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Sumar

Contents

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An optimization study on crosslinking of linen and cotton fabrics

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REZUMAT – ABSTRACT

Studiu privind optimizarea reticulării țesăturilor din in și bumbac

Scopul acestui studiu îl constituie eliminarea tendinței de șifonare și optimizarea proprietăților de întreținere ușoară a țesăturilor din in, prin utilizarea agenților antișifonare. Rezultatele obținute în cazul țesăturilor din in au fost comparate cu cele ale țesăturilor din bumbac. În cadrul studiului, s-a realizat procesul de reticulare pe țesături din in, amestec de in/bumbac (50/50%) și țesături din bumbac, cu diverse caracteristici de eliberare a formaldehidei. Ca reactant de reticulare s-a folosit dimetiloldihidroxietilenureea (DMDHEU). După aplicarea proceselor de fulardare-uscare-condensare, au fost analizate unghiul de revenire din șifonare, rezistența la rupere și stabilitatea dimensională ale tuturor tipurilor de țesături tratate, iar rezultatele au fost evaluate statistic. Rezultatele au arătat faptul că, în urma procesului de reticulare, rezistența la șifonare și stabilitatea dimensională a țesăturilor din bumbac au fost îmbunătățite. În cazul inului, care a fost foarte sensibil la procesul de reticulare, s-a observat o scădere semnificativă a rezistenței la rupere, în special la temperaturi de condensare mai ridicate (170ºC – 180ºC) și la o durată de condensare mai mare (1,5, 2 și 3 minute). Prin urmare, este importantă optimizarea unor condiții de prelucrare, cum ar fi temperatura și timpul de condensare. Țesăturile realizate dintr-un amestec de 50% in/50% bumbac se recomandă a fi condensate la 150ºC, timp de 6 minute și la 160ºC, timp de 4 minute.

Cuvinte-cheie: in, bumbac, finisaj antișifonare, DMDHEU, WRA, rezistență la rupere

An optimization study on crosslinking of linen and cotton fabrics

In this study, we aimed to eliminate the creasing tendency and optimize the easy-care properties of linen fabrics by using crease-resistant agents and the obtained results of linen fabrics were compared with that of cotton fabrics. For this purpose, the crosslinking treatments were carried out linen, linen/cotton blend (50/50) and cotton fabrics with the various formaldehyde-released characteristics of DMDHEU with the pad-dry-cure process. After this process, wrinkle recovery angle, breaking strength and dimensional stability of all treated fabrics have been tested and the results were statically evaluated. Results indicated that the crosslinking process improved crease resistance and dimensional stability of linen fabrics. But linen was very sensitive to the crosslinking process and significant decrease in the breaking strength especially at higher curing temperature (170ºC – 180ºC) for longer curing time (1.5, 2, 3 minutes). Therefore, it is important to optimize the processing conditions such as curing temperature and time especially processing with 50/50 linen/cotton blend and 100% linen fabrics. In this work, the optimum processing conditions were determined that the linen and linen/cotton blend fabrics were cured at 150ºC for 6 min and 160ºC for 4 minutes.

Key-words: linen, cotton, crease-resistant finish, DMDHEU, WRA, breaking strength

Linen is a bast environmentally-friendly fiber, obtained from the inside of the woody stalk of the flax plant. Linen is grown in Russia, Poland, Czech Republic, Ukraine, Belgium, France, Netherlands, and China in the world**.** As compared with cotton, linen has some advantages. Linen is stronger than cotton and it is better than cotton as a conductor of heat. On the other hand, linen is less elastic than cotton and creases easily. Therefore, the minimization the creasing tendency of linen fabric with crease-resistance treatment is very important [1–2].

The cellulosic fibers generally exhibit too much tendency of crease during using also after washing and drying. So, crease resistant treatment is necessary for cellulosic fibers [3]. In this purpose, several crosslinking agents are used in recent years. Finishes were produced that met the environmental challenge of increasingly stringent formaldehyde standards. The important subject is no-formaldehyde and low cost [4]. Selection of the proper synthetic resin is important with respect to performance and the formation of free formaldehyde. Mostly it is used dihydroxethyleneurea (DMDHEU) [5]. Modified DMDHEU compound has low amount of formaldehyde and gives cellulosic fabric the high wrinkle recovery angle and low shrinkage value [6]. On the other hand chemical concentration and processing conditions had been reported as the important parameters in terms of formaldehyde formation too in our previous study [7].

80% of crosslinking agents, which are used worldwide, are based on 1.3-dimethylol, 4.5 dihidroxyethylene urea (DMDHEU) and its modified derivatives [8]. The crease recovery properties of linen and linen/cotton blend fabrics can be improved only by applying finishing technologies [9], but in that case the mechanical properties of the fabrics have been reported as changed [10, 11].

In this work, the crosslinking treatment has been applied to linen, linen/cotton blend (50/50%) and cotton fabrics with the various formaldehyde-released characteristics of DMDHEU with the pad-dry-cure process. After this treatment, the physical properties such wrinkle recovery angle, breaking strength and dimensional stability of all treated fabrics have been tested. It has been discussed the test results for all fabrics.

EXPERIMENTAL PART

All the experiments were carried out with desized, scoured and bleached 100% linen (156 g/m^2), 50% linen/50% cotton blend (152 g/m^2) and 100% cotton (150 g/m^2) plain woven fabrics. The crease resistant processes were realized with Ernst Benz mark laboratory paddler for impregnation and ATAC mark laboratory stenter for drying and condensation. For crease resistant treatment, Fixapret CPN, Fixapret CM and Fixapret AP (60 and 80 g/l – BASF), $MgCl_2$ (15 and 20 g/l, catalyst), Siligen SIO (15 and 20 g/l, micro silicone emulsion – BASF) at *p*H 4 were impregnated with 80% wet pick up and then dried at 100ºC for 10 minutes. Then all samples were cured at different temperatures and times in a stenter. The notation of crosslinking agents and trial plan were mentioned in table 1 and table 2.

All the physical measurements after crease resistant process were carried out after conditioning of the fabrics for 24 hours under the standard atmosphere conditions (20ºC – 2ºC temperature, 65% – 2% relative humidity). The dry wrinkle recovery angles *DWRA* of all treated fabrics were measured according to DIN 53890 standard. Breaking strengths *N* of all fabrics were measured according to ISO 13934-1 standard (strip method) at Lloyd LR5K tester. After crease resistant process, all samples were washed at the Wascator machine according to ISO 6330 standard (5A program) and dried. The changes of dimensional stability (warp and filling directions) of them were determined.

RESULTS AND DISCUSSIONS

Statistical analysis

The results (expressed as means/standard deviation) of all assays were compared using ANOVA, followed by a post hoc test (Duncan's test). For all statistical analyses, the software package SPSS 10.0 (Statistical Analysis Program) was used (table 3).

In order to investigate the effect of such parameters; fabric type, type of chemicals, chemical concentration and curing time (duration) on *WRA* and total

Table 1

THE NOTATIONS OF CROSSLINKING AGENTS

Crosslinking agents	Type	Notation
Fixapret CPN	Classical type DMDHEU	***a***
Fixapret CM	Modified DMDHEU and low formaldehyde values	***b***
Fixapret AP	Modified DMDHEU and extremely low formaldehyde values	***c***

Table 2

CREASE RESISTANT TREATMENT RECIPES

Recipe *1*		Recipe *2*		
60 g/l Crosslinking agents 15 g/l Catalyst 15 g/l Softener		80 g/l Crosslinking agents 20 g/l Catalyst 20 g/l Softener		
Curing temperature	150˚C	160˚C	170˚C	180˚C
Curing times	2, 4, 6 min.	2, 3, 4 min.	45 sec., 1.5, 3 min.	30 sec., 1, 2 min.

Table 3

TESTS OF BETWEEN-SUBJECTS EFFECTS

Source	Dependent variable	150˚C		160˚C		170˚C		180˚C	
		F	Sig.	*F*	Sig.	*F*	Sig.	*F*	Sig.
Corrected model	*WRA*	95.842	0.000	56.829	0.000	26.707	0.000	35.856	0.000
	Total *BS*	294.640	0.000	279.678	0.000	230.131	0.000	261.806	0.000
Intercept	*WRA*	66285.613	0.000	68286.364	0.000	33477.296	0.000	29928.370	0.000
	Total *BS*	25348.821	0.000	26045.899	0.000	17096.786	0.000	17607.736	0.000
Fabric	*WRA*	101.369	0.000	69.480	0.000	36.208	0.000	21.859	0.000
	Total *BS*	885.204	0.000	850.068	0.000	590.771	0.000	620.867	0.000
Concentration	*WRA*	99.733	0.000	17.533	0.000	20.388	0.000	41.971	0.000
	Total *BS*	34.772	0.000	40.294	0.000	19.225	0.000	75.670	0.000
Duration	*WRA*	175.385	0.000	41.520	0.000	31.481	0.000	74.705	0.000
	Total *BS*	97.240	0.000	23.249	0.000	134.819	0.000	187.024	0.000
Chemical	*WRA*	8.825	0.000	140.738	0.000	6.838	0.001	5.756	0.004
	Total *BS*	31.411	0.000	130.525	0.000	33.632	0.000	27.371	0.000

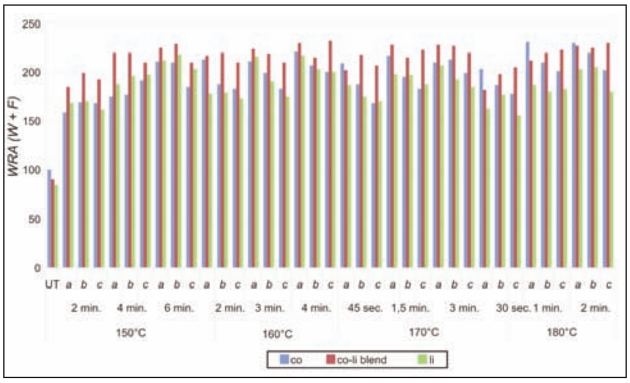

Fig. 1. *WRA* of all fabrics treated with 60 g/l crosslinking agents

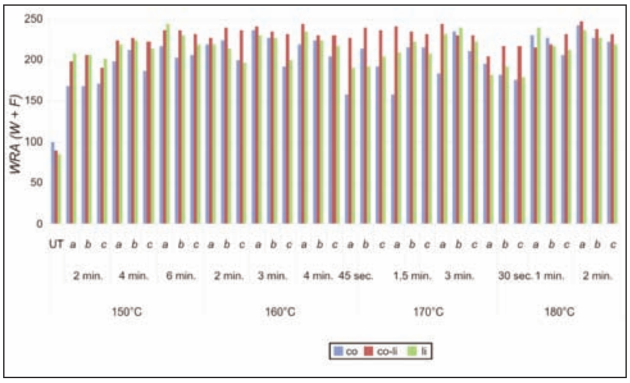

Fig. 2. *WRA* of all fabrics treated with 80 g/l crosslinking agents

BS (Warp + Filling Breaking Strength) a statistical research was carried out for all cure temperatures. ANOVA for *WRA* and total *BS* indicated that there was significant impact of all parameters in all curing temperatures. But when the *F* values were investigated it was observed that the whole parameters are more significant in terms of total *BS* instead of *WRA*. Among the parameters especially fabric type is very important, when the total *BS* was considered.

Dry wrinkle recovery angles of crosslinked fabrics

After crease resistant treatments, the wrinkle recovery angles (*WRA*) of all treated samples were measured. In figure 1, total *WRA* values (warp + filling direction) of all fabrics treated with 60 g/l crosslinking agents in different curing temperatures and times were given.

Figure 1 showed that the *WRA* values of 50% cotton/50% linen blend fabrics was generally higher than the others especially with using *a* and *b* agents. The fabric type is also the other important parameter effects the change in *WRA* as from the ANOVA (table 3). Moreover, in table 4 the Duncan Post hoc test was carried out for the fabric type in order to evaluate the effect on the crease resistance treatment. It was determined that the cotton/linen blended fabric has the best *WRA* after crease resistance treatment. On the other hand, in general the performance of crosslinking agents is limited if the fabric is in the type of cotton woven.

Although there is an increase in *WRA* values with the increasing curing time, the curing temperature is independent. The highest *WRA* were obtained at 150ºC for 6 minutes, 160ºC for 4 minutes, 170ºC for 3 minutes, and 180ºC for 2 minutes (fig. 1).

In figure 2, the *WRA* of all fabrics treated with 80 g/l crosslinking agents in different curing temperatures and times were given.

Figure 2 showed that the *WRA* values of all samples treated with 80 g/l crosslinking agents were higher in comparison to that of 60 g/l crosslinking agents. The *WRA* of cotton fabrics was generally lower than the others. The highest *WRA* were obtained at 150ºC for 6 minutes, 160ºC for 4 minutes, 170ºC for 3 minutes and 180ºC for 2 minutes again.

As showed in figure 1 and 2, it was seen that the chemical *c* has the lowest *WRA* values. This result was confirmed with Duncan Post Hoc test in table 5. So it can be readily said that use of chemicals a and b ensures better *WRA* results when all type of fabric and curing temperatures are taken into account.

Breaking strength values of crosslinked fabrics

After crosslinking treatment, the breaking strength *BS* values of all treated samples was measured; the graphs indicates the total breaking strength values (warp + filling).

In figure 3, the *BS* values of all fabrics treated with 60 g/l crosslinking agents in different curing temperatures and times were given.

In figure 4, the breaking strength values of all fabrics treated with 80 g/l crosslinking agents in different curing temperatures and times were given.

The most important disadvantage of crease resistant process is decreases in the breaking strengths *BS* of

Table 4

DUNCAN POST HOC TEST OF THE FABRIC TYPE

Fabric	*N*	150°C			160°C		170°C		180°C		
		1	2	3	1	2	1	2	1	2	3
Cotton	54	187.54		-	208.69	-	198.56	-	-	209.63	-
Linen	54	-	204.63	-	205.56	-	201.27	-	197.04	-	-
Cotton/linen	54	-	-	214.63		227.41	-	221.76	-	-	219
Sig.	-	1.000	1.000	1.000	0.121	1.000	0.338	1.000	1.000	1.000	1.000

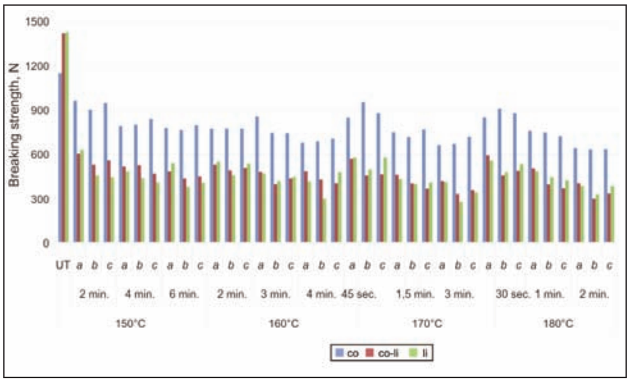

Fig. 3. *BS* of all fabrics treated with 60 g/l crosslinking agents

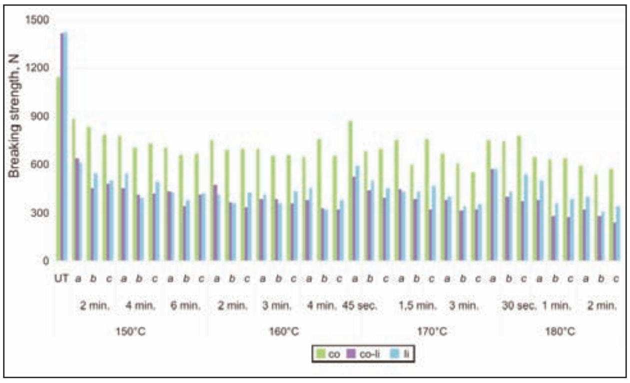

Fig. 4. *BS* of all fabrics treated with 80 g/l crosslinking agents

Table 5

DUNCAN POST HOC TEST OF THE CHEMICAL TYPE

Chem.	*N*	150°C		160°C			170°C		180°C	
		1	2	1	2	3	1	2	1	2
a	54	-	203.33	-		222.41	204.08	-	-	211.18
b	54	-	205.67	-	215	-	-	213	209.74	209.74
c	54	197.80	-	204.24	-	-	204.42	-	204.74	-
Sig.	-	1.000	0.227	1.000	1.000	1.000	0.901	1.000	0.09	0.623

Table 6

DUNCAN POST HOC TEST OF THE FABRIC TYPE

Fabric	*N*	150°C		160°C		170°C			180°C		
		1	2	1	2	1	2	3	1	2	3
Cotton/linen	54	479.07	-	421.72	-	397.95	-	-	381.67	-	-
Linen	54	466.30	-	426.54	-	-	440.44	-	-	442.33	-
Cotton	54	-	798.64	-	704.64	-	-	712.85	-	-	705.92
Sig.	-	0.166	1.000	0.541	1.000	1.000	1.000	1.000	1.000	1.000	1.000

fabrics. From the figure 3 and 4, it is clear that the *BS* of all fabrics was decreased after the process and all results were similar. In table 6 the Duncan Post hoc test was carried out for the fabric type in order to evaluate the effect on the crease resistance treatment. It was determined that the linen and cotton/linen blended fabrics have shown the highest strength losses. The reason of this is the lower elastic recovery and resilience of linen [12].

