G-2, produced highest OMMC value. The Modal® fiber has good absorption as well as air permeability so it produced higher overall moisture management properties. The higher OMMC of polyester and its blend might be due to its better wicking properties.

If we compare the bending length among the weft materials in group G-1, the fabric made from hollow polyester yarns show highest bending length due to the hollow and round cross sectional shape and low yarn elongation % age, while the modal and its blend produced less bending length than other materials in this group due to the low fineness of the Modal® fiber and higher elongation % age, so has better drape and hand value arising the good comfort properties. If we see the group G-2 the first three materials have similar bending length while the 100 % P has least bending length due to the solid fiber cross section and also due to very high elongation % age of polyester yarn in this group. More over the polyester fiber is finer than others so low bending length than other samples in this group. The linen and 100 % CC show higher bending length that might be due to the coarser fiber, their higher modulus and profiled cross sectional shape and low elongation % age.

It is evident that the fabric woven with the modal yarn produced higher crease recovery in group G-1 due to the highest elongation of modal yarn while B:C (50:50) and hollow polyester have least crease recovery due to low elongation of these yarns as shown in the table 11. The polyester and its blend produced best crease recovery among all materials and among their group G-2 due to their better elongation % age while the cotton and linen both possess low crease recovery due to less elongation % age.

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Sound absorption properties of HXNBR/FHHPF composite with needle-punched hollow polyester nonwoven laminated materials

J. HONG S. JIANG X. YAN

REZUMAT – ABSTRACT

Proprietățile de absorbție acustică ale compozitelor din HXNBR/FHHPF cu materiale nețesute interțesute laminate din poliester cu lumen

Au fost produse patru compozite din cauciuc nitril carboxil hidrogenat, consolidate cu fibre din poliester cu lumen, cu un raport de masă de 70/30 și grosime de 1 mm (denumite A). Acestea au fost laminate cu nețesut din poliester cu lumen, cu 300 g/m^2 și o grosime de 3 mm (denumite B). Au fost realizate materiale laminate cu două straturi AB și materiale laminate cu trei straturi ABA și BAB. Au fost testate proprietățile de absorbție acustică ale acestora. Referitor la materialele laminate cu două straturi AB, studiul a arătat că diferite laturi incidente au prezentat proprietăți diferite de absorbție acustică. Atunci când a fost ales materialul B ca latură incidentă, AB a prezentat proprietăți excelente de absorbție acustică a materialului poros. La frecvența de 1150 Hz și superioară, materialul a prezentat o performanță bună de absorbție acustică. Atunci când a fost ales materialul A ca latură incidentă, AB a prezentat proprietăți excelente de absorbție acustică la frecvența joasă și medie, dar a prezentat proprietăți inferioare la 1800 Hz și peste această valoare. La materialele laminate cu trei straturi ABA și BAB, performanța generală de absorbție acustică a fost îmbunătățită ulterior. Performanța de absorbție acustică s-a îmbunătățit la frecvență joasă și medie, în timp ce la frecvența de 1800 Hz și superioară a fost, de asemenea, bună, iar materialul BAB a prezentat proprietăți ușor îmbunătățite în comparație cu materialul ABA.

Cuvinte-cheie: HXNBR, poliester cu lumen, absorbție acustică, nețesut, laminat

Sound absorption properties of HXNBR/FHHPF composite with needle-punched hollow polyester nonwoven laminated materials

Four-hole hollow polyester fiber reinforced hydrogenated carboxyl nitrile rubber composite with a mass ratio of 70/30 in 1 mm thickness was fabricated (named A). Then it was laminated with needle punched single-hole hollow polyester nonwoven which was 300 g/m^2 and 3 mm in thickness (named B). Two-layer laminated material AB, three-layer laminated material ABA and BAB were made. Their sound absorption properties were tested. For two-layer laminated material AB, the study found that different incident sides showed different sound absorption properties. When chosen material B as the incident side, AB showed sound absorption properties of porous material. In frequency of 1150 Hz and above, the material has good sound absorption performance. When chosen material A as the incident side, AB has excellent sound absorption property in medium and low frequency, but with inferior property in 1800 Hz and above. For the three-layer laminated material ABA and BAB, the overall sound absorption performance was further enhanced. The sound absorption performance improved in the low and medium frequency while in frequency of 1800 Hz and above it was also good, and material BAB was slightly better than material ABA.

Keywords: HXNBR, hollow polyester, sound absorption, nonwoven, laminate

INTRODUCTION

Rubber as a kind of viscoelastic polymer which can perfectly transform the absorbed energy into heat, especially the synthetic rubber that can be used as sound absorbing material [1–2]. Synthetic fibres in textile as flexible materials also have viscoelastic property can be used as sound absorption material through viscous effect, thermal conductivity and self-vibration to consume acoustic energy [3–5]. And one special characteristic of the hollow synthetic fibre is it has a larger quantity of still air which makes it have better consuming ability of the acoustic energy. The application of hollow synthetic fibre in this field will achieve better results. However, nonwoven form is used more in actual research and application [6–7]. Few studies have been done on synthetic fibre reinforced rubber composite in sound absorption material filed. Jiang et al. fabricated chlorinated polyethylene (CPE)/seven-hole polyester fiber (SHPF) composites, the effect of fiber content and material thickness on the sound absorption property and the effect of fiber content on mechanical property were studied [8]. When the composite thickness was 1 mm with fiber content 20%, the sound absorption coefficient was 0.42 at 2500 Hz and tensile breaking tenacity was 12.73 Mpa with elongation of 16.12%. With 20% SHPF proportion the sound absorption coefficient at 2500 Hz reached to 0.695 when increased the composite thickness to 3mm. Zhou et al. fabricated reclaimed rubber/seven-hole polyester fibre (SHPF) composites [9]. The sound absorption coefficient was 0.407 at 2500 Hz when the composite thickness was 1 mm with fiber content 20%, and tensile breaking tenacity was 11 Mpa with elongation of 44.12%. In addition, relevant research documents of hollow synthetic fiber reinforced rubber composite and its sound absorption property have been seldom found. However, there exists a shortage in their study, although the materials have good sound absorption in 1mm thickness, the effective acoustic absorption frequency range of the sound absorption coefficient more than 0.2 is narrow. There is no sound absorption effect at frequency below 1500 Hz [8–9]. How to improve the sound absorption property of this material and broaden its effective frequency domain? Through increasing the thickness of the material can improve the absorption coefficient and the frequency domain, but the improvement is limited. In the research of Jiang et al., the material thickness raised to 3mm with SHPF content 20%, although the acoustic absorption coefficient reached 0.695 at 2500 Hz [8]. But the effectively improved area is only 1500 to 2500 Hz, especially better in 2000 to 2500 Hz, and the absorption coefficient is only 0.2 to 0.4 at 1500–2000 Hz. There is no improvement in the range below 1500 Hz.

As for the hollow synthetic fiber nonwoven which is widely used in sound absorption field has good acoustic absorption performance. But based on the characteristics of porous acoustic absorption material, it only has good acoustic absorption performance at medium and high frequency. The thickness of the material has to be increased a lot in order to get better results in low frequency. In the study of Lee et al., the acoustic absorption coefficient of a 15 mm thickness nonwoven material close to 0.7 at 2500 Hz and less than 0.3 while at 1000 Hz below [10]. Increasing the thickness of the material to 50 mm has significantly improved the acoustic absorption of the material, the acoustic absorption coefficient close to 0.9 at 2500 Hz and larger than 0.7 at 1000 Hz and below.

For this purpose, a four-hole hollow polyester fiber (FHHPF) reinforced hydrogenated carboxyl nitrile rubber (HXNBR) matrix composites HXNBR/FHHPF was made, named A. Then, a needle punched nonwoven using the single-hole hollow polyester fiber was made, named B. Three kinds of laminated materials, two-layer laminated material AB, three-layer laminated material ABA and BAB were made by laminating process. The acoustic absorption properties of these materials were studied.

MATERIAL FABRICATION

HXNBR/FHHPF composite fabrication

The rubber matrix HXNBR marked Therban XT VP KA8889 used for preparation of material A was produced by LANXESS Deutschland GMBH. The material specification of FHHPF used is 0.833 tex × 60 mm with hollow degree 22.9%, produced by Sinopec Yizheng Chemical Fibre Co., Ltd., China. The fabrication procedure of material A was as follows: (1) Weighing. According to the study of Jiang et al. [8] and my pre-research, weigh a certain amount of HXNBR and FHHPF in a mass ratio of 70/30 respectively. (2) Mixing. After HXNBR was kneaded with X (S) K-460 type two-roller mill (Wuxi Chuangcheng Rubber and Plastic Machinery Co., Ltd., China) at 30°C for 5 min, FHHPF were added. Then the mixture was kneaded again, using a cutting knife by mixing at 30°C for 40 min to enhance the homogeneity of the composite. (3) Vulcanization. Spread the HXNBR/FHHPF mixture on 1mm thick mold, the mold was hold by 30 cm × 30 cm and 5 mm thickness stainless steel plate, and between the mold and steel plate, a layer of thermostable PTFE cloth with a layer of anti-sticky thermostable PET film were put on it. The finished steel plate was packed into QLB-50D/Q type plate vulcanizing press (Wuxi Chuangcheng Rubber and Plastic Machinery Co., Ltd., China), preheating at 1–2 Mpa pressure and 140°C for 5 min. Then adjust the pressure to 10 Mpa and press for 20 min at 140°C. Release the pressure and take the steel plate out. Let it cool down and demold it, obtain the required material A with a smooth surface of 1 mm thickness.

Preparation of the needle punched nonwoven

The material specification of single-hole hollow polyester fibre used in the preparation of material B is 0.667 tex × 64 mm, produced by Sinopec Yizheng Chemical Fibre Co., Ltd., China. The fabrication procedure of material B was as follows: (1) Fibre opening and blending (2) Carding and forming web (3) Cross lapping (4) Pre-needling (5) Finish needling. The needle punched single-hole hollow polyester fibre nonwoven material B was made with thickness 3 mm and weight 300 g/m^2.

Preparation of the laminated materials

Material A and B were laminated by the QLB-50D / Q-type plate vulcanizing press to get three kinds of laminated materials: two-layer laminated material AB, three-layer laminated material ABA and BAB. Their structure was shown in figure 1.

The preparation process of the two-layer laminated material AB is as follows. Take one piece of stainless steel plate sizing 30 cm × 30 cm and in 5 mm thickness, then a layer of thermostable PTFE cloth and a layer of anti-sticky thermostable PET film sizing 30 cm × 30 cm were put on it respectively. Cut one piece of material A sizing 8 cm × 8 cm and place it on 1mm thick stainless square mold as figure 2 and then put it on thermostable PTFE cloth. It was then put on the heating plate of the plate vulcanizing press to preheat at 100°C for 5 min. Cutting material B into 8 cm × 8 cm and put it on the preheated material A simultaneously. Place one piece of thermostable PET film sizing 30 cm × 30 cm and one piece of stainless plate sizing 30 cm × 30 cm with 5 mm thickness. Start the plate vulcanizing press, the material was pressed for 0.5 min without additional pressure. Remove the composite out of the machine and take the two-layer laminated material AB out until the stainless steel plates cool down.

The preparation process of the three-layer laminated materials is as follows. For material ABA, first according to the process of the preparation of two-layer laminated material described, preheat the material A, put

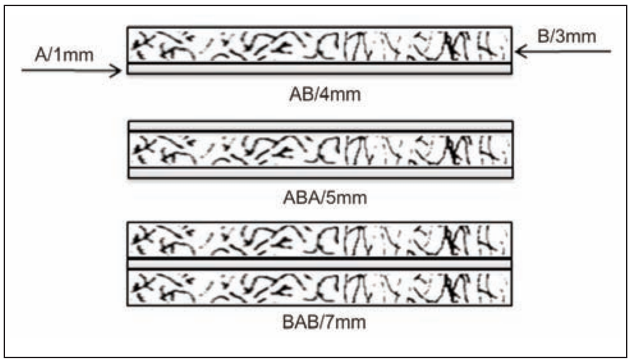


Fig. 1. Structure of laminated materials

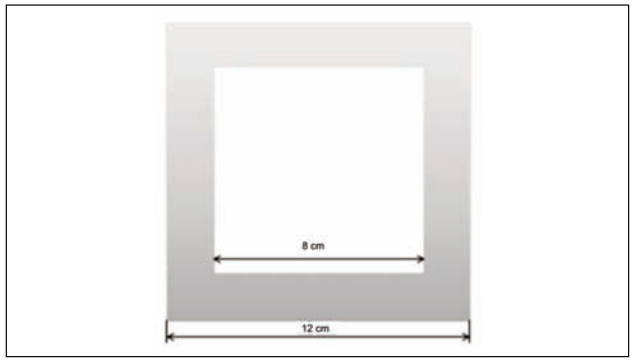


Fig. 2. The sketch of mold

the prepared material AB with side B down on the preheated material A, and place one layer of thermostable PTFE cloth and a layer of thermostable PET film respectively. Then place one piece of sizing 30 cm × 30 cm and 5 mm thickness stainless steel plate. Start the plate vulcanizing press, the material was pressed for 0.5 min without additional pressure. Remove the composite out of the machine and take the three-layer laminated material ABA out until the stainless steel plates cool down.

When prepare the material BAB, put the prepared two-layer laminated material AB in the 4mm thick stainless steel mold shown in figure 2. Make sure side A is upward. Put the material together with mold on a stainless plate on which was already placed thermostable PET film. Then the composite was put on the plate vulcanizing press to preheat at 100°C for 5 min, cut one piece of material B sizing 8 cm × 8 cm and put on the preheated material AB, place another piece of thermostable PET film and a piece of 30 cm × 30 cm 5 mm thick stainless steel plate. Start the plate vulcanizing press, the material was pressed for 0.5 min without additional pressure. Remove the composite out of the machine and take the three-layer laminated material BAB out until the stainless steel plates cool down.

MATERIAL TESTING

Morphology of the material A was conducted by using a Quanta-250 Environment Scanning Electron Microscope (ESEM). The sample was immersed in liquid nitrogen for 5 min and then broken. The fractured surface was sputter-coated with gold before examination. The fibre dispersion of the material A was revealed by Hitachi desk type scanning electronic microscope TM3000.The composite surface was sputter-coated with gold before examination.

Sound absorption properties of the materials were assessed using a two microphone transfer-function method, according to the standard of ISO 10534-2. The testing apparatus was a part of a complete acoustic system SW230 (BSWA Technology Co., Ltd., China). A middle-tube setup was employed to measure different acoustical parameters in the range of 100–2500 Hz (figure 3). At one end of the tube, a loudspeaker was placed as a sound source and the

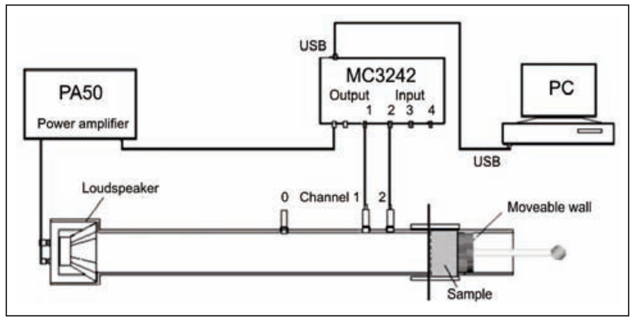


Fig. 3. Assembled diagram of measured sound absorption coefficient with an impedance tube

test material was placed at the opposite end to measure sound absorption properties. Samples were placed into a measurement tube using a machined aluminium rod (length 20 mm, diameter 60 mm). Each set of the experiment was repeated three times in order to have average measurements.

RESULTS AND DISCUSSION

The acoustic absorption property of single layer material

The acoustic absorption properties of material A and B are shown in figure 4. In order to reflect the degree of improvement in acoustic absorption of adding FHHPF, the acoustic absorption data of the 1 mm thickness pure HXNBR material is quoted for comparison.

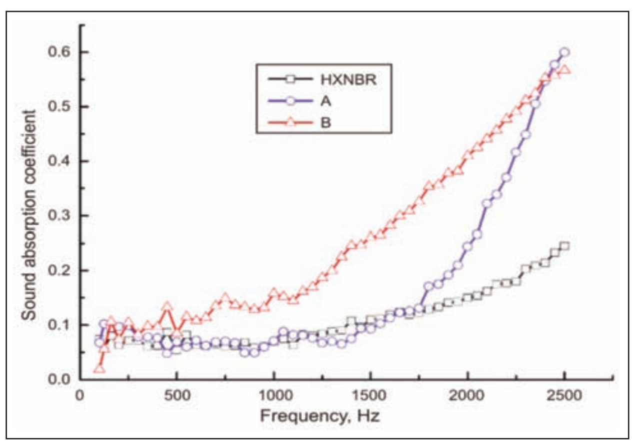


Fig. 4. Sound absorption property of material A and B

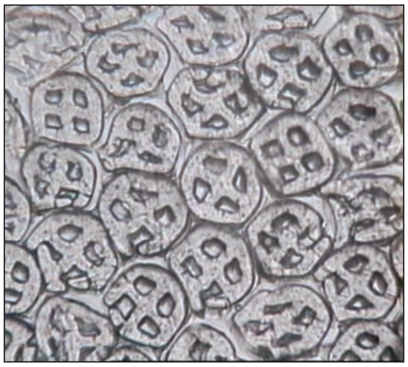


Fig. 5. Cross sectional shape with FHHPF amplified 1000

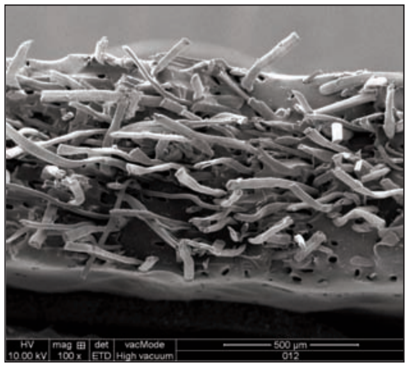


Fig. 6. Section SEM of material A

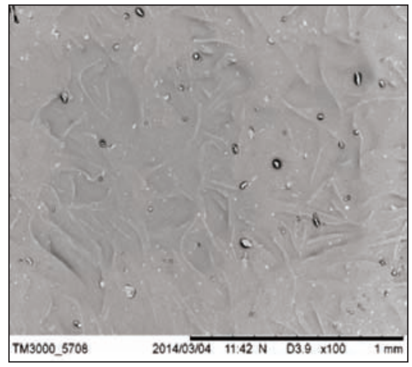


Fig. 7. Surface SEM of material A

As can be observed in figure 4, the acoustic absorption property of material A is better than the pure HXNBR material. This is because the acoustic absorption became a diversified effect after adding FHHPF in HXNBR. For material A, besides the acoustic absorption of the viscoelasticity damping of the HXNBR matrix, there also has the combined acoustic absorption effect of viscoelasticity, thermal conductivity and the vibration of the FHHPF fibre [4]. Meanwhile from figure 5 we can found that the hollow structure of FHHPF with hollow degree 22.9% increasing the voids in material A, wherein the presence of air plays a role of viscoelasticity and increasing the abrasion with the cavity wall, this result in more energy consumption and greater improvement of the sound absorption performance [11–12]. On the other hand, figure 6 and 7 shown that the FHHPF uniformly dispersed in the matrix of material A and a complete dense fibre network was formed. The energy consumption increased because of the vibration friction effect between the fibres and the rubber matrix is strengthened which further improved the acoustic absorption property of the material [8–9]. Acoustic absorption property of material A exhibits similar characteristics of porous material, the acoustic absorption coefficient increases with corresponding increasing of the frequency.

But from figure 4, we can also find that this improvement mainly above 1750 Hz. In range of 1950–2500 Hz, the acoustic absorption coefficient is greater than 0.2. And the coefficient at 2500 Hz reached the peak is 0.6. Whereas in the range of less than 1750 Hz, there also hasn't been improved. The acoustic absorption performance was poor and disorder, particularly in the low frequencies of below 500 Hz. Material B is a porous material with porosity 92.25%. Its acoustic absorption characteristic is similar to material A [13–14]. Figure 4 shown that comparing with material A, material B has better acoustic absorption performance in the entire frequency range. The effective frequency domain of acoustic absorption coefficient great than 0.2 is also wider than material A which is 1300–2500 Hz. The acoustic absorption coefficient at 2500 Hz is 0.567. However, acoustic absorption

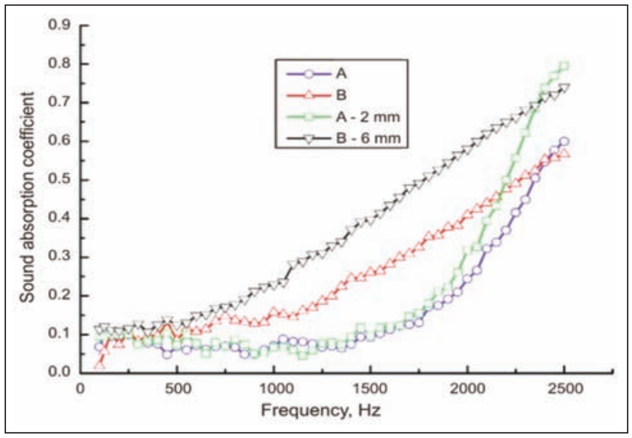


Fig. 8. Sound absorption property of A and B with double thickness

performance of material B at the low frequency is also poor with disorder feature below 500 Hz.

According to the literature, increasing the thickness of material can improve the acoustic absorption property [8, 10]. The thickness of material A and B was doubled to 2 mm and 6 mm respectively, and then their acoustic absorption performance was tested. Shown in figure 8, the acoustic absorption rule of the two materials did not change. Two kinds of materials still present the acoustic absorption characteristic of porous material, but the absorption coefficient at each frequency has increased. The effective frequency domain of acoustic absorption coefficient great than 0.2 was broadened to 1850–2500 Hz and 900–2500 Hz which mean the acoustic absorption performance is further improved. With increasing of the thickness of material, although the mechanism rule of acoustic absorption is the same, but the propagation distance increased which led to increasing of energy consumption, so the acoustic absorption effect was improved. Whereas for material A in the frequency range of less than 1750 Hz and material B in the frequency range of less than 750 Hz, the improvement was limited. Furthermore, after the thickness of the material increased to a certain value, the improvement of the acoustic absorption of the material is limited. Moreover, using thick material wastes resources and is not suitable for actual application [10].

The acoustic absorption property of two-layer laminated material

The acoustic absorption property of the prepared two-layer laminated material AB is shown in figure 9 and table 1. The curve of AB_{A-B} is a test result with A as the incident surface, and the curve of AB_{B-A} is the test result with B as the incident surface. According to figure 9 and table 1, the acoustic absorption performance of material AB with different incident surface is completely different.

When use side B of material AB as the incident surface, figure 9 shown that material AB has the changing similar law with material B of the acoustic absorption property. The reason is except the reflected part, the other part of the acoustic wave get into material B, the presence of the still air in voids between the single-hole fibres and the hollow, under the effect of the acoustic incident wave, viscous friction of the air and the friction between the fibres can consume energy and make the sound energy attenuated. But material B as a porous material has good acoustic absorption performance at medium-high frequency and bad performance at medium-low frequency. After the reflection and attenuation of the acoustic energy, the remains incident to the surface of material A which also part reflected back into the material B and part get into material A. Diversified sound absorption effect was caused just as stated in the previous of this article. But material A as a porous material also only has good acoustic absorption performance at medium-high frequency and almost has no acoustic absorption effect at medium-low frequency. In short, material AB still showed the acoustic performance characteristics of porous material. And the thickness of material was increased from 3 mm to 4 mm, the acoustic absorption coefficient at the corresponding frequency has increased to some extent, the coefficient is 0.598 at 2500 Hz. The range of absorption coefficient more than 0.2 has been widened to 1150–2500 Hz and the average absorption coefficient for each frequency point in figure 9 is 0.421.

Table 1

ACOUSTIC ABSORPTION PROPERTY OF TWO-LAYER LAMINATED MATERIAL

Frequency (Hz)	Acoustic absorption coefficient value			Frequency (Hz)	Acoustic absorption coefficient value		
	B	AB_{A-B}	AB_{B-A}		B	AB_{A-B}	AB_{B-A}
100	0.019	0.124	0.051	**1300**	0.2	0.357	0.245
125	0.056	0.128	0.097	**1350**	0.225	0.358	0.291
160	0.106	0.124	0.094	**1400**	0.246	0.33	0.294
200	0.074	0.129	0.086	**1450**	0.247	0.302	0.307
250	0.105	0.138	0.097	**1500**	0.261	0.289	0.328
300	0.083	0.121	0.082	**1550**	0.265	0.272	0.338
350	0.098	0.127	0.084	**1600**	0.282	0.26	0.348
400	0.097	0.174	0.101	**1650**	0.3	0.24	0.375
450	0.133	0.232	0.098	**1700**	0.309	0.237	0.392
500	0.085	0.242	0.114	**1750**	0.326	0.207	0.409
550	0.115	0.257	0.083	**1800**	0.353	0.202	0.42
600	0.108	0.285	0.104	**1850**	0.357	0.189	0.444
650	0.114	0.382	0.106	**1900**	0.378	0.172	0.451
700	0.135	0.508	0.11	**1950**	0.382	0.161	0.466
750	0.149	0.619	0.101	**2000**	0.41	0.159	0.492
800	0.137	0.672	0.132	**2050**	0.425	0.146	0.496
850	0.133	0.65	0.138	**2100**	0.441	0.125	0.511
900	0.129	0.622	0.139	**2150**	0.457	0.122	0.531
950	0.132	0.593	0.157	**2200**	0.477	0.133	0.538
1000	0.158	0.589	0.155	**2250**	0.491	0.124	0.55
1050	0.152	0.588	0.167	**2300**	0.512	0.108	0.56
1100	0.145	0.529	0.187	**2350**	0.525	0.119	0.568
1150	0.162	0.48	0.202	**2400**	0.553	0.102	0.58
1200	0.17	0.434	0.228	**2450**	0.558	0.091	0.589
1250	0.187	0.401	0.238	**2500**	0.567	0.102	0.598

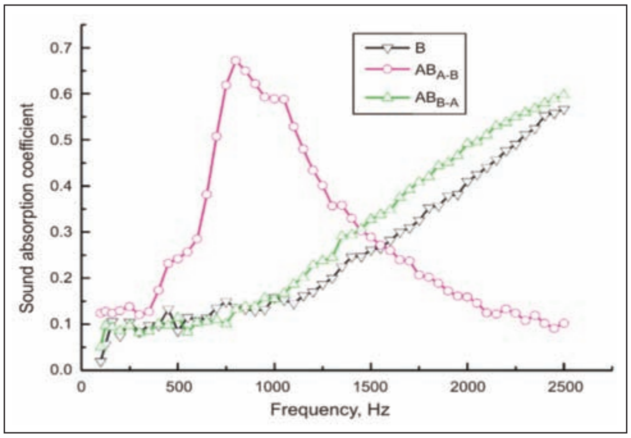


Fig. 9. Sound absorption property of AB (100–2500 Hz)

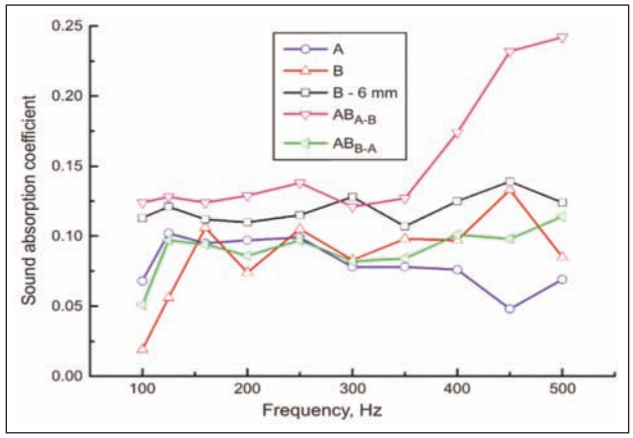
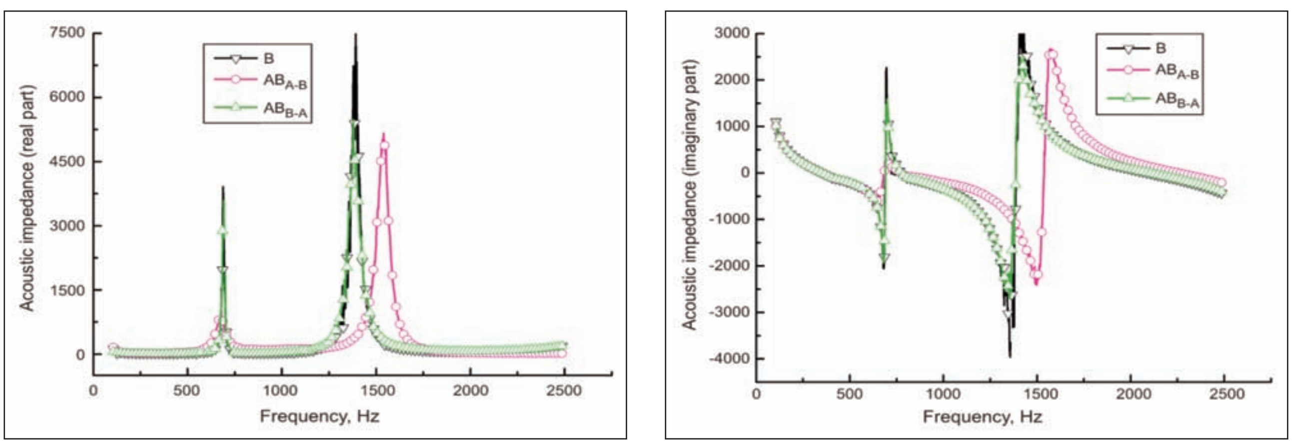


Fig. 10. Sound absorption property of AB (100–500 Hz)

When use side A of material AB as the incident surface, the acoustic absorption performance had undergone a fundamental change. From figure 9 and table 1 we can find that the acoustic absorption coefficient increased as the frequency increased, but when reached a peak, the acoustic absorption coefficient decreased. And the peak position is significantly moving to medium-low frequency which is 800 Hz with acoustic absorption coefficient of 0.672. The frequency range of acoustic absorption coefficient above 0.2 is 450–1800 Hz. This means that when use side A as incident surface, the acoustic absorption performance was significantly improved at medium-low frequency. The average absorption coefficient for each frequency point in figure 9 is 0.398. For further observation of figure 10, using material A as incident surface has significantly improved the acoustic absorption of material AB at the low frequency range of 100–500 Hz, which is better than that of 6mm thickness material B and the changing rule is in order. From figure 7, we can find that the fibres in material A were well dispersed and fixed in the rubber matrix, and it is an enclosed film sheet material. Material B with porosity 92.25% at the back of material A which is an open porous material has a large number of still air in the hollow fibre itself and gap between fibres, so a cavity was formed at the back of material A. This will cause the cavity resonance effect on absorbing sound, and this is predominance effect which restrained the porous material acoustic absorption effect, and changed the acoustic absorption rule of material AB [15]. The acoustic absorption performance was significantly improved at medium-low frequency. The absorbing frequency peak moved to medium-low frequency, and the effective frequency range also shifts to low frequency. Meanwhile, the material thickness increased can also improve the acoustic absorption performance at medium-low frequency to a certain degree, but the performance declined at the medium-high frequency [16]. Comparing to increase the thickness or setting the air layer at the back of material A, it is more simply by using the proper incident surface to significantly improving the acoustic absorption property at medium-low frequency [10,17]. Meantime, the prepared material is lightweight.