In particularly, from figure 3 and 4 the *BS* values of 50% linen/50% cotton blend and 100% linen fabrics were decreased nearly 60–70%. However, the lowest strength loss was managed if the cotton woven fabric was used instead of linen or linen/cotton blended fabrics.

The lowest *BS* values were obtained at 170ºC for 1.5 and 3 minutes, 180ºC for 2 minutes. It meant that the higher curing temperature and longer curing time caused a disadvantage.

As a summary, it is obvious that while the *WRA* of all samples were generally increased due to the increasing the concentration of crosslinking agents after treatment, the *BS* values were decreased dramatically. The reductions of *BS* values were at 150ºC and 160ºC. The lowest *BS* values were obtained at higher curing temperature (170°C and 180ºC) for longer curing time (1.5, 2, 3 minutes). Therefore, it is necessary to optimize the processing conditions such as curing temperature and time especially processing with 50% linen /50% cotton blend and 100% linen fabrics.

Dimensional stability of crosslinked fabrics

Table 7 and 8 indicates (%) shrinkage of fabrics treated with 60 g/l and 80 g/l crosslinking agents in different curing temperatures and times.

After some wet process and washing, the cellulose based fabrics can be shrinkage. One of the most important purposes of crease resistant treatment is to reduce the shrinkage of fabrics. As shown in tables 7 and 8, when the shrinkage values of untreated cotton,

Table 7

% SHRINKAGE OF FABRICS TREATED WITH 60-80 G/L CROSSLINKING AGENTS AT CURING TEMPERATURE 150-160°C														
Curing temp.	Curing time	Chem.	60 g/l						80 g/l					
			100% CO		50% LI/ 50% CO		100% LI		100% CO		50% LI/ 50% CO		100% LI	
			W	***F***	***W***	***F***	***W***	***F***	***W***	***F***	***W***	***F***	***W***	***F***
		UT	-3.2	-4.5	-6.9	-0.4	-7.4	-0.5	-3.2	-4.5	-6.9	-0.4	-7.4	-0.5
150°C	2 min.	***a***	-0.5	0.0	-0.5	0.9	0	0.5	-0.5	0.0	0	0.5	0	0.5
		b	-0.5	0.0	-0.5	0.9	0.5	0.5	0.0	0.0	0	0.9	0	0.5
		c	-0.5	-0.5	-0.5	0.9	0.9	0.5	0.0	0.0	0	0.5	0	0.5
	4 min.	***a***	0.0	0.0	-0.5	0.9	0.5	0.9	-0.5	0.5	0.5	0.5	0.5	0.5
		b	0.0	0.0	-0.5	0.5	0.5	0.9	-0.5	0.0	0	0.9	0.5	0.9
		c	0.5	0.5	-0.5	0.5	0.5	0.5	-0.5	0.0	0	0.9	0.5	0.9
	6 min.	***a***	0.5	0.5	-1	1.4	0.5	0.9	-0.5	0.0	0	0.5	0.5	0.9
		b	0.5	0.5	0	0.9	0.5	0.9	0.0	0.0	-0.5	0.9	0.5	0.9
		c	0.5	0.5	0	0.9	0.5	0.5	0.0	0.5	0	0.9	0	0.5
160°C	2 min.	***a***	0.5	0.5	0	0.9	0.5	0.9	0.0	0.5	-0.5	1.4	0.5	0.9
		b	0.5	0.5	-0.5	0.9	0.5	0.9	0.0	0.0	0	0.5	0.5	0.9
		c	0.5	0.5	0	0.9	0	0.9	0.0	0.0	0	0.5	0.5	0.9
	3 min.	***a***	0.5	0.5	0	0.9	0.5	0.5	0.0	0.5	0	0.9	0.5	0.9
		b	0.5	0.9	-1	1.4	0.5	0.9	0.5	0.0	0	0.9	0.5	0.5
		c	0.5	0.5	0	0.9	0.5	0.5	0.0	0.0	0	0.5	0.5	0.9
	4 min.	***a***	0.5	0.9	0	0.9	0.5	0.9	0.0	0.5	0	0.9	0.5	0.9
		b	0.9	0.9	0	0.5	0.5	0.5	0.0	0.0	0	0.5	0.5	0.9
		c	0.5	0.5	0	0.9	0.5	0.5	-0.5	0.0	0	0.9	0.5	0.9

Table 8

% SHRINKAGE OF FABRICS TREATED WITH 60-80 G/L CROSSLINKING AGENTS AT CURING TEMPERATURE 170-180°C														
Curing temp.	Curing time	Chem.	60 g/l						80 g/l					
			100% CO		50% LI/ 50% CO		100% LI		100% CO		50% LI/ 50% CO		100% LI	
			W	***F***	***W***	***F***	***W***	***F***	***W***	***F***	***W***	***F***	***W***	***F***
		UT	-3.2	-4.5	-6.9	-0.4	-7.4	-0.5	-3.2	-4.5	-6.9	-0.4	-7.4	-0.5
170°C	45 sec.	***a***	0.5	0.0	-0.5	0.9	0	0.9	-0.5	-0.5	0	0.5	0.5	0.9
		b	0.5	0.5	0	0.9	0.9	0.9	-0.5	0.0	0	0.9	0.5	0.9
		c	0.5	0.5	-1	1.4	0	0.9	-0.5	0.0	0	0.9	0.5	0.9
	1.5 min.	***a***	0.5	0.9	0	0.9	0.5	1.4	-0.5	0.0	0	0.5	0.5	0.9
		b	0.5	0.9	0	0.9	0.5	1.4	0.0	0.5	0.5	0.9	0.5	0.9
		c	0.5	0.9	0	0.9	0.5	0.5	0.0	0.0	0	0.5	0.5	0.9
	3 min.	***a***	0.5	0.5	0	0.9	0.5	0.9	-0.5	0.0	0	0.9	0.5	0.5
		b	0.5	0.9	0	0.9	0.5	0.9	-0.5	0.5	0	0.5	0.5	0.9
		c	0.5	0.9	0	0.9	0	0.9	0.0	0.0	-0.5	0.9	0.5	0.9
180°C	30 sec.	***a***	0.5	0.9	0	0.9	0	0.9	0.0	0.0	-0.5	1.4	0	0.9
		b	0.5	0.9	-0.5	0.9	0.5	0.9	0.0	0.0	0	0.9	0	0.5
		c	0.5	0.5	-0.5	0.9	-0.5	0.9	-0.5	0.0	0	0.9	-0.5	0.9
	1 min.	***a***	0.5	0.9	-0.5	0.9	0	0.9	0.0	0.5	0	0.9	0	0.9
		b	0.5	0.9	0	0.9	0.9	0.5	0.0	0.5	0.5	0.5	0.5	1.4
		c	0.5	0.5	0	0.5	0	0.9	-0.5	0.5	0.0	0.5	0.5	0.9
	2 min.	***a***	0.5	0.5	0	0.9	0.5	0.9	0.0	0.5	0.5	0.9	0.5	0.9
		b	0.5	0.5	0.5	0.9	0.5	0.9	0.0	0.0	-1	1.4	0.5	1.4
		c	0.5	0.5	0	0.9	0.5	0.9	0.0	0.0	0	0.5	0.5	0.9

50% linen/50% cotton blend and linen fabrics were 3.2 – 4.5, 6.9 – 0.4, 7.4 – 0.5 respectively, these values of treated all fabrics were between 0 – 1.4 after treatments. It meant that the dimensional stabilities of all fabrics were enhanced after crosslinking treatment. Also, there were no major differences between the process conditions such as curing temperature, curing time, type of agent, concentration rate.

CONCLUSIONS

In this work, it has been purposed to reduce the creasing tendency and optimize the easy-care properties of linen fabrics by crease resistant process. After this treatment, the obtained results of linen fabrics have been compared with that of cotton and 50% linen/50% cotton blend fabrics.

Results indicated that the crosslinking process improved crease resistance and dimensional properties of linen fabrics. But linen was very sensitive to the crosslinking process and significant decrease in the breaking strength at higher curing temperature (170ºC and 180ºC) for longer curing time (1.5, 2, 3 minutes). Therefore, it is important to optimize the processing conditions such as curing temperature and time especially processing with 50% linen/50% cotton blend and 100% linen fabrics. In this work, the optimum processing conditions were determined that the linen and linen/cotton blend fabrics were cured at 150ºC for 6 minutes and 160ºC for 4 minutes.

As it is well known, the most important disadvantage of the cellulose based fabrics is shrinkage after some wet process and washing. After crease resistant process, the dimensional stabilities of all fabrics were enhanced and the shrinkage of all fabrics was reduced.

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Investigation of antibacterial activities of tin ions on wool fabric

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REZUMAT – ABSTRACT

Investigații asupra activității antibacteriene a ionilor de staniu asupra țesăturilor din lână

Rolul procesului de finisare este într-o continuă creștere, datorită importanței sale în sporirea competitivității, a valorii adăugate și a ponderii produselor în sectorul textil. Nevoile consumatorilor nu sunt determinate doar de aspectele estetice, ci și de funcționalitatea produselor. Din acest punct de vedere, materialele cu proprietăți antibacteriene ocupă un loc important în industria textilă. În general, pentru a conferi materialelor textile proprietăți antibacteriene se utilizează ioni de argint și săruri cuaternare de amoniu. În urma cercetărilor efectuate, s-a constatat că, pentru finisarea antibacteriană din sectorul textil, o alternativă la ionii de argint ar putea fi compușii de staniu, care – de multă vreme – sunt utilizați în industria alimentară, stomatologie și galvanizare. În cadrul acestui studiu, pentru conferirea unor proprietăți antibacteriene, probele de țesături crude din 100% lână au fost tratate cu ioni de staniu (II), în diferite concentrații. Testele antibacteriene efectuate conform standardului AATCC 100-2004 și testele de rezistență au arătat că ionii de SN_2^+ conferă proprietăți antibacteriene țesăturilor din lână.

Cuvinte-cheie: finisare, textile medicale, rezistență, antibacterian, lână, ioni de staniu

Investigation of antibacterial activities of tin ions on wool fabric

The importance of finishing is gradually increasing on the purpose of competition, adding value and increasing the share of product in the textile sector. Consumers' needs are determined by not only aesthetics but also by functional features. In this era, materials which have antibacterial properties occupy an important place in the textile industry. Generally, silver ions and quaternary ammonium salts are used for obtaining antibacterial properties in textile. As a result of researches, tin compounds which are used in the food sector and in plating and dentistry for ages could be an alternative to silver and be used as an antibacterial finishing material in the textile sector. In this research, 100% raw wool fabric samples were treated by tin (II) ions that are prepared in different concentrations to obtain antibacterial properties. After that procedure, antibacterial tests of fabric according to the AATCC 100-2004 standard and strength tests were made and the results were interpreted. In this study, it has been observed that SN_2^+ ions imparted antibacterial properties to the wool fabric.

Key-words: finishing, medical textiles, strength, antibacterial, wool, tin ions

Microorganisms can be found in the air we inhale, in our bodies, in the soil and in all surfaces we come in contact with. A special bacterium causes degradation and staining of textile products, in addition to health problems. Generally, silver ions are used for obtaining antibacterial properties in textile, as well as quaternary ammonium salts and chitosan [1–9].

Tin is a metal which has been used since ancient times and has a growing importance. It is one of the important materials used in preserving, food packaging, electronics, handicrafts, tooth decay (dental amalgam), anti-corrosion and engineering coatings, fire extinguishers etc. Refrigerator cooling coils and dairy products are coated with tin. Korkmaz Y. et al. used tin fluoride compounds in their studies which have antibacterial properties in the treatment of dental caries [10].

Various researches were presented, showing that SnF_2, which has antibacterial properties, is used in toothpastes [11].

Researches about mouthwash indicate that "in fluoride" is more effective than "sodium fluoride". This is also attributed to the antibacterial properties of the tin ion [11–13].

Tin is one of the hundreds of chemicals which kill microorganisms and it is used in dentistry around the world. It has antibacterial properties similar to mercury and silver. In addition to this, is demonstrated that is has a lower toxic substance content. In some studies, the antibacterial properties are investigated by forming thin films on the surface of glass which contains tin ions [14–16].

Tin compounds have been also used frequently in mordanting (dyeing) processes in the textile industry [17]. The aim of this research is offer antibacterial properties to wool fabrics by using tin ions and reducing costs by creating an alternative to silver ion usage [18–20].

EXPERIMENTAL PART

Materials and methods

100% raw (unscoured) wool fabric (yünsa 153 g/m^2, 36 warp ends/cm, 34 weft ends/cm) was used in the studies. For the antibacterial process, tin-II-chloride (in various concentrations between 5 g/L and 25 g/L) was applied to the wool fabric samples in a beaker. The liquor ratio was 20:1. The finishing was carried out at 60°C for 30 minutes at *p*H 5 – 5.5. After that, the treated materials were dried at 170°C. The antibacterial activities of the washed and unwashed samples were evaluated according to the AATCC100-2004 Test Methods. Three different kinds of bacteria: Staphylococcus Aureus (SA) as gram positive bacteria, Escherichia Coli (EC) as gram negative bacteria and Bacillus Subtilis (BS) as gram positive spore-forming bacteria were studied.

To evaluate the washing durability, the treated samples were washed according to the AATCC61-2006 (method 1A). After washing, the samples were rinsed in pure cold water, squeezed and dried at room temperature. The inhibition zone was measured in mm and all tests were performed in duplicate.

According to the AATCC100 Standard method general activity was calculated by the following formula (1):

$$RG = 100(B - A)/B \qquad (1)$$

where:

RG is % reduction.

A is the number of bacteria recovered from the inoculated treated test specimen swatches in the jar incubated over desired contact period.

B is the number of bacteria recovered from the inoculated treated test specimen swatches in the jar immediately after inoculation(at "0" contact time).

The color measurements of the materials were carried out by Datacolor SF 600+ spectrophotometer (Illuminant D_{65}, specular reflection included mode, 10º Standard Observer).

Table 1

THE AMOUNT OF BACTERIA ON WOOL FABRIC SAMPLES TREATED WITH $SnCl_2$

Bacteria	Samples	% reduction of bacteria
SA	W_a	52.5
	W_b	72.5
	W_c	85.0
	W_d	88.5
	W_e	91.0
EC	W_a	45.0
	W_b	61.0
	W_c	72.0
	W_d	82.0
	W_e	86.0
BS	W_a	55.0
	W_b	70.0
	W_c	77.5
	W_d	85.5
	W_e	88.5

Note: *W* is untreated swatches (control); W_a – 100% wool fabric treated with 5 g/L $SnCl_2$ solution; W_b – 100% wool fabric treated with 10 g/L $SnCl_2$ solution; W_c – 100% wool fabric treated with 15 g/L $SnCl_2$ solution; W_d – 100% wool fabric treated with 20 g/L $SnCl_2$ solution; W_e – 100% wool fabric treated with 25 g/L $SnCl_2$ solution

The tensile strength tests of wool yarns (warp and weft) taken from the samples were carried out using Instron 4411 according to TS 245 EN ISO 2062 standard for comparative purpose and TS 251 Standard was used to weight the samples.

RESULTS AND DISCUSSIONS

Colony numbers of SA, EC and BS bacteria used to transfer onto 100% wool fabric samples according to the AATCC 100 standard are formed after incubation and determined. The percentage of reduction values of SA, EC, BC bacteria are given in table 1.

Reduction percentages of SA and BS bacteria ratio are about 50% by using 5 g/L concentrated $SnCl_2$ solution. The effect is lower in EC bacteria for the same concentration (45%). The antibacterial effect is rising with the increasing concentration for all types of bacteria (SA, EC, BS).