Figure 11 is the acoustic impedance of the corresponding material in figure 9. From the figure 11 we can found that when set side B as the incident surface, the acoustic impedance of the two-layer laminated



a b

Fig. 11. Acoustic impedance of AB: *a* – real part; *b* – imaginary part

material AB is basically in coincidence with material B, except at the second peak of real part and corresponding imaginary part, material B shows higher value. So the acoustic absorption performance rule is consistent, only when at the frequency of 1000 Hz above, the acoustic absorption coefficient of material B is relatively smaller, refer to figure 9 [18–19]. When set side A as the incident surface, the acoustic impedance of the material AB is different, the values of first peak at real part and corresponding imaginary part are much smaller than B and $AB_{B\text{-}A}$, however, it is more matching with the acoustic impedance of air. So according to figure 9, the acoustic absorption performance of material $AB_{A\text{-}B}$ better than B and $AB_{B\text{-}A}$ near this frequency. Meanwhile, the second peak at real part and corresponding imaginary part of material $AB_{A\text{-}B}$ located at higher frequency than material B and $AB_{B\text{-}A}$. So after reaching to the peak, with the increase of frequency the acoustic absorption coefficient of material $AB_{A\text{-}B}$ began to decline and gradually smaller than material B and $AB_{B\text{-}A}$, refer to figure 9 [18].

The acoustic absorption property of three-layer laminated material

When using side A of the material AB as the incident surface, the acoustic absorption performance is good at medium-low frequency, but is not good at medium-high frequency, especially 1800 Hz above. Regarding to this reason, two kinds of three-layer laminated materials ABA and BAB were prepared, using material A and material B as the core middle layer respectively, their acoustic absorption performances were shown in figure 12 and table 2.

From the figure 12 and table 2, we can find that the acoustic absorption performance of material ABA and BAB is similar. With the increasing of frequency, the sound absorption coefficient increased accordingly until reached to the peak and began to decline. From the acoustic absorption property curves we can find that the two materials show almost coincide at the frequency of 100–1250 Hz and only show different amplitude of variation after 1250 Hz. Further observed in figure 12, the acoustic absorption coefficient of material ABA increased with increasing of the

Table 2

ACOUSTIC ABSORPTION PROPERTY OF THREE-LAYER LAMINATED MATERIALS

Frequency (Hz)	Acoustic absorption coefficient value			Frequency (Hz)	Acoustic absorption coefficient value		
	$AB_{A\text{-}B}$	ABA	BAB		$AB_{A\text{-}B}$	ABA	BAB
100	0.124	0.112	0.099	**1300**	0.357	0.723	0.702
125	0.128	0.116	0.126	**1350**	0.358	0.744	0.709
160	0.124	0.128	0.124	**1400**	0.33	0.752	0.714
200	0.129	0.126	0.127	**1450**	0.302	0.768	0.715
250	0.138	0.129	0.144	**1500**	0.289	0.778	0.714
300	0.121	0.139	0.14	**1550**	0.272	0.781	0.713
350	0.127	0.15	0.146	**1600**	0.26	0.787	0.71
400	0.174	0.186	0.138	**1650**	0.24	0.788	0.708
450	0.232	0.193	0.191	**1700**	0.237	0.79	0.704
500	0.242	0.198	0.204	**1750**	0.207	0.78	0.7
550	0.257	0.223	0.231	**1800**	0.202	0.77	0.695
600	0.285	0.251	0.256	**1850**	0.189	0.759	0.692
650	0.382	0.289	0.299	**1900**	0.172	0.743	0.688
700	0.508	0.311	0.355	**1950**	0.161	0.72	0.684
750	0.619	0.367	0.392	**2000**	0.159	0.697	0.679
800	0.672	0.427	0.428	**2050**	0.146	0.67	0.676
850	0.65	0.44	0.471	**2100**	0.125	0.638	0.672
900	0.622	0.458	0.508	**2150**	0.122	0.607	0.669
950	0.593	0.502	0.547	**2200**	0.133	0.569	0.667
1000	0.589	0.547	0.584	**2250**	0.124	0.535	0.663
1050	0.588	0.59	0.614	**2300**	0.108	0.5	0.66
1100	0.529	0.613	0.644	**2350**	0.119	0.462	0.66
1150	0.48	0.647	0.665	**2400**	0.102	0.432	0.656
1200	0.434	0.682	0.677	**2450**	0.091	0.4	0.655
1250	0.401	0.703	0.693	**2500**	0.102	0.37	0.653

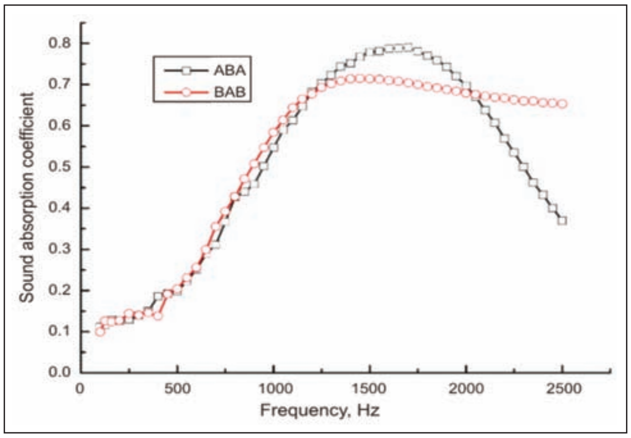
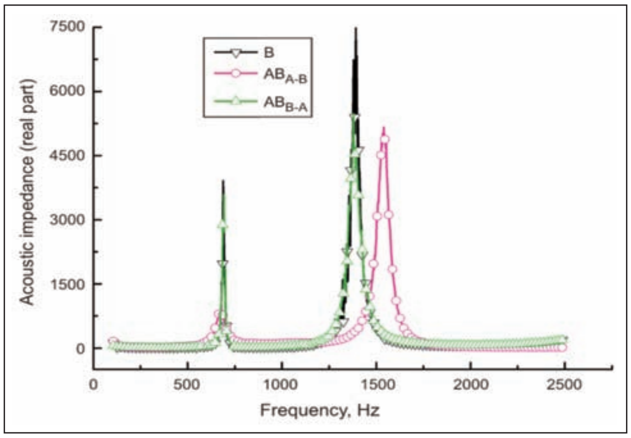


Fig. 12. Sound absorption properties of ABA and BAB

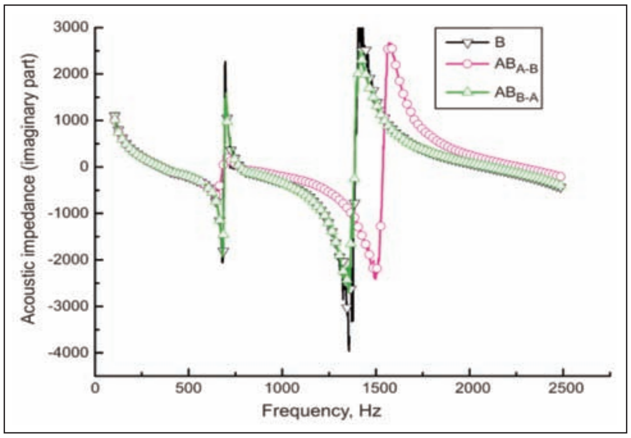
frequency until reach to the peak and begin to decline after peak point, and the descend amplitude is larger. The peak value of the sound absorption coefficient is 0.79 at frequency of 1700 Hz. At 2500 Hz the coefficient declined to 0.37. The frequency range with regard to sound absorption coefficient above 0.2 was widened to 550–2500 Hz, and the average absorption coefficient in this frequency range is 0.59 that ABA has an excellent sound absorption property. This is due to the sandwich structure, with reference to previous analysis there are a lot of air in material B forming an air layer, which played a role to promote the cavity resonance effect. Furthermore, the thickness of the material ABA was increased from 4 mm to 5mm that is also helpful to improve the performance of medium-low frequency. After attenuation the sound wave gets into the last layer material A. Material A is enclosed film sheet material which exhibits sound absorption characteristics of porous material, also contribute to the improvement of medium-high frequency sound absorption performance, therefore material ABA has better absorption property in wider frequency.

For the material BAB, the acoustic absorption coefficient reached the maximum value of 0.715 in 1450 Hz and decreased moderately which is generally stable. The acoustic absorption coefficient is 0.653 at 2500 Hz frequency. The frequency range of the sound absorption coefficient above 0.2 was 550–2500 Hz, and the average absorption coefficient in this frequency range is 0.603 that is more excellent than material ABA. The reason is except the reflected portion of the sound wave, the rest portion gets into the interior of material B. According to the prior description, the acoustic absorption of material B is better than material A at medium-high frequency. Similarly, the sound wave penetrates material B and reaches the surface of material A, part of the sound wave is reflected back to material B and the rest gets into material A. At the back of material A there is another layer of material B, where the presence of large quantities of still air formed an air layer and lead to cavity resonance of sound absorption effect. This has improved the sound absorption performance at medium-low frequency. And the thickness increased to 7 mm, not only the sound absorption performance at the medium-low frequency is improved, but also in the whole frequency.

Figure 13 is the acoustic impedance of three-layer laminated material. The figure shows that the acoustic impedance curve of material ABA and BAB is almost coincide at the frequency of 100–1250 Hz. So both acoustic absorption performance curve as shown in figure 12 is also coincide within this frequency range. Comparing with BAB, in the frequency range of 1250–2000 Hz, ABA is more matching with the acoustic impedance of air, and the peak frequency is higher and therefore the higher value of the acoustic absorption coefficient of material ABA corresponding to higher frequency as shown in figure 12 [19]. In the frequency of 2000 Hz above, comparing the acoustic impedance variation trend of the two materials as shown in figure 13, material BAB is more matching with the acoustic impedance of air, so material BAB can get a better sound absorption effect. As illustrated in figure 12, the sound absorption coefficient of material BAB is better than material ABA [19].



a



b

Fig. 13. Acoustic impedance of ABA and BAB: *a* – real part; *b* – imaginary part

CONCLUSION

HXNBR/FHHPF composite with a mass ratio of 70/30 in 1 mm thickness (named A) and a 300 g/m^2 needle punched hollow polyester nonwoven in 3 mm thickness (named B) was prepared. Their acoustic absorption properties were studied and their shortages were analysed. Results confirmed the acoustic absorption property of material A and B has the characteristics of porous material, and poor at the medium-low frequency. The way to improve the acoustic absorption properties of the material by increasing the thickness is limited.

Then laminated material A and B, two-layer laminated material AB and three-layer laminated material ABA and BAB were prepared and their acoustic absorption performance was tested. For using material A and B to make two-layer laminated material AB, the acoustic absorption property is improved, but different incident surface shows different performance. When make side B as the incident surface, the material AB revealed characteristic of porous material. The acoustic absorption performance is further improved at medium-high frequency. At frequency of 2500 Hz the material reaches the peak sound absorption coefficient of 0.598. The frequency of the sound absorption coefficient greater than 0.2 ranges from 150 to 2500 Hz. However, the improvement is not obvious at medium-low frequency especially of below 1000 Hz that rarely has any improvement. When use side A as the incident surface, material AB has excellent acoustic absorption property at medium-low frequency, especially below 500 Hz, the improvement is obvious. For the acoustic absorption coefficient 0.2 and above, the corresponding frequency range from 450 to 1800 Hz, it reaches to the peak value of 0.672 at 800 Hz. However, the acoustic absorption performance is poor at frequency of 1800 Hz and above.

For material ABA and BAB, both have excellent acoustic absorption property in low and high frequency, with better performance in a wider frequency range. The effective frequency range of acoustic absorption coefficient more than 0.2 was 550–2500 Hz and 500–2500 Hz respectively, the peak value of the sound absorption coefficient was reached 0.79 at 1700 Hz and 0.715 at 1450 Hz, respectively. The average value of the sound absorption coefficient in the effective frequency range is 0.59 and 0.603 respectively.

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Pressure ulcer in the ICU and the use of biomaterials

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REZUMAT – ABSTRACT

Ulcerul de presiune în unitățile de terapie intensivă și utilizarea biomaterialelor

Context: *Ulcerele de presiune din unitățile de terapie intensivă pot complica reabilitarea pacientului, astfel încât tratamentul cel mai acceptat este prevenirea și utilizarea de pansamente simple.*
Obiectiv*: Revizuirea literaturii medicale în ceea ce privește utilizarea diferitelor biomateriale în tratarea ulcerului de presiune.*
Surse de date și selecția studiului*: Articolele referitoare la utilizarea biomaterialelor au fost selectate de la PubMed. Au fost selectate articole relevante publicate în perioada 2002–2015.*
Toate căutările au folosit termeni precum: durere de presiune, pansament ulcer de presiune, durere de presiune în unitățile de terapie intensivă. Au fost cercetate ulterior informații relevante din articole.
Sinteza informații*: Unsprezece studii au fost considerate relevante pentru această analiză. Acest articol analizează diferite materiale considerate a fi superioare pansamentelor simple. Acesta conține studii care abordează și compară pansamente cu colagen, hidrocoloid, silicon și chitosan. Unele dintre aceste pansamente pot fi folosite, de asemenea, în prevenirea ulcerului de presiune, nu numai în tratarea acestuia.*
Concluzii*: Pansamentele cu biomateriale pot varia de la cele simple și accesibile la preț, până la cele personalizate, cum ar fi bioimprimarea.*

Pressure ulcer in the ICU and the use of biomaterials

Context*: Pressure ulcers in the Intensive Care Units may complicate patient rehabilitation, so the most accepted treatment is prevention and the use of simple dressings.*
Objective: *To review the medical literature regarding the use of different biomaterials in treating pressure ulcer.*
Data Sources and Study Selection*: The articles regarding the use of biomaterials were selected from PubMed. We selected relevant articles published between 2002 and 2015.*
All searches used the terms biomaterials in pressure sore, dressing pressure ulcer, pressure sore in the ICU. Relevant information from the articles was further researched.
Data Synthesis: *Eleven studies were considered relevant for this review. This article reviews different materials considered to be superior to simple dressings. It includes studies that discussed and compared dressings with collagen, hydrocolloid, silicones and chitosan. Some of these dressings may also be used in preventing pressure ulcer, not only in treating them.*
Conclusions: *Dressing with biomaterials may vary from simple and affordable ones to personalized ones like bioprinting.*

INTRODUCTIONS

A pressure ulcer is defined as a lesion of the skin and underling tissues due to constant pressure over a bony prominence and or shear [1]. In developed countries, treating pressure ulcers is considered to be the third most costly pathology, after cancer and cardiovascular diseases [2].

Critically ill patients are vulnerable to the development of hospital-associated pressure ulcers, which are an important concern for the patient and for the medical personnel. The incidence of pressure ulcers is higher in the intensive care unit (ICU) and can sometimes complicate patient rehabilitation.

The incidence of pressure ulcer in ICU varies between 14.9% and 34.4% and is much higher compared to the rest of the wards [3–5]. The risk factors includes: age, length of stay, infection, positioning of the patient, the Braden scale for predicting pressure sore risk, history of vascular disease, hemodialysis, mechanical ventilation, the use of sedatives, body temperature above 38.5 °C and sedentary state [6].

Pressure ulcer staging was first documented in 1955 (Guttman) and 1975 (Shea). Shea's classification included 4 grades from acute inflammatory response to penetration of the fascia and was used until 1988 when Wound, Ostomy and Continence Nurses' Society developed a more elaborate description of pressure ulcer. Stage I included “erythema not resolving within thirty minutes of pressure relief. Dermis remains intact”, while stage IV stated “deep tissue destruction extending through subcutaneous tissue to fascia and may involve muscle layers, joint, and/or bone. The aspect is of a deep crater and may include necrotic tissue, undermining, sinus tract formation, exudates and/or infection. Wound bed is usually not painful” [7].

This staging was used until 2007, when the National Pressure Ulcer Advisory Panel (NPUAP) redefined the definition of a pressure ulcer and the stages of

Fig. 1. Stage IV sacral pressure ulcer

pressure ulcers. It included the original 4 stages and added 2 stages on deep tissue injury and unstageable pressure ulcers.

According to the NPUAP, pressure ulcer can be categorized as followed:

- Stage I – non-blanchable erythema (intact skin with non-blanchable redness, the area may be painful, firm, soft, warmer or cooler as compared to adjacent tissue);
- Stage II – partial thickness (loss of dermis presenting as a shallow open ulcer with a red pink wound bed);
- Stage III – full thickness skin loss (subcutaneous fat may be visible but bone, tendon or muscle are not exposed);
- Stage IV – full thickness tissue loss (exposed bone, tendon or muscle) – figure 1.
- Unclassified – full thickness skin or tissue loss – depth unknown (actual depth of the ulcer is completely obscured by slough (yellow, tan, gray, green or brown) and/or eschar (tan, brown or black) in the wound bed).
- Suspected deep tissue injury – depth unknown (purple or maroon localized area of discolored intact skin or blood-filled blister due to damage of underlying soft tissue from pressure and/or shear) [8].

Developing pressure ulcer is dependent on the time and amount of pressure to a specific area. The pressures developed by a healthy person seating on a flat board are between 300 and 500 mmHg.

MAIN PART OF THE REVIEW

A review of the medical literature was conducted regarding the use of different biomaterials in treating pressure ulcer. Among the medical literature of biomaterials for bedsores we selected only studies having the following characteristics: comparisons between different biomaterials, their use in the ICU and trials of biomaterial done from 2002 to 2015. The research was performed between September – December 2015 and we included 11 studies which evaluated a total number of 1113 pressure ulcers.

The key word used for this researched were: biomaterials in pressure sore, dressing pressure ulcer, pressure sore in the ICU. The articles were selected from the PubMed database.

The biomaterial science is a new and growing industry, with a history of fifty years and important studies made in medicine, biology, materials, chemistry and tissue engineering [9].

The ideal wound dressing should have special properties like compatibility, preventing infections and water loss, but with good oxygen permeability. The dressing should have properties similar to that of the skin and should rush the healing process. Special dressings have been developed to allow healing according to the characteristics of the ulcer stage.

Beginning with the 1960's, the moist wound dressing appears to be superior to the dry one due to its ability to increase re-epithelialization and healing, thus opening the era of modern wound management [10].

The material considered superior to the traditional dressings (such as gauze) is the hydrocolloid. It consists of a layer of gel-forming material attached to a semi-permeable film or foam backing. The gel may contain a combination of absorbent materials such as sodium carboxymethylcellulose, pectin and gelatin [11].

In a systemic review and meta-analysis regarding the effectiveness of hydrocolloid dressings versus other dressings in the healing of pressure ulcers in adults and older adults, Ribas showed that there is insufficient evidence in the medical literature and clinical based medicine to state that hydrocolloid dressing is superior to other types of dressing [12].

The most abundant animal protein is the collagen; it began to be used as a biomaterial for the first time by

Joseph Lister in 1881 and it was used for suturing. Collagen has special properties like: biodegradability, nontoxicity, biocompatibility, weakly antigenicity. It can be found in the medical market in different forms (sponges, fibers, powders, hydrolyzed collagen, composite dressing). In pressure ulcer dressing it can be used as a powder (Catrix®), as a membrane (ColActive® Plus), sponge (GENTA-COLL®) or gels [13–14]. Powder collagen reduces the duration of the treatment and the wound size, but compared to hydrocolloid there are no significant differences in healing [15]. The treatment with collagen was considered to be more expensive that the one made with hydrocolloids [16].

The chronic wound contains an increased level of proteases such as elastase and plasmin, for this reason it was demonstrated that oxidized regenerated cellulose/collagen matrix improves the wound microenvironment because it binds and inactivates excess proteases in wound exudates. In a study conducted by Ulrich, 33 patients with pressure ulcers were divided into two groups : one control group of 10 patient that were treated with a foam hydropolymer dressing (TIELLE®, Systagenix) and the other group of 23 patients that were treated with oxidised regenerated cellulose/collagen matrix plus a foam hydropolymer dressing (TIELLE®, Systagenix). The second group showed significant faster healing with a decreased activity of elastase and plasmin in wound exudates [21].

The next step in advanced biomaterials dressing began in the 1980's when Mölnlycke created Mepitel®, by covering it with a silicon layer. The advantages include: no skin reactions or systemic toxicity, painless when removed, no maceration around the pressure sore making it an atraumatic dressing. They are not adhesive to the wound and especially to the granulation tissues. They reduce the inflammation and improve the healing time [17–18].

In a study performed by Jonathan Knott and co. regarding the use of soft silicon multi-layered foam dressing on 440 trauma and critically ill patients showed an important decrease in the development of pressure ulcer. The patients were divided into an interventional group (219) and control group. The interventional group had Mepilex® Border Sacrum and Mepilex® Heel dressings applied in the emergency department and maintained throughout their ICU stay. There were significantly fewer patients with pressure ulcers in the interventional group compared to the control group. It represented a 10% difference in incidence between the groups [19].

The highest incidence in developing pressure ulcer is in the ICU, for this reason at the Danbury Hospital, Danbury, Connecticut – a protocol was implemented. It consisted of an application of a silicone foam dressing every 3 days, that further diminished the number of patients with pressure sore [20].

The use of siliconic dressing can reduce the incidence of pressure ulcer to the sacrum from 13.6% to 1.8% [22].

The effectiveness of multi-layer, self-adhesive soft silicone foam heel dressing was demonstrated in a survey done on 150 patients from the ICU. They received on the day of admission dressing on both heels that were replaced every three days and examined daily. The silicone foam was clinically effective in reducing ICU-acquired heel pressure ulcers [23].

The use of silicone border foam dressing is reduces the incidence of pressure ulcer and also the associated dermitis [24].

In a comparison study between self-adherent soft silicone dressing and a self-adherent polymer dressing for stage II pressure ulcer, the polymer dressing showed an accelerated wound healing properties, but there were more cases of surrounding skin problems, maceration and dressing removal difficulties [25].

Another promising alternative biomaterial is chitosan, a natural polysaccharide derivate from chitin which is found in the exoskeleton of insects, crustaceans and arachnids [28]. Since its testing performed on mice in 2009 that showed accelerating wound healing continuous effort were done in creating the best dressing, easy to use for treating pressure sore [29].

In an open multicenter comparative randomized clinical study on chitosan published in August 2015 by Percival, revealed that dressing performed with this biomaterial can intensify wound healing through reepithelialization and pain relive [30].

CONCLUSION

The medical scientific world is dedicated to finding new therapies for ulcers and developing a more personalized wound dressing. There are continuing studies regarding the development of human use of biomaterials, like silk proteins – sericin and fibroin, that have the property to provide excellent oxygen permeability), antioxidant action, moisture regulating ability, UV resistance, antibacterial, anticancer and anticoagulant properties [26].

The future of tissue engineering stands in bioprinting. This is a method for creating 3-D tissues and organs in the laboratory that recreates tissue using different biomaterials such as polymers, gels and hydrogels. Different materials are currently being tested along with new ways of maintaining the tissues/organs viable until transplantation [27].

The industry of dressing for ulcers had a continuous and constant development, improving healing and quality of live. Their shape, consistency, structure and properties vary according to the stage of the pressure ulcer. Among different complication of an Intensive Care Unit patient stands also the pressure sore, which complicates or diminishes the evolution on such a patient.

Hydrocolloids dressing are superior to the simple dressing that use no active substance for healing, but has the same healing rate as collage, with the advantage of being more affordable. The silicon dressing has the supremacy among biomaterials for pressure ulcer, because it prevents and heals this type of lesion.

Chitosan is one of the new discoveries among ulcers because it intensifies wound healing.

The medical science continues to discover and study new proteins that are able to deliver oxygen the wound, but the future of wound healing is the 3-D bioprinting.

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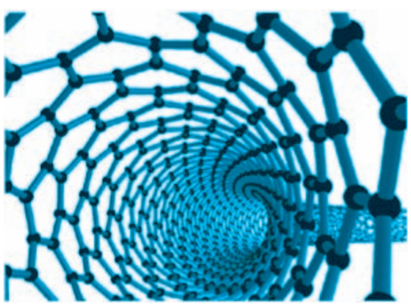


The influence of mechanical effects on coated textile hydrophobic properties

VIRGINIJA SACEVIČIENĖ MILDA JUCIENĖ LORETA ŠVEIKAUSKAITĖ

REZUMAT – ABSTRACT

Influenţa efectelor mecanice asupra proprietăţilor hidrofobice ale materialelor acoperite

În acest studiu, a fost investigată influența oboselii ciclice și a abraziuii asupra hidrofobiei textilelor peliculizate. În acest scop, au fost alese șase materiale peliculizate care sunt utilizate la confecționarea îmbrăcămintei de protecție. Studiile efectuate au demonstrat că abraziunea suprafeței de același tip permite proiectarea comportamentului produsului în timpul exploatării. Microfisurile, care deteriorează materialul stratului protector, pot apărea în locul flexiunii după solicitarea la îndoire sau tracțiune. Testul la oboseală ciclică a țesăturii care imită îndoirea, flexiunea sau întinderea a fost efectuat cu ajutorul echipamentului IPK 2M. Epruvetele au fost testate la oboseală utilizând modulul ciclic 3000, 6000, 7500, 9000, 12000 și 15000. Abraziunea suprafeței țesăturii a fost măsurată utilizând echipamentul cu rotații de abraziune YГH-1, 2000, 3000, 7000, 8000, 9000 și 15000. Metoda măsurării unghiului de contact liber a fost utilizată pentru a evalua hidrofobia. Studiile demonstrează că, în cele din urmă, influența asupra rugozității suprafeței a fost determinată de abraziunea suprafețelor de același tip. Conform rezultatelor de cercetare obținute, materialul cu peliculă PU este cel mai rezistent la abraziune. Materialul peliculizat cu PVC este, de asemenea, rezistent la abraziune, iar după abraziunea maximă a rămas hidrofob.

Cuvinte-cheie: textile peliculizate, oboseală, abraziune, proprietăți hidrofobe, unghi de contact

The influence of mechanical effects on coated textile hydrophobic properties

In this study, the influence of cycle fatigue and abrasion on hydrophobicity of coated textile was investigated. For this purpose, six coated materials were chosen that are used for protective clothing. The studies carried out show that the abrasion of the surface of the same nature allows project behaviour of product during exploitation. Micro-cracks, which damage the protective layer material, can occur in flex place after bending or tensile stress. Cycle fabric fatigue that imitates bending, flexing and stretching was performed using equipment IPK500, 9000, 12000 and 15000 cycle mode. Fabric surface abrasion was measured using equipment YГH-1, 2000, 3000, 7000, 8000, 9000 and 15000 abrasion rotations were chosen to do the test. The method of drop contact angle measuring is used to evaluate hydrophobicity. The studies show that ultimately influences on the surface roughness had abrasion of the same surfaces. According to the obtained research results the material with PU coating is the most resistant against abrasion. The material coated with PVC is also resistant against abrasion and after maximum abrasion remained hydrophobic.

Keywords: coated textile, fatigue, abrasion, hydrophobic properties, contact angle

INTRODUCTION

Coated, laminated and impregnated textile materials which protect against environmental conditions are used in industry more frequently, so the products made from the mentioned materials have become more widely used. Coated materials are used not only for protective clothing but also in car and furniture industry [1–3]. Hydrophobicity is one of the most important requirements for these materials. The method of water drop contact angle is widely used for defining hydrophobic properties of coated textile materials [4–8]. The basis of this method is that when using it droplet of liquid is instilled onto the observational surface and the water drop contact angle is measured; according to the determined contact angle surfaces are classified into groups [9]. Surfaces are hydrophobic if water drop contact angle is bigger than 90°, if this contact angle is smaller than 30° it shows that surfaces are hydrophilic [10]. Water drop contact measurement angle is used while measuring textile fibre that have various hydrophobic coating paper with protective coating, various kinds of polymeric films, polymers and composites [4–8, 10–12]. The size of water drop contact angle depends on the properties of the surface under observation and various effects that appear during the measurement [5, 6]. Some factors are used to evaluate a garment's durability. Abrasion refers to the wearing of any part of a material when rubbed against another surface. For durability, be sure to purchase clothing that can withstand rubbing against skin and other materials. Products for special purpose have to satisfy high requirements of durability, heat and humidity transferring. To evaluate the durability of coated materials during their exploitation the resistance against cycle fatigue [13–16], extension [2, 3, 15] and abrasion [7, 11–12] is measured. Although coated and laminated materials are tough and resistant, at the same time they are stiffer and thicker because they have at least two layers, i.e. textile base and polymer. Bending rigidity of coated materials, depending on the bending side of the specimen, i.e. if the textile backing or polymeric coating is the upper side, it can differ up to 7 times [17]. Various mechanical effects such as cyclic extension, bending, shear, abrasion and compression influence physical properties of multi-layer materials. Fatigue or cyclic extension has impact on hydrophobic properties of coated and laminated materials. Even insignificant permanent fatigue can worsen mechanical behaviour of the material and change its properties as well as reduced usage duration of the product. It was estimated that after 9000 fatigue cycles 160–640 μm cracks appear and water permeability in the coated materials increases [16]. Bending rigidity of the materials that were laminated using polyurethane film increases after fatigue up to 50 % and thickness of the materials increases up to 13 % [13]. Whereas cyclic extension opens microscopic pores of the textile materials that are coated with polyurethane coating and increases water permeability of that material up to 20 % [15]. The rigidity of coated materials decreases after mechanical effect but water permeability does not make any influence [8]. Analysis of scientific literature of other authors shows that in some cases different researchers receive counterproductive. This shows that the present problem is current and requires a more detailed investigation. Surface abrasion while exploiting materials changes surface roughness and increases the probability of wettability. Hydrophobic TiO_2 nano-coating experiences surface destruction already in 2 cycles of abrasion and obvious destruction is noticeable in 10 cycles of abrasion [7]. During abrasion the materials having PVC coating experience the loss of thickness up to 0.6 % and the loss of weight up to 4 % after 30000 cycles. It was identified that cotton fibre materials coated with PU coating are twice more abrasion-resistant than analogical materials coated with epoxy resin. The result was that the contact angle of the material coated with PU coating does not change after abrasion cycles in the interval from 600 to 1000 [11]. It may be mentioned that during the exploitation even composite materials of very high quality grow old and weaken like all other materials. Even inconsiderable permanent fatigue can considerably reduce strength, change qualities of laminated leather and shorten the duration of product exploitation [14]. Surface changes can be estimated using optical microscope and the material weight loss. Water drop contact angle reduces when the roughness of material surface increases. During exploitation products may be washed, so they are affected not only by multi-fold mechanical but also by chemical effects. It was evaluated that the biggest changes increase after first five washing cycles when water drop contact angle decreases up to 20 % [8]. The review of scientific literature has shown that hydrophobic properties of materials are important for protective products. Depending on the particularity of work, materials are affected by various mechanical effects and these have different influence on the properties of materials. However, there are not more wide researches which would evaluate the influence of different mechanical effects on the hydrophobic properties of coated textile materials.