When SA, EC, BS bacteria are cultivated on nutrient agar, the raw wool fabric samples (5 x 5 cm^2) which treated with $SnCl_2$, are placed on medium. Non-reproductive zones are detected at 37ºC after 24 hours of incubation period. The photos are given in figures 1–3. The antibacterial finishing process used in this work was found to be effective against the bacteria SA, EC and BS. After the washing process, the antibacterial activity decreased. The clear zone diameters of the

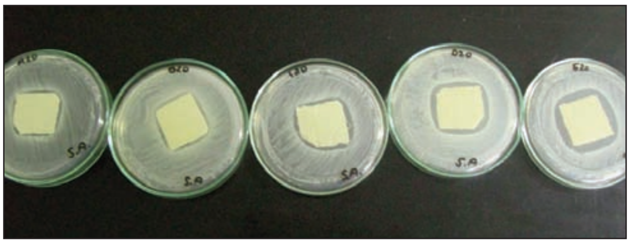

Fig. 1. The effect of SA bacteria in increasing concentration (5 to 25 g/L) that $SnCl_2$ solution was treated

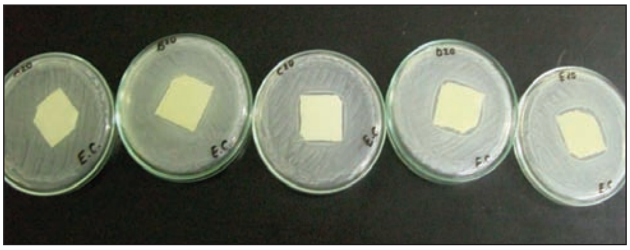

Fig. 2. The effect of EC bacteria in increasing concentration (5 to 25 g/L) that $SnCl_2$ solution was treated

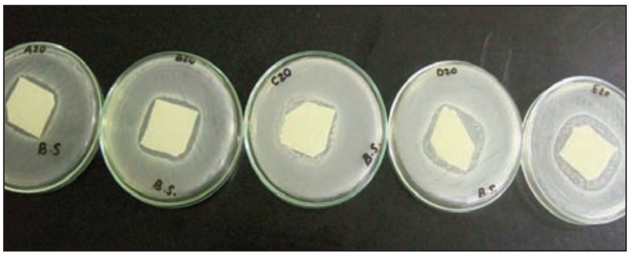

Fig. 3. The effect of BS bacteria in increasing concentration (5 to 25 g/L) that $SnCl_2$ solution was treated

washed and unwashed samples are given in table 2 – no zone has been observed on the untreated wool fabric.

According to the clear zone diameters, it was also observed that the antibacterial activity was better against SA and BS than EC bacteria.

Reduction percents – equation (1) – of used tin (II) chloride in increasing concentration are calculated for all three bacteria (SA, EC, BS) and the results are given in figures 4 – 6 as a graph.

The rise of antibacterial effect is observed in samples of all three bacteria treated with $SnCl_2$. The antibacterial effect of $SnCl_2$ solution is somewhat better against SA and BS than EC bacteria.

In increasing concentration of tin (II) chloride, the ratio of % reduction for all types of bacteria (SA, EC, BS) increased.

To observe the persistency of antibacterial property after washing, 100% wool fabric samples treated with $SnCl_2$ solution were washed five to ten times and the results are given in table 3.

Wash results were compatible with the data. Samples of wool fabric which were treated with tin (II) chloride prevented the SA, EC and BS bacteria reproduction. This effect continued after five times of washing, but was then reduced after 10 times of being washed lightly.

Table 2

THE ANTİBACTERİAL ACTİVİTY RESULTS OF THE WOOL SAMPLES TREATED WİTH $SnCl_2$ SOLUTİON

Antibacterial agent $SnCl_2$ solution, for 25 g/L	**Clear zones**, mm		
	Before washing	***After washing***, 5 times	***After washing***, 10 times
SA	8.3	5.6	2.7
EC	5.1	2.3	1.6
BS	9.5	6.2	3.5

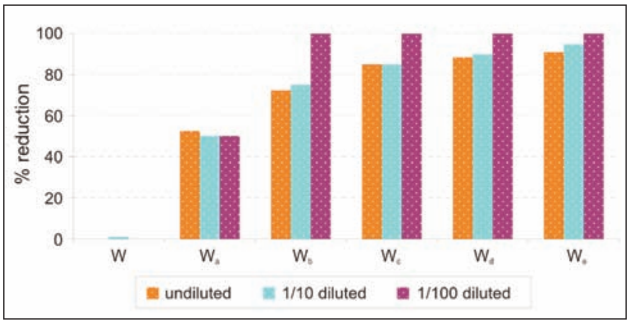

Fig. 4. % reduction of Staphlococcus Aureus bacteria

Table 3

TTHE AMOUNT - AND % REDUCTİON OF SA, EC AND BS BACTERİA ON WOOL FABRİC SAMPLES TREATED WİTH Sn İONS AND WASHED

Samples	**The amount of SA (10^{-5})**	**% reduction of SA**	**The amount of EC (10^{-5})**	**% reduction of EC**	**The amount of BS (10^{-5})**	**% reduction of BS**
W	2.00	0.00	2.00	0.00	2.00	0.00
W_1	1.98	1.00	1.90	5.00	1.90	5.00
W_2	2.00	0.00	2.00	0.00	2.00	0.00
W_a	0.95	52.50	1.10	45.00	0.90	55.00
W_{a1}	0.95	52.50	1.10	45.00	0.90	55.00
W_{a2}	1.18	41.00	1.20	40.00	1.10	45.00
W_b	0.55	72.50	0.78	61.00	0.60	70.00
W_{b1}	0.57	71.50	0.80	60.00	0.65	67.50
W_{b2}	0.87	56.50	1.10	45.00	0.85	57.50
W_c	0.30	85.00	0.56	72.00	0.45	77.50
W_{c1}	0.30	85.00	0.60	70.00	0.50	75.00
W_{c2}	0.87	56.50	1.05	47.50	0.85	57.50
W_d	0.23	88.50	0.36	82.00	0.29	85.50
W_{d1}	0.24	88.00	0.40	80.00	0.34	83.00
W_{d2}	0.80	60.00	0.95	52.50	0.80	60.00
W_e	0.18	91.00	0.28	86.00	0.23	88.50
W_{e1}	0.18	91.00	0.34	83.00	0.23	88.50
W_{e2}	0.80	60.00	0.90	55.00	0.68	66.00

Note: W is untreated swatches (control); W_a – 100% wool fabric treated with 5 g/L $SnCl_2$ solution; W_b – 100% wool fabric treated with 10 g/L $SnCl_2$ solution; W_c – 100% wool fabric treated with 15 g/L $SnCl_2$ solution; W_d – 100% wool fabric treated with 20 g/L $SnCl_2$ solution; W_e – 100% wool fabric treated with 25 g/L $SnCl_2$ solution; W_{a1}, W_{b1}, W_{c1}, W_{d1}, W_{e1} – 100% wool fabric treated with 5-25 g/L $SnCl_2$ solution and washed five times; W_{a2}, W_{b2}, W_{c2}, W_{d2}, W_{e2} – 100% wool fabric treated with 5-25 g/L $SnCl_2$ solution and washed five times

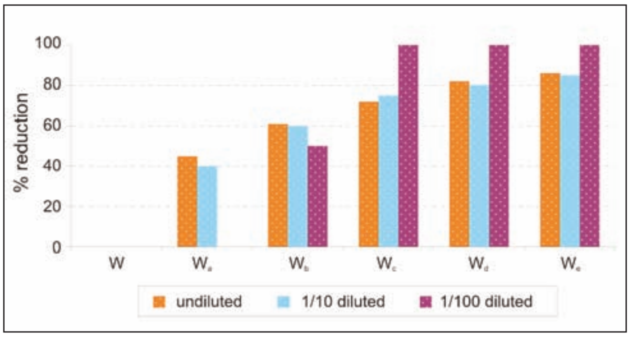

Fig. 5. % reduction of Echerichia Coli bacteria

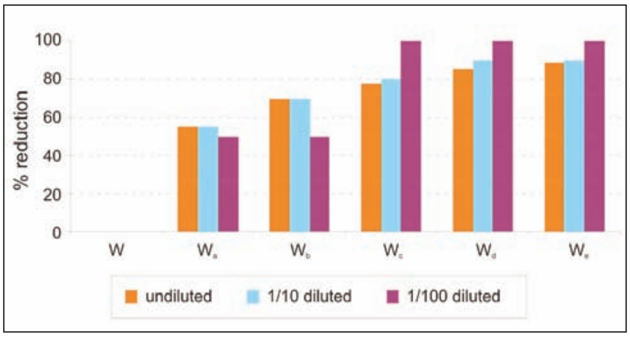

Fig. 6. % reduction of Bacillus Subtilis bacteria

Table 4

CIELAB AND *K/S* VALUES OF TREATED SAMPLES WITH $SnCl_2$ BY USING DIFFERENT CONCENTRATIONS (max. *K/S* values, at 360 nm)

$SnCl_2$ concentration, g/L	L^*	a^*	b^*	*K/S*
0	86.34	-1.24	12.33	1.01
5	85.58	-0.41	16.32	2.82
10	84.78	0.32	16.79	3.06
15	81.55	2.47	17.29	3.34
20	78.15	4.81	16.69	3.55
25	75.99	6.15	19.91	3.40

Table 5

THE WEİGHT OF THE SAMPLES

$SnCl_2$ concentration, g/L	Weight, g/m^2	İncrease in weight, %
Untreated	153.2	-
5	191.3	24.9
10	195.5	27.6
15	201.8	31.7
20	204.3	33.0
25	207.1	35.1

Table 6

TENSİLE STRENGTH AND ELONGATİON TEST VALUES OF TREATED WOOL FABRİCS

$SnCl_2$ concentration, g/L	Warp direction		Weft direction	
	Tensile strength, cN/tex	Elongation, %	Tensile strength, cN/tex	Elongation, %
Untreated	0.71 ± 0.036	12.20 ± 0.10	0.69 ± 0.026	14.04 ± 0.12
5	0.67 ± 0.070	11.33 ± 0.12	0.66 ± 0.040	13.81 ± 0.11
10	0.65 ± 0.090	11.10 ± 0.21	0.66 ± 0.055	13.40 ± 0.11
15	0.64 ± 0.050	11.09 ± 0.14	0.64 ± 0.049	13.35 ± 0.11
20	0.63 ± 0.015	10.87 ± 0.12	0.64 ± 0.065	13.33 ± 0.10
25	0.63 ± 0.041	10.87 ± 0.11	0.61 ± 0.026	13.26 ± 0.10

CIELab values of samples which the increasing concentration (5 to 25 g/L) of $SnCl_2$ solution implemented are given in table 4.

Rise of tone is observed in samples directly proportional with the increasing concentration of $SnCl_2$. Increase of weights in samples which were treated with $SnCl_2$ solutions, concentrated 5 to 25 g/L, are given in table 5. Tensile strength and percentage values of elongation are given in table 6.

It has been observed that there is an increase in the weight of the fabric in proportion to $SnCl_2$ concentration which had used on 100% wool fabric.

A slight decrease was determined in tensile strength and percentage elongations of the treated materials according to untreated wool fabric.

CONCLUSIONS

Antibacterial treatments are important for textiles, especially those used for medical purposes. In this study, $SnCl_2$ solution was used for the antibacterial coatings against the bacteria SA, EC and BS. According to the clear zone diameters, it was observed that the antibacterial activity was better against SA and BS than EC bacteria.

It was also observed that the antibacterial effect increases as the concentration of $SnCl_2$ solution increases. Sn salts brought antibacterial property to the wool fabric even in the lowest concentration used (5 g/L). The number of bacteria is also determined and the % reduction by the treated specimen is calculated. % reduction of SA and BS bacteria ratio are about

50% by using 5 g/L concentrated $SnCl_2$ solution. The effect is lower in EC bacteria for the same concentration (45%).

In increasing concentration of tin (II) chloride, the ratio of % reduction for all types of bacteria (SA, EC, BS) increased.

The repeated washing process had no significant effect on the antibacterial properties of wool fabric treated with Sn ions. The antibacterial effect of Sn^{2+} salts was continuing after five times of washing for all three types of bacteria (SA, EC, BS). Even though the effect is a bit lowered after 10 times of washing, this effect did not completely disappear.

Overall, according to concentration raises in $SnCl_2$ solution, weights of fabric have proportionate rates of increase and the colours are darkened. The antimicrobial finishing had little adverse effect on the colour values of the samples.

There was not a significant decrease in tensile strength and the elongation percentage of the treated materials compared with untreated wool fabric.

In conclusion, Sn ions are identified as an alternative to Ag ions in terms of antibacterial effect and cost. Further studies of the usage of Sn salts may have a promising future in the textile sector.

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A study on the needle heating in polyester blend upholstery fabrics

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BURCU ÇETINKAYA

REZUMAT – ABSTRACT

Studiu privind încălzirea acului în timpul coaserii țesăturilor pentru tapiserie, realizate din amestecuri cu poliester

Lucrarea prezintă un studiu experimental despre încălzirea acului în timpul coaserii diferitelor țesături destinate tapiseriei, obținute din amestecuri cu poliester. În acest scop, trei tipuri de materiale textile, realizate dintr-un amestec cu poliester, au fost cusute cu două fire cu miez din PES/PES, cu trei fineți diferite, folosind trei viteze ale mașinii de cusut, cuprinse între 1 000 și 3 000 rpm. Au fost efectuate diferite teste, atât pentru fire, cât și pentru țesături. Pentru a identifica temperatura acelor în anumite perioade ale procesului de coasere, a fost utilizată o cameră video în infraroșu. După 60 de secunde de coasere, s-a observat că temperatura acelor oscila între 113 și 311.2°C. Rezultatele au arătat că temperatura acului crește, în special, odată cu mărirea vitezei de coasere a mașinii și a fineții firului. Cele mai ridicate temperaturi ale acului au fost observate la țesăturile mai groase (2.23 mm), cu finețea cea mai mică (150 tex) și, de asemenea, la viteze mari ale mașinii de cusut, de 3 000 rpm. În plus, s-a analizat structura firului la un microscop optic și s-a observat că firele superioare au un grad de fibrilare mai mare decât cele inferioare. Totodată, principalele rezultate obținute au fost analizate și din punct de vedere statistic.

Cuvinte-cheie: încălzirea acului, țesătură pentru tapiserie, fire cu miez PES/PES, cameră video în infraroșu

A study on the needle heating in polyester blend upholstery fabrics

This paper presents an experimental study on needle heating in sewing different polyester blends of upholstery fabrics. For this purpose, three polyester blends of upholstery fabrics which have been sewn with two ply PES/PES corespun threads at three different thread counts with a three ranges of machine speed from 1 000 rpm to 3 000 rpm. Several of physical tests were carried out in both threads and fabrics. Thermal camera has been used to identify the temperatures of the needles during different time durations of the sewing process. The needle temperatures were observed between 113 and 311.2°C at the end of 60 seconds of sewing process. The results revealed that needle temperature especially increases with an increase of machine speed and thread count. The highest needle temperatures were observed in all the thickest fabrics (2.23 mm) with the coarsest threads (150 tex). The most highest temperatures within the sewing machine speeds were obtained at the 3 000 rpm. Additionally, the thread structures were observed under a light microscope and showed that the upper threads have more fibrilation on the surface of the yarn than their lower threads. The overall results were also statistically analysed.

Key-words: needle heating, upholstery fabric, PES/PES corespun, thermal camera

The knowledge of sewing needle heat is important for sewing process in textile materials which are sensible to heat. During the sewing process, the mechanical energy needed for the needle penetration through the fabric and is changed in the equivalent amount of the thermal energy and this leads to heating of the needle. If the fabric is made of thermoplastic fibres then it may melt or the sewing thread may melt and break. Therefore, this heat can cause both loss of needle temper and resulting some sewing faults with a decrease in production.

Today, many high-speed industrial sewing machines sew at very high speeds about 4 000 stitches per minute. During the sewing process needle punches through and withdraws from the fabric and therefore high temperatures can be observed as much as 350°C depending on the fabric thickness and thread types that are used. The needle temperature is formed by the friction at the needle between the fabric or the needle between the thread and causes sewing damages. The heating of a needle is a complicated one which has two states: one is the heat flux generated from the friction between the fabrics and the needle, and the other is the heat flow generated from the friction between the thread and the needle-eye when the thread is in tension. It must be noted that with the motion of the needle, the fabric position relative to the needle is changing during a stitch. During the sewing process, the thread tension varies within a stitch [1] and generally synthetic threads are more effected than natural ones on needle heating. Although synthetic threads are produced using a melt-spinning process and can melt with causing to wear of needle eye if the needle temperature surpasses the melting point of the thread. The reason for using more synthetics rather than natural threads are that they show very good strength and elongation, also are resistant to getting mouldy, sweat and chemical materials.

On the other hand, the friction between the needle and the fabric creates a heating in the needle and it is known that the following factors can have an impact on the amount of heat that is generated fabric thickness, sewing machine speed, thread size and type and needle contact surface. Larger needle sizes and longer needle types have more contact area. Some needle surfaces generate more friction than others and it was also found that, sewing machine speed and the materials are the most influential factors, where an increase on both fabric thickness and sewing machine speed generally cause a higher needle temperature [1].

Many researches have been focused on needle heating where high needle temperatures observed causing a breakage on the threads and may damage fabrics. Howard et al. [2] have studied on needle heating using infrared pyrometer; they discussed many variables such as emissivity, geometrical view factors, and signal shape and frequency which relate the flux to the needle temperature. Additionally, they [2] described a calibration procedure which eliminates these factors as variables and permits determination of the peak needle temperature with an accuracy of ± 2°C. Howard et al. [3], also have examined the effect of various needle characteristics on the needle temperature during high-speed sewing without a thread; they found that nickel, plain steel, and chrome needles gave an increase in the temperatures. Howard et al. [4], have analysed the effect of various sewing conditions and needle characteristics on the temperature using infrared flux measurements and found that thread size and needle diameter were oserved to be not significant on needle heating but machine speed was very important. Liasi et al. [5] have analysed needle heating in heavy materials using infrared radiometry at 500, 1 000, 2 000 rpm of sweing machine speeds; it was found that the needle temperature is affected by the sewing speed, the specific sewing energy which is characterized by the material being sewn, the thread tension, the thermal conductivity and volume specific heat of the material being sewn. Q. Li et al. [1] have studied two models which can predict the needle temperature; in their work one which was a sliding contact model and the other was the lumped variable model; both two models have an average error about 25 percent. Q. Li et al. [6] also have studied an another model which can predict the needle temperature where the FEA model is very accurate with a little error. Recently, Yukseloglu S.M. et al. [7] have observed needle heating on the sewing of cotton denim fabrics which was found that needle heating has more effect on the cotton/polyester corespun rather than the spun polyester threads. It was also stated that the less strength and slightly lower in weight of 100% cotton denim fabrics have given the lowest needle temperature during the sewing with spun polyester threads.

As it is well know that, the upholstery fabrics are thicker and the usage of these fabrics is very widespread, the needle heating becoming more important problem for upholstery fabrics. Because of this and also from the higlights of the literature which are mentioned above, we have studied the effect of the machine speed, fabric thickness and thread type to see if any heating is going to occur during the sewing process of polyester blend upholstery fabrics in this work.

EXPERIMENTAL PART

In this study three polyester blend upholstery fabrics which all of them are two plies, have sewn with PES/PES corespun threads at 1 000, 2 000 and 3 000 rpm. Thickness, breaking strength, weight of fabrics were determined on the upholstery fabrics. Strength, elongation, twist, shrinkage, friction and hairiness tests were also done on the sewing threads. Several of physical tests were carried out in both threads and in fabrics under the standard atmosphere conditions regarding to the TS 240 EN 20139 [8]. Also a thermal camera (IRISYS 4010) has been used to identify the temperatures of the needles during the sewing process.

Fabrics used

Table 1 shows the fabric properties, tenacity results and the thickness of the fabrics. Breaking strength and elongation of these fabrics were determined according to TS EN ISO 13934-1 [9] by using Instron 4411 Tester, the thickness obtained from the R & B Cloth Thickness Tester by according to TS 7128 EN ISO 5084 [10].

Table 1

Fabric type	**Thread components and count,** dtex	**Weight of fabric,** g/m^2	**Fabric components**	**Warp density,** unit/cm	**Weft density,** unit/cm	**Thickness,** mm	**Breaking strength,** kN	**Elongation,** %
A	Warp - 166.6 dtex PES; Weft - 333.3 dtex PES, 2 500 dtex acrylic	384	56% PES 44% acrylic	68	24	1.66	Warp - 1.906 Weft - 1.200	Warp - 68.56 Weft - 65.40
B	Warp - 166.6 dtex PES; Weft - 2500 dtex acrylic, 295.3 · 2 dtex cotton	506	28% PES 58% acrylic 14% cotton	68	23.3	2.23	Warp - 1.604 Weft - 0.567	Warp - 95.70 Weft - 60.75
C	Warp - 166.6 dtex PES; Weft - 210.9 · 2 dtex viscon	280	47% PES 53% viscon	68	34.5	0.92	Warp - 1.875 Weft - 1.066	Warp - 74.87 Weft - 38.46

Table 2

Thread code	Thread type	Thread count, tex	Strength, cN/Tex	Elongation, %	CV, %	Twist, tpm	Shrinkage, %	Friction	Hairiness, N_3 (< 3 mm)
1	PES/PES corespun	60	3 395	23.2	2.43	642	0.2	17	361
2	PES/PES corespun	105	5 230	21.1	2.75	498	0.1	18	1 118
3	PES/PES corespun	150	7 845	21.5	2.34	370	0.2	20	1 077

Sewing threads

Three polyester/polyester corespun sewing threads have been chosen and their test results can be seen in the table 2. Tensile strength and elongation of threads were determined according to TS 245 [11] by using Statimat and Testometric M 250 testers, twist of the threads were measured on the Zweigle D 312 Tester by using TS 247 [12], hairiness was evaluated by using Zweigle Hairiness Tester G566, thread count was obtained according to TS 244 [13] by using Mettler and shrinkage was measured according to TS 392 standards [14].

Needle size

Needle size was chosen according to the fabric thickness and weight. Needle number 16 was used for 60 tex sewing thread, needle number 18 was used for 105 tex and 150 tex sewing threads.

Sewing parameters

Sewing process was carried out on Juki DDL-9A-SS sewing machine and sewing parameters can be seen below:

- machine speed 1 000, 2 000, 3 000 stitches/minutes;
- seam geometry plain lockstitch seam;
- linear stitch density 4 stitches/cm.

RESULTS OBTAINED

In this study three upholstery fabrics made of various blends of poliester with acrylic, poliester with both acrylic and cotton and poliester with viscon were chosen (table 1) and later all were sewn two plies with the PES/PES corespun threads at 1 000, 2 000 and 3 000 rpm of machine speeds. During the sewing process, thermal camera has been used to identify the temperatures of the needles at four different period of time. The emissivity of the needle is taken 0.07 for the thermal images due to the needle's material is made of chromium.

The needle temperatures for 60 tex, 105 tex and 150 tex PES/PES corespun threads at 1 000 rpm are given at table 3. Minimum needle temperature is highlighted (*) in table 3. The needle temperatures for 60 tex, 105 tex and 150 tex PES/PES corespun threads at 2 000 rpm are seen at table 4. The needle temperatures for 60 tex, 105 tex and 150 tex PES/PES corespun threads at 3 000 rpm are given in table 5. Maximum needle temperature is highlighted (*) here in table 5.

Figure 1 and figure 2 only present the thermal images of minimum and maximum needle temperatures of the overall samples. It is seen from the thermal images that the higher temperatures were obtained at the needle eye of the sewing machine which was expected.

Figures 3, 4 and 5 shows the needle temperature (°C) versus sewing time. From the figure 3, it can be observed that the maximum needle temperature

Table 3

Thread code	Fabric code	Needle temperature at 15 seconds, °C	Needle temperature at 30 seconds, °C	Needle temperature at 45 seconds, °C	Needle temperature at 60 seconds, °C
1	*A*	104.4	106.9	114.9	118.8
	B	105.8	108.6	114.2	120.8
	C	98.2*	100.7	107.5	113.0
2	*A*	100.9	116.4	121.3	123.0
	B	110.6	115.7	122.2	126.8
	C	99.8	110.8	120.5	122.7
3	*A*	114.4	123.1	134.7	140.2
	B	139.1	144.1	153.1	155.7
	C	117.6	122.6	132.5	138.5

Table 4

Thread code	Fabric code	Needle temperature at 15 seconds, °C	Needle temperature at 30 seconds, °C	Needle temperature at 45 seconds, °C	Needle temperature at 60 seconds, °C
1	*A*	136.9	139.6	143.9	145.8
	B	139.8	152.0	151.7	153.3
	C	134.2	136.1	140.1	141.0
2	*A*	154.3	164.4	168.2	174.1
	B	141.0	153.3	174.9	177.4
	C	130.7	152.9	158.0	160.6
3	*A*	166.4	167.1	209.3	217.4
	B	184.0	211.5	226.1	237.6
	C	180.7	186.5	190.9	198.5

Table 5

Thread code	Fabric code	Needle temperature at 15 seconds, °C	Needle temperature at 30 seconds, °C	Needle temperature at 45 seconds, °C	Needle temperature at 60 seconds, °C
1	*A*	183.2	196.2	200.2	207.0
	B	177.4	188.7	203.6	227.1
	C	167.2	170.8	173.6	179.6
2	*A*	253.8	258.9	270.2	273.4
	B	237.8	261.7	275.1	278.7
	C	245.1	246.9	256.8	257.5
3	*A*	233.3	273.4	294.9	298.8
	B	250.2	271.5	294.3	311.2*
	C	243.0	262.4	266.1	274.5

(155.7°C) obtained on the *B* fabric at the 60 seconds with the coded thread *3* which is made of 150 tex PES/PES corespun at 1 000 rpm of the sewing machine speed. The minimum needle temperature (around 98.2°C) obtained on the *C* fabric at the 15 seconds with the coded thread *1* which is made of 60 tex PES/PES corespun at 1 000 rpm of the sewing machine speed (table 3).

Figure 4 shows the needle heating of the samples at the 2 000 rpm of the sewing machine speed; it can be seen that the maximum needle temperature (237.6°C) obtained on the *B* fabric at the 60 seconds with the coded thread *3* which is made of 150 tex PES/PES corespun at 2 000 rpm of the sewing machine speed.

The minimum needle temperature (130.7°C) obtained on the *C* fabric at the 15 seconds with the coded thread *2* which is made of 105 tex PES/PES corespun at 2 000 rpm of the sewing machine speed.

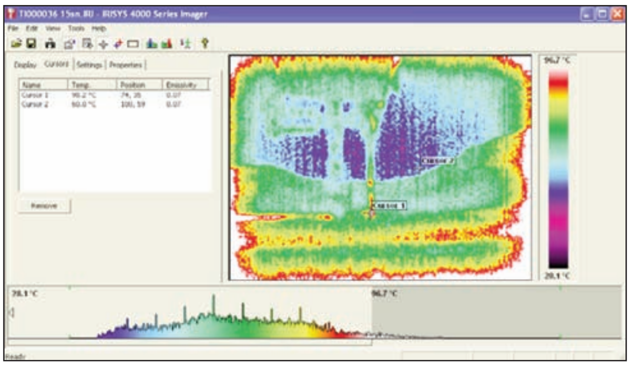

Fig. 1. Thermal image of minimum needle heating at 15 s of the fabric *C*, which sewn with 60 tex PES/PES corespun thread at 1 000 rpm

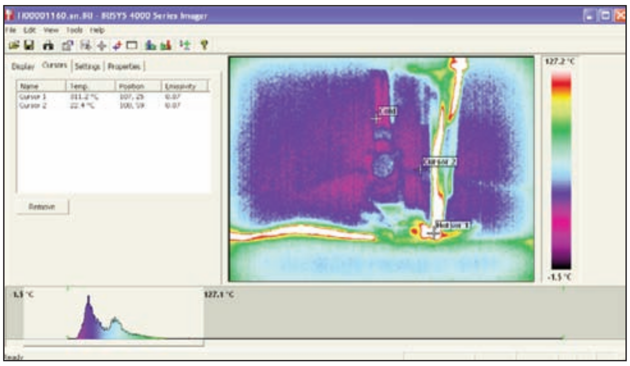

Fig. 2. Thermal image of maximum needle heating at 60 s of the fabric *B*, which sewn with 150 tex PES/PES corespun thread at 3 000 rpm

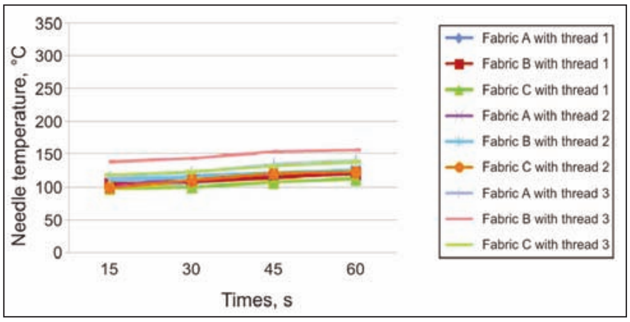

Fig. 3. The needle temperatures during the sewing of upholstery fabrics at 1 000 rpm

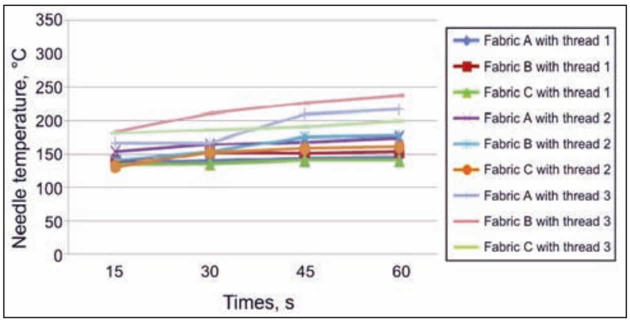

Fig. 4. The needle temperatures during the sewing of upholstery fabrics at 2 000 rpm

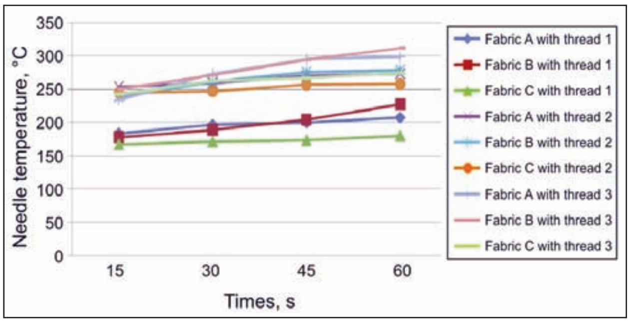

Fig. 5. The needle temperatures during the sewing of upholstery fabrics at 3 000 rpm

It can be observed that the maximum needle temperature (311.2°C) obtained on the *B* fabric at the 60 seconds with the coded thread *3* which is made of 150 tex PES/PES corespun at 3 000 rpm of the sewing machine speed. The minimum needle temperature (167.2°C) obtained on the *C* fabric at the 15 seconds with the coded thread *1* which is made of 60 tex PES/PES corespun at 3 000 rpm of the sewing machine speed.

Generally it can be concluded that, the needle temperature increases as both threads get coarser and fabrics get thicker for the sewing machine speeds (tables 3, 4 and 5). It was also oberved that the longer the sewing time is the higher the needle temperature gets.

All the threads were studied on the LAS (Leica Application Suite) light microscope with a 40x magnification to be able to see if any damages occur during sewing process. The threads of which at minimum (98.2°C) and maximum (311.2°C) needle heating

Fig. 6. Upper thread 60 tex PES/PES, coded as thread *1*, used in fabric *C*, at 1 000 rpm

Fig. 7. Lower thread 60 tex PES/PES, coded as thread *1*, used in fabric *C*, at 1 000 rpm

Fig. 8. Upper thread 150 tex PES/PES, coded as thread *3*, used in fabric *C*, at 1 000 rpm

Fig. 9. Lower thread 150 tex PES/PES, coded as thread *1*, used in fabric *C*, at 1 000 rpm

Fig. 10. Upper thread 150 tex PES/PES, coded as thread *1*, used in fabric *C*, at 2 000 rpm

were given in both figures 6 – 7 and figures 12 – 13, respectively. Also some other micrographs of the threads were presented in figures 8 – 11 and in figures 14 – 15 where can be seen from the upper and lower parts of the bobin case seperately.