The aim of the research is to examine and evaluate the influence of fatigue and abrasion on the hydrophobic properties of coated textile materials.

MATERIALS AND METHOD

In this research six samples of commercial protective textile were investigated. These materials are used for protective clothing as rain coat. Their characteristics are presented in table 1.

Surface density of the investigated materials was estimated according to the standard *LST EN 12127: 1999* using electronical scales *KERN EG (error ± ± 0.001 g)*.The thickness δ of the specimens was measured using a thickness gage *Schmidt* (error ± ± 0.01 mm), the pressure of pressing was p = 1.0 kPa. The coefficient of variation did not exceed 2 %.

To evaluate hydrophobicity the method of drop contact angle measuring is used. One drop of distilled water is applied with a pipette on the surface of the investigated specimens and it is photographed in 20 s using a chronometer. According to the scientific research it is optimal time during which the applied drop forms itself the best [4, 12]. A digital camera

Table 1

THE CHARACTERISTICS OF INVESTIGATED FABRICS

Material code	Fibre content of materials	Weave type	Surface density, g/m²	Fabric thickness δ, mm, at pressure of 0.196 MPa	Threads density, cm^{-1}	
					wale direction	course direction
M1	63% PU, 37% PA	Double jersey	142	0.38	14.0	17.0
M2	40% PU, 60% PA	Double jersey	212	0.56	11.0	10.0
M3	40% PU, 60% PA	Double jersey	234	0.58	10.0	10.0
M4	90% PVC, 10% PES	Weft knitted	301	0.52	16.0	20.0
M5	92% PVC, 8% PES	Weft knitted	577	0.65	10.0	10.0
M6	92% PVC, 8% PES	Weft knitted	599	0.78	16.0	18.0

Notes: the names of fibres and their abbreviations are presented according to standard LST ISO 2076:2000: PES – polyester, PA – polyamide, PVC – polyvinyl chloride, PU – polyurethane.

Samsung 5 MP was used and its resolution is 2560 × 1920 mega pixels. The centre of the camera object glass is at the same level as the plane of the photographed material. The distance from the object glass to the specimen is 10 centimetres. Six tests were performed using each tested material and the coefficient of variation of drop contact angle did not exceed 1.0 %. Cycle fabric fatigue that imitates bending, flexing and stretching was performed using equipment *IPK 2M*. According to the standard *ISO 7854* textile fabrics coated with rubber or plastic have to withstand 7500 cycle fatigue and remain unchanged so in order to estimate fabric resistance against cycle fatigue the specimens were fatigued using 3000, 6000, 7500, 9000, 12000 and 15000 cycle mode. The specimens were fatigued in wale and course directions. All specimens were tested when polymer film was on top. Fabric surface abrasion was measured using equipment *УГН-1*. Considering the purpose of fabric and thickness 30.0 N force loads to the specimen was chosen because abrasion is done between the two layers of the same fabric. Such abrasion method was chosen considering the interactions between the components of the product during exploitation. These loads were chosen in order to imitate intensive wearing conditions that are usually characteristic feature of outdoor clothes. 2000, 3000, 7000, 8000, 9000 and 15000 abrasion rotations were chosen to do the test. The number of abrasion rotations was chosen according to *LST EN ISO 5470-2: 2003,* here rubber and plastic coated fabrics have to withstand 7000 abrasion rotations. All specimens were tested when polymer film was on top and had contact with abrasion equipment.

RESULTS AND DICUSSIONS

The influence of cycle fatigue on the hydrophobic properties of coated materials

Analysing the influence of cycle fatigue on coated materials it was noticed that their hydrophobic properties changed marginally. After the first 3000 cycle fatigue in wale and course directions the contact angle change of the specimens was ~0.5 %. It should be mentioned that after 7500 fatigue cycles contact angle decreased from 0.75 % to 2 %. The specimens that weathered the biggest chosen fatigue also remained quite hydrophobic i.e. contact angle decreased from 2 % to 6 %. Slight decrease of the results is seen while increasing the number of fatigue cycles. It was found that after 15,000 cycles fatigue contact angle decreased by 4 %. The hardest material M6 is the most hydrophobic of the investigated ones. The control specimen of this fabric had 92.12° contact angle. The surface of the materials with the contact angle that is more than 90° is very hydrophobic [18]. Contact angle slightly – up to 89.50° decreased after the biggest 15,000 fatigue cycles (the variation is ~3 %). It may be mentioned that the contact angle of the materials which were fatigued in wale direction similar measurements are observed. Contact angle of material M1 after the biggest chosen 15,000 fatigue cycles decreased by 5 %. Material M6 contact angle after cycle fatigue and changed by 3 % (figure 1).

From the obtained results we can see that the surfaces of materials M5 and M6 that were coated with PVC are the most hydrophobic of all the investigated surfaces. Material M1 had the lowest hydrophobicity; this material is the thinnest of the investigated materials. Contact angle slightly decreases when the number of fatigue cycles is increased. Linear correlative

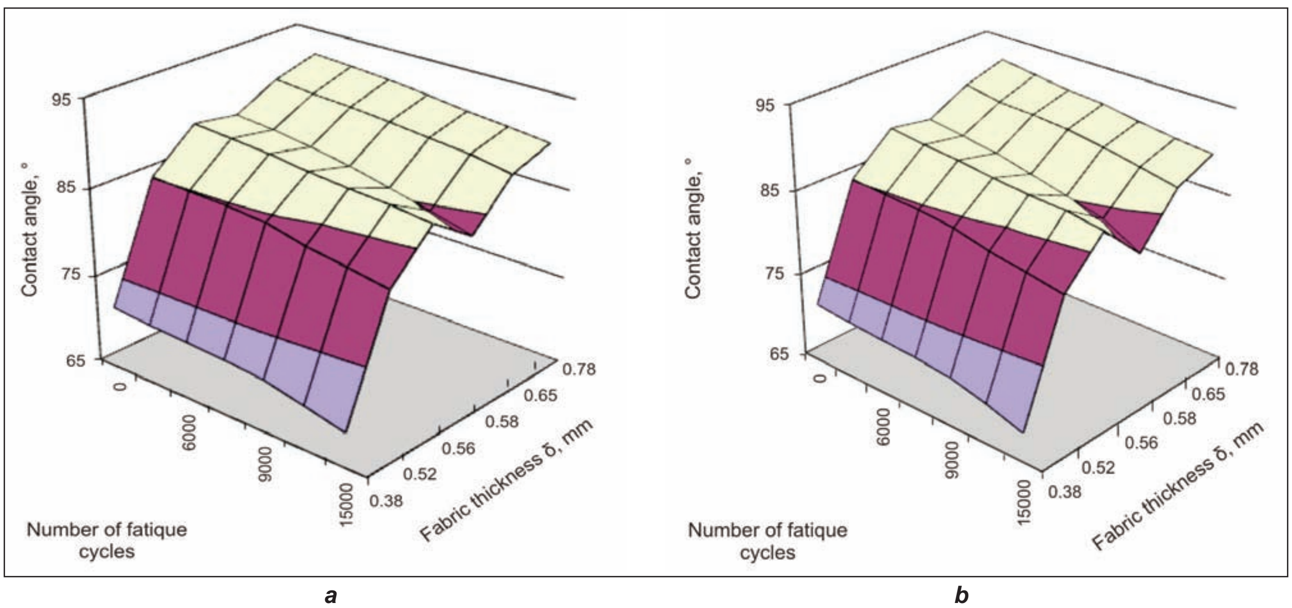


Fig. 1. The dependence upon coated material fabric thickness and the number of fatigue cycles: *a* – in the course direction, *b* – in the wale direction, when – 65°–75°, – 76°–85°, – 86–95°

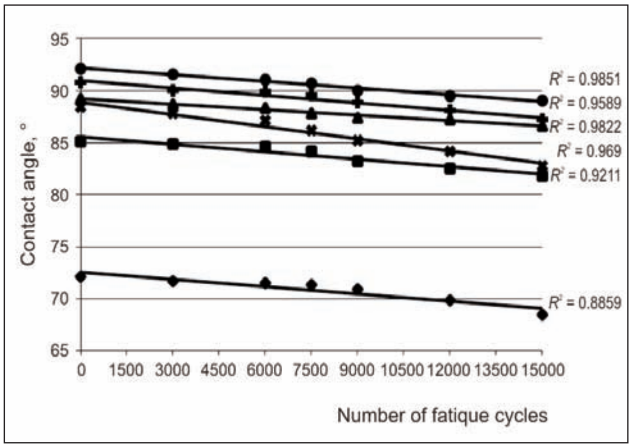


Fig. 2. The influence of fatigue cycle number on the variation of water drop contact angle in coated materials, when ■ – M1, ◆ – M2, ▲ – M3, ✖ – M4, ✚ – M5, ● – M6

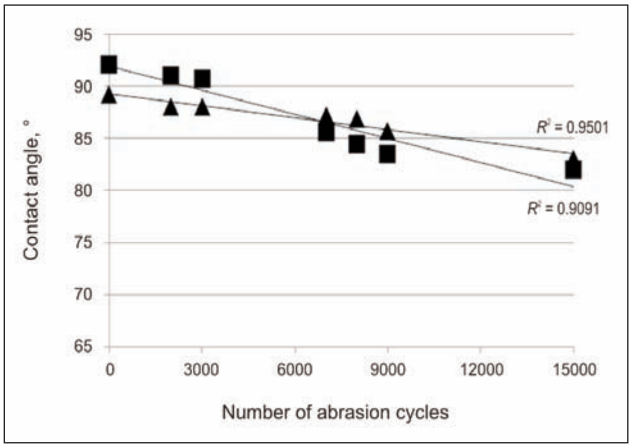


Fig. 3. Contact angle dependence on the number of abrasion cycles for materials M3 and M6, when ▲ – M3, ● – M6

dependence is observed in all coated materials that were affected by fatigue both in the course and wale directions. As it can be seen from figure 2 surface hydrophobic capacity slightly decreases when the number of fatigue cycles is increased.

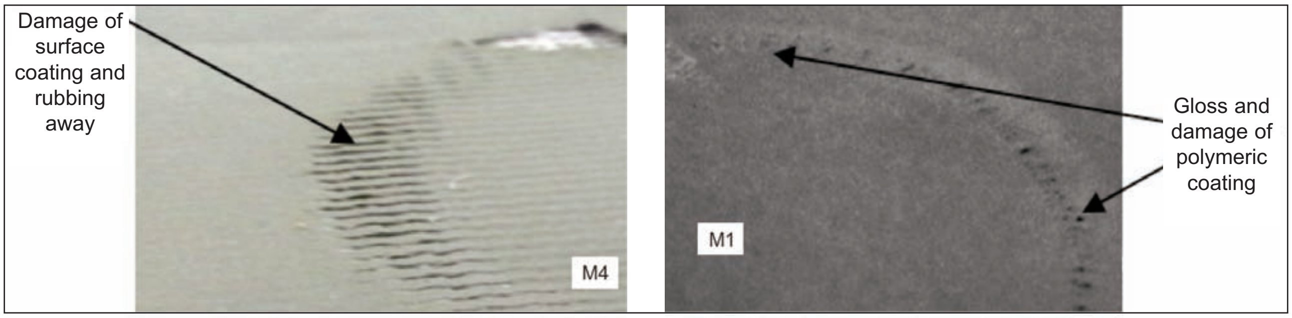
The coefficient of correlation changes in very narrow interval after different number of fatigue cycles to the specimens in the wale direction. It may be mentioned that from the obtained results we can see that cycle fatigue did not have any significant influence on the surface hydrophobic capacity of specimens. Even after the biggest chosen 15,000 cycles fatigue the properties of the investigated materials did not change significantly, i.e. the surface of coated materials that were folded remained hydrophobic and no changes in coating were noticed. While investigating the influence of cycle fatigue on PU micro pore coating it was determined that almost did not have any impact on the strength of PU film while increasing the number of folding cycles from 100,000 to 500,000 when the temperature was 20 °C. Any notable cracks or surface damage was not noticed [19]. While wearing different parts of clothing are deformed in various directions and with cycle folding of different frequency and intensity, so it is relevant to take into account the direction of material components [20]. Clothing components should be orientated in course direction in those places where folding and extension deformations are more intensive.

The influence of abrasion on the hydrophobic qualities of coated fabrics

The hydrophobicity of the all materials was investigated by measuring the variation of contact angle after abrasion. It was obtained that materials with thicker polymer layer and bigger surface density (M3 and M6) are more resistant to mechanical effect such as abrasion. It must be mentioned that correlative dependence of water drop contact angle change on abrasion cycle number for the materials with PU and PVC coating as typical materials are presented in figure 3.

Roughness of coating and first destructions appeared of material M4 after 2000 cycles abrasion and as it can be seen from after 3000 cycles of abrasion the coating of material M4 was damaged and it crumbled (figure 4, a). Coated material M1 became glossy and had small changes in surface structure (figure 4, b).

When bigger abrasion was applied, the number of cycles for materials M5 and M2 correspondingly 9000 and 8000 abrasion cycles, first surface coating damage was noticed – there was gloss and roughness in some places. Contact angle after abrasion was measured and it was found that hydrophobic



a *b*

Fig. 4. Surface damage after abrasion: *a* – material M4, *b* – material M1

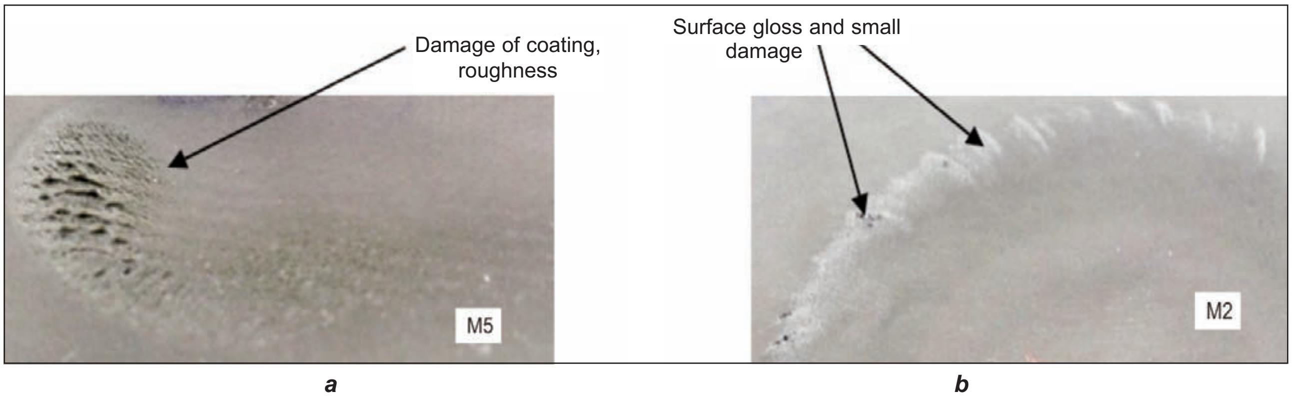


Fig. 5. Surface damage after abrasion: *a* – material M5, *b* – material M2

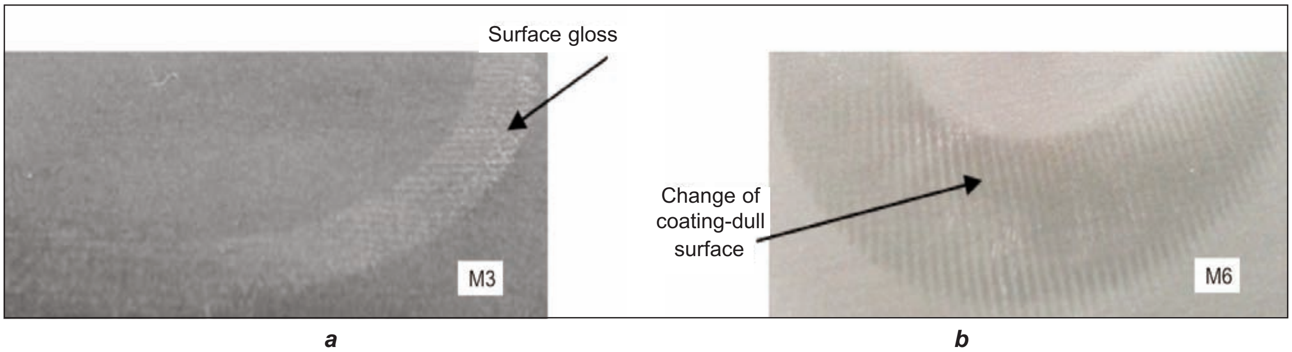


Fig. 6. Surface damage after abrasion: *a* – material M3, *b* – material M6

capacity decreased correspondingly to 13 % and 16 %. Materials M3 and M6 could withstand 15,000 abrasion cycles and their upper surface layer did not change. Materials M5 and M2 are more resistant against abrasion, they became flaked after 9000 and 8000 abrasion cycles (figure 5, a, b).

It must be mentioned that after estimating thickness and surface density of the materials the materials with PU coating are more resistant against abrasion than the materials with PVC coating. According to the standard (*ISO 5470-2*) the materials with polymeric coating have to withstand 7000 abrasion cycles. However, only materials M2, M3, M5 and M6 could withstand this effect, so further only the analysis of hydrophobic quality changes in these materials are presented. While testing materials M2 and M5 which could withstand 8000 and 9000 abrasion cycles it was observed that material M5 with PVC coating that is thicker was more resistant against abrasion than material M2 with PU coating (figure 3). Smaller change of hydrophobic capacity was seen in material M5. After 8000 abrasion cycles contact angle changed about 11 %. The wettability of material M2 that is coated with PU coating increased about 16 % after 8000 abrasion cycles. Greater hydrophobic capacity remained for material M3 after 15,000 abrasion cycles, M3 is coated with PU coating (contact angle decreased by 7 %). Hydrophobicity of material M6 decreased more, i.e. by 11 % though this material is thicker and has bigger surface density. Two materials (M3 and M6) had the smallest damage after abrasion, they could withstand 15,000 abrasion cycles. The rubbed surface of material M3 became a bit glossy but was not rubbed through, and change of surface coating is seen in material M6, i.e. it became dull in the place of abrasion (figure 6 a, b).

It is evident from results, the abrasion action had been done it was ascertained that thicker materials with bigger surface density are more resistant against abrasion. Polymeric coating has impact on surface damage as well. The surface of materials coated with PU becomes harder during abrasion and gloss appears. The surfaces of materials with PVC coating roughness and the coatings rub away and become flaked faster. The influence of the maximum number of abrasion cycles on the durability on coated materials is given in figure 7.

From the obtained results we can see that thickness of material, surface density and the type of polymeric coating have impact on abrasion. Material with PVC coating could sustain smaller number of abrasion cycles than material coated with PU – it is thinner and has smaller surface density. As evident from research, the materials coated with PVC are less resistant against abrasion than the materials with PU coating.

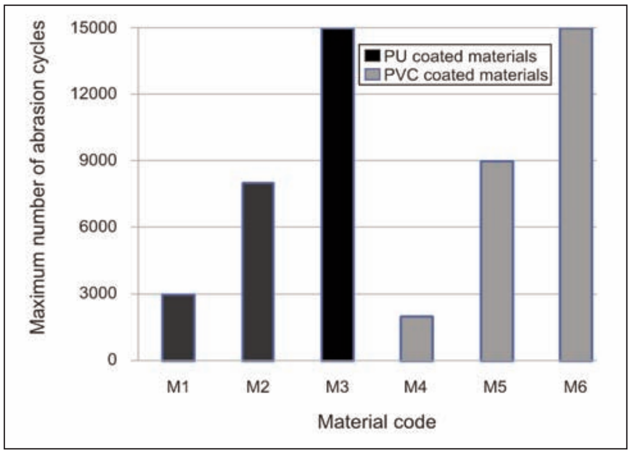


Fig. 7. Influence of the maximum number of abrasion cycles on the durability on coated materials: ● – PU coated materials, ● – PVC coated materials

CONCLUSIONS

The experimental study presented in this paper was focused on analysis of the mechanical effects (influence flexing fatigue and abrasion) on knitted coated fabrics hydrophobic properties.

As it is known, different clothing parts are deformed in various directions during the wearing time and with cycle bending of different frequency and intensity therefore it is relevant to pay attention at the direction of material in clothing parts. During the fatigue the drop contact angle decreased up to 3.4 %. After the largest number chosen 15000 fatigue cycles, contact angle of the material specimens decreased up to 6 %. In the places where bending and extension deformations are more intensive clothing parts should be oriented in the course direction. It was identified that resistance against abrasion depends not only on the type of polymeric coating but also on the thickness polymer layer. According to the obtained research results the material with PU coating is the most resistant against abrasion. Its hydrophobicity decreased by 7 % after 15,000 abrasion cycles. The material coated with PVC is also resistant against abrasion and after maximum abrasion remained hydrophobic. While choosing materials for a product it is necessary to estimate not only their hydrophobic properties, resistance against friction, extension and compression but also their surface density. It may be mentioned that the materials with bigger surface density and thickness polymer layer are more resistant against water permeability, abrasion and other deformations.

It is relevant that fabrics would be characterized as having sustained exploitation and retains protective functions after they had been used for a long time.

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An investigation on the thermal comfort properties of textiles fabrics made of cellulose-based fibers

OKSAN ORAL

REZUMAT – ABSTRACT

Studiu asupra proprietăților de confort termic al țesăturilor textile din fibre celulozice

În prezent, firele realizate din fibre celulozice naturale și artificiale sunt utilizate pentru obţinerea materialelor textile. Este deja evident că tipul de materie primă și structura țesăturii influențează proprietăţile de confort. În timpul proiectării unei țesături, proprietățile funcționale și parametrii structurali de bază ai țesăturilor trebuie să fie pe deplin înțeleși. Confortul îmbrăcămintei este strâns legat de confortul termic. Scopul acestei lucrări este de a prezenta comparativ proprietățile de confort termic, cum ar fi: rezistența, conductivitatea şi absorbtivitatea termică, permeabilitatea la vapori de apă, permeabilitatea la aer, precum și alte proprietăți, ale ţesăturilor din fire de bumbac, tencel, modal și cupro. Probele au fost testate cu ajutorul dispozitivelor Alambeta, Permetest, respectiv Textest FX3000. Rezultatele testelor au fost evaluate statistic și a fost determinat nivelul de importanță al relației dintre parametrii măsurați.

Cuvinte-cheie: permeabilitate la aer, țesătură celulozică, confort termic, rezistență termică, conductivitate termică, absorbtivitate termică, permeabilitate la vapori de apă

An investigation on the thermal comfort properties of textiles fabrics made of cellulose-based fibers

Yarns made of natural and man-made cellulose fibers are nowadays commonly applied in textiles. It is already apparent that the type of raw material and fabric structure influences the properties of the comfort. While designing a fabric, functional properties and basic structural parameters of fabrics must be fully understood. Clothing comfort is closely related to thermal comfort. The aim of this paper is to present a comparative of thermal comfort properties such as thermal resistance, thermal conductivity, thermal absorptivity, water vapour permeability, air permeability, and other properties for fabrics made of cotton, tencel, modal and cupro yarns. Samples were measured with the aid of Alambeta, Permetest, and Textest FX3000 devices respectively. The results of the tests were evaluated statistically and the importance levels of the relationship between the measured parameters were determined.

Keywords: Air permeability, cellulose fabric, thermal comfort, thermal resistance, thermal conductivity, thermal absorptivity, water vapour permeability.

INTRODUCTION

The main function of clothing is to protect the wearer from cold and heat. Clothing should also ensure appropriate heat transfer between the human body and its environment in order to maintain the physiological thermal balance of the wearer. Since it was found that a large portion of total comfort is thermal comfort, the heat transfer characteristics of textile fabrics are very important in textile comfort evaluation [1]. Clothing comfort is closely related to thermal comfort [2].

The acceptability of a textile fabric largely depends on the comfort aspects which involve thermal properties, air permeability and water vapour permeability. Although a plethora of researches have been conducted on the mechanical properties of textile fabrics, they have hardly played any role during the actual use of the fabrics. In contrast, comfort properties determine the way in which the heat, air and water vapour are transmitted across the fabric. Thermal comfort properties of textile fabrics are actually influenced by fiber, yarn and fabric properties. The type of fiber, spinning technology, yarn count, yarn twist, yarn hairiness, fabric thickness, fabric cover factor, fabric porosity and finish are some of the factors, which play decisive role in determining the comfort properties of fabrics [3].

The most important parameter that determines the comfort of a cloth is the material, so fiber type is the most effective parameter in defining the comfort of the end-product. Fiber content is the ratio of presentation of different type of fibers in textile production. This factor determines the moisture absorbency which in turn affects the thermal balance of the product, the moisture vapour and liquid permeability, the durability and the electrostatic properties in particular and all the other aforementioned properties of textile material in general [4].

Clothing with good thermal comfort has an efficient role in maintaining the heat and moisture balance of a person by transferring the heat and moisture of body that change under different atmospheric conditions and/or during different activities [5].

While designing a fabric, functional properties and basic structural parameters of fabrics must be fully understood [6]. A fabric consists of fibers and air. The still-air amount in fabric is more important than the fiber amount when thermal resistance is considered; still-air provides more thermal resistance in comparison to a great number of textile fibers. Regarding this matter, the amount of still-air within the structure of knitted fabrics played an important role in terms of the thermal properties of fabric [7, 8].

The aim of this paper is to present a comparative of thermal comfort properties such as thermal resistance, thermal conductivity, thermal absorptivity, water vapour permeability, air permeability, and others properties for fabrics made of cotton, tencel, modal and cupro yarns.

The effect of different materials and fabric constructions on the thermal properties was investigated by various researchers.

Frydrych analysed thermal insulation properties (such as thermal resistance, thermal conductivity, thermal absorptivity) of fabrics made of cotton and tencel [9]. It was observed that the finished fabrics made of tencel yarn showed lower values of thermal conductivity and thermal absorption than fabrics made of cotton yarns, and higher values of thermal diffusion and resistance. The influence of the type of weave on thermal properties was observed for all fabrics made of cotton and tencel.

Majumdar investigated the thermal properties of different knitted fabric structures made from cotton, regenerated bamboo and cotton-bamboo blended yarns [4]. It was found that the thermal conductivity of knitted fabrics generally reduces as the proportion of bamboo fiber increases. For the same fiber blend proportion, the thermal conductivity was lower for fabrics made from finer yarns. The thermal conductivity and thermal resistance values of interlock fabric was the maximum followed by the rib and plain fabrics. The water vapour permeability and air permeability of knitted fabrics increase as the proportion of bamboo fiber increases. The air permeability and water vapour permeability values were higher for plain fabric as compared to those values of rib and interlock fabrics.

Stankovic studied knitted textile fabrics which are made of hemp, cotton, and viscose yarns [2]. The thermal properties and the properties closely related to the thermal behavior of fabrics (porosity and air permeability) were investigated. The results obtained indicate that heat transfer through the fabrics is highly related to both capillary structure and surface characteristics of yarns (a continuous package of short fibers), as well as air volume distribution within the fabrics.

Ozdil studied thermal comfort properties of the socks knitted with the most popular fibers such as wool, acrylic, cotton, and PA [10]. The results show that thermal conductivity values of wool socks are lower than acrylic socks. Thermal resistance values of wool-acrylic socks are higher than 100% acrylic socks and give warm sense at first contact. The socks which contain PA fibers give high thermal conductivity and thermal absorptivity values.

Cubric [8] studied thermal resistance of 33 single jersey knitted fabrics. It is observed a strong correlation between the thermal resistance of the knitted fabric and thickness, mass per unit area, cover factor and prosity. The results showed that the correlation of fiber conductivity and the resistance of the knitted fabric to heat transfer is small (R = 0.32). It is to conclude that the air entrapped in the knitted fabric structure plays a prevalent role for thermal resistance of that kind of products.

Ramakrishnan compared the properties of the knitted fabrics made out of micro denier and normal denier viscose yarns and investigated the physical, mechanical, comfort properties of them. It is concluded that micro denier fabrics have shown soperior properties when compared to normal denier fabrics in various aspects of physical, mechanical, comfort properties [11].

Utkun studied 4 different fabrics which were manufactured by utilizing cotton, tencel, bamboo, modal yarns and Dri-release yarn [7]. Thermal comfort properties of these fabrics were analyzed. As it is obvious from the results, high-comfort fabrics can be manufactured by using cotton and Drirelease yarns.

The fibers used in the study

COTTON: Cotton fibers are natural hollow fibers; they are soft, cool, known as breathable fibers and absorbent. They are strong, dye absorbent, its hygiene property, and can stand up against abrasion wear and high temperature. In one word, cotton is comfortable. Cotton fiber is used especially in underwear and active-wear manufacturing [1, 12].

MODAL: Modal is a fiber obtained from the cellulose of beech. It is the trademark of Lenzing. The most prominent feature of this fiber is that it is soft and radiant. Among the other properties, its low fiber hardness, smooth fiber surface, low yarn imperfection, high strength, natural softening material content and high chroma can be listed [13].

TENCEL: Tencel is a natural, man-made fiber. It is produced from natural cellulose in wood pulp. It has good moisture absorbency, comfort, luster and biodegradability [14]. Its most prominent feature is that it is soft due to its smooth fiber structure, that it is high-strength and that it provides quite high water absorption [7].

CUPRO: Cupro is a genererated cellulosic fiber produced from cellulose dissolved in a mixture of copper sulfate and ammonia, called cuprammonium liquor. The raw materials used are cotton linters and wood pulp [15]. This fiber is valuable and high performance. Biodegradation rate of the fiber is very fast. Cupro yarn is softer and smoother than cotton yarn. It brings the best features of both natural and synthetic fibers and cupro fabrics are very evident with their silky feeling even at the very first touch. The fabric is very soft and smooth and is skin friendly.