It can be seen that the upper threads have more fibrilation than their lower threads during the sewing

Fig. 11. Lower thread 150 tex PES/PES, coded as thread *3*, used in fabric *C*, at 2 000 rpm

Fig. 12. Upper thread 150 tex PES/PES, coded as thread *1*, used in fabric *B*, at 3 000 rpm

Fig. 13. Lower thread 150 tex PES/PES, coded as thread *1*, used in fabric *B*, at 3 000 rpm

Fig. 14. Upper thread 150 tex PES/PES, coded as thread *3*, used in fabric *C*, at 3 000 rpm

Fig. 15. Lower thread 150 tex PES/PES, coded as thread *3*, used in fabric *C*, at 3 000 rpm

process (figures 6 – 15). Again, less fibrilation was observed at the lowest sewing machine speed (1 000 rpm). The regression equation for the needle temperature is given below:

$$y = -24.8 + 10.8\, x_1 + 0.616\, x_2 + 0.0658\, x_3 \quad (1)$$

$$R^2 = 93.8\%$$

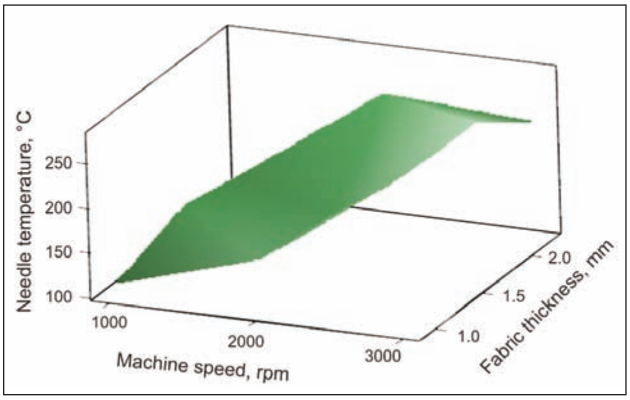

Fig. 16. Surface plot of needle temperature

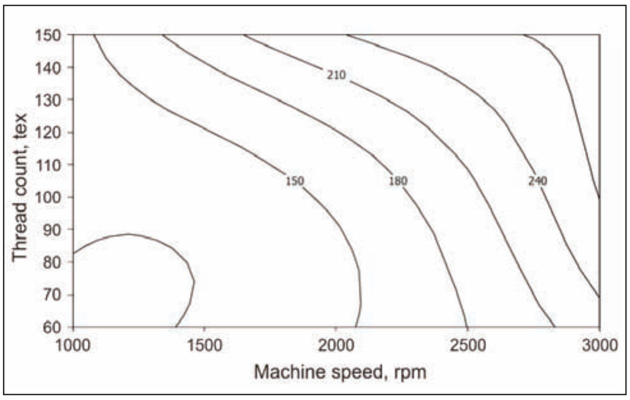

Fig. 17. Contour plot of needle temperature

where:

y is needle temperature, °C;

x_1 – fabric thickness, mm;

x_2 – thread count;

x_3 – machine speed.

For the needle heating data, the 3D surface plot shows (fig. 16) that the highest needle temperature was found near an average fabric thickness of 2 mm and an average machine speed of 3 000 rpm.

Figure 17, also shows the contour plot data where the highest needle heating values were found near an average of 3 000 rpm of machine speed regardless of the thread count.

ANOVA tables for S/N ratio are given in tables 6, 7, 8. Table 6 gives the sum of squares, mean square, *F* value, residual and also percentage contribution of fabric weight and thread count, table 7 gives fabric weight and machine speed and table 8 gives thread count and machine speed. The degrees of freedom, d_f, for each factor is calculated as d_f = number of level –1 .

With respect to tables 6, 7, 8, Prop values lower than 0.05 shows that the established model is meaningful. Since the arithmetical average value of R^2 is 93.8%, expressiveness of the model is high. This indicates that thread count and machine speed have the most significant effect on the needle heating.

Table 6

Factors	Degree of freedom	Sum of squares	Mean square	*F* value	Prop value
Fabric thickness	2	338.0	168.98	0.02	0.976
Thread count	2	4 630.1	2 315.07	0.33	0.736
Error	4	27 977.7	6 994.43	-	-
Total	8	32 945.8	-	-	-
R-squared = 15.08%					

Table 7

Factors	Degree of freedom	Sum of squares	Mean square	*F* value	Prop value
Fabric thickness	2	338.0	169.0	0.11	0.902
Machine speed	2	26 253.6	13 126.8	8.26	0.038
Error	4	6 354.3	1 588.6	-	-
Total	8	32 945.8		-	-
R-squared = 80.71%					

Table 8

Factors	Degree of freedom	Sum of squares	Mean square	*F* value	Prop value
Thread count	2	4 630.1	2 315.1	4.49	0.095
Machine speed	2	26 253.6	13 126.8	25.46	0.005
Error	4	2 062.1	515.5	-	-
Total	8	32 945.8	-	-	-
R-squared = 93.8%					

CONCLUSIONS

In this paper, needle heating was studied on the sewing of polyester blends of upholstery fabrics. For this, different thickness of three upholstery fabrics were sewn in two plies with different counts of PES/PES corespun threads at 1 000, 2 000 and 3 000 rpm sewing mchine speeds. The thermal camera has been used to identify the temperature of the needles during the sewing process and the sewn threads were also observed on the Leica Application Suite (LAS) light microscope under 40x magnification (figures 6 – 15). The following conclusion can be made:

- In generally, the highest fabric thickness (2.23 mm) of upholstery fabric has given the highest needle temperature during the sewing process. It is thought that when the fabric is thicker, the friction between thread in the needle eye and the fabric creates much more heating in the needle.
- The highest sewing machine speed has more effect on needle heating than smaller speed 3 000 rpm sewing machine speed gives maximum needle temperatures.
- Needle temperature decreases as threads get finer; this is maybe due to the fact that finer threads have more twist in the yarn and have shown less hairiness within the thread structure.
  Therefore, the more twist in the thread structure can tolerate needle heating more easily and also with the less hairiness the thread can show less friction between the needle eye and the fabric during a needle punches through and withdraws from the fabric.
- Needle temperature increases as fabric gets thicker; because during a sewing process the needle punches through and withdraws from a fabric. Hence, the more thicker the fabric is the more needle friction occurs and this results an increase on the needle heating.
- From the thermal images, it can be concluded that the higher temperatures were obtained at the needle eye of the sewing machine which was expected. This may then cause a slight damage to the sewing threads which are made of synthetic fibres; this has also been noticed on the micrographs where the stitched thread samples presented fibrillation (more hairy surface on the thread) within the yarn body that can be detected.
- Less thread damage was observed on the upper and lower parts of the bobbin case rather than the higher sewing machine speeds. This may indicate that threads are not as much as under stress at the lower speeds (i.e. 1 000 rpm) of the sewing machine. At lower sewing machine speeds, needle punching through and withdrawing from the fabric decreases and hence both needle friction and needle heating decrease.
- The upper threads have shown more fibrilation on the surface of the yarn than their lower threads**;** this may be due to that upper thread passes by many places at the sewing machine starting from bobbin case until reaching the needle; additionally after the needle eye it also penetrates through the fabric and this results a change in mechanicalenergy to equivalent amount of thermal energy and therefore this leads to heating of the needle itself. It is also thought that during the penetration of a needle to the fabric will cause a friction both between the thread-needle and thread-fabric may result additional fibrilation to the upper thread**.**

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Morphological assessment of human body for clothing patterns design

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REZUMAT – ABSTRACT

Evaluarea morfologică a corpului uman în scopul proiectării îmbrăcămintei

Pentru realizarea îmbrăcămintei la scară industrială și în conformitate cu mărimile concrete ale purtătorilor (îmbrăcăminte individualizată, este foarte important ca proiectantul să opereze cu un volum cât mai mare de informații privitoare la forma corpului potențialilor utilizatori de produse vestimentare. În etapa de constituire a bazei de date, necesară în proiectarea constructivă a produselor de îmbrăcăminte, este necesar ca proiectantul să evalueze rapid și cât mai corect particularitățile morfologice ale clientului, în vederea realizării tiparelor în condiții de eficiență maximă. Lucrarea are ca scop principal elaborarea unui model care, pe baza unui număr relativ redus de mărimi antropometrice prelevate de pe un subiect oarecare, să permită proiectantului să evalueze în mod obiectiv și într-un timp foarte scurt tipodimensiunea și particularitățile morfologice – ținuta, proporțiile și conformația – în care se încadrează un subiect oarecare. Pentru elaborarea modelului, a fost necesară constituirea unei baze de date, care să permită evaluarea în sistem automatizat a particularităților morfologice ale subiecților testați.

Cuvinte-cheie: evaluare, proiectarea modelului, populație de sex feminin, îmbrăcăminte

Morphological assessment of human body for clothing patterns design

In the activity of clothing realization in industrial system and based on user specific sizes (customized clothing), it is very important for the pattern designer to operate with a maximum amount of information about potential users body shape. At the stage of establishing the necessary database, it is necessary that the pattern designer to assess swiftly and accurately the morphological features of the customer in order to design patterns in terms of efficiency. This paper aims to develop a model center on a relatively small number of anthropometric sizes taken on any subject, to allow the pattern designer to evaluate objectively and in a very short time – body type and morphological features – posture, size and conformation to any subject. In order to develop the model, it was necessary to establish a database that assesses the morphological features of the automated test subjects.

Key-words: assessment, pattern design, female population, clothing

In conventional manufacturing technology of clothing – the industrial system, the body-clothing correspondence is often assessed in stores according to the stock products which remain. Unsold products do not reflect that they are obsolete or don't have the best quality in terms of accuracy of manufacturing technology, appropriate use of raw and auxiliary materials, but they were not purchased because they corresponded to the dimensional morphological requirements of the users.

When disposing of products through a network of stores is possible that users do not find their size products or products not correspond with their morphological features. When the client is trying on these products on the body appear so-called structural defects that are manifested by the appearance of wrinkles fixed tense, change the equilibrium position of the main elements, limiting the amplitude of movement body segments etc.

In order to reduce these drawbacks, a viable solution that is currently rarely used is to extend the system to achieve customized garments but using facilities of the industrial system. Such concerns are more frequent, both globally and in our country due to the development and technical progress in the field of computing [1], [2].

The qualitative leap in the field of industrial design, but after the body sizes of customers, so-called customized clothing is feasible at present due the performances of the CAD systems, integration of both modules for MTM and simulation in the virtual environment of the correspondence between body and the product designed in 2D [3], [4].

This represents a whole new approach to manufacturing flow clothing based on individual sizes of clients with important repercussions on clothing quality, evaluated by providing a high correspondence with user requirements, sales and expansion of virtual trade clothing products.

Current performance of CAD systems have specialized modules such as MTM module in Gemini Pattern Editor program, allowing the development of clothing based on individual sizes of the customers, through the adaptation of algorithms structure for calculating the construction segments to concrete form of the body surface of different users.

CAD systems performances are joined by 3D scanning technology development, that results in storing a large number of anthropometric sizes used in improving current technology of constructive designing for clothing.

3D virtual simulation of the correspondence between product design and the human body is an innovative technique to improve the whole process of constructive design of clothing products. This technique has many advantages among which the rapid renewal of models and reducing costs associated with the implementation of practical prototypes.

In this context, it explains the permanent concern of specialists in the field of constructive designing of clothing to improve the entire process, from initial database creation to its operation so that the outcome of this process will ensure recipients with clothing products correlated with morphological features of users.

Regardless of the garment manufacturing system, industrial or customized, in the constructive designing activity, the pattern designer must use a significant amount of information about body shape of potential users, information necessary to ensure a high correspondence between elements of body-clothing, during the whole garment utilization [5].

The always increased demands of users in purchasing products mainly within the fashion trends determine the shorter series and a more wide dimensional range of clothing for all age groups.

In this context the time for the constructive design work is often very short, so the concern of specialists in this field should be oriented towards the establishment of databases with information about:

– morphological types that appear with greater frequency in the population;
– patterns construction algorithms for average conformational types;
– constructive solutions to adapt the patterns to the form of various body types that do not meet the standard types.

Within the activity of making clothing in individual system is very important for the pattern designer to quickly and correct evaluate the morphological features of the customer in order to design patterns in terms of efficiency.

This paper aims to develop a model center based on a relatively small number of anthropometric sizes taken on a certain subject, to allow the pattern designer to evaluate objectively and in a very short time: body type (standard dimensions) and morphological features – stature, size and conformation to any subject *i*. In order to develop the mathematical model, it was necessary to establish a database that assesses the morphological features of the automated test subjects.

SETTING DATABASE OPERATING THE MORPHOLOGICAL ASSESSMENT

The database for operating mathematical model consists of all the information necessary to solve the two above mentioned objectives, establishing the typo-dimension of one tested subject and the morphological features that characterize the body of the tested subject.

In order to fit subjects into a body type were used information taken from the current anthropometric Standard - SR 13545 Clothing. Body measurements and clothing sizes for women.

Morphological characterization using the developed mathematical model was based on results of statistical and mathematical processing raw data resulting from 3D scan of the women population in Romania, which allowed the processing of average values and the limits of variation of the basic morphological indicators in evaluating stature, conformation and body proportions for women [6].

The database needed to fit subjects into body type (size, height group, conformation) was achieved on account of the current Anthropometric standard - SR 13545, information collated in tables 1, 2 and 3.

Setting body type that will fit any subject includes:

- indication of the size that will fit the subject (table 1);
- specifying the heights group that will fit the subject (table 2);
- specifying the conformation that will fit the subject (table 3).

For the development of the database need for the morphological evaluation of the subjects required by the mathematical developed model, were selected anthropometric sizes necessary in the mathematical calculation of morphological indicators to assess

Table 1

SIZES GROUPS	
Standardized size	**Interdimensional range for P_b,** cm
40	78 - 81.9
42	82 - 85.9
44	86 - 89.9
46	90 - 93.9
48	94 - 97.9
50	98 - 101.9
52	102 - 105.9
54	106 - 111.9
56	112 - 117.9
58	118 - 123.9
60	124 - 129.9

Table 2

HEIGHT GROUPS LIMITS OF THE INTER-DIMENSIONAL RANGE FOR BODY HEIGHT, I_c		
Indicator symbolization	**Standardized size**	**Interdimensional range**
I	176	172 - 180
II	168	164 - 171.9
III	160	156 - 163.9
IV	152	148 - 155.9

Table 3

CONFORMATION GROUPS												
Conformation groups symbolization	$P_ş - P_b$	**Clothing sizes**										
		40	42	44	46	48	50	52	54	56	58	60
		P_b										
		80	84	88	92	96	100	104	110	116	122	128
		$P_ş$										
A	-4	-	-	-	-	-	-	100	106	112	118	124
B	0	80	84	88	92	96	100	104	110	116	122	128
C	4	84	88	92	96	100	104	108	114	120	126	132
D	8	88	92	96	100	104	108	112	118	124	130	136
E	12	92	96	100	104	108	112	116	122	128	134	140
F	16	96	100	104	108	112	116	-	-	-	-	-
Interdimensional range		4 cm							6 cm			

Table 4

SELECTED ANTHROPOMETRIC DIMENSIONS		
No.	**Significance of anthropometric size**	**Symbol**
1	Body height	I_c
2	Bust circumference	P_b
3	Hips circumference	$P_ş$
4	Shoulders length	L_u
5	Thorax length from neck to waist	$L_{'tf}$
6	Vertical arch of the back	A_{vs}
7	Shoulders inclination angle	α
8	Distance from a reference plane at 7 CV landmark	D_1
9	Distance from a reference plane at point bulging scapula	D_2
10	Distance from a reference plane back waist point	D_3
11	Distance from a reference plane at buttock point	D_4

Table 5

CALCULATION OF MORPHOLOGICAL INDICATORS						
Morphologic indicators	P_c, cm	A_{ts}, cm	P_{fes}, cm	$Î_u$, cm	E_{v1}, cm	I_{pt}, %
Calculation ecuation	$D_1 - D_2$	$D_2 - D_3$	$D_3 - D_4$	L_u* sin α	$L_{'tf} - A_{vs}$	P_b/I_c

curvature and prominences on the anterior/posterior thorax and shoulder position (table 4). Note that in this table are included anthropometric sizes necessary to establish the body type that is fitted for any subject [7].

Anthropometric sizes in table 4 were subjected to statistical and mathematical processing which allowed determining the average values and the range of variation:

- body posture, assessed by body position (P_c), waist deep in the back or first waist depth (A_{ts}) and buttocks prominence or second waist depth (P_{fes});
- shoulder height ($î_u$);
- vertical balance (E_{v1});
- body proportions, the index thoracic perimeter (I_{pt}).

In table 5 are given relations for calculating morphological indicators of subject's body characterization, which were processed mathematically in order to determine the ranges of variation to analyze how a subject will fit into the above mentioned morphological indicators.