MATERIAL AND METHOD

In this research, thermal comfort properties of single jersey structures which were knitted appropriate machine settings using 100% cotton, 100% modal, 100% tencel, and 100% cupro yarns were studied. All of yarns were Ne 30/1, ring.

Alambeta instrument was used to measure thermal conductivity, thermal resistance and thermal absorptivity values [16]. Relative water vapour permeability was measured on Permetest instrument by similar procedure as given by the ISO 11092 [17]. The number of measurements is five for Alambeta and 3 for Permetest. All of the fabric samples were conditioned by keeping under standard atmospheric conditions (20 ± 2°C temperature and 65% ± 5 relative humidity) for 24 hours before the experimental studies and the contact pressure was 200 Pa in all cases. The CV values of all samples are lower than 3%.

Air Permeability tests of the samples were carried out by using a Textest FX3000 testing machine in accordance with ISO 9237 standard specifications [18]. The number of measurements is ten for Textest FX3300 (pressure was 100 Pa, measured area was 20 cm²) and their average values were calculated.

Porosity values were calculated using the equation given below.

$$P = (1 - m/\rho \cdot h)\,100 \quad (1)$$

where P = porosity, m = fabric weight (g cm^{-2}), ρ = fiber density (g cm^{-3}) and h = fabric thickness (cm) [10].

The data obtained were analyzed by utilizing the SPSS 23.0 statistical package software. To determine the statistical importance of the variations, ANOVA tests were applied. To deduce whether the parameters were significant or not, p values were examined. If p value of a parameter is greater than 0.05 ($p > 0.05$), the parameter will not be important and should be ignored.

RESULTS AND DISCUSSIONS

The fibers used in the study, yarn number, fabric thickness and fabric weight are given in table 1. The results on the thermal properties, relative water vapour permeability, air permeability, fabric thickness and porosity are given in table 2.

The results of Anova Test "p-significance level" are given in table 3.

According to statistical evaluation, the differences between thermal conductivity values of the fabrics knitted with cotton, modal, tencel, and cupro yarns were statistically significant. Thermal conductivity values of fabrics were compared and it was found that thermal conductivity of cotton fabrics higher than the others. As cotton fabric had the lowest porosity in this four fibers, it is obvious that it had high thermal conductivity (figure 1).

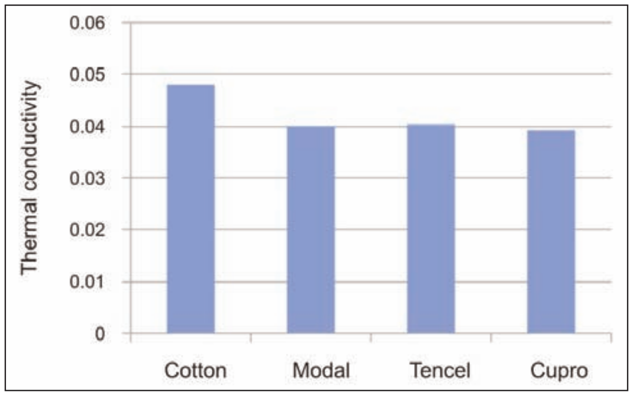

Fig. 1. Thermal conductivity values of fabrics

Table 1

FABRIC PROPERTIES			
Material	**Yarn number**	**Fabric thickness (mm)**	**Fabric weight (g/m^2)**
100% Cotton	Ne 30/1	0,644	125,8
100% Modal	Ne 30/1	0,554	105
100% Tencel	Ne 30/1	0,668	105,6
100% Cupro	Ne 30/1	0,629	102,5

Table 2

THERMAL COMFORT PROPERTIES OF THE DIFFERENT FABRICS							
Material	**Fabric thickness (mm)**	**Porosity (%)**	**Thermal conductivity (Wm^{-1}K^{-1})**	**Thermal resistance (m^{2}KW^{-1})**	**Thermal absorptivity (Ws^{½}m^{-2}K^{-1})**	**Water vapour permeability (%)**	**Air permeability (l /m^2/s)**
100% Cotton	0,644	87,23	0,048	0,01343	126,6	59,5	1729
100% Modal	0,554	87,61	0,04	0,013872	125,400002	61,76	2944
100% Tencel	0,668	89,46	0,0404	0,016512	120,42	61,02	2855
100% Cupro	0,629	89,34	0,0394	0,015966	105,859999	63,44	3458

Table 3

STATISTICAL SIGNIFICANCE VALUES					
p	**Thermal conductivity**	**Thermal resistance**	**Thermal absorptivity**	**Water vapour permeability**	**Air permeability**
p	0.000*	0.001*	0.001*	0.351	0.000*

* p < 0.05 it is significant

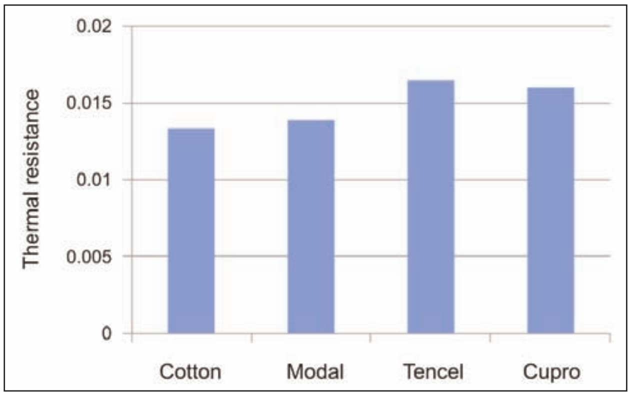

Fig. 2. Thermal resistance values of fabrics

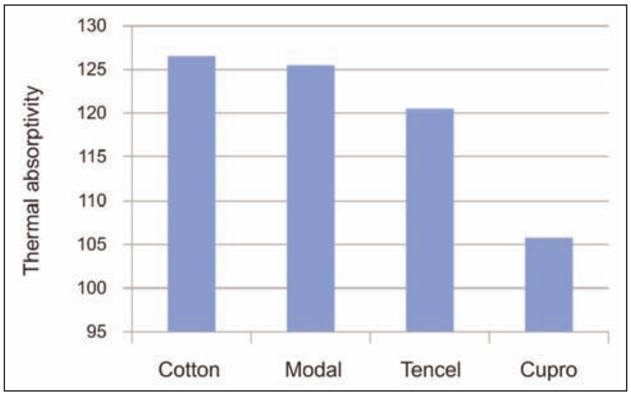

Fig. 3. Thermal absorptivity values of fabrics

Given the results in terms of thermal resistance, differences in thermal resistance values were statistically significant. Tencel fabric had the highest value. As the fabric thickness increases, the thermal resistance increases (figure 2).

When thermal absorptivity was investigated, differences between thermal absorptivity values of the fabrics were statistically significant. It was found that the thermal absorptivity values of the cotton was the highest and cupro's was the lowest (figure 3).

Statistical evaluation shows that differences between water vapour permeability values of fabrics weren't statistically significant.

When the results were analyzed in terms of air permeability, it was seen that differences between fabrics were statistically significant. In these four fabrics, cupro fabric had high porosity and low thickness, so it indicated the highest air permeability value. It is seen that cotton which had the lowest porosity and high thickness, had the lowest air permeability value all of them (figure 4).

CONCLUSIONS

On the basis of the results obtained, it is seen that there are many possibilities for creating fabric properties which influence their comfort of use.

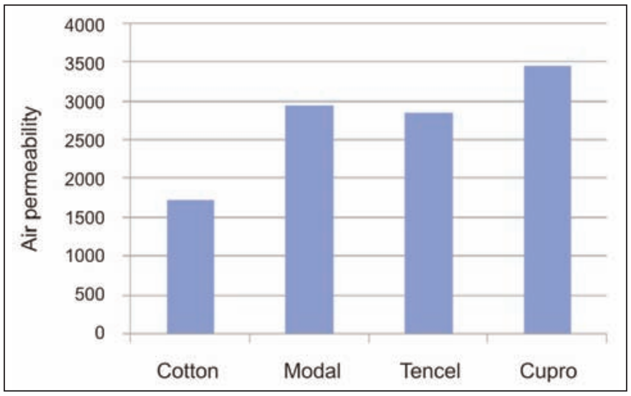

Fig. 4. Air permeability values of fabrics

The greater the thermal conductivity, the greater heat transmission from the skin to the fabric. The cotton sample gave the highest values in this category, and the cupro sample had the lowest values.

Thermal absorption is related to thermal resistance. The increase in thermal absorption of textile materials leads to a cold feeling at first touch. Among the samples, cupro sample gave the lowest, whereas cotton gave the highest results. The order of the samples from the lowest to the highest in terms of thermal absorption is: cupro, tencel, modal, and cotton.

Water vapour permeability is the ability of fabric to transfer water vapour in percentage scale. Especially, for products which are used in hot weather or for active sports when perspiring is maximal, water vapour permeability is one of the most important comfort parameters. Garments which have high water vapour permeability feature can easily ensure evaporation of moisture from body after sweating and enhance the sense of comfort [19].

Air permeability is a hygienic property of textiles which influences the flow of gas from the human body to the environment and the flow of fresh air to the body. Air permeability depends on fabric porosity, which means the number of canals in the textile fabric, its cross-section and shape. Thermal properties are essentially influenced by air permeability [9]. As the air permeability and water vapour permeability of cupro are high, it can be used in sportswear.

Cupro is a fiber which has been used recently. Because its comfort properties are excellent, the use of cupro is increasing day by day. Cupro fabrics can be used both in summer and winter. This fiber is considered as an alternative fiber to cotton and regenerated cellulose fibers.

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Emergency vascular access through a cuffed iliac vein catheter. A report of 2 cases

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REZUMAT – ABSTRACT

Accesul vascular de urgență printr-un cateter venos iliac tunelat. Raport cu 2 cazuri

Context: *Crearea și menținerea unui acces vascular funcțional este crucială pentru pacienții cu boli de rinichi în fază terminală (ESKD), care necesită hemodializă cronică. Pentru pacienții care au epuizat opțiunile convenționale de acces vascular și care nu se încadrează la dializă peritoneală sau care au avut cateterul peritoneal scos din cauza complicațiilor, utilizarea locurilor de acces pentru dializă neconvențională pentru cateterul intravascular reprezintă singura opțiune până când va avea loc transplantul renal. Se prezintă 2 cazuri în care a fost creat un acces vascular de urgență neconvențional.*

Raport de caz*: Cazul 1: Bărbat în vârstă de 60 de ani, cu ESKD pe hemodializă de menținere din august 1992. Pacientul a avut un istoric îndelungat de acces dificil la dializă, cu eșecul ambelor fistule și cateter tunelat. A fost efectuată o operație de urgență la câteva ore după ce pacientul a fost spitalizat și i s-a introdus un cateter tunelat în vena iliacă comună, pe partea dreaptă. Pacientul s-a recuperat fără complicații. Cateterul este încă funcțional în momentul scrierii acestui articol (872 zile).*

Cazul 2: femeie în vârstă de 58 de ani, cu ESKD, pe hemodializă de menținere din mai 2009. Pacientul a avut un istoric de acces dificil la dializă, cu eșecul ambelor fistule și cateter tunelat. A fost introdus un cateter tunelat în vena iliacă externă dreaptă. Pacientul s-a recuperat fără complicații. Cateterul este încă funcțional în momentul scrierii acestui articol (500 de zile).

Concluzie: *Cateterele tunelate pentru vena iliacă reprezintă un loc fezabil de acces vascular și trebuie să fie luate în considerare atunci când alte locuri tradiționale nu mai sunt disponibile.*

Cuvinte-cheie: raport de caz, cateter tunelat pentru vena iliacă, acces vascular, hemodializă

Emergency vascular access through a cuffed iliac vein catheter. A report of 2 cases

Background: *Creating and maintaining a functional vascular access site is crucial for patients with end stage kidney disease (ESKD), that require chronic hemodialysis. For those patients who have exhausted conventional vascular access options, and that are not candidates for peritoneal dialysis, or that had the peritoneal catheter removed due to complications, the use of nontraditional dialysis access sites for intravascular catheters is the only option while awaiting renal transplantation. We present a series of 2 cases in which a nontraditional emergency vascular access was created.*

Case report*: Case 1 a 60 years old male, with ESKD on maintenance hemodialysis since August 1992.The patient had a long history of difficult dialysis access with failure of both fistulas and cuffed catheters. We performed emergency surgery a few hours after the patient was admitted and inserted a cuffed catheter in the right common iliac vein. The patient recovered without any complications. The catheter is still functional at the time this article was written (872 days)*

Case 2: 58 years old female, with ESKD on maintenance hemodialysis since May 2009.The patient had a history of difficult dialysis access with failure of both fistulas and cuffed catheters. We inserted an external right iliac vein cuffed catheter. The patient recovered without any complications. The catheter is still functional at the time this article was written (500 days)

Conclusion*: Cuffed iliac vein catheters are a feasible vascular access site and should be considered when other traditional sites are no longer available*

Keywords: case report, iliac vein cuffed catheter, vascular access, hemodialysis

INTRODUCTION

Creating and maintaining a functional vascular access site is crucial for patients with end stage kidney disease (ESKD) that require chronic hemodialysis.The first choice in creating the vascular access is the radio-cephalicarterio-venous fistula [1]. According to the Dialysis OutcomesQuality Initiative (DOQI) guidelines, peripheral arteriovenous (AV) fistulas or grafts are the preferred type of access [2]. The use of central venous catheters for chronic hemodialysis is being discouraged. It is well known that compared to arteriovenous fistulas, central venous catheters have a greater risk of infection and bacteremia [3]. However in about 25% of the patients, peripheral vascular access is no longer obtainable, or it never was in the first place [4–5]. Central venous cannulation has proven to be more efficient via the internal jugular vein or the subclavian vein. Unfortunately the subclavian vein is prone to a higher incidence of failure because of thrombosis or stenosis, and if stenosis occurs it may prohibit the creation of an arteriovenous fistula to the ipsilateral arm [6]. Femoral catheters have a high risk of complications such as exit site infections, bacteremia, thrombosis or even life threatening embolism. Patients that are not suitable for hemodialysis, or for whom vascular access is no longer achievable have the option of peritoneal dialysis. The technique regarding the placement of the peritoneal catheter was improved when the laparoscopic approach was introduced [7–9].

For those patients who have exhausted conventional vascular access options, and that are not candidates for peritoneal dialysis, or that had the peritoneal catheter removed due to complications, the use of nontraditional dialysis access sites for intravascular catheters is the only option while awaiting renal transplantation. Among this nontraditional vascular access sites literature data acknowledges the following methods: cannulation of the innominate vein by surgically entering the superior vena cava, cannulation of the superior vena cava via right parasternal acces, cannulationof the small thoracic or neck collaterals, cannulation of the hepatic vein via the transhepatic route, cannulating the azygos vein via the percutaneous translumbar route, cannulating the renal vein via the percutaneous transrenal route, cannulating the aorta via the femoral artery, surgical cannulation of the inferior vena cava, intracardiac access [10–22]. Another alternative vascular access site is through the iliac vein [23–25]. In our report we present a series of two patients in which we created the vascular access through a cuffed tunneled iliac vein catheter.

CASE REPORTS

Case 1

The first patient was a 60 years old male, with ESKD on maintenance hemodialysis since August 1992. The patient had a long history of difficult dialysis access with failure of both fistulas and cuffed catheters. During 1992–2000 a total of 7 arteriovenous fistulas were performed on this patient with different patency rates, as follows (figure 1–3): On the right upper extremity: 2 radio-cephalic fistulas, one-brachio-cephalic fistula and one brachio-basilic fistula with transposition of the basilica vein. On the left upper extremity: 2 radio-cephalic fistulas were performed and one brachio-basilic fistula with transposition of the basilica vein. Since 2000 because the patient had no more peripheral venous capital, a peritoneal dialysis catheter was inserted laparoscopically.

Peritoneal dialysis lasted for almost 6 years (2000–2005). During these years the patient suffered 3 episodes of acute peritonitis, and in September 2005 the catheter was removed. Since September 2005 he was back on hemodialysis which was performed through a series of catheters, both temporary and permanent. He had 6 temporary catheters inserted and removed (one for each internal jugular vein, and 2 for each femoral vein) and 2 permanent catheters (one for each internal jugular vein). The patient was admitted on the 21st of August 2012 with no vascular access patent for 72 hours, and no hemodialysis performed for the past 3 days, and with symptoms of intestinal obstruction. The patient also had the following comorbidities: Hypertension, Anemia (Hb 10.2 g/dL, Ht 33.1%), Secondary hyperparathyroidism, Virus C Hepatitis, Hyperkalemia (K 8.5 mmol/L), Trombocytopenia (119000/mm^3). Biological blood samples also showed: creatinine 15.68 mg/dL, urea 223 mg/dL, INR 2.22.

Due to the patient's status, the fact that he had had no vascular access and no hemodialysis performed for the past 72 hours, and that he was having symptoms of bowel blockage, we performed emergency surgery a few hours after the patient was admitted. During these hours we also tried to insert a catheter but both the patients' internal jugular veins, and both femoral veins were not permeable due to stenosis or thrombosis. The patient was put under general anesthesia and we performed a median laparotomy revealing the cause of the bowel blockage to be adherential syndrome. The presence of the adherential syndrome also contraindicated the placement of a peritoneal dialysis catheter. After performing viscerolisis we decided to insert a hemodialysis catheter in the iliac vein. We dissected the left common iliac vein and the left external iliac vein. At the origin of the left common iliac vein and the last 3 cm of the left external iliac vein we detected a fibroses present which made the veins non-compressible, therefore making this veins non suitable for the placement of a dialysis catheter. We then dissected the right common iliac vein and the right external iliac vein. The

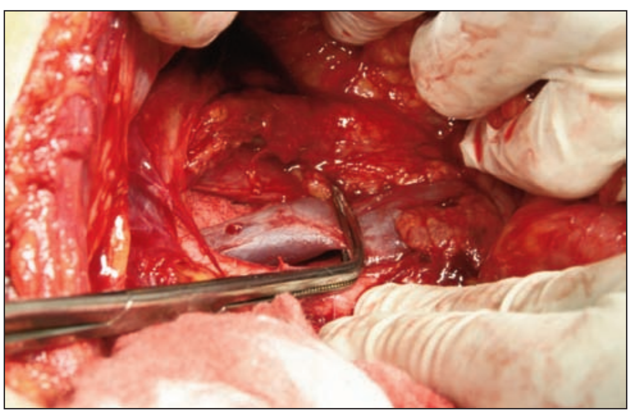

Figure 1

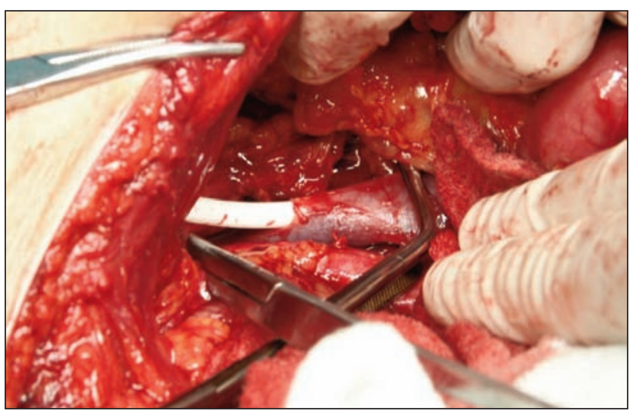

Figure 2

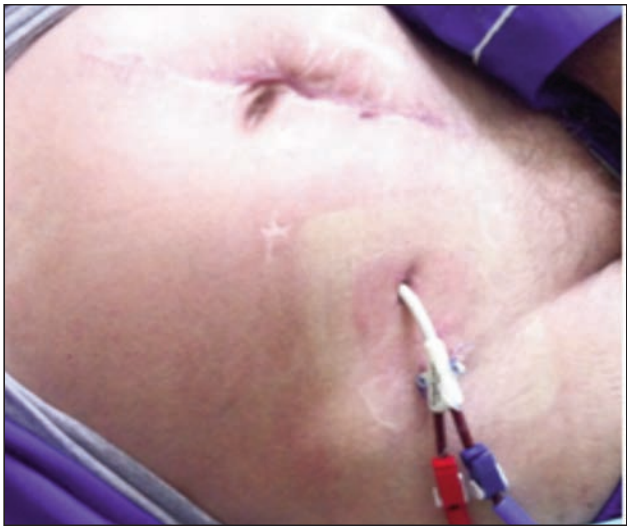

Figure 3

right common iliac vein was compressible, permeable, and showed no signs of stenosis or thrombosis. We then dissected it further separating it from the common iliac artery, clamped it at 2 cm above the internal iliac vein ending. Then we performed a 3 mm transversal venotomy and inserted the catheter. Prior to that a subcutaneous tunnel was performed and the catheter was pulled through the abdomen wall.After verifying that the catheter was functional we sutured the peritoneum so that the catheter is in fact retroperitoneal placed.After that a Douglas drainage was placed followed by abdominal wall closure. 30 minute after the surgery the patient began hemodialysis. The patient recovered without any complications, bowel movement restored 3 days after the surgery, and at the time of the discharge he had performed 8 hemodialysis sessions. The catheter is still functional at the time this article was written (607 days).

Case 2

The second patient was a 58 years old female, with ESKD on maintenance hemodialysis since May 2009. The patient had a history of difficult dialysis access with failure of both fistulas and cuffed catheters. During 2009–2013 a total of 3 arteriovenous fistulas were performed on this patient with different patency rates, as follows: On the right upper extremity: one brachio-cephalic fistula that was patent for 4 months. On the left upper extremity: one radio-cephalic fistula was performed and one brachio-cephalic fistula. The combined patency rate was 4 years. The patient also had a history of dialysis catheters that included: temporary jugular and femoral catheters, bilaterally, permanent cuffed subclavian and femoral catheters and since May 2013 hemodialysis was performed through a right subclavian cuffed catheter. The patient was admitted on the 28th of August 2013 with no vascular access patent for 72 hours, and no hemodialysis performed for the past 3 days.The patient also had the following comorbidities: Hypertension, Anemia (Hb 9,8 g/dL, Ht 30.4%), Hyperkalemia (K 6.6 mmol/L), right femoral vein thrombosis. Biological blood samples also showed: creatinine 8.45 mg/dL, urea 9 mg/dL, Na 139 mmol/L. Due to the patient's status, the fact that she had had no vascular access and no hemodialysis performed for the past 72 hours, the fact that she refused peritoneal dialysis and because all attempts at inserting another dialysis catheter were unsuccessful we performed emergency surgery with the intention of inserting a catheter in the iliac vein. The patient was put under general anesthesia and an umbilical-suprapubic incision was made. We than entered the retroperitoneal space and dissected the external right iliac vein. The vein was compressible and permeable and after clamping it we made a transversal 3 cm incision and inserted the catheter. Prior to that a subcutaneous tunnel was performed and the catheter was pulled through the abdomen wall. After verifying that the catheter was functional we sutured the peritoneum so that the catheter is in fact retroperitoneal placed. After that Douglas drainage was placed followed by abdominal wall closure. 30 minute after the surgery the patient began hemodialysis

The patient recovered without any complications, bowel movement restored 2 days after the surgery, and at the time of the discharge he had performed 5 hemodialysis sessions. The catheter is still functional at the time this article was written (313 days).

DISCUSSION

With the current shortage of donors for renal transplant, and due to the increased number of patients with ESKD that require dialysis, and considering that a large proportion of patients cannot perform peritoneal dialysis, obtaining and maintaining vascular access becomes crucial. The arterio-venous fistulas as described by Cimino and Brescia remains the first choice, but for the patients that can no longer have fistulas performed, vascular catheters remain their lifeline [26]. Cuffed tunneled right atrial cathetersinserted into the jugular or subclavian veins permit adequate blood flow for dialysis. The femoral veinsmay be used in situations where the jugular orsubclavian veins are not available. But where all these traditional vascular access sites are no longer patent untraditional sites have to be considered. The iliac veins, as shown in literature data can provide feasible vascular access [23, 24, 25].

We chose this type of access for our 2 patients and managed to obtain good vascular access followed by a long patency rate. Considering the status of the patients on admittance we preferred to insert this catheters through a surgical approach, minimalizing the risk of complications such as: perforation of the peritoneum, bowel perforation, uncontrollable hemorrhage, perforation of the iliac artery. Cuffed iliac vein catheters are a feasible vascular access site and should be considered when other traditional sites are no longer available.

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Real-time virtual clothes try-on system

MEHMET DAYIK
OĞUZ ÇOLAK
HAKAN YÜKSEL

REZUMAT – ABSTRACT

Sistem virtual de probare a îmbrăcămintei în timp real

Probarea virtuală a intrat recent în atenția cercetătorilor datorită potențialului său comercial. Aceasta poate fi folosită ca un instrument eficient în cumpărăturile on-line, permițând utilizatorilor să-și restrângă opțiunile la câteva modele și dimensiuni. În acest studiu, a fost propus un sistem virtual 3D real de probare a îmbrăcămintei, care le permite utilizatorilor să-și poată vizualiza corpul pe un monitor virtual, purtând haine virtuale și fără a se dezbrăca de hainele reale. Instrumentul le permite, de asemenea, utilizatorilor să aleagă diverse articole de îmbrăcăminte pentru a le proba. Cel mai important aspect al acestei lucrări este că, prin utilizarea unui senzor de mișcare și de captură a scheletului, sunt calculate dimensiunile corpului utilizatorului. Prin compararea dimensiunilor corpului calculate cu măsurătorile din standardele pentru dimensiunile corpului, dimensiunea corpului utilizatorului poate fi estimată cu ajutorul unui sistem expert, iar aceste date sunt utilizate pentru o ajustare corespunzătoare pe corp și pentru simularea îmbrăcămintei pe sistemul virtual de probare a îmbrăcămintei. Hainele sunt selectate printr-o mișcare a mâinii din lista de îmbrăcăminte de pe ecran, iar utilizatorii pot vizualiza, astfel, îmbrăcămintea aleasă prin afișare virtuală pe propriul lor corp. Acest studiu reprezintă o contribuție la literatura de specialitate actuală, oferind o abordare originală, care aduce o nouă perspectivă asupra scanării corpului, determinării dimensiunilor corpului și simulării îmbrăcămintei virtuale în sectorul de îmbrăcăminte.

Cuvinte-cheie: scanarea corpului, dimensiunea corpului, probare virtuală, grafică pe calculator, senzor Kinect

Real-time virtual clothes try-on system

Virtual clothes try-on has recently come into the researchers' focus owing to its commercial potential. It can be used as an efficient tool in online shopping, allowing users to narrow down their choices to a few designs and sizes. In this study, a real 3D virtual clothes try-on system is proposed, which makes it possible for users to see themselves on a virtual monitor, wearing virtual clothes without taking off their real clothes. The tool also allows users to choose various clothes to try on.

The most important point in this paper is that by using a motion and skeleton capture sensor, the user's body measurements are computed. By comparing the computed body sizes with the measurements in the body size standards, the user's body size can be estimated via an expert system and these data are used for proper clothes fitting and clothes simulation in our virtual try-on system. Clothes are selected by hand motion from the clothing list on the screen and users can thus view the clothing of their choice virtually displayed on their body. This study contributes to the current literature by offering an original approach, which brings a new perspective on body scanning, body determination and virtual clothing simulation in the clothing sector.

Keywords: body scan, body size, virtual try-on, computer graphics, Kinect sensor

INTRODUCTION

The widespread use of computers and the developments in information technology (IT) have caused important changes in everyday life. With the use of 3D technology and virtual reality techniques, IT has become popular in new fashion industry, featuring consumer-centered service and production methods. In recent years, due to the high production cost, the international market power of the fashion industry has lost its strength mostly. In order to find a solution for this problem, new markets should be built with technology-intensive fashion industry. Virtual clothing simulation software effected the fashion industry's IT-based digitalization positively and caused technological developments which have the potential to adapt existing 2D (two-dimensional) design work to 3D design work virtually. These changes have enabled the fashion industry to increase the profits [1].

Trying on clothes physically is a time-consuming process in retail shopping. Before making a decision about the color, size and design of clothes, the shopper wants to try on different clothes. Virtual try-on software solves this problem by speeding up the process and enabling users to see the clothes on their body without actually wearing them or by minimizing their choices before physical try-on. Also, it provides new features for users, such as comparing different clothes side by side and seeing the outfits from different angles simultaneously.

A literature overview allows highlighting some earlier systems based on image processing techniques. Cordier et al. (2001) described a framework for a web based solution using a generic database for dressing a user look-alike clothed avatar and simulating the clothes on the avatar [2]. Hilsmann and Eisert (2009) presented a dynamic texture overlay method in a virtual environment from monocular images for real-time visualization of garments in a "Virtual Clothing System". It consisted in taking the user's picture in minimum clothes and covering it with a picture of a model wearing desired clothes [3]. In their research, Thanh and Gagalowicz (2009) describe a system that provides users the possibility to load their own 3D model, choose 3D clothes from a list and superimpose them on the model interactively [4]. The work of Spanlang et al. (2004) was also based on the idea of superimposing a pre-generated 3D human model in target clothes on a user's 2D picture [5]. Another study reported a virtual clothing system, in which a user is scanned and registered to the system once, and then clothes can be simulated on the reconstructed model [6]. Li et al. (2011) implemented a web-based platform allowing interactive viewing of clothes simulation, as well as selection of different hairstyles and other accessories on a model [7].

In addition to these studies, some interactive virtual try-on solutions using new sensor technology have been recently reported. The requirement of accurate pose recovery for fitting virtual clothes on a user's image is a challenging problem in this technology [8–9]. The new generation of sensing technologies, which have the capacity of providing high quality videos of both color and depth, enable researchers to increase the capabilities of virtual try-on solutions [10–11]. Givonni et al. (2012) describes a virtual try-on system, which provides performance comparisons of their system with two skeletal tracking SDKs: Kinect and OpenNI for Windows SDK [12]. Using the Microsoft Kinect Sensor, a virtual dressing room application is produced [13]. Yolcu, Kazan and Oz (2014) also presented a real-time image processing approach that offers the possibility to try on virtual garments in front of a virtual mirror [14]. Kumari and Bankar's system (2015) enabled users to try on clothes of different styles and various sizes in a virtual environment rather than trying them on physically, which made the process of trying on and choosing clothes easier [15]. Kim and Cheeyong (2015) created an application in which a depth camera was used to capture the figure of a user standing in front of a large display screen. With this system, user's convenience was provided by assuming the role of a professional fashion coordinator giving an appearance presentation [1].

These developed simulation systems are innovations that keep up with the new developments of the sector, and can have a great impact on the consumers' shopping strategy and attitude. From the consumer's perspective, trying on clothes is a time-consuming physical activity. Moreover, most of the shopping system has the disadvantage that clothes try on is necessary in order to assure that the product fits on the customer's body.

Today, the development of these simulation systems accelerates the process of consumer decision making and provides the opportunity of increasing the probability of purchasing.

In this work, a virtual clothes try-on system has been developed using a contactless motion and skeleton capture sensor and combining real body measurement with size estimation. With the help of this original software, clothes can be tried on in real-time. Being based on both real human body measurement and estimated body size, this approach increases the applicability of simulation systems.

MATERIAL

Kinect depth sensor was launched onto the market in 2010 by Microsoft. The sensor's perception specialty occurred automatically in plays with XBo×360 game console [16]. However, Microsoft also developed the Software Development Kit (SDK), which allowed applying Kinect to computer system [17]. With this software development tool, it became possible to create interactive applications using the sensor, which has attracted considerable attention of the research community.

Kinect is a 3D depth sensor consisting of an RGB camera, an infrared projector combined with an infrared camera and four microphones (figure 1). Also, at its base, there is a tilt motor, which enables the sensor to move up and down [18]. The RGB camera and the depth camera have horizontal and vertical viewing ranges of 57.5° and 43.5° degrees. Kinect can also angle up and down within –27 to +27 degrees. In normal mode, the territory of the depth camera ranges between 0.8 and 4 m and in near mode, it is at least 0.4 – 3 [15]. In this work, we preferred Kinect SDK 1.8 library in order to reach the resources of the sensor. For this study, the sensor was placed at 600 mm height from the floor and at 2000 mm distance from the scanned user. The sensor's field of view is nearly 6 m^2.

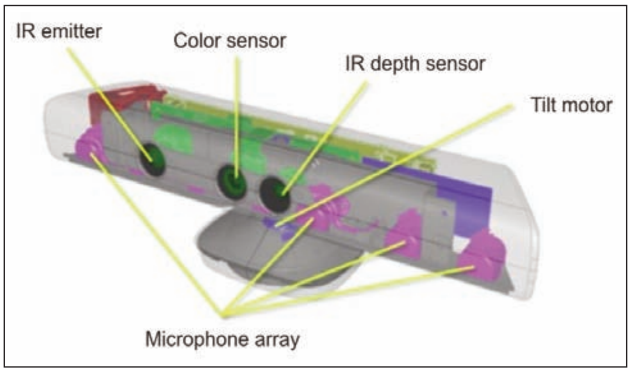

Fig. 1. Microsoft Kinect sensor

PROPOSED SYSTEM

In this work, the user's body measurements are computed by using a motion and skeleton capture sensor. Using these measurements, body size estimation for the virtual clothing try-on system was performed. In order to make a rule base in the size estimation part, the developed expert system contains a database with "Body Size Standards" [19]. The system can estimate the user's real body size according to the measurements captured by the sensor. After the body determination needed for virtual clothing, the user is

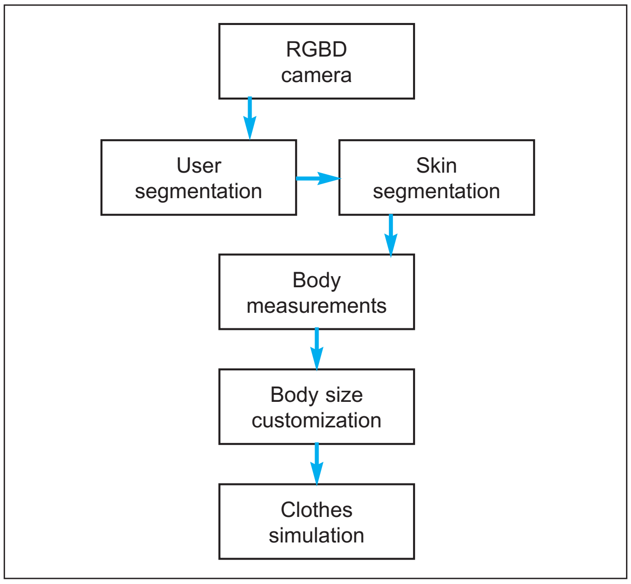

Fig. 2. Architecture of the system

dressed in the selected clothes in the virtual clothing part, according to the estimated body size. Thus, the user is clothed in the selected outfit in a contactless manner in front of the sensor. Figure 2 shows the proposed system's architecture.

User extraction

By extracting the user, it is possible to create an augmented reality environment by isolating the user area from the video stream and superimposing it onto a virtual environment in the user interface.

The depth image and the user ID are provided by Kinect SDK. During the process, the depth image is segmented in order to separate the background from the user. The background is removed by blending the RGB image with the segmented depth image for each pixel by setting the alpha channel to zero if the pixel does not lie on the user.

Skin segmentation

The user always stays behind the model, which restricts some possible actions of the user, such as holding hands in front of the clothes or folding arms, because the model is superimposed on the top layer. As a solution to this problem, skin colored areas are found and brought to the front layer. For skin color segmentation, RGB, HSV and YC_bC_r color spaces are mostly used. In this work, we preferred YC_bC_r color space and the RGB images that are turned into YC_bC_r color space by using the following equations:

$$\begin{aligned} Y &= 0.299R + 0.587G + 0.114B \\ C_b &= 128 - 0.169R - 0.332G + 0.5B \\ C_r &= 128 + 0.5R - 0.419G - 0.081B \end{aligned} \tag{1}$$

Chai and Ngan (1999) described the most representative color ranges of human skin on YC_bC_r color space [20]. Within the following ranges, a threshold is applied to the color components of the image:

$$\begin{aligned} 77 &< C_b < 127 \\ 133 &< C_r < 173 \\ Y &< 70 \end{aligned} \tag{2}$$

The threshold is applied only on the pixels that lie on the user, because we have the extracted user image as a region of interest. So, the areas on the background that may resemble the skin color are not processed.

Computing real measurement

The Kinect sensor can catch the pose data in depth and RGB poses. The RGB camera can get 30 frames and each frame has a resolution of 640×480 pixels. It also has different frame and pose resolution possibilities. From the depth poses taken by the sensor, depth measure parameters can be computed by using camera measuring methods.

The raw depth distance of the sensor's depth perception is 2^{11}. During the measuring process, depth knowledge must be turned into real depth knowledge. Each pixel's real measures are computed with the following equations 3, 4 and 5.

$$\begin{aligned} Xir &= \frac{f_{xir}}{(x - c_{xir})dm} \\ Yir &= \frac{f_{yir}}{(y - c_{yir})dm} \\ Zir &= dm \end{aligned} \tag{3}$$

$$\begin{pmatrix} Xrgb \\ Yrgb \\ Zrgb \end{pmatrix} = \begin{pmatrix} Xir \\ Yir \\ Zir \end{pmatrix} R + T \tag{4}$$

$$\begin{aligned} Xrgb &= \frac{Xrgb + f_{xrgb}}{Zrgb} + c_{xrgb} \\ Yrgb &= \frac{Yrgb + f_{yrgb}}{Zrgb} + c_{yrgb} \end{aligned} \tag{5}$$

X and *Y* depth coordinates of the pixel position are indicated by f_{xir} and f_{yir} focal length, c_{xir} and c_{yir} camera point position of infrared perceivers, and *dm*, which means the depth of meter. In RGB mapping, the slope conversion of the infrared sensor between color pose and depth pose is shown as R and its translation is T. As X_{rgb}, Y_{rgb}, Z_{rgb} give the position of the RGB camera in the 3D coordinate system, x_{rgb} and y_{rgb} consist of the knowledge of the 2D plane, corresponding to the RGB camera's x and y depth pose.

Computing body size from skeleton poses

In Kinect SDK, a skeleton stream object is used to keep the skeleton pose data sets and their specialties. The RGB data sets and the Depth data sets objects are benefited. There are 3 different streams and frame specialty in Kinect SDK.

The usage of raw depth data by the sensor is limited. To use these data correctly and interactively, besides depth data, other RGB and skeleton data sets provided by the sensor are needed.

Many skeleton points on the human body can be detected with the skeleton capture system. These are the hands, head, body, legs etc. *x*, *y*, *z* data of these detected skeleton points can be computed.

The application detects the *x*, *y*, *z* coordinates of 20 different skeleton points in the 3D space. By computing the distances of each skeleton point, the user's body measurements are determined. The Euclidean theorem is used to calculate the linear distance between two different skeleton points.

In 3D space, in order to calculate the linear distance between the first skeleton point defined as $P = (p_x, p_y, p_z)$ and the second skeleton point defined as $Q = (q_x, q_y, q_z)$, equation 6 is used.

$$\sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2 + \ldots + (p_n - q_n)^2}$$

$$\sqrt{\sum_{i=1}^{n} (p_i - q_i)^2} \qquad (6)$$

With the computed values, the human body's height, shoulder, arm, leg, body can also be computed. Body sizes can be estimated by comparing these values according to the rule base of the expert system, containing the information of the database.

This expert system comprises 30 rules, divided into four categories, thus forming 4 different rule bases, as follows: top and bottom clothes, and women's and men's clothes. These rule bases are established according to the data of the general Body Size Standard [19].

Virtual clothes try-on

In the body sizing part, body size can be estimated by taking body measurements. After determining the user's body size, he/she can use the virtual clothing module. The virtual clothing try-on part is the simulation showing how the clothes fit on the user.

The clothes in the virtual clothing part are divided into two categories, as top product group and bottom product group. In the database, the top product groups, including shirts, t-shirts, dresses, and the bottom product group, comprising shorts, skirts, have different locations. In the virtual clothing try-on, the skeleton data are used to set the clothes accurately on the user in the database (figure 3).

In this part, after body size determination, the user can select the clothes from the bottom side of the application. It is also possible to categorize the clothes that will be tried on to list as top products or bottom products, if wanted. The user can select the clothes that he/she wants try on by using the left or right hand to control the development software.

If the selected clothing is a product from the category of the top product group, the Centre of Shoulder skeleton point is taken as reference, and if it is from the bottom product group, the Centre of Hip skeleton point is taken as reference, these being provided to try on the clothes on the RGB pose set. In order to continue to try on different clothes, the clothing on the user can be removed by the "clear" option in the application.

Fig. 3. Virtual try-on

RESULT

The most important feature of the real-time virtual clothing application is the appropriateness of the size of the clothes shown on the display to the user's real body sizes, and adjusting the results for accurate posing on the screen. Thus, this developed application contains a background for the accurate computing of body measurements and correct estimation of body sizes. To evaluate the effectiveness of the application, a total of 30 users, 15 male and 15 female, were chosen, with ages ranging between 20 and 35, and with different body sizes. Their height, shoulder width, arm, leg and body measurements were taken (table 1).

In order to compute the data, each user was asked to stand in the same pose for 10 seconds. Quantitative data were collected from the sensor (table 2) and

Table 1

Measurements	Explanation
Height (H)	Measurement of height
Shoulder (S)	Measurement of taken from the outside edge of a shoulder to the outside edge of the other shoulder
Arm (A)	Length of the arm
Leg (L)	Length of the leg
Body (B)	Length between the neck and hip

Table 2

	n	Min	Max	$\overline{X}$	SD
Height (H)	30	155,00	184,00	170,93	8,10
Shoulder (S)	30	30,00	48,00	40,30	4,00
Arm (A)	30	54,00	63,00	59,50	2,16
Leg (L)	30	99,00	112,00	105,60	3,56
Body (B)	30	45,00	69,00	57,30	7,37

n = count; Max = maximum; Min = minimum; SD = standard deviation

Table 3

	Sensor acquired		Real data		Difference
	$\overline{X}$	*SD*	$\overline{X}$	*SD*	
Height (H)	170,93	8,10	172,40	8,07	–1,47
Shoulder (S)	40,30	4,00	41,36	3,98	–1,06
Arm (A)	59,50	2,16	60,50	2,30	–1,00
Leg (L)	105,60	3,56	106,73	3,46	–1,13
Body (B)	57,30	7,37	58,66	7,22	–1,36

manually taken measurements. The data were then analyzed using the Statistics programme.
30 different users' Height (H), Shoulder (S), Arm (A), Leg (L) and Body (B) measurements were computed to test the accuracy of the results using the sensor scanner. Height measurements of the users ranged from 155.00 to 184.00 cm, with an average of 170.93 cm. The shoulder measurements of the users ranged from 30.00 to 48.00 cm, the average being 40.30 cm. The arm measurements ranged from 54.00 to 63.00 cm and the average was 59.50 cm. The leg measurements of the users ranged from 99.00 to 112.00 cm, with the average of 105.60 cm. The body measurements ranged from 45.00 to 69.00 cm and the average was 57.30 cm.

Comparing the sensor data with manually taken data

The results of the paired t-test are presented in table 3. The standing posture body measurements acquired from the sensor show a difference ranging between –1.00 and –1.47 cm from the manually taken measurements.
Upon examining the data in table 3, it may be remarked that there is no significant difference between the sensor acquired data and the real data. Although sensor calibrations are provided, minimal differences can be explained by the deformation in the captured images and by the user's improper standing position. However, these differences are very small, near to the minimum percentage level, therefore, it can be concluded that the results are very close to the real values.

CONCLUSIONS

Companies in the clothing sector need to continually improve their current technologies in order to have success and continuity on the market in a globalized world economy. Indeed, the cost and the arrival time of the products have decreased, the quality of the products has increased, and virtual clothing, body scanning and body sizing applications have emerged with the developments in the textile industry.
In this study, size estimation was carried out by means of a Kinect sensor, one of the most important products of Microsoft, and compared to manual body measurement. After the user's body measurements were computed, he/she was able to try on the clothes defined in the system with the sensor in the virtual clothing module.
In the 21st century, human habits are changing. Instead going shopping and trying on clothes, which is time-consuming and requires an extra effort, virtual clothing applications are becoming increasingly popular. However, the biggest problem here is to accurately define the user's body size and to correlate it with that of virtual clothing. Body size estimation is thus the most important factor in virtual clothing applications.
Due to the high performance of the virtual clothing applications in body size assessment, users can try on clothes that fit accurately to their sizes. By means of the contactless controlling system, the presented application offers users the possibility to try on clothes easily and in a short time. These advantages also have a positive effect on the time of decision making.

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Textile capacitive humidity sensors made by printing technique

M. FRYDRYSIAK L. TESIOROWSKI

REZUMAT – ABSTRACT

Senzori capacitivi de umiditate integrați în textile prin tehnica de imprimare

Această lucrare prezintă rezultatele de proiectare și cercetare a senzorilor capacitivi de umiditate integrați în textile flexibile. Au fost analizate diverse structuri de senzori realizate prin tehnici diferite. Autorii au prezentat două tipuri de structuri textile componente. Aceste structuri sunt formate din electrozi textili și o umplutură din material textil. Testele au fost efectuate într-o cameră climatică, care permite reglarea și controlul temperaturii și al umidității relative. De asemenea, au fost prezentate exemple de utilizare a senzorilor din domeniul textronicii în aplicații integrate în îmbrăcăminte.

Cuvinte-cheie: textronică, senzori integrați în materiale textile, măsurare, textile electroconductoare

Textile capacitive humidity sensors made by printing technique

In the paper there are presented the design and research results of flexible textile capacitive humidity sensor. Various sensor structures made with different techniques were considered. The authors have presented two types of component textile structures. These structures consist of textile electrodes and a textile filling. Tests were performed in a climate chamber, which enables to set and control the temperature and relative humidity. The examples of application of textronics sensors in clothing applications were also presented.

Keywords: Textronics, textile sensors, measurement, electroconductive textiles

INTRODUCTION

Methods of humidity measuring can be generally divided into hygroscopic and condensation methods. In the first category of devices, which are classified as resistive and capacitive sensors, the electrical properties of materials change as a result of absorbing moisture from the environment. In the condensing hygrometers using sensors with a chilled mirror, humidity is determined indirectly by measuring the dew point. [1, 3, 13]

Capacitive relative-humidity sensor is similar to a capacitor structure. The sensor consists of two metal electrodes and between them there is a thin layer of an absorbent polymer acting as a dielectric. The surface of an upper electrode is usually porous, which aim to protect the hygroscopic layer against condensation and dirt. The substrate of the sensor is usually made of glass, ceramic or silicon. Changing the dielectric constant of the absorbent material is proportional to the relative humidity surrounding the sensor. Hygrometers capacitance change from 0.2 to 0.5 pF while the relative humidity change of 1% and a nominal capacity of from 100 to 500 pF under 50% RH and 25 °C. The response time of capacitive sensors is typically from 30 to 60 s.

The technology of sensors based on the textile structures is one of the major developing areas in the context of textronics [1, 2, 5, 14]. The humidity sensor in textiles application can help to evaluate effort during exercises and measures the humidity of the skin (figure 1).

Despite considerable research in the field of humidity sensors, only a few systems based on flexible substrates have been commercialized so far. The main problems are the characteristics of the textile sensor, changing signals in time and repeatability of electrical parameters [6, 8, 12, 13].

In this paper authors presented the method of obtaining the flexible humidity sensor on the textile substrate with the use of different kinds of textile electrodes. The sensor constructed in the presented way can be easily integrated with the clothes using typical sawing machines. The repeatability characteristics of the sensor is a crucial point in the application for monitoring chosen vital signs [9, 10].

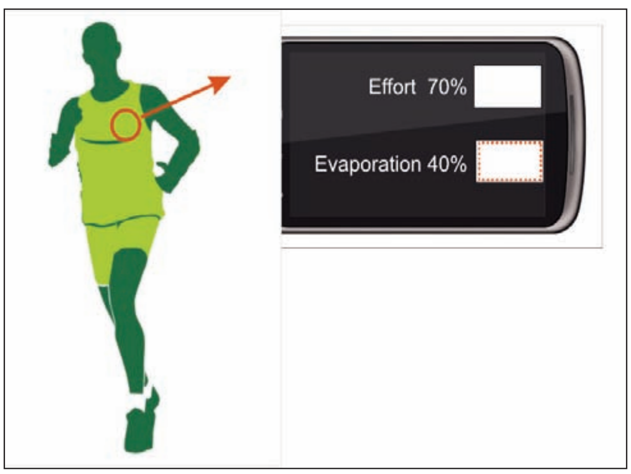


Fig. 1. Example of humidity measurement due to evaporation of the skin by textronic system for runners

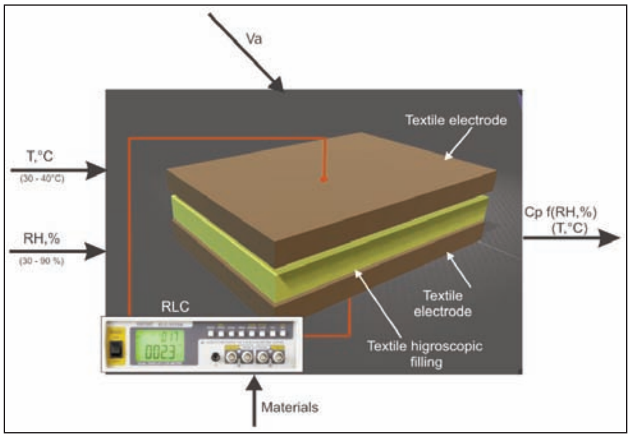


Fig. 2. Structure of capacitive textronic humidity sensor

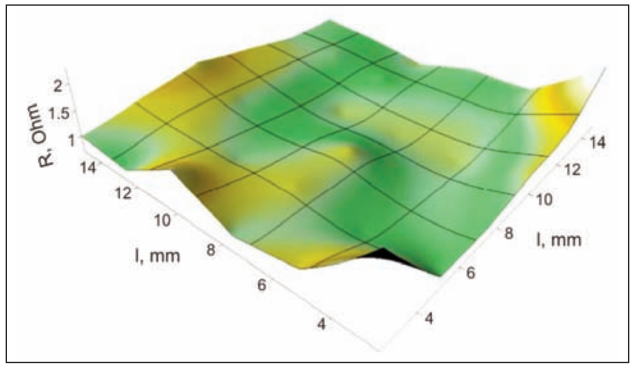


Fig. 3. Distribution of surface resistance on the nonwovens electrodes

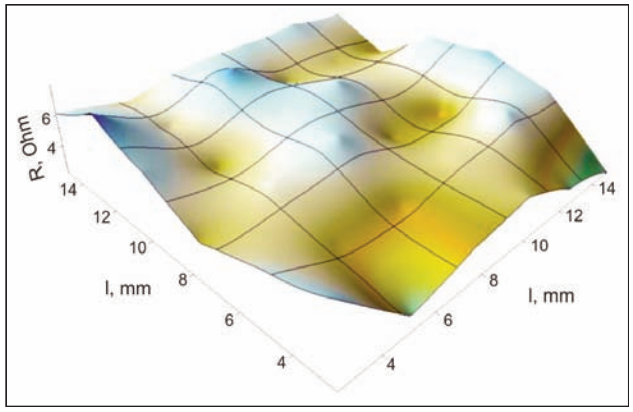


Fig. 4. Distribution of surface resistance on the printing woven electrodes

FUNCTIONAL PRINCIPLE AND MEASUREMENT METHODS

In figure 2 there is presented the structure and qualitative measurement model of the textile relative humidity sensor [15]. The sensor consists of two textile electrodes made of an electrically conductive material. Textile filling made of dielectric material is placed between the electrodes. The whole structure has been combined with a fleece/non-woven fabric with glue. Textile filling absorbs moisture, thereby changing the dielectric permeability, which is a result of the capacity changes.

In the figure 2 there is presented a quality model of the measurement. The variables input values are temperature of 30, 40 T, °C and humidity from 30 to 90 RH %. The range of changes was selected in accordance with the changes of human physiological parameters. In these ranges the sensors can work. The research was done for constant variants of materials (two kinds of sensors). The measurement value is the sensors capacity Cp.

The authors of the paper have been looking for the materials which are flexible and could be used for making the humidity sensor. The choice of material depended on the electroconductive properties [16]. The microscopic images of the electroconductive layer and non-conductive hydroscopic filling are presented in table 1. The measurement of the surface resistance distribution on the textile electrodes was made with the use of the ELCA3433A measuring bridge. The results were read after establishing the meter indications. The research was carried out for an ambient temperature: 21 °C and relative humidity of 60%, RH. The results are presented in figures 3 and 4.

In the first variants of construction, for the electrodes of the capacitive sensor there are selected nonwoven electrical conductive materials. As a filling the wool material was selected. The felt was a dielectric filling. Its hygroscopicity is the highest of all fibers. The nonwoven capacitance was measured with the use of an Agilent E4980A instrument. The measurements were

Table 1

Materials	Textile polyamide, non woven electrodes	Textile cotton, woven electrodes	Wool dielectric substrates
Photo			
Resistance R, [Ω]	0,25	0,12	Non conductive
Thickness d, [mm]	2,5	0,7	3

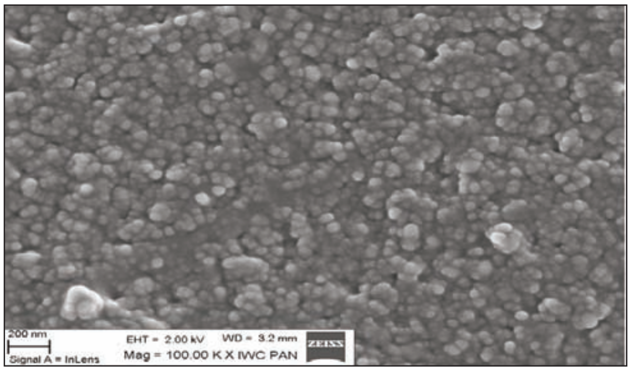
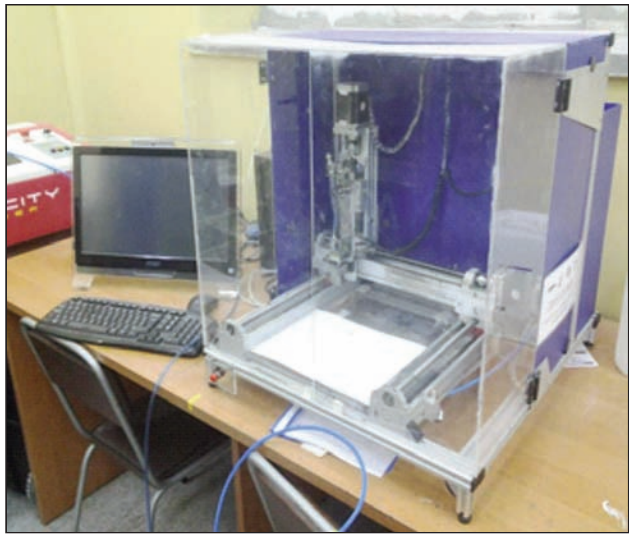


Fig. 5. Microscopic photo of electrical conductive silver-based ink on a glass layer

made in a normal climate, the capacity was C_p = 9.8 pF.

Electrodes were printed by NANO INK AX JP-60n. The used ink is characterized by good electrical properties and low resistance values. A printer uses single-component composition of the silver-filled electro-conductive nanometer-sized. The composition has characteristics that allow the use of the Ink Jet Printing technique on different types of flexible polymeric substrates. The ink filler is silver powder with an average size of 50 nm. The silver powder takes a special type of protective sheath which allows obtaining a stable liquid without the effects of sedimentation or agglomeration of filler. It also enables to achieve full stability of all parameters, which is a very important factor especially in the printing Ink Jet process technology. The microscope image of ink is presented in figure 5.

Numerically controlled prototype printer was built for printing on textiles. The maximum working area of the printer is 210 × 297 mm. The printer uses DOD print technology and printing head REA JET EDS that was shown in figure 6. Mach3 studio software was used for controlling the printer.



A

B

Fig. 6. Printer for textiles functionalization (A), Printing head Rea Jet: 1 – print head, 2 – cable for ink, 3 – control signal wire (B)

RESEARCH

In the qualitative measuring model, the input quantity (leading) was the relative air humidity varying in the range from 30 to 90% for constant temperature values of 30°C and 40°C. These values were chosen adequately to the possible applications of the sensor, which could be placed between the textile layer packets. The output quantity was the change of the textile sensor capacitance. The study was performed in a climate chamber. Basic parameters of the used climatic chamber:

1. Internal dimensions of the chamber: 600×500×500 mm (width × depth × height);
2. Temperature range: from –70°C to 150°C;
3. Accuracy of temperature: 0.5°C ± at ambient pressure;
4. Accuracy of relative humidity: ±3...5%.

The capacity was measured by a RLC ELC 3133 bridge with frequency of 1 kHz, after indication settling of the capacity. In the figure 7 and figure 8 there is presented the relationship of capacity sensors as a function of humidity by two temperature values of 30°C and 40°C for two technologies of electrodes.

The test of the sensors stability during the time of two types of sensors in two temperature points were made. The measurement results are shown in figure 9 and figure 10.

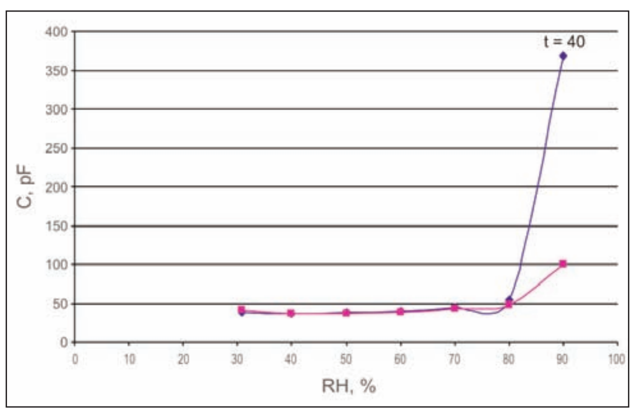


Fig. 7. The capacity changes as a function of relative humidity with nonwoven electrodes

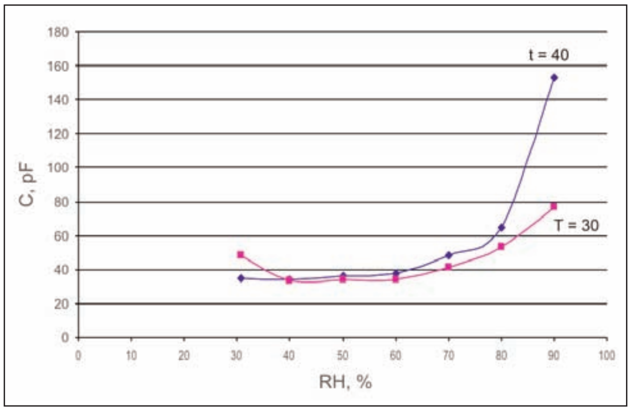


Fig. 8. The capacity changes as a function of relative humidity with printing electrodes

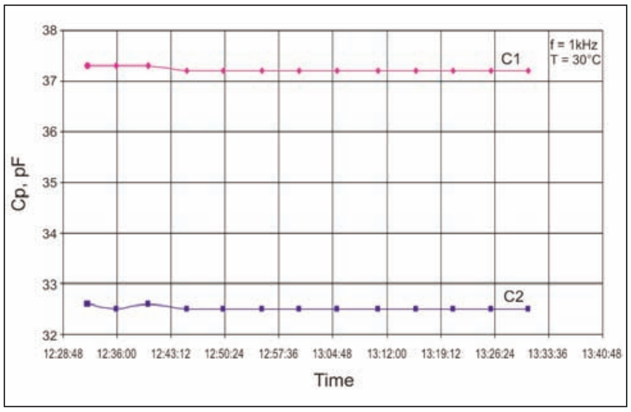


Fig. 9. The capacity changes in time for the two tested textile sensors at 30 °C and RH 50%
C1 – nonwoven capacity sensor; C2 – woven capacity sensor

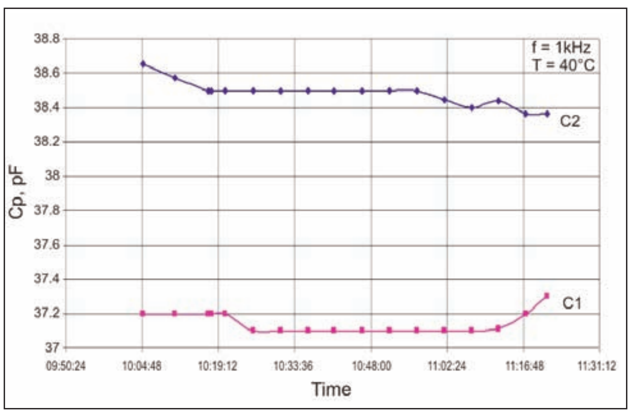


Fig. 10. The capacitance changes in time for the two tested textile sensors at 40 °C and RH 50%
C1 – nonwoven capacity sensor; C2 – woven capacity sensor

One of the parameters of textile, capacitive humidity sensors is a dissipation factor (tan δ) or DF and it is defined as the ratio of the ESR and capacitive reactance and can be calculated from equation (1):

$$DF = \tan \delta = \frac{ESR}{X_C} \quad (1)$$

where:
DF is dissipation factor;

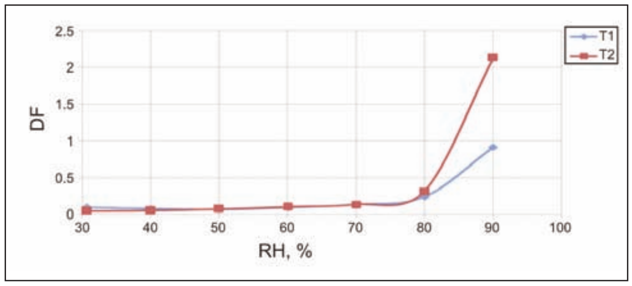


Fig. 11. Change of DF dissipation factor in a function of humidity for nonwoven sensor, T1 = 30°C; T2 = 40°C

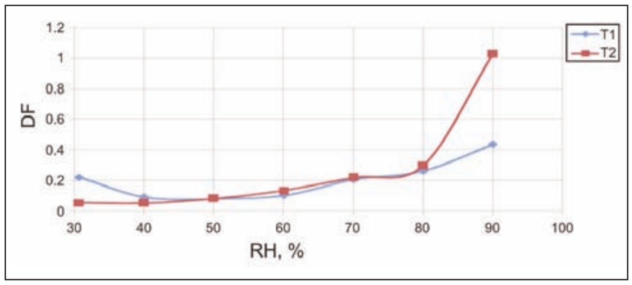


Fig. 12. Change of DF dissipation factor in a function of humidity for printed electrodes sensor, T1 = 30°C; T2 = 40°C

ESR – Equivalent Series Resistance is a sum of the ohmic losses of a dielectric materials and connections used in the construction of the capacitor;
X_C – reactance.