In tables 6 – 11 are summarized the ranges of values resulting from mathematical processing raw data for a selection of 675 women. Note that ranges obtained by mathematical processing of raw data the selection under study are comparable to those given in the literature of the world [8], [9].

Table 6

BODY STATURE, BODY POSITION, P_c, cm	
Stature type	**Range for P_c**
Tense	$P_c < 4.69$
Normal	$P_c = 6.2 \pm 1.5$ (4.7 – 7.7)
Crooked	$P_c > 7.71$

Table 7

BACK WAIST DEPTH (FIRST WAIST DEPTH) A_{ts}, cm	
Stature type	**Range for A_{ts}**
Tense	$A_{ts} < 2.9$
Normal	$A_{ts} = 4.5 \pm 1.5$ (3 – 6)
Crooked	$A_{ts} > 6.1$

Table 8

PROMINENCE OF BUTTOCKS (SECOND WAIST DEPTH), P_{fes}, cm	
Stature type	**Range for P_{fes}**
Tense	$P_{fes} < 3.49$
Normal	$P_{fes} = 5 \pm 1.5$ (3.5 – 6.5)
Crooked	$P_{fes} > 6.51$

Table 9

SHOULDERS HEIGHT, $Î_u$, cm	
Shoulders height	**Range for $Î_u$**
Shoulders lifted	$Î_u < 5.19$
Normal position	$Î_u = 5.9 \pm 0.75$ (5.2 - 6.6)
Shoulders descend	$Î_u > 6.7$

Table 10

VERTICAL BALANCE E_{V1}, cm	
Thorax type	**Range for I_{pt}**
Narrow	$I_{pt} < 56.9$
Average	$I_{pt} = 60 \pm 3$ (57 – 62.9)
Large	$I_{pt} = 66 \pm 3$ (63 – 68.9)
Full	$I_{pt} > 69$

Table 11

THORACIC PERIMETER INDEX I_{pt}, %	
Thorax position	**Range for E_V**
Leaned forward	$E_V < -0.21$
Normal vertical balance	$E_V = 1.8 \pm 2$ (–0.20 - 3.80)
Leaned back	$E_V > 3.81$

USING THE MODEL TO ASSESS MORPHOLOGICAL SUBJECT "*I*"

The mathematical model developed is based on a flowchart which shows an excerpt, the program that allows classification of the subject into the body type (fig. 1). For example, to specify the size, stature and conformation group that is likely to fit the subject, in the program has been developed:

- a block of input data:
  - list of anthropometric sizes (table 4);
  - central values and limits of variation for I_c, P_b and $P_ș$ (tables 1, 2 and 3);
- a block for the calculating of the conformation (conformation = $P_ș$ – P_b).

Finally, the program developed calculates and compares the values obtained for the subject tested in the program as input data.

Therefore, the program runs in the following way (input, calculation, output) allowing the morphological and dimensional characterization for a certain subject in a very short time and by operating with a relatively small number of anthropometric dimensions.

Figures 2 – 5 show how to way that the subject fits into the body posture, vertical balance and shoulder height. From these figures one can see that the subject has normal posture, thorax directed to the backside and shoulders in normal position.

In each figure are shown the fields that specified the subject's anthropometric measurements necessary for his assessment and classification to the body type and specify morphological indicators, using the developed mathematical model.

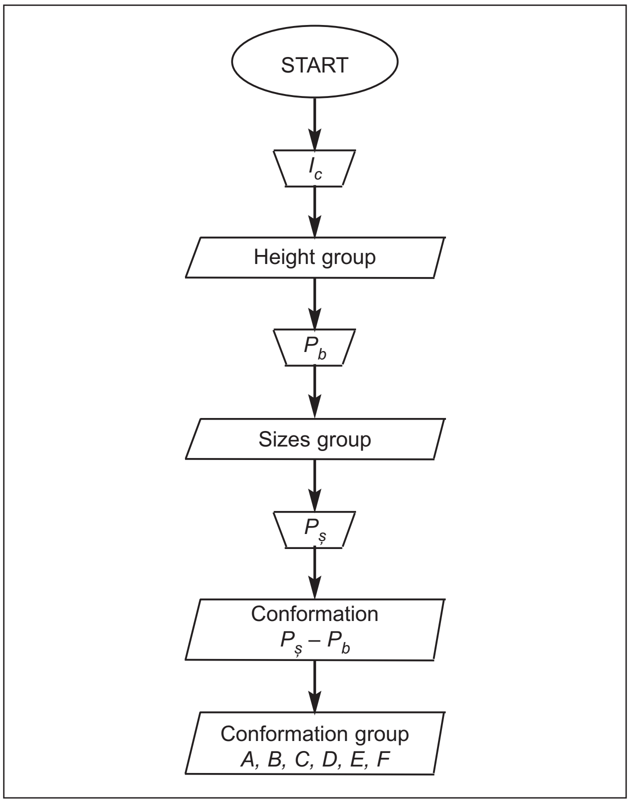

Fig. 1. Correlation between bust circumference and hip circumference

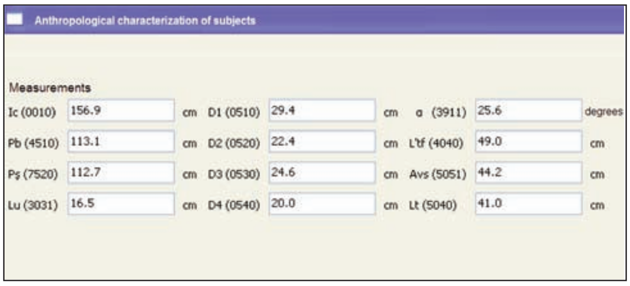

Fig. 2. Anthropometric sizes of the tested subject

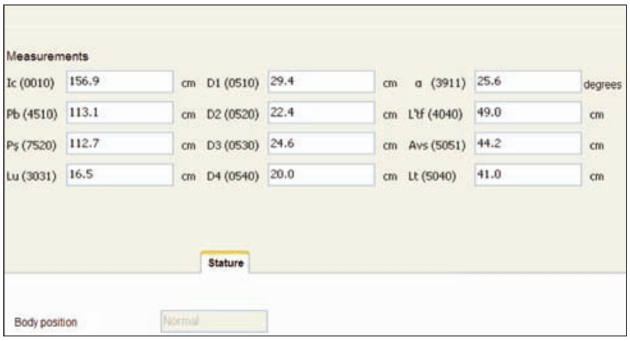

Fig. 3. Assessment of body stature (based on P_c) for the studied subject

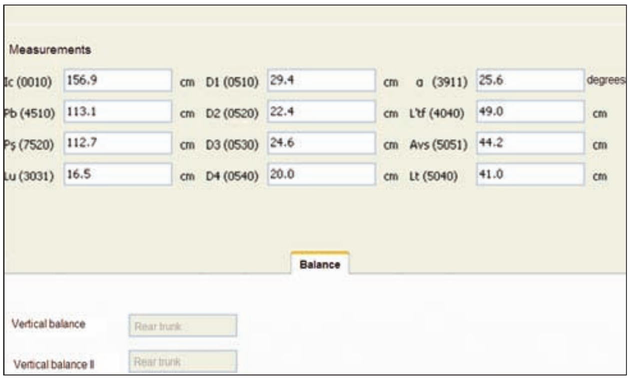

Fig. 4. Assess the vertical balance of the body for the studied subject

CONCLUSIONS

This paper presents a fast and scientifically founded body shape characterization for structural design of clothing, by developing a mathematical model that operates with a relatively small number of tested subject specific anthropometric measurements.

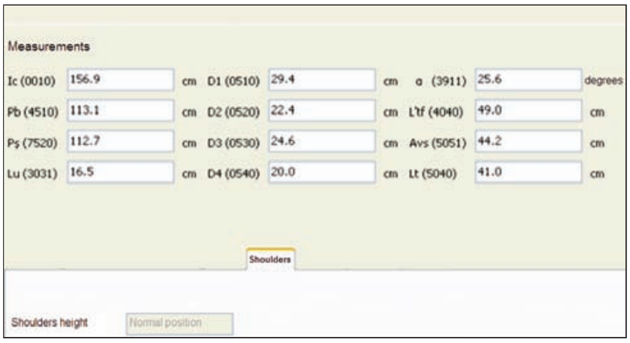

Fig. 5. Assessment of shoulder position for the tested subject

The mathematical model is based on anthropometry research that provided the initial operating database. Initial information needed in the program is the following:

– numerical values for 11 anthropometric sizes taken on the subject body;
– the calculating relations for morphological indicators needed to assess stature, proportions, position of the shoulders and thorax;
– ranges for the main body dimensions (I_c, P_b and $P_ș$), to identify the typo-dimension that fits the tested subject;
– ranges for morphological indicators introduced to assess the general shape of the body.

After the processing of the initial data, we can visualize upon request the information on the typo-dimension and morphological indicators that fit the tested subject.

The mathematical model developed is useful for clothing patterns designers because it allows morphological characterization of the subjects, activity necessary in the phase of developing the initial database that is operating in constructive design of the product, for clothing manufacture both in industrial system and in individual system.

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DOCUMENTARE

Noi tehnologii

ECONOMISIREA APEI CU TEHNOLOGIA E-SOFT

Cu ocazia Zilei Mondiale a Apei, sărbătorită pe 22 martie 2013, compania furnizoare de tehnologii pentru finisarea confecţiilor ***Jeanologia***, din Paterna – Spania, a lansat tehnologia E-Soft.

Noua tehnologie serveşte la emolierea articolelor de îmbrăcăminte cu nanobule, permiţând economii ale consumului de apă de 98%, de substanţe chimice – în proporţie de 80%, şi de energie – în proporţie de 79%.

Tehnologia E-Soft operează prin captarea aerului din atmosferă şi introducerea într-un reactor cu flux, care generează electronanobule, ce sunt direcţionate apoi spre un tambur de antrenare a articolelor de îmbrăcăminte. Produsele de emoliere şi apa formează o peliculă de nanobule, care transmite proprietăţile produselor respective asupra articolului de îmbrăcăminte, în timp ce aerul umed în combinaţie cu cel fierbinte asigură controlul contracţiei. În cazul aplicării tehnologiei E-Soft, pentru un articol de îmbrăcăminte se consumă 0,1 litri de apă, 10 g de produse de emoliere şi 0,08 kW/h, comparativ cu 5 litri de apă, 50 g de produse de emoliere şi 0,38 kW/h în procesul convenţional. În plus, în cazul aplicării proceselor convenţionale rezultă 22,5 milioane m^3 de ape uzate pe an, în timp ce, prin utilizarea tehnologiei E-Soft, volumul de ape uzate este zero, acest lucru fiind o premieră.

Compania Jeanologia a elaborat şi alte tehnologii durabile, cum ar fi spălarea ecologică a textilelor G2, prin care se obține o economie a consumului de apă şi energie în proporţie de 50% şi a consumului de produse chimice şi de timp de aproximativ 60%.

Laserul pentru textile, dezvoltat de companie, poate reproduce efecte mult mai sofisticate ale aspectelor de uzură la purtare şi vintage, conducând la reducerea timpilor de producţie şi la mărirea acurateţei şi reproductibilităţii.

Noua tehnologie nu expune lucrătorii la medii periculoase şi permite economii mai mari de energie, apă, substanţe chimice şi timp, în procesul de finisare a denimului.

Compania a dezvoltat această tehnologie pe principiile solide ale ecologiei, eficienţei şi eticii (3E), ceea ce conduce la creşterea productivităţii, reducerea costurilor şi a impactului asupra mediului.

Melliand International, mai 2013, p. 105

The semantics of communicative functions of smart interactive clothing

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REZUMAT – ABSTRACT

Semantica funcţiilor comunicaţionale ale îmbrăcămintei interactive inteligente

În articol este prezentată o analiză a reprezentărilor semantice ale îmbrăcămintei inteligente, a funcțiilor simbolice ale articolelor de îmbrăcăminte inteligentă și ale modei, a funcţionalității, complexității și diversității acesteia. S-a avut în vedere modul de abordare, în cadrul cercetărilor anterioare, a cerințelor utilizatorilor în timpul procesului de dezvoltare a unor articole de îmbrăcăminte funcțională, a necesităților consumatorului final, a scopului și semnificației îmbrăcămintei și modei. Au fost analizate legătura dintre evaluările esențiale și atributele senzoriale, modul de dezvoltare și întrebuințare a materialelor textile inteligente, precum și introducerea unor tehnologii moderne în realizarea textilelor și a îmbrăcămintei inteligente. Tehnologiile emergente de creare a materialelor textile inteligente, soluțiile eficiente de dezvoltare a textilelor inteligente destinate domeniului medical și de creștere a funcționalității textilelor inteligente, prezentate în literatura de specialitate, sunt relevante pentru derularea acestui studiu.

Cuvinte-cheie: materiale textile inteligente, tehnologii emergente, analiză senzorială, îmbrăcăminte inteligentă, modă

The semantics of communicative functions of smart interactive clothing

The paper presents an analysis of the semantic expression of smart clothes, the symbol functions of clothing and fashion, its functionality, complexity and diversity. We are specifically interested in how previous research investigated the user requirements during the functional clothing development process, the end-user needs for smart clothing, the scope of functional clothing and the meaning of clothing and fashion. The purpose of this study is to examine the relationship between instrumental measurements and sensory attributes, the development and utilization of smart textile materials, and the accelerated introduction of smart technology in textiles and clothing. The emerging technologies for the production of smart textile materials, the effective solutions for the development of smart textiles for the medical field and the functionalities of smart textiles are essential for this study.

Key-words: smart textile materials, emerging technologies, sensory analysis, smart clothes, fashion

The theory that we seek to elaborate here puts considerable emphasis on the concept of smart textiles, the potential impact of smart textiles for healthcare, and the key properties of textiles that are mobilized in smart applications. This study is grounded in the considerable body of scholarship examining the correlations between fabric pattern and tactile properties, the main applications of sensory analysis in textile industry, the integration of sensory feeling in product development, and the working principle of PCM and their applications for smart temperature regulated textiles. The findings of this study have implications for the integration of utilities in smart wearable's and clothing, the embodied nature of clothing, the relationship between clothing and identity, and clothing concepts that facilitate social interaction. We focus on the use of clothing and fashion to symbolize and communicate social roles, the design process of clothing and fashion, smart functions to be applied to clothing and textiles, and remediation of the wearable space. Our paper contributes to the literature by providing evidence on the nexus between the placement and integration of wearable technology, the integration of smart functionality into clothing and other textile products, and the integration of electronic technologies to build smart textile systems.

THE ACCELERATED INTRODUCTION OF SMART TECHNOLOGY IN TEXTILES AND CLOTHING

Van Langenhove et al. contend that smart textiles are active materials that have sensing and actuation properties: they are able to sense stimuli from the environment, to react to them and adapt to them by integration of functionalities in the textile structure (the potential of smart textiles for health care is largely unexploited). Smart textile structures have demonstrated their feasibility both from the point of view of technical specifications and their textile character. Intelligent suits are knowledge based with high added value, and a smart suit should be a stand-alone unit (smart textile suits play an outstanding role in remote monitoring, diagnosis and advanced protection) [1]. Black holds that not all material properties may be regarded as smart, the enablers for smart textiles are both technological and commercial, whereas there are a number of barriers to be overcome before electronic smart textiles become universally usable and acceptable. The power supply to drive the electronic and smart functionalities will be derived from energy harvested from kinetic movement or generated from the environment (power sources are a key issue for smart textiles). Smart textiles and clothing can make a significant contribution to healing. Solutions for

smart textiles in medical care need to be more context-specific. Smart textiles integrated into medical devices and clothing revolutionize the way healthcare is conducted [2].
According to Qin, modern wound dressings are smarter than the traditional products such as cotton gauzes and absorbent swabs (the new generation of smart wound care products is easy to use and cost effective). Smart wound dressings provide the optimal environment for healing to proceed. Clinical efficacy, treatment effectiveness and cost are important issues in the development of new smart wound care materials. New smart wound care products are often more expensive than traditional products [3]. Tao observes that smart materials and structures sense and react to environmental conditions or stimuli. The actuators and the sensors are the essential elements for active smart materials. Fiber sensors are typical smart fibers that can be directly applied to textiles. Integration of sensing networks inside fabric-reinforced structures is the first step to make the materials smart. Passive smart materials can sense the environmental conditions or stimuli, active smart materials can sense and react to the conditions or stimuli, whereas very smart materials can sense, react and adapt themselves accordingly (in a passive smart material, the existence of sensors is essential) [4].