That determines the energy loss. These losses in the capacitor are the resulting of the leakage of the dielectric and electrode's resistances. The measured change of $t \tan \alpha$ for the tested sensors in the response to changes in humidity and at two temperatures points is presented in figures 11 and 12 by measuring frequency 1 kHz.

The nonwoven and printed sensors have a form of a flat capacitor. The capacity can be expressed by an equation (2).

$$C = \frac{\varepsilon_0 \varepsilon_r S}{d} \quad (2)$$

Where:
C is capacity;
ε_0 – dielectric vacuum constant $8{,}8542 \cdot 10^{-12}$ F/m;
ε_r – dielectric constant of dielectric wool material;
d = 3 mm – thickness of dielectric material (space between electrodes);
S = 9 mm^2 – electrodes surface.

The dielectric constant of material used for a construction of studied sensors was measured and it is is ε_r = 1,19. This value was obtained in normal climate (20°C and RH = 60%). The capacity calculated by an expression (2) is 3,15 pF. This value is less than the measured capacity of sensors because it includes only dimension of the electrodes without their capacity changes in the function of humidity

CONCLUSIONS

During this work there were prepared two kinds of sensors using electrical conductive textiles like woven and nonvowen. The authors can see a possibility to use textile sensors in different IOT applications. That is an interesting field to adopt textile sensors in the textronics applications which monitor physiological parameters. For obtaining electrical properties there were used printing methods and the conductive NANO INK AX JP-60n. The produced electrodes of the humidity sensors were characterized by surface resistance per unit area of several ohms. The sensor with nonwoven electrode changes its capacity linearly between 80% humidity for two research temperature points (30°C, 40°C). The same situation occurs with the woven printed sensor. Capacity differences with the same dimensions are related to different structure of electrodes. This also reflects in DF – dissipation factor characteristic. The losses in dielectric and textile electroconductive layers increase with humidity changes. Sensors are a capacity stable during the long hours of the research. Due to the step changes capacity above a certain level of humidity, these sensors may be used in the detection of excessive moisture in the underclothing structures.

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Regional anthropometric characteristics of the adult population in Romania and aspects concerning specific folk costumes

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GEORGETA POPESCU
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ADRIAN SĂLIȘTEAN

REZUMAT – ABSTRACT

Caracteristici antropometrice regionale ale populaţiei adulte din România şi aspecte privind portul popular specific

Lucrarea prezintă caracterizarea antropometrică a populaţiei adulte din diferite regiuni ale ţării: Oltenia, Muntenia, Dobrogea, Moldova, Bucovina, Maramureş, Transilvania, Banat şi Crişana. Rezultatele prelucrării statistice a datelor obţinute din ancheta antropometrică au permis caracterizarea structurii antropologice regionale în funcţie de factorii care o influenţează. S-a constatat că subiecţii de sex masculin din Crişana sunt cei mai înalţi, dar şi cei mai slabi, în timp ce cei din Oltenia şi Muntenia au înălţime medie, dar sunt corpolenţi. De asemenea, subiecţii de sex feminin din Maramureş sunt cei mai înalţi şi cei mai slabi, în timp ce cei din Oltenia sunt de înălţime medie şi corpolenţi.

Lucrarea prezintă, în plus față de caracterizarea antropometrică, rezultatele unui studiu documentar privind caracteristicile etnografice ale costumului popular din diferite regiuni ale țării. Costumul tradițional românesc variază în funcție de regiune: Banat, Transilvania, Bucovina, Moldova, Crișana, Maramureș, Dobrogea, Oltenia și Muntenia. În fiecare dintre regiunile țării, combinația de culori impuse de tradiție este respectată cu strictețe.

Cuvinte-cheie: populaţie, mărime, antropometrie, standard, regiune, costum tradiţional românesc

Regional anthropometric characteristics of the adult population in Romania and aspects concerning specific folk costumes

The paper presents the anthropometric characterization of the adult population in different regions of the country: Oltenia, Muntenia, Dobrogea, Moldova, Bucovina, Maramureş, Transylvania, Banat and Crişana. The results of statistical processing of data from the anthropometric survey, allowed the characterization of regional anthropological structure depending on the influencing factors. It was noted that male subjects from Crişana are the tallest and the skinniest ones, while those from Oltenia and Muntenia have average height but are corpulent. Also, female subjects from Maramureș are the tallest and the skinniest ones, while those from Oltenia have average height and are corpulent.

The paper presents, in addition to the anthropometric characterization, the results of a documentary study on ethnographic characteristics of the popular costume from different regions of the country. The Traditional Romanian costume varies by region: Banat, Transylvania, Bucovina, Moldova, Crişana, Maramureş, Dobrogea, Oltenia and Muntenia. In each of the country regions the combinations of colors imposed by tradition are strictly respected.

Keywords: population, size, anthropometry, standard, region, traditional Romanian costume

INTRODUCTION

Anthropometry is a part of anthropology that deals with the collection, calculation and interpretation of measurements performed on human physical dimensions. These are cephalo-facial dimensions and body (somatic) dimensions.

Anthropometry, as the main method of study in anthropology, has allowed the development of grading scales for dimensions and body types that order somatic great diversity of populations. By anthropometry, anthropology can make a comparative analysis of populations, can "build" national anthropometric standards, on which it defines "normality" and deviations.

Researches on population anthropology enabled tracking the ontogenetic development of the individual or population on the one hand, and on the other hand tracking the phenomenon of microevolution.

EXPERIMENTAL WORK

Anthropometric survey on adult population in Romania

During 2008–2010, the National R&D Institute for Textiles and Leather had conducted an anthropometric survey using a mobile 3D body scanning system, VITUS Smart XXL, (figure 1) on the adult population aged 20–65 years [1].

The composition of the selection took into account the particularities and morphological variability of the population by geographical area, the survey being carried out in representative regions of the country: Oltenia (Dolj, Gorj and Vâlcea counties), Muntenia (Argeş, Brăila, Bucharest-Ilfov, Dâmboviţa, Giurgiu, Ialomiţa, Prahova and Teleorman counties), Dobrogea (Constanţa and Tulcea counties), Moldova (Bacău, Galaţi, Iaşi, Neamţ, Vaslui and Vrancea counties), Bucovina (Botoşani and Suceava counties), Maramureş (Maramureş and Satu Mare counties),

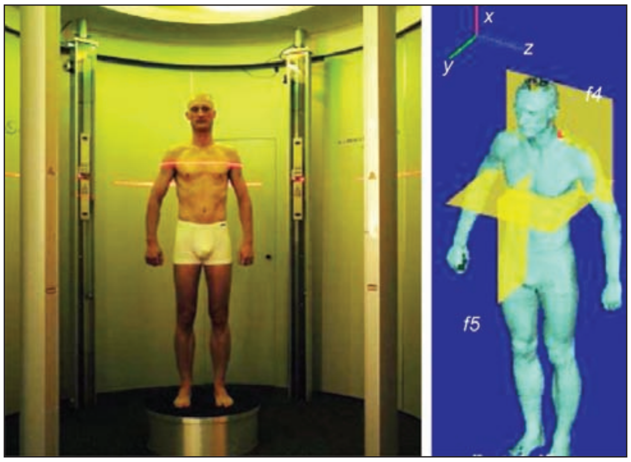

Fig. 1. 3D Body Scanner VITUS Smart XXL

Fig. 2. Geographical regions of Romania

Transylvania (Alba, Bistriţa-Nasăud, Braşov, Cluj, Covasna, Harghita, Hunedoara, Mureş, Sălaj and Sibiu counties), Banat (Timiş county) and Crişana (Bihor and Arad counties), as shown in figure 2.

After 3D scanning of subjects in the anthropometric survey, a primary database has resulted in which each subject presented 150 body measurements. For each measured subject, a protocol was generated in which each body measurement had been displayed [2].

The raw data obtained from the anthropometric survey were statistical processed. These values represent what is typical representative for the studied variable, giving information about the degree of dispersion of individual values compared to typical (average) ones and allowing expansion of findings across communities.

Overall selection of 1406 subjects (684 women and 722 men) is made up of people from many geographical areas as follows:

- from Oltenia: 152 subjects;
- from Muntenia: 635 subjects;
- from Dobrogea: 36 subjects;
- from Moldavia: 189 subjects;
- from Bucovina: 7 subjects;
- from Maramureş: 22 subjects;
- from Transylvania: 243 subjects;
- from Banat: 6 subjects;
- from Crişana: 116 subjects.

RESULTS AND DISCUSSIONS

Influence factors of anthropological structure

Anthropological structure of the population and its dimensional and body type variability are genetically and mesologically determined. The analysis of the anthropological structure of a population takes into account the multiple factors that influence this structure and that determine the differences between different populations or within these populations.

Gender factor – makes a mark on anthropological variability of populations, especially for body dimensions of male population compared to those of the female population. So, the average value for the body height is 176.87 cm in men, as in women, the average value of body height is 162.46 cm. Body height, the "marker" most often cited in the practical applications of anthropology makes its component segments vary in the same sense in men compared to women.

Ontogenetic evolution – gender leaves its mark also on ontogenetic record of the populations, in the way that we evolve and then regress from "youth to old age". Involution of body height – due to spine compaction and flattening the arch of the foot – starts to rural women after the age of 30 years and to urban women after the age of 40 years. In men, the same involution begins in the countryside after the age of 55 years, and in urban areas after the age of 50 years.

These ontogenetic changes which undergo body height throughout life are not unique, they affect all segments of the human body and are differentiated by gender and origin of rural/urban population.

Ontogenetic changes depending on gender and area of residence are as "spectacular" to thoracic and abdominal parameters, which led to the finding that men in urban areas, sedentary in a sense, differ radically from rural men, with average values of these circumferences significantly higher. They are signs, together with weight and body mass index, of a more pronounced tendency for obesity (as disease) to urban population with relatively sedentary lifestyle versus rural population permanently active.

Geographical factor – occurs in the anthropological variability of populations and is exemplified also through the body height as the main "marker" defining anthropological structure (figure 3).

- in Oltenia:
  – men population average body height 175.86 cm;
  – women population average body height 161.4 cm;
- in Muntenia:
  – men population average body height 177.48 cm;
  – women population average body height 162.19 cm;

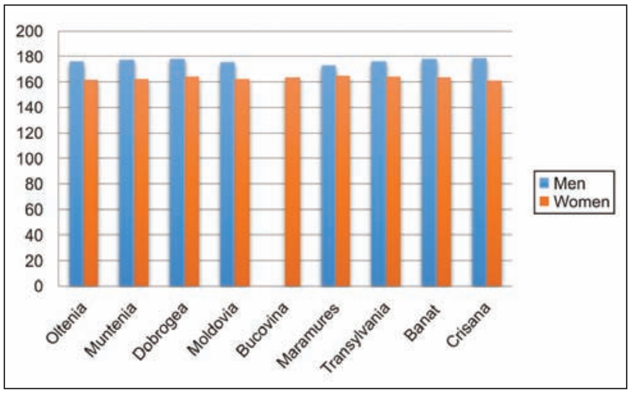

Fig. 3. Body height distribution Body size distribution by geographical area

- in Dobrogea: – men population average body height 178.25 cm; – women population average body height 164.11 cm;
- in Moldavia: – men population average body height 175.38 cm; – women population average body height 162.07 cm;
- in Bucovina: – women population average body height 163.75 cm;
- in Maramureş: – men population average body height 172.67 cm; – women population average body height 165.25 cm;
- in Transylvania: – men population average body height 175.74 cm; – women population average body height 165.25 cm;
- in Banat: – men population average body height 177.9 cm; – women population average body height 163.43 cm;
- in Crişana: – men population average body height 178.47 cm; – women population average body height 160.88 cm.

Analysis of statistical parameters characterizing the anthropometric measurements, calculated on the selection established by geographical area criteria is presented in table 1 [3].

Occupational factor intervenes somehow in the anthropological variability of populations. The workplace and the specific work act as selective factors for employees. An illustrating example is the truck drivers, massive, overweight, with greatly increased thoracic and abdominal circumferences. In this case, there is a body deformation due to the effort in the work carried out, the working time, the driving position of the car. In industry, there is a sharp distinction between people working in the light industry and those working in the heavy industry. In the heavy industry, workers from the thermal overload sectors are clearly distinguishable, especially those with longish constitution.

Constitutional factor is one of the factors that can "make order" in anthropological large diversity of populations and which must be taken into account in clothing design.

In the anthropometric standards SR13544:2010 Clothing. Men's Body Measurement and Garment Sizes and SR 13545: Clothing. Women's Body Measurement and Garment Sizes, A-E body types were defined by the difference between waist and chest circumferences for men and A-F bodies types by the difference between the bust and hips circumferences for women (table 2) [4, 5].

Distribution of body types by regions is presented in table 3, after calculating the difference between circumferences mentioned above.

Ethnographic analysis of the popular costume

We can observe the differences by region related to Traditional Romanian costume. Romanian folk costume

Table 1

MEAN VALUES (IN CM) OF ANTHROPOMETRIC MEASUREMENTS CALCULATED, ON TOTAL SELECTION AND SUBSELECTIONS (GEOGRAPHICAL AREA AND GENDER)

No.	Geographical area	Anthropometric measurements					
		Body height		Bust/Chest circumference		Waist circumference	Hips circumference
		Men	*Women*	*Men*	*Women*	*Men*	*Women*
1	OLTENIA	175,86	161,4	108,5	103,04	97,16	108,18
2	MUNTENIA	177,48	162,19	109,08	98,45	95,07	104,78
3	DOBROGEA	178,25	164,11	103,42	97,34	90,23	103,03
4	MOLDAVIA	175,38	162,07	105,1	99,27	91,76	104,92
5	BUCOVINA	-	163,75	-	90,74	-	98,64
6	MARAMUREŞ	172,67	165,25	102,94	90,05	88,64	96,38
7	TRANSYLVANIA	175,94	164,39	105,28	92,05	90,37	99,72
8	BANAT	177,9	163,43	106	90,53	94,75	98,33
9	CRIŞANA	178,47	160,88	99,4	99,84	85,01	106,97
10	**TOTAL SELECTION**	**176,87**	**162,46**	**107.8**	**97,72**	**94,02**	**104,19**

Table 2

BODY TYPE DEFINED INTO APPLICABLE ANTHROPOMETRIC STANDARDS		
Body type	**Men**	**Women**
	Pt-Pb	**Pş-Pb**
A	– 20	– 4
B	– 16	0
C	*– 12*	*4*
D	– 8	*8*
E	– 4	12
F	-	16

Table 3

BODY TYPES CALCULATED ON TOTAL SELECTION AND SUBSELECTIONS (GEOGRAPHICAL AREA AND GENDER)					
No.	**Geographical area**	**Body type**			
		Men		***Women***	
1	OLTENIA	–11,33	C	5,14	C
2	MUNTENIA	–14,01	B and C	6,33	C and D
3	DOBROGEA	–13,18	C	5,69	C
4	MOLDAVIA	–13,34	C	5,64	C
5	BUCOVINA	-	-	7,9	D
6	MARAMUREŞ	–14,3	B and C	6,3	C and D
7	TRANSYLVANIA	–14,9	C	7,6	D
8	BANAT	–11,25	C	7,8	D
9	CRIŞANA	–14,38	B and C	7,13	D
10	**TOTAL SELECTION**	**–13,77**	**C**	**6,4**	**C and D**

finds its roots in the costume of our Thracians, Gets and Dacians ancestors and resembles with that of the people from the Balkan Peninsula, except of course in the differences that consist of decorative details and colors [6, 7].

From the structural and ornamental point of view, the folk costume created in the mountain and plain areas of **Oltenia** belongs to the category of Romanian folk costumes with two “catrinte” and finely pleated valnic. A specificity for Oltenia are the bright cheerful colors of the embroideries and “alesaturi”, the splendor and sumptuousness of the decorative compositions made with precious materials.

Costumes of remarkable artistic value, the traditional costume of **Muntenia** (figure 4), regardless of the ethnographic area, contributed significantly to the affirmation of folk costume as significant symbol as peasant creation. The blouse, skirt and veil of these costumes are each of them an example of technological performance and artistic craftsmanship.

The costume from **Dobrogea** presents the character of hills and plains areas, on the left shore of the Danube. A characteristic for this region is that alongside with Romanian population other national minorities live, such as: Lipovans, Bulgarians, Turks, Macedonians, Tatars, so the costume from Dobrogea keeps the specific aspects of ethnic plurality.

The traditional costume from **Moldavia** is characterized by simplicity and sobriety, the color palette is often reduced to three colors: black, red and white, later associating other colors.

In **Bucovina,** the female costume consists of a beautifully colored shirt sewn with beads, a skirt with embroidered gold, a bund and for walking “opinci” and wool socks (figure 4). Men costume mainly consists of a long shirt, tied in the middle with a belt or “barnet”, wool “iţari”, lamb hat on his head and “opinci”.

The folk costume of the old country of **Maramureş** (figure 5) preserves the vigor of some ancient clothing pieces: women’s “zadii” (rectangular woolen skirts) with broad stripes in red with black or yellow

Fig. 4. Traditional Romanian costumes from Muntenia, Bucovina and Banat

Fig. 5. Traditional Romanian costumes from Crişana and Maramureş

with blue and "guba" (a long white coat, woven with long woolen treads introduced into the filling to obtain hemstitch effect), worn by both men and women.

The folk costume of **Transylvania** is characterized by a unitary morphological structure of the basic clothing pieces [6, 7].

The costumes from **Banat** (figure 4) are distinguished from other regions by excessive embroidery on blouses, where the motifs are very flat and compact. In **Crişana** (figure 5), the use of new materials is remarkable, decorative embroidery amplification and display of expensive jewels – necklaces of gold and silver coins.

CONCLUSIONS

Analyzing the parameters presented in the paper, the following conclusions were revealed:

- different average values recorded in some anthropometric measurements between analyzed geographical areas may result from different volumes of selections;
- it is remarkable for the selection of male subjects in Crişana, that they have the average for body height (178.47 cm), higher by 1.6 cm compared to the average for the total selection (176.87 cm);
- the selection of male subjects in Maramureş has the lowest average for body height (172.67 cm), less than 4.2 cm from the average for the total selection (176,87 cm);
- male subjects in Muntenia and Transylvania closest to the average value of the total selection for body height because of the number of subjects in the sample;
- chest circumference has the highest value for male subjects in Muntenia (Pb 109.08 cm) greater than 1.3 cm from the average for the total selection (Pb 107,8 cm);
- waist circumference has the highest value for male subjects in Oltenia (Pt 97.16 cm), 3 cm higher than the average on overall selection (Pt 94 cm);
- chest and waist circumferences recorded the lowest values for male subjects in Crișana (Pb 99.4 cm and Pt 85.01 cm), 8–9 cm below the average in the total selection (Pb 107.8 cm and Pt 94.02 cm);
- male subjects in Muntenia and Banat is closest to the average value for the total selection for chest and waist circumferences;
- in female subjects, the values recorded for body height are opposite to those of the male subjects: female subjects in Maramureş have the average for body height (165.25 cm) higher than 2.79 cm compared with average for overall selection (162.46 cm), and those from Crişana recorded the lowest average for body height (160.88 cm), less than 1.58 cm compared to the average for the total selection (162.46 cm);
- female subjects from Muntenia, Moldavia and Banat are closest to the average value for the total selection for body height;
- bust and hip circumferences recorded the highest values for female subjects in Oltenia (Pb 103.04 cm and Ps 108.18 cm), 4–5 cm higher compared to the average for total selection (Pb 97.72 cm and Ps 104.19 cm);
- bust and hip circumferences recorded the lowest values for female subjects in Maramureş (Pb 90.05 cm and Ps 96.38 cm), 7–8 cm below the average for the total selection (Pb 97.72 cm and Ps 104.19 cm);

- female subjects from Muntenia, Dobrogea and Moldavia are closest to the mean value selection for the bust and hips circumferences;
- it was noted that male subjects from Crişana are the tallest and the skinniest ones, while those from Oltenia and Muntenia have average height but are corpulent;
- also, female subjects from Maramureş are the tallest and the skinniest ones, while those from Oltenia have average height and are corpulent;
- subjects of both sexes from Muntenia recorded values for anthropometric measurements very close to the average for total selection; this is due to the large amount of selection in this area;
- analyzing the difference between waist and chest circumferences (difference that defines the body type of a subject), it was found that the male subjects from Muntenia, Maramureş and Crişana belong to groups B and C (proportioned bodies and corpulent but proportioned bodies) and the subjects of the overall selection and of the selections by other geographical areas belong to group C; this point is supported when we consider that men conformation changes with an increase in waist circumference, so in anthropometric size that differentiates bodies (along with chest circumference);
- analyzing the difference between hip and bust circumferences (difference that defines the body type of a subject), it was found that the female subjects from Oltenia, Dobrogea and Moldavia belong to group C (corpulent but proportioned bodies), those from Bucovina, Transylvania, Banat and Crişana belong to the group D (corpulent and less proportionate bodies) and the subjects of the overall selection and the selection by other geographic areas belong to groups C and D.

The Romanian traditional costume has the same general features as similarity across the country, with of course differences in detail, with changes of shape, cut or only for the use of haircut and ornaments. The Traditional Romanian costume varies by region: Banat, Transylvania, Bucovina, Moldova, Crişana, Maramureş, Dobrogea, Oltenia and Muntenia. The clothing pieces and embroidery patterns have a certain meaning that differs from one region to another.

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Clothing label and ecological label: a missed opportunity or a powerful tool in the marketplace?

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REZUMAT – ABSTRACT

Eticheta de pe îmbrăcăminte şi eticheta ecologică: o oportunitate pierdută sau un instrument puternic pe piaţă?

Acest studiu a analizat comportamentul şi opiniile consumatorilor privind eticheta de pe îmbrăcăminte. Ca răspuns la preocupările de degradare a naturii, au fost analizate percepțiile cu privire la eticheta ecologică și factorii care împiedică achiziționarea de îmbrăcăminte cu etichetă ecologică. Informațiile care sunt cel mai frecvent citite pe eticheta de pe îmbrăcăminte și cele mai importante sunt mărimea, compoziţia fibroasă şi preţul. Aproape jumătate dintre consumatori cred că îmbrăcămintea cu etichetă ecologică are un impact mai redus asupra mediului și că prin achiziționarea acesteia contribuie la protejarea mediului. Lucrarea propune ca piața pentru produse ecologice să fie exploatată mai mult în cadrul grupurilor de consumatori cu valori pro-mediu.

Cuvinte-cheie: îmbrăcăminte, consumator, ecologic, etichetă, comportament de citire a etichetei de către consumator

Clothing label and ecological label: a missed opportunity or a powerful tool in the marketplace?

This study examined consumers' behavior and beliefs related to clothing label. In response to nature degradation concerns, perceptions about the ecological label and the factors that hinder the acquisition of ecological label clothing were investigated. The most frequently read information on the clothing label and the most important ones are size, fibre composition and price. Almost half of consumers believe that eco-labeled clothing has a lower negative impact on the environment and that by purchasing it they contribute to environment protection. The paper suggests that the market for greener products could be exploited more within consumer groups that have pro-environmental values.

Keywords: clothing, consumer, ecological, label, consumer label reading behavior

INTRODUCTION

Nowadays clothes we wear or the way we dress have gained new functions besides the classical ones – social, cultural (individual, occupational, sexual differentiation, and social status indicator) and protection. We are living in a world where vision is the dominant sense, where the creation of emotions attached to shopping and product use is the key for marketing success and where additional functions of clothing, such as health protection through the type of material and dye used or environment protection guaranteed by an ecological label (eco-label) often outgrow the traditional ones. The benefits sought by apparel consumers range from fashion, body appearance and impression, brand value, personal identity, price, comfort benefits to social fairness, contribution to nature protection etc. [1].

Globalization has created a continuously changing business environment in terms of customers and markets requirements [2]. The US, Japans or European textile and clothing import prices have fallen continuously since 1996 and, in an oversupplied and liberalized market, this trend is likely to continue, potentially bringing about a deterioration of the position of the domestic apparel companies, which are fiercely competed by those from outside with cheaper labor force [3]. New forms of market appear, such as the online one, which increases rapidly. For instance, at Romania level, it rose to approximately 50 million euro, representing 2.5–3% of the entire Romanian apparel market [4]. Each of us, at one point in the day, week, month or year becomes consumer of clothes and clothing provides a unique consumption experience for consumers [5]. Consequently, the need to know more about clothing consumer behavior is growing, stimulated by the increase in clothes consumption and competition. Labeling is a form of communication between two parties, which, to function correctly, requires knowledge from both sides, must be comprehensible, recognizable, believable and, sometimes, needs to be checked and approved by an independent party [6]. Label has the functions to inform, educate, influence, protect and help consumers in their decision process. It is usually available to consumers at the time of information, evaluation and decision, making the label reading behavior relevant for marketers. While food label has received more attention, information about clothing label reading behavior is scarce, especially about Romanian consumers. Within the academic literature, there is limited research about the reading behavior or the perceptions about clothing label. At international level, only the reading behavior related to care, size and ecological or ethical label aspects have been investigated.

Addressing this critical gap, the present study makes an inquiry about label reading behavior and aims to find out: if the Romanian consumers read the information on the label of clothing, what type of information they read, which are their beliefs about the label and which are their perceptions regarding ecological label for textiles. The inclusion of the ecological label in the discussion is motivated by the increasing need to face sustainability challenges and by the contribution that eco-clothing can have both to environment protection and to the development of a market segment [7, 8, 9, 10]. Eco-labelling schemes currently serve primarily as a marketing tool, and products with eco-labels tend to target niche markets.

The novelty of the research is given by the inquiry in the clothing label reading behavior and the focus on the ecological label, which were not studied within the Romanian market context and also not in the context of any other country, to the best knowledge of the authors.

The study made several important contributions to consumer behavior research in the apparel field by providing insights into clothing label reading process (actions and beliefs), highlighting how the ecological label is perceived and revealing marketing opportunities. Fierce competition and dazing increase of information content raise the importance of label as a communication and information instrument. Falling prices, decrease in quality, an overwhelming number of designs delivered on the market at fast speed, premature disposal and psychological obsolescence generate overconsumption, which, together with pollution and resource consumption associated to raw material production and processing, long transportation routes etc. exhaust surviving forces of the natural environment and impose urgent revision [11]. One tool that supports the shift to sustainable production and consumption patterns is the ecological label. Eco-labels aim at helping consumers identify products and services that have a comparatively low environmental impact throughout their life cycles. In the case of clothing, at EU level, the ecological label guarantees: a limited use of substances harmful to the environment, limited substances harmful to health, reduced water and air pollution, textile shrink resistance during washing and drying and color resistance [12].

METHOD

The purpose of this study was to achieve an understanding of Romanian clothing label reading behavior in a dynamic and extremely tender market. Because Romanian consumer profile is part of a range of research hardly explored, the research was interpretive in nature, using an exploratory descriptive study. Results are based on data obtained through a survey, non-probabilistic, that used a convenience sample of 371 persons, young, from Romanian urban areas, with access to a vast choice of clothing, through shops (in-store and online) and malls.

Two focus group sessions of twelve and ten participants were develop with the purpose of understanding which are (a) the types of information on the label and (b) the features associated with the label which are the most relevant for the clothing label reading behavior. A special focus was maintained on the ecological label. The resulting information was used in the design of a questionnaire with closed and open-ended, which was implemented on-line and through face to face interviews. The questionnaire was structured in two sections: (I) actions and (II) beliefs related to the label reading behavior (table 1).

Data analysis was made using the software Excel and SPSS version 21. For comparison of differences regarding an ordinal or continuous variable, between two groups, the Mann-Whitney U test was used. The relationship between two ordinal or continuous variables was investigated using Spearman's Rank Order Correlation. The level of statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSIONS

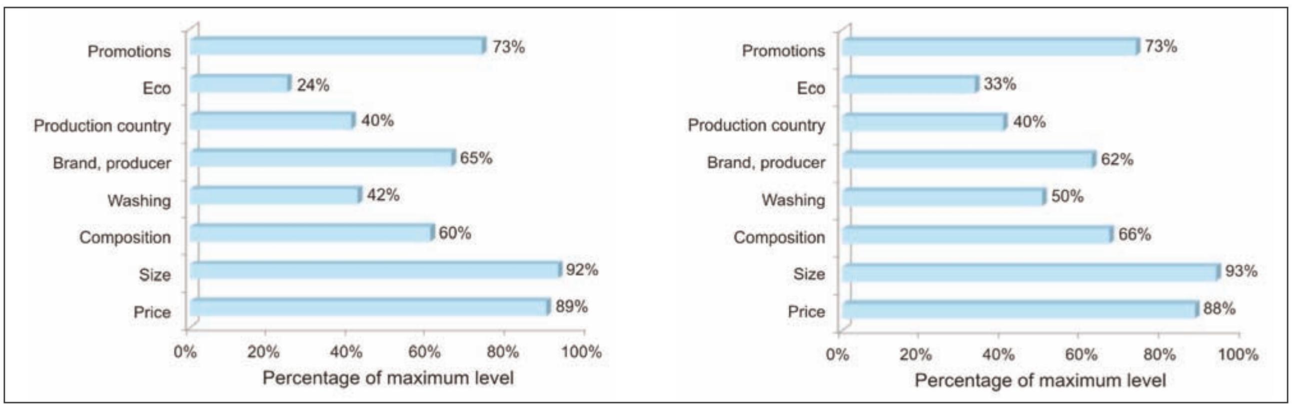
Actions and beliefs related to the clothing label

Reading frequency of label information will give indication of the usefulness of the information printed on the label for the consumers. In some cases the reading frequency may not reflect the importance assigned to that information, and this is why a separate question about the importance of each type of information of the label was also asked. An average score for the reading frequency and an average score for the importance of each piece of information were calculated like this: (4 X no of the highest evaluation +… + 0 X no of the lowest evaluation) / total no of answers. These scores were compared to the maximum level, resulting percentages that show how much of the maximum possible score was achieved by each piece of information (figure1). The most frequently read information on the clothing label are size, price, promotions and they are also rated as the most important ones in the purchasing decision. The winning of the best position in reading and importance by the size should draw producers' and retailers' attention on the way the size is displayed and on the opportunities gained by placing a specific piece of information next to it. The type of size system becomes important in this context and a widely and easy to understand known one should be used or at least added to a less common one, in order to avoid confusion [13, 14, 6]. The results also picture a good situation from the label reading behavior point of view: 72% of consumers read some information on the clothing label in at least half of the cases they buy clothing.

The ecological information gathered the lowest reading frequency and importance (figure 1), probably due to the rare presence on the market of the ecological clothing products and of the news or information about it. If this assumption is true, the reading frequency obtained has a good level. However, we must bear in mind that these figures are based on

Table 1

VARIABLES ANALYZED IN THE STUDY		
Variables	**Categories**	
(I) Actions	Reading frequency of various types of information on clothing label, based on self-reported evaluations	(Close ended question, 5 points Likert scale) price, size, composition (type of materials and fibers), information on washing, drying, ironing etc., brand and/or producer, country of origin, ecological information – the existence of the ecological label (e.g.: Eco label), promotions.
(II) Beliefs	Importance of various types of information on clothing label, based on self-reported evaluations	(Close ended question, 5 points Likert scale) price, size, composition (type of materials and fibers), information on washing, drying, ironing etc., brand and/or producer, country of origin, ecological information – the existence of the ecological label (e.g.: Eco label), promotions.
	Beliefs about label characteristics that could indicate superior quality	(Agreement level on a 5 points Likert scale) "A larger number of interior labels indicates superior quality of the product"; "A greater number of exterior labels indicates higher quality of the product"; "A beautiful design of the exterior labels indicates higher quality of the product"; "As the amount of information on the exterior labels is higher, the product quality is higher"; "As the amount of information on the interior labels is higher, the product quality is higher"; "Clothing with textile interior labels are of better quality than clothing with plastic interior labels"; "When I trust in the brand, I do not read the label"
	Beliefs about product characteristics that could indicate superior quality and could be used as the rules of thumb to asses product quality instead of reading detailed information on the label	"As the price is higher, the quality is better"; "As the brand is more famous, the product quality is better".
	Beliefs about the ecological label characteristics	"Ecological label gives me the certainty that the product has a reduced negative impact on the natural environment"; "By purchasing eco-labeled clothing, I have a significant contribution to environmental protection".
Demographic variable: Gender (M, F)		



a b

Fig. 1. (a) Percentage of average reading frequency score in maximum level and (b) percentage of average importance score in maximum level for each piece of information on the clothing label

subjective evaluations, which means they described the perceived reality and not necessarily the objective one. A similar behavior, with price and personal criteria overpassing ecological one, was observed in UK consumers, too [15].

The differences according to gender regarding the reading frequency of and the importance assign to various pieces of information on the label were tested. It was found that there is a statistically significant difference between men and women, with women: having higher reading frequencies of price, size and promotions and assigning higher importance to the price, size, composition, ecological criteria and promotions (table 2). It was also observed that women have a higher agreement level about the ideas that the Eco label of textiles indicates a low negative environmental impact of the product and that the buyer

Table 2

MAN WHITNEY U TEST RESULTS FOR SIGNIFICANT DIFFERENCES BETWEEN MEN AND WOMEN REGARDING READING FREQUENCIES AND IMPORTANCE OF VARIOUS PIECES OF INFORMATION ON CLOTHING LABEL				
Variable		**p value**	**Higher value**	
			Men	**Women**
reading frequency of:	price	p=0.000		X
	size	p=0.001		X
	promotions	p=0.000		X
importance level assigned to:	price	p=0.005		X
	size	p=0.003		X
	composition	p=0.021		X
	ecological criteria	p=0.028		X
	promotions	p=0.000		X
agreement level about the idea that:	the eco label of textiles indicates a low negative environmental impact of the product	p=0.008		X
	the buyer has a positive contribution to environment protection by purchasing textiles with eco label	p=0.019		X

Table 3

SPEARMAN'S RHO CORRELATION COEFFICIENT FOR THE RELATIONSHIP BETWEEN READING FREQUENCY AND IMPORTANCE OF VARIOUS PIECES OF INFORMATION ON CLOTHING LABEL								
	Price	**Size**	**Composition**	**Info washing etc.**	**Brand/ Producer**	**Country of origin**	**Eco criteria**	**Promotions**
r	.496	.508	.642	.657	.645	.597	.636	.739

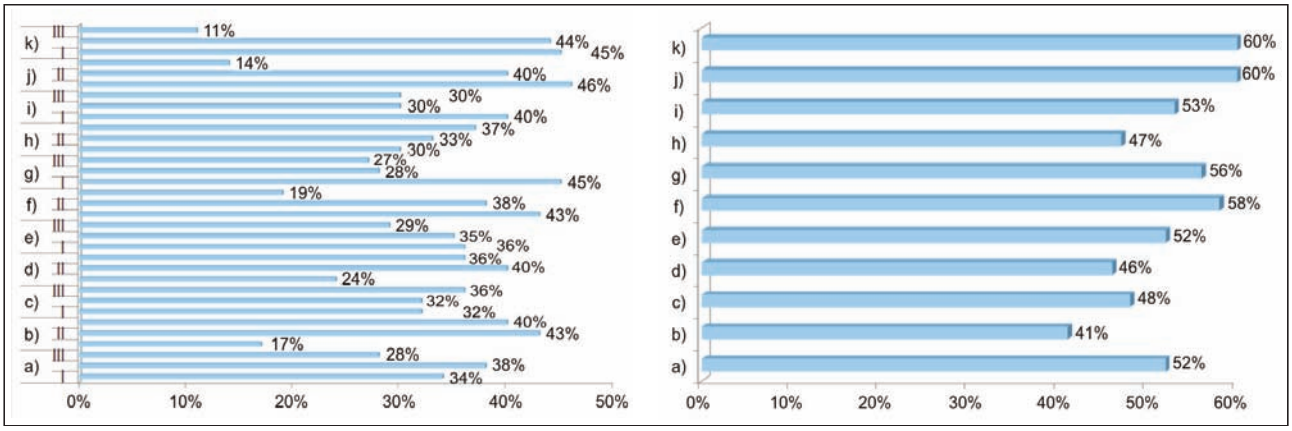
has a positive contribution to environment protection by purchasing textiles with eco label (table 2).

In a highly competitive environment, each piece of information can be a motivating with the appropriate interest of consumers. For instance, the visible display of the country of origin (through "Made in Romania" tags) will help inland producers to capture consumers' attention and gain more market share. Gender differences observed may suggest label design adjustment to fit gender profile. While price, size and promotions are more frequently read by and more important to women, other aspects, such as country of origin are not influenced by gender. In other countries, males were more interested in country of origin and in laundering indications [16].

The reading frequency of one piece of information and the importance attached to it are strongly correlated to each other for all cases: the higher is the importance, the higher is the reading frequency of that specific information (table 3).

The existence of certain beliefs may influence the reading frequency of clothing labels. The highest agreement level was collected by the ideas that the ecological label is an indicator of the fact that the clothing item has a reduced negative impact on the environment and by the idea that the consumer has a significant contribution to environment protection by the purchase of clothing with ecological label, both indicating an acceptable level of trust in the ecological label for a market where eco clothing is not very common, but a low one if the market was more abundant in this category. The next strongest belief (but very close to the neutral level) is that textile interior labels are an indicator of higher quality of the product. On average, consumers tested do not agree with the ideas that a higher number of exterior label, a nicer design of these or a bigger quantity of information on them are an indicator of superior quality of the clothing product, nor that a high price is an indicator of a better quality (figure 2) where:

a) A larger number of interior labels indicates superior quality of the product;
b) A greater number of exterior labels indicates higher quality of the product;
c) A beautiful design of the exterior labels indicates higher quality of the product;
d) As the amount of information on the exterior labels is higher, the product quality is higher;
e) As the amount of information on the interior labels is higher, the product quality is higher;
f) Clothing with textile interior labels are of better quality than clothing with plastic interior labels;
g) When I trust in the brand, I do not read the label;
h) As the price is higher, the quality is better;
i) As the brand is more famous, the product quality is better;
j) Ecological label gives me the certainty that the product has a reduced negative impact on the natural environment;



a b

Legend:
I = strong agreement and mostly agreement; II = neither agreement, nor disagreement; III = mostly disagreement and strong disagreement

Fig. 2 (a) Percentage of consumers having a specific agreement degree with clothing label statements and (b) percentage of average score of agreement of statements compared to the maximum level possible (based on scores from 0 – total disagreement to 4 – total agreement)

Table 4

SPEARMAN'S RHO CORRELATION COEFFICIENT FOR THE RELATIONSHIP BETWEEN THE STRENGTH OF BELIEF AND THE AVERAGE READING FREQUENCY OF CLOTHING LABEL	
Belief	**r**
A larger number of interior labels indicates superior quality of the product	.222
A greater number of exterior labels indicates higher quality of the product	.226
A beautiful design of the exterior labels indicates higher quality of the product	.208
As the amount of information on the exterior labels is higher, the product quality is higher	.247
As the amount of information on the interior labels is higher, the product quality is higher	.141
Clothing with textile interior labels are of better quality than clothing with plastic interior labels	.112
When I trust in the brand, I do not read the label	.064
As the price is higher, the quality is better	.157
As the brand is more famous, the product quality is better	.149
Ecological label gives me the certainty that the product has a reduced negative impact on the natural environment	.068
By purchasing eco-labeled clothing, I have a significant contribution to environmental protection	.166

Table 5

SPEARMAN'S RHO CORRELATION COEFFICIENT FOR THE RELATIONSHIP BETWEEN THE STRENGTH OF BELIEF THAT THE CLOTHING WITH ECO LABEL HAS A LOW NEGATIVE IMPACT ON THE ENVIRONMENT AND THE STRENGTH OF BELIEF THAT A CONSUMER HAS A SIGNIFICANT CONTRIBUTION TO ENVIRONMENT PROTECTION BY BUYING CLOTHING WITH ECO LABEL

			EcoLabel_LowNegative	EcoLabel_EnvProtContrib
Spearman's rho	EcoLabel_LowNegative	Correlation Coefficient	1.000	.513**
		Sig. (2-tailed)	.	.000
		N	371	371
	EcoLabel_EnvProtContrib	Correlation Coefficient	.513**	1.000
		Sig. (2-tailed)	.000	
		N	371	371

** Correlation is significant at the 0.01 level (2-tailed)

k) By purchasing eco-labeled clothing, I have a significant contribution to environmental protection

The correlation between eleven beliefs and the average reading frequency of clothing label (including all pieces of information on the label) was tested. In nine cases, the stronger is the belief in consumers' mind, the higher is the average reading frequency of clothing label, but the power of the relationship is weak (table 4).

A strong positive correlation was found between the belief that the clothing with eco label has a low negative impact on the environment and the belief that a consumer has a significant contribution to environment protection by buying clothing with eco label (table 5). Thus, consumers demonstrate a correct understanding and acceptance of the functions of the ecological label, possibly because during the last years the ecological market, especially the food one, has been increasing in Romania and terms such as bio, organic, eco are widely spread [17]. This finding is important in the current context and should draw producers' attention, because more and more companies recognize the role of consumption sustainability as an integral component of their business strategy and consumers increasingly reward businesses that treat the environment fairly [18]. Even if the hold of a belief or knowledge does not guarantee that the behavior will follow it, taking advantage of the existence of this knowledge in combination with other measures, such as visible display of eco logos can lead to very good results. Findings suggest that apparel companies may benefit from using hang tags featuring explicit messages and logos to convey their eco or social responsible business practices [19] and that standardized eco-label to facilitate identification of eco-friendly alternatives, concise, clear and factual message content, and interpersonal communication may stimulate the pro-environmental apparel behavior [20].

CONCLUSIONS

Consumers have a practical orientation in their label reading behavior, as price, promotions and size are the most often read and have the highest importance for studied population. Gender influences label reading behavior, because women read the clothing label more often than men and allocate it higher importance.

Ecological information has a good reading frequency and importance, for a market with low presence of eco clothing, but among other pieces of information on the label it is currently positioned at the lowest end of consumers' ratings. The ecological label is positively appreciated by consumers:

(1) they believe that the ecological label is an indicator of a reduced negative impact on the environment of the clothing products that has it and

(2) they consider that they have a significant contribution to environment protection by purchasing clothing with ecological label. The environmental consciousness in relation to clothing purchase and use should be, therefore, enhanced, as there is a good basis to build on – the favorable perception of eco-label. Consumers are not exposed enough to green product marketing communication in clothing field, revealing the need of a greater use of marketing and brands to promote and sell products that are environmentally friendly and the opportunity of exploiting more the market for greener products, especially within consumer groups that have pro-environmental values.

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The model of continuous improvement of branding process – the key towards an efficient communication within Romanian textile industry

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REZUMAT – ABSTRACT

Modelul de îmbunătăţire continuă a procesului de branding – cheia spre o comunicare eficientă în industria textilă din Romania

Într-o economie oscilantă, într-un mediu economic aflat într-o continuă transformare, rezultatul efortului de marketing al unei organizaţii poate fi dezastruos fără o analiză atentă a mediului de afaceri. Într-un articol anterior, autorii au propus abordarea brandingului ca proces organizaţional şi analizarea interacţiunii acestui proces cu toate celelalte procese organizaţionale în vederea obţinerii unei poziţii clare la un moment dat. Datorită unui declin puternic al industriei româneşti, în special în industria textilă, se impune găsirea unei soluţii de redresare cât mai rapidă. Revenirea în elita mondială a firmelor din industria textilă, în condiţiile unei concurenţe acerbe, se poate face prin redefinirea brandului firmei, prin îmbunătăţirea procesului de construire a acestuia.
Plecând de la acest fapt, autorii propun în lucrare un model de îmbunătăţire continuă a procesului de branding într-o organizaţie industrială. Având la bază interacţiunea cu celelalte procese organizaţionale, modelul evidenţiază paşii necesari în dezvoltarea unui astfel de proces de îmbunătăţire şi prezintă punctual modalităţi de soluţionare a situaţiilor întâlnite. Modelul astfel propus a fost validat pe un studiu de caz şi poate constitui un ghid pentru managerii organizaţiilor din industria textilă, în încercarea acestora de a crea sau de a menţine avantajul competitiv al organizaţiei pe care o conduc.

Cuvinte-cheie: industria textilă, proces de branding, îmbunătățire continuă

The model of continuous improvement of branding process – the key towards an efficient communication within Romanian textile industry

In a fluctuating economy in an economic environment under constant transformation, the result of an organization's marketing effort can be disastrous without careful consideration of business environment. In a previous article the authors have proposed branding approach as organizational process and an analysis of the interaction of this process with all other organizational processes in order to obtain a clear positioning of its current situation. Due to a sharp decline in the Romanian industry, in particular in the textile industry, it is necessary to reach a swift redress. In this fierce competition, returning to the world elite companies for textile industry can be done by redefining the company's brand and through a process of brand continuous improvement. Given this fact, the authors propose in the paper a model of continuous improvement of the branding process in an industrial organization. Based on the interaction with other organizational processes, the model shows the steps in developing such a process improvement and shows how to solve punctual situations encountered. The proposed model has been validated on a case study and presents a guide for managers of industrial organizations in their attempt to create or maintain competitive advantage of the organization they lead.

Keywords: textile industry, branding process, continuous improvement

CONTEXT

Romanian industry has faced a series of significant changes due to a continuous fluctuation of business environment's factors. According to Eurostat, the turnover registered in the European Union by enterprises active in all business sectors has improved by 3.8 billion euro in 2014 compared to the level recorded previously. Therefore, the European business market has recorded overall a positive trend in terms of performance. In this regard, the attractiveness of different industrial sectors has significantly diminished, as companies did not manage to properly correlate the information and knowledge gathered based on product's requirements engineering in order to maintain competitive advantage and/or exploit new business opportunities. In this context, textile industry is a representative industry, as Romania has an enriched history regarding textile manufacturing. The share of newly enterprises entering this particular industry is on a descending trend, while the death rate of businesses has increased, i.e. the total number of enterprises recorded in the industrial market is: 172.2755 companies – 2014, 174.254 companies 2013, 180.200 companies – 2012, emphasizing the utter need for processes' continuous improvement. (Eurostat, 2014).

With all the last restructuring undergone by industry sector due to lack of coherence, continuity, predictability and good fiscal and monetary regulatory trading, however textile industry currently has an industrial production of 8547.1 million, exports of 5.574 7 million, a total of 341 800 employees and is the branch that does not produce trade deficit with 1990 until now, positive trade balance (imports of 4.736 million euros). (Romanian National Institute of Statistics).

We still have a contribution to Romania's industrial production and a GDP which is also significant. This allows us to build a public-private partnership by establishing a branch brand, to ensure the sustainability of industrial production and design, using brands already established on the European and international level. Worldwide Romania is among the largest exporters of clothing in the world along with China, Turkey, India, Bangladesh, Morocco, and Tunisia. The fact that Romania has moved from 7th to 3rd place on the EU market, is another argument for developing a brand strategy that will complement the export strategy with the main objective to reconsider its position on the global market.

A study conducted in 2012 analysed the value of Romanian brands pinpoints that there are no fully successful national brands developed and administrated by Romanian management. The characteristics of Romanian business market are highly different from the countries with a solid economic development, i.e. the concepts of "branding", "market positioning" and "business performance" are redundant as long as the single driver towards business growth is the existence of the product itself. Moreover, the branding process does not retrieve immediate results, as the outcomes of an adequate strategy, i.e. a branding program, which enables the enterprises' long-term stability and performance, can be identified and quantified only throughout time.

Therefore, only few Romanian companies have developed highly qualitative branding programs up to this moment, and there are fewer Romanian brands which managed to gain the consumer's awareness for this particular reason rather than the nationalism criteria. The lack of knowledge regarding branding management, i.e. specialised human resource shortage, as well as the current economic, legal and social framework are improper for brand development.

To gain a better position on the national and international market, the Romanian textile industry, must build strong brands or improve the existing brands. The Romanian textile industry comprises highly competitive brands due to their qualitative products. However, in order to attain success through branding, it is mandatory not only to gain knowledge regarding the in-depth of the aforementioned concept, but also to thoroughly understand it based on long-term experience, and to disseminate branding know-how, hence to be afterwards implemented and used on a scale-basis in the Romanian economy context.

Given these unfavourable conditions, there are Romanian brands which have achieved competitive advantage not only on the local market, but also globally. In this regard, there are Romanian brands which are highly attractive for foreign consumers, such as:

- **ID Sarieri** – Romanian lingerie brand highly appreciated on the Italian market.
- **Braincoff** – with a tradition of nearly 60 years in the industry of garments is one of the most renowned lights garments companies in Romania. In the last years the Braincoff's management understand that addressing new markets and continuous improvement of organizational process can mean the path to success. Despite this, the communication process and the branding process seem to need more and more attention.
- **Nissa, TinaR –** Romanian fashion brands well-known on Romanian market but with a poorly defined and poorly communicated brand strategy.

ID Sarieri and Braincoff are only two examples of successful companies, which have emerged on the local market years ago and are recognised nowadays, both locally and globally as well established brands. There are other companies in this industry well-known for qualitative products but without a well-defined brand. In order to compete successfully with foreign brands internationally, it is necessary for managers to turn their attention to improving the branding process. Their commonalities include quality and, in some cases, uniqueness, as well as an effective brand strategy. The proposed model for continuous improvement of the branding process helps the companies in the textile industry in a bid to achieve and maintain long-term competitive advantage. Such an approach leads to more efficient marketing efforts and an appropriate communication strategy goals.

BRAND EQUITY

A brand is an asset. The brand impact can be noticed on three different levels: consumer market, product market and financial market. On each of these three aforesaid markets, the brand generates an added value. Hence, the sum of these three added values generates the "**brand equity**". This term was defined at the end of 1980's, and its conceptual development has resulted in recognising the brand's importance in the organization's marketing strategy. The complexity of the concept has led to a general confusion among scholars regarding how all its facets should be captured within one definition. David Aaker defines "**brand equity**" as a concept which includes the brand's assets and liabilities, as well as its name and symbol which are then further detracted from the total value generated by the good or service, either to the organization or to the consumers [1]. Therefore, according to Aaker brand equity is, in fact, the intangible component of both the brand and consumers' perception [1].

Moreover, the researcher has developed a conceptual model of brand equity in order to depict the concept's theoretical description, which comprises five dimensions (figure 1): loyalty towards the brand, degree of brand awareness, the perception of brand quality, brand's associations, and other brand assets [1].

Marketing Science Institute (MSI) defines brand equity as "the entire set of associations and behaviour of the elements connected to the brand, i.e. clients,

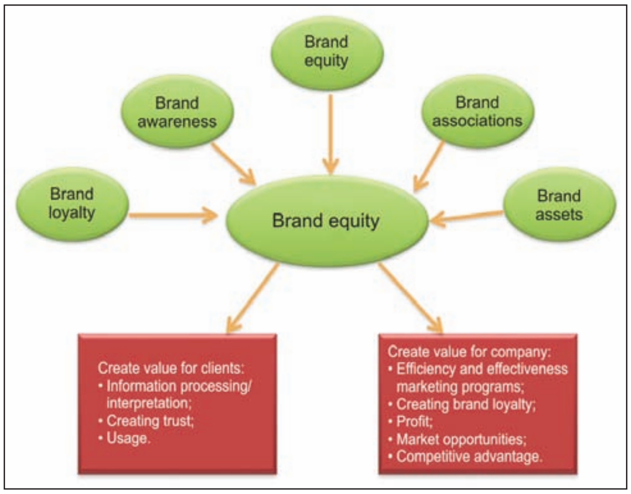

Fig. 1. Brand Equity. Aaker Model

distribution channels and industrial enterprise, hence allowing for sales and/or profit enhancement, which otherwise would not have been able to be attained, i.e. the brand strengthens the enterprise on the market, facilitates its sustainable development and enhances the organization's competitive advantage.
The MSI definition emphasizes the clear distinction between the added value provided by the brand and the benefits generated by the product itself on all the layers of interaction, i.e. consumer, market, financial. Raj Srivastava, a researcher from University of Texas, describes brand equity as the sum of brand's value and its strengths [2].
The brand's value is defined as the generated financial income based on the manager's ability to properly exploit the brand's strengths, alongside with undertaking effective tactic and strategic activities for profit improvement and risk detraction.
Although this particular definition comprises two new concepts, its applicability is connected with the same elements identified by previous researchers. However, the main difference lies in the constraints of brand equity, and such Sivastava highlights the importance of risk analysis against the brand's financial performance, quantified by net and/or gross profit [2]. In this regard, the scientific opinions towards this particular concept have varied over time and there are still scholars who define "brand equity" excluding the elements which generate the brand's added value. Therefore, brand equity is directly connected to the brand's added value generated by marketing services, as the added value depends on the marketing strategy.
Keller asserts that designing a brand implies to create that element on which the enterprise can gain competitive advantage by notably differentiating on the market against other products. The financial added value is in fact the cumulative result of marketing strategy, products' research and development and innovation, technology improvement etc. during a specific timeframe, i.e. the period of time is an expanded timeframe, as the process outcomes are retrieved after years of activity.

The efforts undertaken within the organization's functions, especially the marketing department, for designing and developing a brand, are directly reflected in the brand equity, hence the concept can be used not only for consolidating the business but also for helping the organization to better exploit the opportunities and strengthen the existing brand within the market. In a dynamic economic environment, the concept of brand equity facilitates new means to improve the decisional process, by identifying new alternatives to valorise the brand and solve related problems to brand management [3].

Conceptual model developed for continuos improvement of branding process

The importance of brand equity as an intangible asset implies the continuous improvement of branding process. Therefore, the authors have developed a complexed model, which aims to support industrial organizations during their efforts regarding brand management. As the current model comprises the required steps for developing such a process, it can be used by managers active on the industrial textile industry as a guide attaining and maintaining competitive advantage.
In this regard, for developing an efficient model for branding process improvement within an industrial organization, with a specific orientation towards strategic management, it is mandatory to permanently assess the brand equity.
A crucial characteristic which the enterprise should take into consideration when analysing its brand is its dynamic property, i.e. a brand evolves based on the internal and external factors; hence the ratio between the brand's strategic management process and organization's processes has also a dynamic behaviour. When considering the strategic management process, its particularities should be clearly emphasised, as the brand's strategic management cannot be regarded only as a sequential flow of activities, with specific inputs and outputs based on standards.
However, the holistic view of the process remains a very important approach when analysing the variations recorded by the organization's processes. These fluctuations determine significant changes not only on product's attributes, but also on the perception regarding the company, hence generating an immediate impact on the brand, with long-term consequences.
The continuous measurement of brand equity can be regarded as a continuous method to continuously improve the business processes, which according to, should be conducted on a constant-basis in order to [4]:
- Identify the proper manner for the brand to meet client's requirements;
- Identify the brand evolution against competition;
- Identify the brand's weaknesses before they materialise;
- Identify the opportunities related to the brand in order to enhance the added value.

Therefore, undertaking a thorough and constant analysis and measurement program regarding the market conditions, clients' expectations and perception and financial results is mandatory for the organization as it has a crucial role during the enterprise's endeavours to fulfil its objectives. In this regard:

- The metrics should be easy to use – time economy.
- The metrics should quantify actions which can be adjusted – the metric should measure a business decision; the focus should lie on the "need for measurement" and not on the "it's good enough just to measure something".
- The metrics should measure a repetitive activity – in order to obtain results regarding an activity evolution, it has to be repetitive.
- The metrics should retrieve quantifiable results – in order to apply benchmarking process, hence to compare the enterprises' results with the competition or the proposed objectives.

The problem with which the enterprises are confronting during this analysis is the miscorrelation of causal relationships between brand perception, brand performance and financial results. A thorough understanding of demand's key factors, as well as knowing the proper moment when the interaction consumer-brand triggers the consumer's impulse to choose the brand over competition are key elements for achieving brand's future success, i.e. understanding this aforementioned causal relationship between perception, performance and impact generates the information and knowledge regarding the key activities which create value for the brand.

Munoz, Kuma, have divided the metrics in three categories, as described in table 1. Therefore, during this process it is not enough only to identify and plan communication activities, but also operational, financial and strategic activities, as follows [4]:

- Connect the brand's metrics with the business strategy.
- Identify the strategic objectives which can be influenced by the brand.
- Determine the main processes which are influenced by the brand.

The indicators which are subject to permanent analysis are divided in three categories, each of them generating a specific characteristic of the efficiency of brand's strategy:

a. Consumer

b. Market

c. Financial

a. The indicators used for studying the brand against the consumer have been selected in order to retrieve a complex overview of:

- *Perception*
- *Behaviour*
- *Degree of knowledge*

Hence, for describing the perception the following indicators were used:

- ***Notoriety*** – the share of existing or potential clients which were able to recognize a brand or an element of the brand;
- ***Attitude*** – clients' attitude evaluation, i.e. existing or potential clients, against a particular brand,
- ***Perceived quality*** – clients' attitude evaluation against brand's quality.

Regarding the consumer's behaviour towards the brand, the following indicators were taking into consideration:

- ***Brand penetration*** – the ratio between the clients who have purchased the brand at least

Table 1

Metrics for brand perception		Metrics for brand performance		Metrics for financial performance
Knowledge	**Familiarity and consideration**	**Acquisition decision**	**Loyalty**	**Value development**
Are the consumers aware of the brand?	What are the consumers thinking and feeling regarding the brand?	What is the behaviour of the consumers?	How has the behaviour of the consumers changed in time?	How does the consumer's behaviour impact the brand's value development?
Standing out	**Distinction**	**Acquisition**	**Consumer's satisfaction**	**Market share**
Brand awareness	**Relevance**	**Influence**	**Retention**	**Profit**
	Credibility	**Trial**	**Win on the costumer**	**Operational cash flow**
	Pleasure	**Repeating acquisition**	**Share of wallet**	**Marketing budget share**
	Perceived quality	**Preference**	**Total values of consumer's acquisition (LTV)**	**Brand value**
	Shopping intention	**Premium price**	**ROI**	**Analysts' evaluation**
	Resemblance		**Reference**	
			Cost saving	

Table 2

Process involved	Targeted factor	Brand objective	Brand strategy	Recommended action
Research and development	Innovation	Development	Generate brand extension	Develop connected products in order to provide the consumer a "complete solution" for the brand
Research and development	Innovation	Development	Create favorable associations	Enhanced attributes for brand's associated product
Research and development	Adjustment according to market needs	Development	Correlate the consumers' perception with their expectation	Develop adjacent attributes based on the consumers' existing trends
Research and development	Continuous improvement	Development	Market leaders' brands Benchmarking	Develop brand's attributes with properties which are at least at the same level with those of the market leader's brand
Production	Product's quality stability	Development	Create loyalty toward the brand	The stability of brand's quality generates trust and loyalty. A permanent system for quality measurement and failure prevention
Production	Technology improvement	Brand equity enhancement	Profitability improvement	As the production process is more efficient and less expansive, the brand's quality and safety increase, hence improving the sales volume and, therefore, the profit
Production	Production plan compliance	Credibility - development	Create favorable associations	Marketing plan compliance regarding brand communication can be seriously affected by a miscorrelation between production process and distribution process, resulting in a inefficient brand's distribution
Human resource	Training	Development	Create a favorable image regarding the company and product	Highly qualified human resource – efficient solutions and readly and highly qualitative answers
Human resource	Organizational structure adjustment	Development	Efficiency	An efficient and balanced organizational structure leads the organization towards progress
Supply	Constant quality of raw material	Development	Associations' loyalty	The constant quality of raw material directly reflects in the product's constant quality, which generate consumer's trust and, hence, loyalty
Supply	Constant adjustment of raw material prices	Development	Brand value enhancement	
Supply	Continuous flow - avoid bottlenecks	Development	Create a favorable image regarding the company and product	Avoiding bottlenecks leads to a continuous production flow, which implies an efficient distribution and production plan compliance – an additional trust and loyalty
Marketing	Price	Development	In time connection with market reality	An efficient price policy generates sales and profit enhancement
Marketing	Innovation	Development	Create brand extensions	A complex and efficient analysis allows for a proper identification of market niches, as well as related and uncovered market segments, i.e. new market opportunities
Marketing	Distribution channels	Development	Create brand value	Permanent identification of distribution channels connected with consumer's trends and habits
Marketing	CIM	Design - Development		
Financial	Budgets	Design - Development		Defining a realistic and complete brand budget, which is correlated with organization's development plan
Financial	Brand Cash flow	Design - Development		Providing the required cash-flow to support constant flow of brand activities

once and the total number of clients within a particular segment;

- ***The number of clients*** – the number of clients who have purchased the brand during a specific timeframe;
- ***Recent expenditure*** – the recorded timeframe between two acquisitions of the brand by the same consumer;
- ***The rate of attracting new clients*** – the ratio between the number of newly attracted clients and the existing clients in a particular timeframe.