THE FUNCTIONALITIES OF SMART TEXTILES

Mondal emphasizes that thermo-regulated textiles are smart textile products that contains low temperature phase-change materials (PCM). PCM incorporated textile can take a major role in future smart textiles segments [5]. Coyle et al. stress that smart textiles are a critical part of the emerging area of body sensor networks, can sense and react to environmental conditions or stimuli, may emulate and augment the sensory system of the skin by sensing external stimuli, and often start as a specialized application before becoming a generally available consumer product. The fundamental components within smart textiles are sensors, actuators, and control units. Nanotechnology is key to the smart textiles industry. With nanotechnologies, smart textiles may provide a haptic interface. The advent of smart nanotextiles has revolutionized the clothes we wear. Smart nanotextiles will form a ubiquitous part of our lifestyle. Developments in smart nanotextiles may produce clothing that is contextually aware [6]. Singh et al. argue that the notion of bioinspired, smart material design performs artificial mechanosensing and actuation phenomenon in our daily wearing clothes. Technological developments in microelectromechanical systems (MEMS) and nanoelectromechanical systems (NEMS) have offered technological inputs to design smart sensors. The subject of biomimesis and bioinspired designs for smart clothing borders advance material design and their subsequent integration into fabrics. Bioinspired emulations may give way to benefit in designing smart fabrics [7].
Park and Jayaraman present an engineering design framework for the design and development of intelligent protective textile structures and clothing. The field of defense-related intelligent textiles and clothing realizes the ultimate objective of cost-effective protection anytime, anywhere for anyone [8]. Van Langenhove et al. think that smart textile products are stand-alone systems, smart or intelligent textiles actively contribute to our health and safety, whereas a textile is smart when it has the capability to measure and/ or to react. A smart textile can monitor humans, the environment and itself. Smart textile absorbs a series of active components without changing its characteristics of flexibility and comfort. Smart clothes are an ideal vehicle for carrying active elements that permanently monitor our body and the environment. Electroactive fibers play an outstanding role in the future development of smart textiles. Energy is one of the key challenges in a smart textile system [9]. As Lobnik explains, smart fabrics are capable of sensing body or environmental conditions arising from various sources. The integration of chemical sensing into textiles adds an important dimension to the field of smart clothing. The development of smart textiles can make outstanding changes in the field of citizens' healthcare and safety [10].

THE DRIVERS FOR THE CURRENT DEVELOPMENT OF SMART TEXTILES

Wan and Stylios remark that intelligent textiles based on shape memory effects are able to change the structure and properties in response to relatively small variation in the environment. Intelligent textiles with self-regulating structures and performance have been created from a blend of traditional textile materials and shape memory materials [11]. Hu et al. report that stimuli-responsive polymers (SRPs) can show noticeable changes in their properties with environmental stimulus variations. Smart shape memory polyurethane (SMPU) hollow fibers can be used for thermal management in garments, or as stuffing in pillows and mattresses. Phase change materials possessing an SME can be used in smart textiles. Perfumes, vitamins and drugs may be incorporated in smart textiles for controlled release. The microstructure or macrostructure changes in smart clothing in response to stimuli may help to achieve heat and moisture management of human bodies with a feeling of comfort [12].
Heimdal and Lenau state that scientific-technological aspects are part a textile designer's work (the nature of textiles is changing). The emergence of new application fields for textiles based on non-textile technologies have been included in the design process. Outstanding aspects of any product design process are the physical materials and technologies that are worked with. A responsive textile is a structure consisting of a textile material and eventual add-ons that may offer a certain response to a given stimuli.
The point here is that the testing of the responsive textiles reveals the importance of the meaning designers give physical objects. Heimdal and Lenau contend that fiber and textile composites are an extension to textile materials, representing a transition material between stiff materials and soft textiles. The developed textile design game makes a physical visualization and creative experimentation with textiles possible [13]. Ray et al. say that the smart healthcare textile

is a mobile system for remote/wireless data recording and conditioning. The smart healthcare textile system can be used for event detection with cardiac patients, corroborating smart textile sensor system's ability to function as a point of care system that can provide quality healthcare [14]. López et al. claim that e-textiles are able to measure biometric parameters in a noninvasive manner, and thus wearable healthcare-monitoring systems can avoid the use of cables wired around the patient. The LOBIN platform provides remote location and healthcare-monitoring support for hospital environments based on the combination of e-textile and WSN technologies. The technology of smart fabrics is based on the combination of known materials to obtain major benefits, adding functionalities to textiles [15].

Schacher et al. insist that specific fabrics tactile properties desired by consumers can be reached by adjusting the process parameters, reliable and practical instrumental methods are needed to accurately predict sensory tactile attributes, the neural networks and fuzzy logic provide an approach for predicting sensory properties from instrumental measurements of fabrics, and modification of structure parameters or finishing treatments have an important effect on sensory feeling. The measured mechanical parameters cannot reflect human sensation in a precise way. Fabric perception is the human sensory response towards fabric. The sensory analysis method uses the human senses as measurement device. Sensory analysis employs objective methods to collect the subjective sensory responses of human beings. Sensory evaluation is able to perform objective measurements of sensations using a panel of people as an instrument.

It follows, what seems to be true in fact, that classical computing techniques are efficient to analyze the relationship between sensory properties and production parameters. Schacher et al. point out that the intelligent techniques can model the relationship between manufacturing parameters and instrumental or sensory tactile properties. Neuro-fuzzy models can provide scopes to link sensory attributes or mechanical properties with processes parameters of fabrics. The intelligent techniques are used for modeling the relationship between instrumental measurements and sensory properties. Sensory analysis is a powerful tool for helping textile industries in product design and marketing tasks. Schacher et al. note that the risk of not feeling and trying on clothing before purchase is the greatest challenge for Internet clothing sales. Virtual 3-D try-on technology reduces the risk of ill-fitting or inappropriately styled clothing for one's body type. The intelligent techniques have found increasing applications in the textile field (new methods based on intelligent techniques treat a great number of textile applications). Haptic perceptions guide consumers' choice for clothes and textile manufacturers for development of new products. An artificial neural network (ANN) tries to simulate the structure and functional aspects of biological neural networks. Neural networks can model complex relationships between inputs and outputs or find patterns in data [16].

SMART FUNCTIONS TO BE APPLIED TO CLOTHING AND TEXTILES

On Steffen's reading, clothing and apparel are used for protecting the body against inhospitable climates and for reasons of modesty and attraction. Fashion is a matter of symbolism, whereas the concepts or male and female clothing are socially constructed (the gender concept of male and female clothing is a matter of symbolism). A fabric or a garment communicates its manufacturing technique as well as its decoration technique. The semantic or communicative functions of clothing serve as a non-verbal medium by which meanings and values are produced and exchanged. Clothing and garments are an important bearer of meaning and communicate. The growing segment of smart textiles and smart clothes are a challenge for textile and fashion designers [17].

Textile and fashion designers are faced with the challenge to adapt the novel hybrid clothing to customer expectations [18]. By clothing Twigg means the empirical reality of dressed bodies: clothing operates as part of class identity, forming the vestimentary envelope that contains the body and presents it to the social world. Wearing the right clothes are the dominant concerns of most people. Competitive class emulation is the engine of fashion. Fashion helps to reproduce gender as a form of body style. Clothes are cultural artefacts, operating in conjunction with and in response to the body (they stand alone as artefacts, and act simultaneously as an intermediary between the body and its public presentation) [19]. Vincent says that fashion has the ability to imply novelty, acts as a meeting point for relations of power, and is at once fantasy and social regulation (practices of dress denote forms of citizenship in a variety of ways). Dress reflects something about the body and character of the wearer, and about the body politic [20]. Suh et al. assert that clothing products start with market needs. Functional clothing development can be characterized by user-oriented processes. Consumers wear functional clothing because they have special needs, and may want to enjoy most advanced technology without losing their fashion sense. Smart clothing integrates functional clothing design and portable technology (technical aspects have strong influences in smart clothing development) [21].

THE INTEGRATION OF SMART FUNCTIONALITY INTO CLOTHING AND OTHER TEXTILE PRODUCTS

Hwang and Seruga explore a collaborative network model and an intelligent framework to effectively manage the textile supply chains (an alternative to improve competitive power of the Korean textile industry). The Korean textile companies have focused on exporting fabric cloths based on mass production, experiencing a rapid down of competitive edge in global market (Korean textile industry is facing severe competition and losing competitive power). The supply chain management (SCM) of the textile industry constitutes a complex supply-demand structure and value chain, being an alternative to improve the competitive power. The complexity of SCM has forced companies to improve online network communication systems. SCM requires a practical change in the organization level and a substantial change in the attitude and the corporate culture. Hwang and Seruga point out that global supply chains of textile industry are interested in supplying a quality product to customers at an affordable cost and in increasing the profit margin for investors and shareholders (companies in a supply chain shift their business models to work in virtual networks). Effective management of supply chains is a core competitive strategy. The utilization of an intelligent textile supply chain management system helps the supply chain be intelligent and effective. Developing an efficient supply chain help companies reduce costs and deliver better services to the customers while maintaining the quality of the products.

It should also be noted that the cycle of materials flow from supplies until it reaches the customer. Hwang and Seruga stress that an intelligent textile supply chain management system standardizes best practices throughout supply chain. Members of a supply chain network in a virtual environment use technology and management collaboratively. The textile companies are not actively utilizing the information sharing, many companies have turned to supply chain management to leverage the resources, whereas companies need a large investment for redesigning internal organizational and technical processes (a firm's ability to develop and successfully manage its relationships with other firms is a source of sustainable competitive advantage). Hwang and Seruga hold that effects flow through the relationships that the focal firm has established with other connected actors, and the outcomes of the firm's actions are influenced by the attitudes and actions of those firms with whom the focal firm has relationships. The textile industry requires complex processes to supply products to consumers. Due to the short life cycle of the textile products, it is difficult to standardize most products, and the level of innovation is low [22].

Cho et al. write that smart clothing is capable of sensing and communicating with environmental and the wearer's conditions and stimuli, pursues the integration of clothing and electronic devices (human aspects derive from the integrated characteristics of clothing and electronic devices), expands from a function-oriented system to a system that focuses on the function and affective states of the wearer, and needs to satisfy the users in emotion as much as in function. We achieve smart clothing for real wearability by combining wearable technology and clothing/ textile science. Textile-based input interfaces and communication devices have been actively developed (smart clothes should provide easy input and output interfaces). No existing smart clothing fully integrates high technology and fashion design.

This suggests that user-oriented technology development that reflects consumers' latent needs is essential. Cho et al. remark that conductivity in textiles is essential to smart clothing, and can be imparted at various textile stages. Visual displays must be compliant and conformable to the body to be worn as a part of smart clothing, because of permanent proximity to the skin, tactile displays are an effective tool in smart clothing, usability in smart clothing can be a function of the cognitive requirements associated with interactive matters, and affective computing motivates the creation of smart clothing that can recognize physical and psychological patterns [23].

THE MULTIDISCIPLINARY NATURE OF SMART CLOTHING

Ariyatum et al. note that smart clothing is defined as all clothes made with intelligent textiles, referring to garments and fashion accessories that contain intelligent functions based on electronic technologies. Smart clothes are designed to sense user requirements and environmental contexts, and should look like an ordinary garment and work well when the embedded technology is not functioning (the true potential of smart clothing can only be reached if improvements are made in consumer-based products). The electronic parts of smart clothing application may be perceived and chosen due to several features and practicality (electronic properties should provide emotional value to the user and could be used for aesthetic reasons) [24].

Baurley argues that market growth in clothing has been fuelled by the emergence of innovative processing technologies (technical innovations in textiles may become more important than the fashion content itself): the design of textile products will converge towards computing and the field of human-computer interaction design, textiles have their own language that is tactile, sensorial, and visual, whereas textiles' huge range of tactile qualities and acoustic properties has certain effects on the way people feel and respond to them. Clothing is an emotional medium, enveloping us, and being our second skin and an extension of our body, facilitates social interaction and individualistic expression, can be used as a channel of communication, can serve to reflect, hide or generate mood (the wearer can influence other people's moods), and can enhance performance by providing extra strength. Interactions between people are based on gestures and actions as communicators of emotion, triggering changes in either the sender's or the recipient's clothing. The user or wearer customizes the visual appearance, tactile quality, or shape of the textile, giving the wearer a sense of self-expression.

From this, it is evident that the ICT industries are expressing keen interest in textiles (the design of textiles and clothing can converge with ICT). Baurley writes that embedded intelligence will change the way designers design and develop products (intelligence will give the designer greater scope for creativity). The realization of intelligent functions into textiles will rely on nanotechnology. High-tech should become integrated into everyday objects, without altering their character, and enhance their function. Sensory science (psychophysics) is being applied to textiles to measure people's subjective experiences of textiles when touched. The future of smart textiles lies in the potential of technology convergence [25], [26].

Gepperth holds that smart wearables and clothes have exiting application scenarios and concepts.

Accessories and clothing should be comfortable and functional, integrating into the users' natural appearance. Conductive, capacitive and solar fibers are woven into the yarn level of textiles (sensors and actors need to be placed carefully in order to achieve the desired functionality) [27], [28]. Samdanis et al. explore the notion of wearable space that emerges from the intersection of wearable and spatially embedded interfaces (the emergence of wearable and embedded interfaces shares elements "transparency" and "reflectivity": the wearable space is evident to a process of digital bricolage, emerges in terms of an intelligent computing environment, and is the result of collective intelligence/interdisciplinary collaboration (wearable space is a hybrid and intelligent environment that generates novel human-computer interaction (HCI) implications). Samdanis et al. hold that wearable and embedded interfaces aim to deliver information and compelling experiences, emerge from clothing and architectural spaces, have evolved through remediation, emerging as new media forms enriched with digital and intelligent qualities. Wearable technologies communicate and interact with the embedded computation of interactive architecture, are the products of fashionable technologies, which combine style with electronic textiles and smart garments, inspire fashion designers to create "electronic fashion", and enact the embodied conditions on spatial environment (wearable technologies and interactive architecture share an interrelated future). The underlying notion in this paper is that the intersection of wearable technologies and interactive architecture challenges the ways in which users participate, improvise and shape their experience. Samdanis et al. put it that architecture and fashion converge in order to shape users' experience on the hybrid wearable space. Wearable interfaces generate information springing from human emotions [29], [30]. Transparent remediation is responsible for transmitting accurate information between the wearable and embedded interfaces, whereas reflective remediation considers the experience of the user who interacts with the wearable space. Clothing may reflect style as bricolage and architectural spaces which communicate meaning and frames function. Digital bricolage enables users to perform their desired tasks and express their self-identity. Clothing and architectural elements have been shifted from static to interactive [31], [32].

CONCLUSIONS

The current study has extended past research by elucidating usability in smart clothing and wearable computing, information and power transfer between the components of smart clothes, textile-based interfaces for smart clothing, and the demands for expressiveness and functionality of smart clothing. These findings highlight the importance of examining intelligence of smart clothing, the multi-disciplinary nature of smart clothing, the characteristics of clothing products and fashion industry, and functional textile and clothing development. This research makes conceptual and methodological contributions to the intersection of wearable technologies and interactive architecture, critical success factors of textile supply chains, the down-sloping of competitive edge of the Korean textile industry, and the visual look and haptic qualities of smart clothing.

The results of the current study converge with prior research on the interest in smart textiles for healthcare, the development of smart nanotextiles, and challenges and opportunities to design smart interactive clothing. The paper generates insights about the drivers for the current development of smart textiles, the potential benefits of smart textiles in medical use, and the incorporation of PCM in textiles by coating or encapsulation to make thermo-regulated smart textiles.

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Visibility of graphic elements on textiles

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REZUMAT – ABSTRACT

Vizibilitatea elementelor grafice de pe materialele textile

Scopul acestui studiu este acela de a stabili factorii ce trebuie luați în considerare pentru asigurarea vizibilității logourilor și etichetelor de întreținere de pe materialele textile. De obicei, acestea sunt imprimate direct pe produsul final și, mai rar, sunt cusute. În scopul cercetării, imprimeurile au fost realizate pe un suport textil natural, cu unul, două sau trei straturi de cerneală, prin tehnologia cu jet. Au fost experimentate trei tipuri diferite de caractere, în patru dimensiuni, pentru 16 simboluri de întreținere a textilelor cu 11 dimensiuni diferite, în câmpuri de intensitate a culorii negre de 100% și 40%. Imprimeurile au fost supuse unui număr variat de cicluri de spălare și uscare rapidă. Cea mai bună rezistență a culorii imprimeurilor s-a obținut atunci când cerneala a fost imprimată în două sau chiar trei straturi. Diferențele de rezistență a culorii textului imprimat au fost măsurate pentru cele mai mici dimensiuni ale caracterelor (6 și 8 pt). Dimensiunea minimă acceptabilă pentru simbolurile simple ale etichetelor de întreținere a textilelor este de 4.50 · 4.50 mm, iar pentru cele mai complexe dimensiunile sunt mai mari.