The degree of knowledge is quantified based on AAU index – ***Awareness attitude and usage,*** as previously described.

b. The indicators for market analysis were identified in such manner to allow for a continuous analysis and also to depict a complete and complex overview of the case (table 2). These metrics are structured in four categories:

- *Distribution*
- *Competition*
- *Volume*
- *Price*

Therefore, ***distribution*** metrics include:

- *Numeric distribution* – number of stores in which the brand is distributed;
- *The quality of distribution* – evaluate the quality of distribution channels regarding a particular brand;
- The ***equity brand index*** allows for a proper quantification of the brand's position on the market against current ***competition.***

The market volume index is defined by:

- ***The market's total volume*** – the total units sold by each brand active on the market;
- ***Volumetric market share*** – the ratio between the total volume of units sold by the brand and the total volume of the market;
- ***The total quantity of sales*** of a brand.

The price evolution of a particular brand is quantified based on the *relative average price,* i.e. the ratio between the average price of a brand and the average price of all existing brands on the market [5].

c. The evaluation of the brand's financial evolution is based on a set of metrics which are structured in four main categories:

- *Financial value*
- *Sales*
- *Marketing expenditure*
- *Profit*

Regarding the financial value of a brand in a particular time point, the relevant metrics include:

- ***The total value of the market*** – the cumulative value of sales recorded by each brand, which is active on a market;
- ***The market share value*** – the ratio between a brand's turnover and the total volume of sales recorded by all brands active on the market.

However, from the financial perspective of *sales*, the most relevant indicator which enables to capture the overall evolution of the business in a specific timeframe is the ***total volume of sales***.

The performance of *marketing expenditure* is depicted by the ***market share of marketing budget***, i.e. the ratio between the brand's marketing budget and the cumulative value of the marketing budgets recorded by all the existing brands on the current market [6].

Depending on the in-depth of the analysis regarding marketing expenditure, there are efficiency indicators which can retrieve more insight regarding this indicator's performance.

In order to determine the *profit's evolution*, it is mandatory to reason about financial indicators and such, to assess the brand's net profit or gross profit. This particular evolution is, hence, correlated with specific efficiency measures in order to allow the enterprise to develop a coherent plan for branding process improvement.

The conceptual model is a powerful tool which enables to depict the interaction between the enterprise's branding process and the organization's main processes, i.e. the core engine for continuous improvement of branding process, and therefore, the main driver for a sustainable enhancement of the industrial enterprise's overall performance (figure 2).

The general plan for continuous improvement based on the analysis of the aforementioned indicators, allows for gaining in-depth insight, and hence, a valuable input when developing strategies regarding specific processes on which the enterprise should focus its effort by sustainably channelling its resources in order to obtain an efficient outcome.

CONCLUSIONS

"Branding has become, in organizations that use process approach, a holistic process whose influence on other processes and depending on other processes may be an important determinant of success or failure of an organization. Enhanced economic development and globalization have increased the value that brands bring to companies. The brand has become an intangible asset of the company that far exceeds the value of tangible assets. Brands are traded and brands are those that establish the price of a company. For a long time brands from industrial organizations, including textile and leather industry, operating in the B2B sector have been regarded as insignificant when judged against their target group. Experience has shown that large companies' brands both operating in B2B markets and the B2C markets, have a significant role for creating long-term competitive advantage" [7].

By constantly analysing the environment based on the three main directions which influence the brand development, i.e. financial, market and consumer, and also by linking the branding process with other organizational processes, the model allows managers of the textile industry to gain knowledge regarding market requirements, as well as to better understand the factors which led the organization

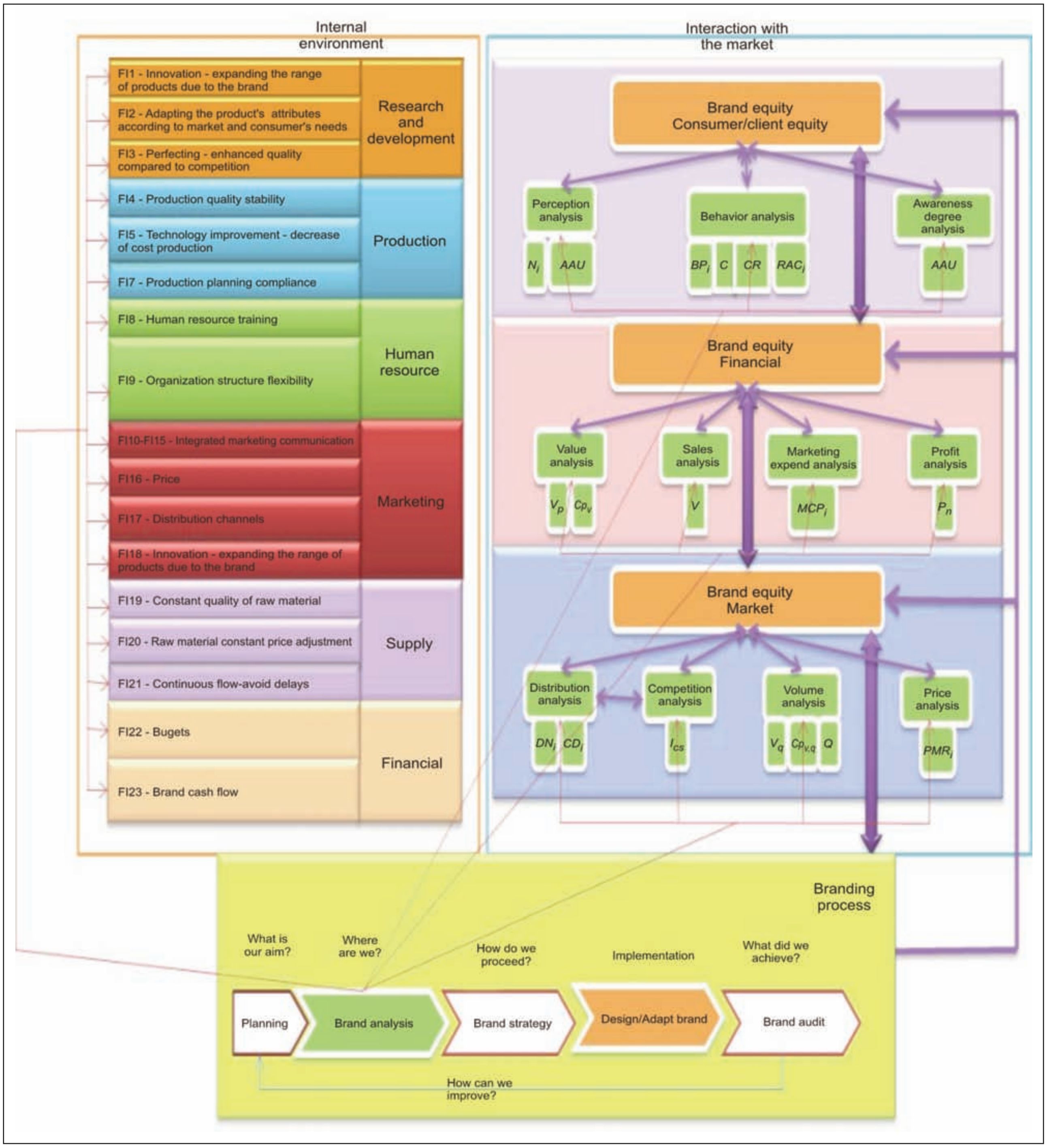

Fig. 2. The conceptual model of continuous improvement of the process of branding

towards the current position that their brand holds in consumers' preferences.

The model has been successfully applied in a Romanian industrial organization, managed to maintain the premium brand of the company as a market leader. The model opens up new prospects for maintaining competitive advantage and enables managers in textile industry to maintain a permanent upward trend for their companies.

To create added value in a market as unstable as in the textile industry, it is important to have a strong brand present in the minds of consumers – Brand Awareness. It is also important that consumer-brand relationship to be a strong one, and the associations to be favourable. This process of knowledge and analysis is favoured by the proposed model and opens a perspective to streamline and focus the efforts of marketing and communication of an industrial company [8]. Each action of the model helps to create added value for brand success.

Acknowledgements

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Why T&C companies need to develop global strategies? Empirical evidences on the influence of the organization's global strategy on its competitiveness and performances

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REZUMAT – ABSTRACT

De ce este necesară dezvoltarea strategiilor globale de către companiile de T&C? Dovezi empirice cu privire la influența strategiei globale asupra competitivității și performanțelor organizației

Această lucrare are ca scop studierea particularităților utilizării strategiei și managementului strategic în cadrul firmelor din România, precum și influența pe care acestea le-ar putea avea asupra competitivității și performanțelor manageriale și economice. Informațiile necesare pentru acest studiu au fost obținute prin intermediul unui sondaj la care au participat 1595 respondenți din 93 de firme din sud-estul României. În urma analizei datelor prin intermediul IBM SPSS 23.0 Statistics, ambele ipoteze ale cercetării au fost validate. Luând în considerare limitările care decurg din caracterul de studiu pilot, rezultatele obținute sunt de natură să constituie baza unor cercetări viitoare.

Cuvinte-cheie: competitivitate, ipoteze, performanță, strategie, studiu

Why T&C companies need to develop global strategies? Empirical evidences on the influence of the organization's global strategy on its competitiveness and performances

This paper aims at studying the peculiarities of strategy and strategic management within Romanian firms and the influence they might have on managerial and economic performances and competitiveness in order to create premises for increasing their competitiveness and performances. The necessary information for this study was collected through a survey attended by 1595 respondents from 93 companies located in south-east Romania. After analysing the data by means of IBM SPSS 23.0 Statistics statistical program, most of the *research hypotheses were validated. Taking into consideration its limitations, the results open future research directions.*

Keywords: competitiveness, hypotheses, performance, strategy, survey

WHY DO WE NEED GLOBAL STRATEGIES?

One of the defining characteristics of contemporary society is change in a general sense, manifested on all levels of human activity. It directly affects the conduct of activities of organizations required to shape, adapt to new conditions which appear in its internal and external environment, changes brought mainly by scientific and technical progress, nationally and worldwide acute competition, changing consumer needs and expectations, but also the trends manifested in the economy and society [1].

Every manager has to ask himself questions regarding the advantages that allowed his success in the past and those that sustain his business in the present, because this way he is able to judge the advantages that will ensure his future success [2]. Implementing organizational strategies has a positive impact on increasing efficiency and improving its managerial performances, reflected in a better ability to identify and respond to changes in the organization's external environment and increased competitiveness; hence the need to implement organizational strategies and practice of strategic management [3]. Strategy can be defined as the major objectives of the organization as a whole over the long term, the main ways of achieving with the resources allocated, in order to obtain competitive advantage according to the organization's mission [4]. The strategy shows how the organization operates, how it uses the resources to fulfil its mission, in compliance with the policy which it has defined.

Strategic management is a dynamic process, in which, via strategic decisions, company managers foresee and ensure future company changes, under the impact of environmental endogenic and exogenic constraints [2]. According to Kerzner strategic planning process to prepare decisions on the future direction of the organization is vital to its survival because it helps to adapt to a changing environment, being applicable to all managerial levels and all types of organizations [5]. Development and implementation of strategic management in Romania is a necessity, but its transformation into reality is still a serious problem. We need more intelligence and creativity to develop policies and strategies that would contribute to a real change [6].

Although the above theoretical approach enjoys wide recognition among specialists and internationally there was conducted a number of studies to support them, there are available little or no empirical data addressed this issue referring to Romania [7–9]. For instance, on a sample of 200 SMEs in North-West Romania, into the structure of which prevails the firms with up to 10 employees and less than 5 years old and using a partially different methodology, could not report a significant correlation between the aggregate indicator of strategic planning and aggregate indicator of performances, but only partial correlations [10].

WHY GLOBAL STRATEGIES WITHIN T&C COMPANIES?

The clothing industry in Romania is a branch with a long tradition in export of a diversified product mix, ranks second in exports of Romania, fourth in the EU clothing exports, focuses the largest number of SMEs in the industry and a considerable number of employees [2].

In the post-crisis conditions and given the increasing competition on the national and international market, the textile and garments companies are forced to identify potential factors able to increase their performances and competitiveness. We believe that this is a good reason (in addition to the well-known theoretical approach) to provide the same empirical evidences on the peculiarities of strategy and strategic management within Romanian organizations and the influence they might have on their managerial and economic performances and competitiveness in order to create premises for increasing the competitiveness and performances of Romanian organizations (figure 1). In this respect, we have defined a set of four research hypotheses, as follows:

H1. *The development of firm's global strategy is influenced by its region of origin, age and size.*

H2. *Developing the firm's global strategy has a positive impact on its managerial performances.*

H3. *Developing the firm's global strategy has a positive impact on its economic performances.*

H4. *Developing the firm's global strategy has a positive impact on its competitiveness.*

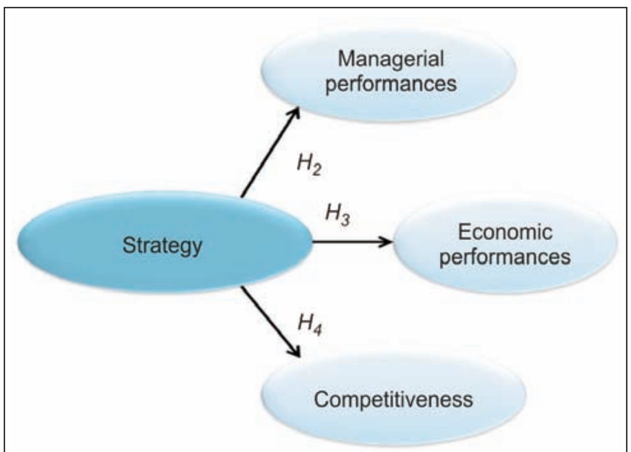

Fig. 1. Research hypotheses
Source: own representation

METHODOLOGY

Design and sampling

The methodology developed for the purpose of this research involved the following steps: (1) formulating research hypotheses, (2) questionnaire design, based on the independent and dependent variables necessary in order to test the research hypotheses, (3) choosing the investigated populations, (4) selecting the sample of respondents, (5) collecting and processing information with the technical support of IBM SPSS Statistics 23.0 statistical program and (6) testing the research hypotheses in order to confirm or invalidate them [11]. This research method enjoyed great interest in the last few years in the area of social and human sciences, in general, and particularly in management.

In order to collect the necessary data for this study it was designed a questionnaire based survey conducted in March – May 2015 addressed to 93 firms from south-eastern Romania, namely Bucharest – Ilfov, South and South-East regions, selected through a non-probabilistic sampling method. Depending on its size, from each company a number of respondents with both managerial and executive positions were selected. Of the 93 companies, 4.3% had less than 10 employees 26.9% between 10 and 49, 32.3% between 50 and 249, and 36.6% more than 250 employees. When referring to firms' age, 4.3% were younger than 5 years old, 16.1% were between 5 and 10 years, 25.8% between 10 and 15 years and 53.8% over 15 years old.

The questionnaire was divided in two parts. Part I, contained questions concerning the characteristics of investigated companies and Part II serves the most direct purpose of the research, being aimed to capture the specific aspects of strategy and strategic management within Romanian organizations as well as the influence they might have on managerial and economic performances.

To achieve the research objectives and given the nature of the analysed variables there was performed both univariate and bivariate analysis (mean, standard deviation, absolute and relative frequency, ANOVA, correlation and regression analysis and factor analysis by means of IBM SPSS 23.0 Statistics statistical program.

Variables

To validate research hypotheses, first we built four aggregate variables based on primary variables defined on the responses to the questionnaire items:

1. *Str* – the aggregate indicator of strategy, built on six primary variables defined on the questionnaire responses to six statement corresponding to the six components of the strategy. On a five-point Likert scale, responses ranged from 1 – Strongly Disagree to 5 – Strongly Agree. (1) *Mis* – Mission reflect the views of management about what to do and what the organization wants to become on long-term (M = 4.0328), (2) *Obj* – Organization's goals are broken down for each department and

position (M = 3.7955), (3) *StrO* – To achieve strategic objectives there are appropriate means of action (M = 3.7295), (4) *Res* – The organization has the human, material, information and financial resources necessary to achieve strategic objectives (M = 3.8757), (5) *Ter* – Are stipulated deadlines to accomplish objectives (M = 3.9850) and *CompA*.

2. *ManP* – the aggregate indicator of managerial performances, built on three primary variables: (1) *ManPT* – managerial performances compared with the targets set, (2) *ManPC* – managerial performances compared with main competitors and (3) *ManPY* – managerial performances compared to five years ago. Responses were recorded on a five-point scale, where 1 = Much less good and 5 = Much better.
3. *EcP* – the aggregate indicator of economic performances, built on three primary variables: (1) *EcPT* – economic performances compared with the targets set, (2) *EcPC* – economic performances compared with main competitors and (3) *EcPY* – economic performances compared to five years ago.
4. *Comp* – the aggregate indicator of competitiveness, built on three primary variables: (1) *CompT* – competitiveness level compared with the targets set, (2) *CompC* – competitiveness level compared with main competitors and (3) *CompY* – competitiveness level compared to five years ago.

Principal component analysis

Since we want that the four aggregate variables reflect as closely as possible the information contained in the primary variables, we employed a factor analysis procedure: extraction method – Principal Component Analysis and rotation method – Varimax with Kaiser Normalization.

The high values of Cronbach's Alpha coefficient of reliability (.07), presented on the third column of table 1, mean that there is evidence that the individual indicators measure the same underlying construct [12–13]. Furthermore, the significant Bartlett's Test of Sphericity ($p < .01$) and the overall Kaiser-Meyer-Olkin Measure (KMO) of Sampling Adequacy (displayed on the fourth column of table 1) means that all four our datasets are suitable for factor analysis [14].

Following the procedure described above, of the six primary variables representing components of strategy was extracted only one component with Eigenvalue greater than 1, which cumulates 70.155% of the initial variability of all the six original variables and is strongly and positively correlated with each of them: mission (.796), objectives (.850), strategic options (.857), resources (.841) and terms (.844).

From the three primary variables related to managerial performances was extracted only one component with eigenvalue greater than 1, which cumulates 75.861% of the initial variability of all the three original variable and is strongly and positively correlated with each of them: managerial performances compared with the targets set (.909), managerial performances compared with main competitors (.883) and managerial performances compared to five years ago (.819).

Following the same procedure, from the three primary variables related to economic performances it was extracted one component too with Eigenvalue greater than 1, which cumulates 66.974% of the initial variability of all the three original variable and is strongly and positively correlated with each of them: economic performances compared with the targets set (.909), economic performances compared with main competitors (.895) and economic performances compared to five years ago (.618).

Finally, from the three primary variables related to competitiveness it was extracted only one component with Eigenvalue greater than 1, which cumulates 78.862% of the initial variability of all the three original variable and is strongly and positively correlated with each of them: competitiveness level compared with the targets set (.925), competitiveness level compared with main competitors (.899) and econ competitiveness level compared to five years ago (.838).

Table 1

	Cronbach's Alpha	KMO	Items	Eigenvalue	% of variance
1 Str	.892	.796	5	3.508	70.155
2 ManP	.833	.694	3	2.276	75.861
3 EcP	.735	.585	3	2.009	66.974
4 Comp	.860	.700	3	2.366	78.862

Source: made by authors with SPSS 23.0

Using Bartlett method, we produced component scores which will be used in further analyses. Therefore, using the values from the component score coefficient matrix, we built the following equations:

$$Str = (.227)Mis + (.242)Obj + (.244)StrO + (.240)Res + (.240)Ter \quad (1)$$

$$ManP = (.399)ManT + (.388)ManC + (.360)ManPY \quad (2)$$

$$EcP = (.453)EcPT + (.445)EcPC + (.308)EcPY \quad (3)$$

$$Comp = (.391)CompT + (.380)CompC + (.354)CompY \quad (4)$$

RESULTS AND ANALYSES

Testing H1 hypothesis

H1. *The development of firm's global strategy is influenced by its region of origin, age and size.*

Next we were interested in whether there are significant differences in terms of the aggregate variable of strategy (Str) according to different characteristics of firms: country region, age and size:

- Grouping firms by country region (table 2, third column and figure 2) mean scores are statistically different as determined by one-way ANOVA ($F_{2,98}$ = 3.646, p = .030). Thus, the highest mean

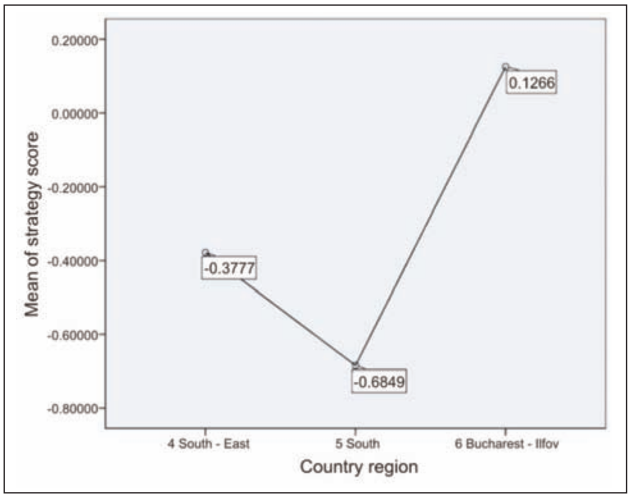

Fig. 2. The mean scores of aggregate variable of strategy by country region
Source: made by authors with SPSS 23.0

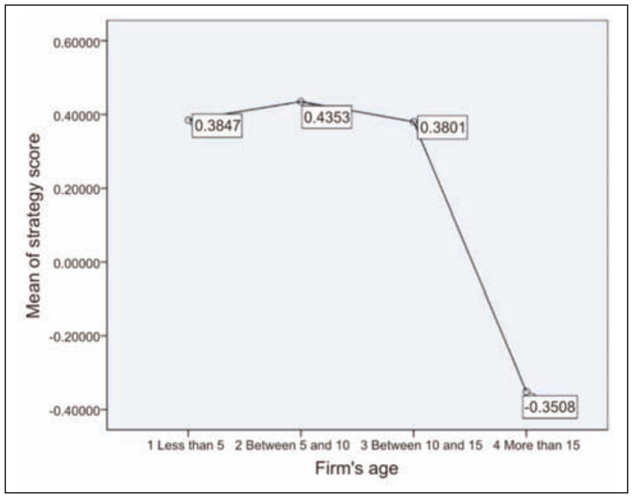

Fig. 3. The mean scores of aggregate variable of strategy by firm's age
Source: made by authors with SPSS 23.0

scores have the firms from Bucharest – Ilfov (M = .127), followed by those from South-East (M = –.378) and South (M = –.685).

- Considering the age of the analysed firms, as one can see in table 2, fourth column and figure 3, the mean scores of aggregate variable of strategy are also statistically different ($F_{3,88}$ = 4.860, p = .004). Thus, companies older than 15 years (M = –.350) have a significantly lower mean score of aggregate variable of strategy than those Between 10 and 15 years old (M = .3801) and those between 5 and 10 years old (M = .4353) as a Tukey post-hoc test revealed statistically significant differences between their mean scores (p = .013) and respectively (p = .029). The same Tukey post-hoc test revealed no significant differences between the mean scores for other comparisons between groups of firms.
- As one can see in table 2, last column, the mean scores of aggregate variables of strategy are not influenced by firms' size ($F_{3,88}$ =1.215, p = .309).

Table 2

No.		Country region	Firm's age	Firm's size
1	The aggregate variable of strategy (Str)	F = 3.646* p = .030	F = 4.860** p = .004	F = 1.215 p = .309

** Significant at .01 level, * Significant at .05 level
Source: made by authors with SPSS 23.0

In conclusion, if we were to sketch a profile of organizations which develop organizational strategies, considering the above characteristics, they should be located in Bucharest – Ilfov and aged between 5 and 10 years.

Testing H2 – H4 hypotheses

H2. *Developing the firm's global strategy has a positive impact on its managerial performances.*

H3. *Developing the firm's global strategy has a positive impact on its economic performances.*

H4. *Developing the firm's global strategy has a positive impact on its competitiveness.*

In order to test H2, H3 and H4 hypotheses, we employed the simple linear regression. Linear regression determines the value of a dependent variable based on its linear relationship to one or more independent variables (predictors) as it is described in the following formula [13]:

$$y_i = b_0 + b_1x_{1i} + b_2x_{2i} + ... + b_kx_{ki} + e_i \quad (5)$$

In this case, the dependent variables are *ManP* – managerial performances, *EcP* – economic performances and *Comp* – competitiveness and predictor (independent variables) is *Str* – strategy with the linear specifications as there are presented in table 3, second column.

As one can see in table 3, second row, in case of the first variable (*ManP*), F = 94.011 and p < .01 shows that at least one of the independent variables are

Table 3

No.	Regression equation	Constant	Coefficients	t	R^2	Adj. R^2	F	Sig.
1	$ManP_i = f(Str_i) + e_i$	.008	.716**	9.696	.511	.505	94.011	.000
2	$EcP_i = f(Str_i) + e_i$	.008	.664**	8.400	.439	.433	70.561	.000
3	$Comp_i = f(Str_i) + e_i$	.007	.693**	9.076	.478	.472	82.415	.000

** Significant at the .01 level
Source: made by authors with SPSS 23.0

related to the dependent variable, therefore the model is valid. The independent variable coefficient has a value of .716 statistically significant at .01 level (t = 9.696, p = .0000), so the independent variable *Str* is significantly related to the dependent variable *ManP.* Moreover, the coefficient of determination has a medium value (R^2 = .511), which mean that approximately 51.1% of the variance of *ManP* could be explained by *Str*. Therefore, *developing the firm's global strategy has a positive impact on its managerial performances.*

For the second regression equation (F = 70.561, p < .01) it can be seen that the independent variable has a statistically significant influence on *EcP* (t = 8.400, p < .01), 43.9% from its variance could be explained by Str. Besides that, the regression coefficient has a positive value (.664), thus we can state that *developing the firm's global strategy has a positive impact on its economic performances.*

Finally, in respect for the third regression equation (F = 82.415, p <.01) one can see that the independent variable (Str) has a statistically significant influence on the dependent one (Comp) (t = 9.076, p < .01) as 47.8% from its variance could be explained by *Str*. Furthermore, the regression coefficient has a positive value (.693), thus we can state that *developing the firm's global strategy has a positive impact on its competitiveness.*

Thus, the regression equations are as follows:

$$ManP = .008 + (.716)Str + e \quad (6)$$

$$EcP = .008 + (.664)Str + e \quad (7)$$

$$Comp = .0087 + (.693)Str + e \quad (8)$$

The results of research hypotheses testing are presented in figure 4.

As we expected, aggregate variable of strategy (Str) has a positive influence on all three dependent variables (ManP, EcP and Comp – figure 4) . The final coefficients of determination were .511, .437 and .478, indicating that approximately 51.1% of the variability organizations' managerial performances, 43.9% of the variability its economic performances and 47.8% of the variability competitiveness could be explained by the variability of aggregate variable of strategy. This is a fairly decent amount of variability explained by the model, considering that the outcomes may be influenced by a number of other factors which however does not subject of our study.

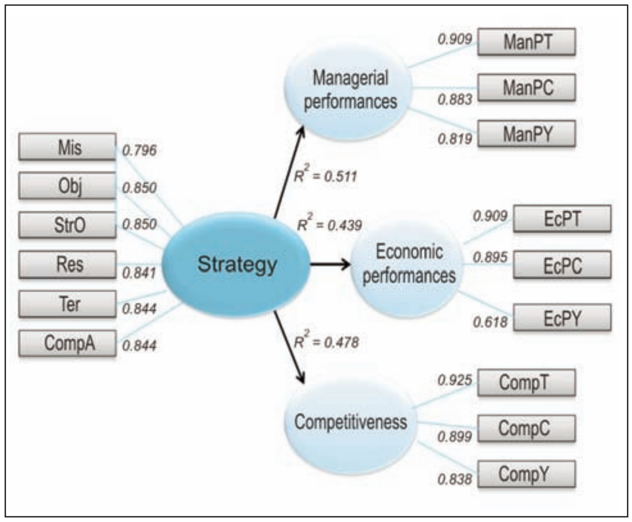

Fig. 4. The influence of the firm's strategy on its competitiveness and performances
Source: own representation

CONCLUSIONS

The main results of the research are consistent with the theoretical approach and confirmed most of the research hypotheses:

- Hypothesis 1 is partially supported. The development of firm's global strategy is influenced by the country region of origin (F = 3.646, p = .030) and age (F = 4.860, p = .004) but not by its size (F = 1.215, p = .309). If we were to sketch a profile of firms which develop overall strategies, considering the above characteristics, they should be located in Bucharest – Ilfov and aged between 5 and 10 years.
- Hypothesis 2 is also supported. Developing the firm's global strategy has a positive impact on its performances and competitiveness since approximately 51.1% of the variability of firms' managerial performances, 43.9% of the economic performances and 47.8% of the competitiveness could be explained by the variability of aggregate variable of strategy.

Being a pilot study, it involves certain limitations that make its results cannot be extrapolated to the national level. Consequently, most of our results should be tested on a more representative sample, both in terms of number of firms and their territorial distribution [11]. Also, future research should consider all the elements of strategic management process as determinants of performances and competitiveness.

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