Cuvinte-cheie: simboluri de codificare, etichete de întreținere, element grafic, imprimare, jet de cerneală, vizibilitate

Visibility of graphic elements on textiles

The aim of the research was to ascertain what factors need to be taken into consideration to be able to give recommendations on ensuring the visibility of symbols and typographic elements on logos and textile care labels. From being sewn-in, these are nowadays more frequently printed directly on the final product. For the research purpose, the prints were made on a natural material in one, two and three layers of ink with the inkjet printing technology. Three different typefaces were tested in four sizes, complemented by 16 different textile care symbols in 11 different sizes, and by 100% and 40% intensity fields of black colour. The prints were exposed to a different number of wash and tumble drying cycles (1–5). The fastness of prints was better when the ink was printed in two or even three layers. The most substantial difference in the fastness of printed text was measured at smaller type sizes (6 and 8 pt). The smallest acceptable size of simple textile care symbols is 4.50 · 4.50 mm, while more complex symbols have to be larger in size.

Key-words: care labelling, code symbols, graphic element, printing, inkjet, visibility

In fashion design, the role of products we use on a daily basis with various patterns printed on them for different purposes is gaining recognition. For several years now, the importance of information graphics is on the increase, i.e., logos and marking symbols which prolong the lifecycle of final products by making the information on proper care more visible.

The influence of technology and the increasing number of available materials are efficiently changing our habits. Not only the material composition but also the quality of what is printed is important, not forgetting the brand logo and the desire to take proper care of a product to use it for as long and as easy as possible. The latter presented the focus of our research on the visibility of different textile care symbols, of typographic elements and achromatic surfaces printed on a textile material, where an important part of the quality assessment also lies on the printing technology. At the use of textile care symbols, which are nowadays more commonly printed directly onto the textile product instead of onto a sewn-in label, the problem of symbol sizes arises. The size has to ensure their visibility and recognition.

Printing on textiles is a widespread technology which has been changing through years. The printers and materials which enable simple printing on textiles are nowadays available to almost anyone; however, they are practically unsuitable for a more professional work and producing larger quantities [1]. In consequence, the question on the quality and long-term print fastness has to be dealt with. Print fastness is influenced by several factors, e.g., material composition, printing technology, amount of applied ink [2], and most of all the size of printed graphic and typographic elements. This field has either been rarely studied with corresponding recommendations [3] or without available standards to define the minimal or optimal size, respectively, of textile care symbols. The ISO 3758 standard only mentions that symbols have to be large enough to be legible, whereas the exact size is not determined.

A similar situation is in the field of typography, where it is neither strictly defined which typeface family should be used nor in what size; there is only a recommendation [3] on the most suitable typeface family. Moreover, several other typographic characteristics

which make a text more legible need to be taken into consideration. Such characteristics are distinctive character features (counter shape), x-height, ascenders, descenders, serifs, contrast (stroke weight), set width, type size, leading (i.e., space between lines) etc. [4]. A precise type size depends on the x-height of a typeface – typefaces with large yet moderate x-heights are generally more legible at smaller sizes [5] – [7]. In case of textile care instructions, the size is usually between 6 and 8 pt. In the visualization of information, typographic tonal density (or typographic tonality) has a significant influence. The typographic tonal density refers to the relative blackness or shades of grey of type on a page. It can be expressed as the relative amount of ink per square centimetre, pica or inch [8]. The changes in various type features can create variations in the typographic tonal density [4], [5], [8]. Typefaces with larger counters trap a larger amount of white space in the enclosed spaces of letters. The cumulative effect decreases the typographic tonal density. A thicker stroke width creates more ink per area [8] – [11].
The visibility of a typeface and recognition of symbols is also influenced by the type and amount of applied ink. These two factors are extremely important in the today's world of ecological awareness [12], and production and material cost-cutting. Our research was conducted in this respect, and its goal was to find the smallest type and symbol size for textile care labels printed with a modern digital printing technology, i.e., piezo inkjet [13] – [14], ensuring suitable visibility even after several washes. The quality of direct printing onto a natural material was evaluated in the research.

EXPERIMENTAL PART

In the research, we wanted to establish how many ink layers printed with a modern digital printing technology for printing onto textiles enable the best quality and long-term fastness. Furthermore, we wanted to find out what typeface family in relation to its size contributes to better legibility and what minimal symbol size enables its recognition.

Textile properties

The prints for the research were made on a natural material, i.e. cotton. The mechanical and colorimetric properties of cotton are shown in table 1. The colorimetric properties (whiteness and hue) were measured with a spectrophotometer DataColor, Spectra Flash 600 Plus-CT (aperture size 6.6 mm).

Table 1

FABRIC PROPERTIES	
Fabrics	100% cotton; combed, mercerised
Mass per unit area, g/m^2	144.10
Yarn density, yarns/10 cm	warp density – 253 weft density – 200
Type of weave	plain weave P1/1
Whiteness (CIE)	74.48
Hue, h°	98.21

Test form and printer properties

The prints with one, two and three layers of ink ($L_1 - L_3$) were made with a non-impact printing (NIP) technology and its cartridge: Roland LEC-300; piezo inkjet technology with Roland ECO-UV ink.
For textile care marking, 16 different symbols in accordance with the ISO 3758 standard were printed. The symbols were printed in 11 different sizes – from 2.50 · 2.50 mm to 10 · 10 mm (altogether 166 symbols).
Different, widely used typefaces were tested, i.e., one sans-serif (Arial), one transitional (Times) and one modern (Blaznic) [15], [16] typeface, each in four different sizes (i.e., 6, 8, 10 and 12 pt). On the test form, also the 100% (K 100) and 40% (K 40) intensity fields of dimensions 10 · 10 mm were printed.
The test form was designed with the program Adobe InDesign CS5 and was used as a PDF file, which ensured a unified appearance of the form on various computers and operation systems, and in consequence, on the print.

Print fastness

The prints were exposed to different temperature and mechanical conditions defined in accordance with the standard on textile washing and drying procedures, i.e., ISO 6330 standard. With a washing machine Gorenje WA 1341S (at temperature 40°C), five repeated washes were performed with a 2458 ECE phosphate reference detergent (B), whereas for drying, a Benz laboratory drier (at temperature 60°C) was used. Print fastness was measured after the first, second, third, fourth and fifth cycle of washing and tumble drying.
A visual evaluation of 166 textile care symbols was conducted, the results defining the minimal size of each symbol which still ensures its recognition before and after a different number of washes.
The differences in the typographic tonal density of the unwashed and washed samples of typefaces were measured with the image analysis (the program Image J). This software gives the opportunity to measure, analyse and provide output values, e.g., area, number of particles and percentage of coverage [17], [18].
The CIE L*a*b* parameters of prints were measured with a spectrophotometer DataColor, Spectra Flash 600 Plus-CT (aperture size 6.6 mm) in accordance with the ISO 105-J01 standard using the D65 standard illumination, 10° standard observer, black backing and instrument geometry 45/0. The colour difference (ΔE) between the unwashed and washed samples was calculated according to the CIEΔE2000 L*a*b* equation for colour differences [19], [20]:

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T\left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)} \quad (1)$$

where:
$\Delta L'$ is difference in lightness;
$\Delta C'$ – difference in chroma;
$\Delta H'$ – difference in hue;
R_T – correction of ellipsoid orientation in the blue region;
k_L, k_C, k_H – parameter factors which are under referential conditions set to 1;
S_L, S_C, S_H – factors representing correction of visual disunity of the colour space CIEL*a*b* and defining the ellipsoid half-axes.

RESULTS AND DISCUSSIONS

Visibility of textile care symbols

Figure 1 shows the visual evaluation results on the visibility of textile care symbols. More complex symbols, e.g., those including wash temperature, hand wash, tumble drying, chlorine bleaching, ironing temperature, were not identifiable in their smallest size (2.50 · 2.50 mm) after the fifth wash. As a matter of fact, they were already unidentifiable as soon as being printed. These symbols were recognized in the sizes from 4.50 · 4.50 mm to 6.00 · 6.00 mm. The best results were given by three printed layers of ink (L_3), which was expected, as this was the largest amount of ink applied onto the substrate. Simpler symbols printed with three layers of ink (L_3) can remain in smaller sizes (3.25 · 3.25 mm), while simpler symbols printed with one or two layers should be larger (4.50 · 4.50 mm (L_1) or 3.25 · 3.25 mm (L_2), respectively). More complex symbols have to be larger in size, i.e., 4.50 · 4.50 mm printed with L_3, 5.25 · 5.25 mm printed with L_2 or even 6.00 · 6.00 mm printed with L_1. It is recommended for all the tested layers of ink that the symbol size not be less than 6.00 · 6.00 mm to ensure suitable visibility and recognition of even more complex symbols.

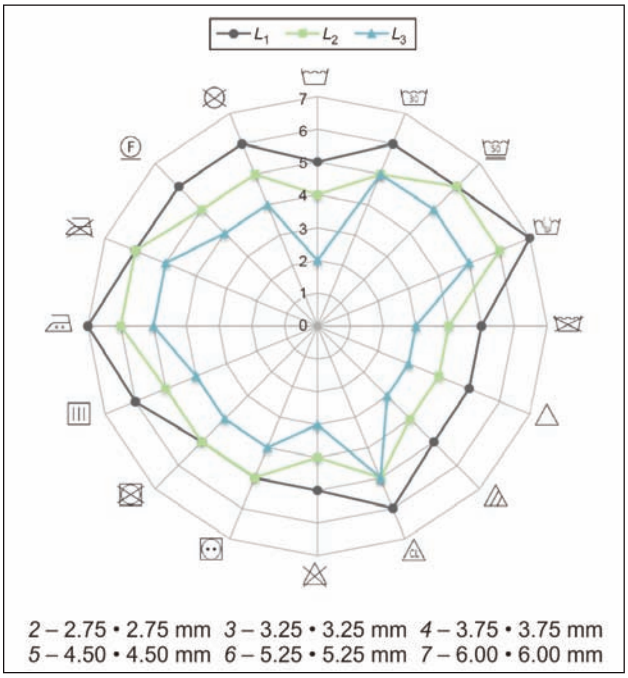


Fig. 1. Minimal textile care symbol size with satisfactory visibility, printed with one, two and three layers of ink after fifth wash

Typographic properties of prints

The typographic tonal density (*TTD*) of typefaces, each in different size, was measured before and after each of five washes. The *TTD* of tested typefaces according to the used type sizes, printed with different layers of ink is presented in tables 2, 3 and 4. The differences in the *TTD* of printed typefaces after five washes are demonstrated in figure 2. The differences in the *TTD* of printed typefaces in different sizes after each of five washes are presented in figure 3. In figure 4, all tested typefaces in size 6 pt printed with different layers of ink after the fifth wash can be seen. Figure 5 includes the differences in *TTD* after each of the five washes.

The results show an expectedly higher *TTD* at the sans-serif typeface (tables 2, 3, 4), due to the differences in the letter stroke width being smaller. The lowest *TTD* was observed at the transitional typeface Times. Times has its thick stroke thinner than the typeface Blaznic. The highest values of TTD were given by three printed layers of ink (L_3), which is a consequence of a greater amount of applied ink. It is also evident that the smallest values in *TTD* were given by a single printed layer of ink (L_1).

Table 2

TTD OF TESTED TYPEFACES PRINTED WITH L_1 IN DIFFERENT SIZES

Typeface	*TTD*, %			
	6 pt	8 pt	10 pt	12 pt
Times	21.83	22.19	19.33	16.11
Arial	28.34	27.47	23.66	18.82
Blaznic	26.02	26.88	21.25	18.66

Table 3

TTD OF TESTED TYPEFACES PRINTED WITH L_2 IN DIFFERENT SIZES

Typeface	*TTD*, %			
	6 pt	8 pt	10 pt	12 pt
Times	31.83	29.53	23.37	19.65
Arial	37.42	33.79	28.84	22.62
Blaznic	35.37	33.96	25.61	22.05

Table 4

TTD OF TESTED TYPEFACES PRINTED WITH L_3 IN DIFFERENT SIZES

Typeface	*TTD*, %			
	6 pt	8 pt	10 pt	12 pt
Times	37.38	33.50	26.04	21.96
Arial	41.38	37.88	31.11	23.79
Blaznic	39.76	38.01	29.16	24.48

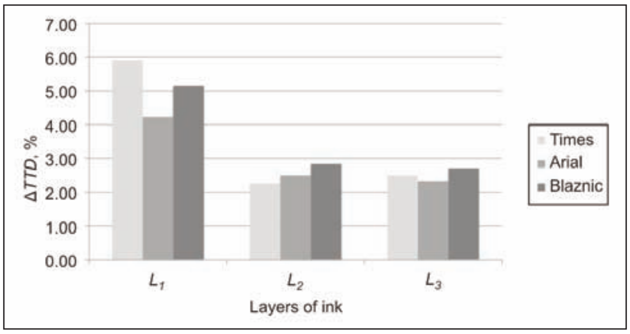


Fig. 2. Average difference in TTD of tested typefaces printed with different layers of ink ($L_1 – L_3$)

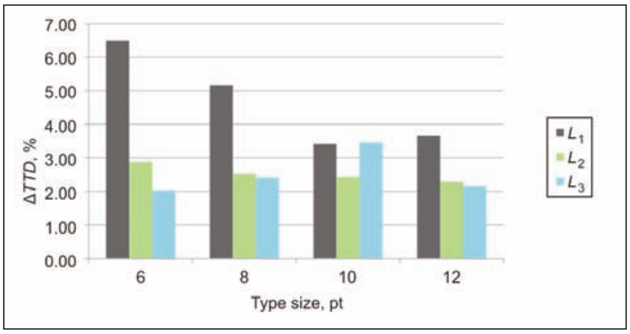


Fig. 3. Average difference in TTD of tested typefaces in different type sizes printed with different layers of ink ($L_1 – L_3$)

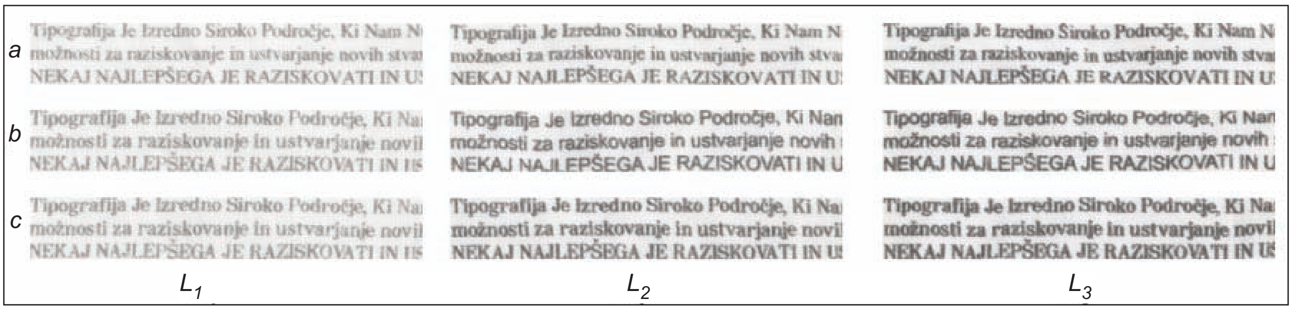


Fig. 4. Samples of tested typefaces Times (*a*), Arial (*b*), Blaznic (*c*) printed in size 6 pt with all three printed layers of ink ($L_1– L_3$) after fifth wash

After a different number of washes, the smallest difference in *TTD* was observed on the prints printed with three layers of ink (L_3), while the largest difference was seen on the prints with one layer of ink (L_1). This was expected due to the textile material being directly printed on [3] and the smallest amount of ink. The most noticeable average difference in *TTD* occurred at the Times (transitional) typeface (fig. 2). The obtained results show the biggest differences at the typefaces used in sizes 6 and 8 pt (fig. 3). *TTD* at smaller sizes of the typeface is usually higher due to a smaller counter size of letters and leading. Furthermore, the differences were more evident after the washing, especially on the prints printed with just one layer of ink (L_1). From figure 4, it is seen that the typefaces with differences in stroke width (i.e., Times and Blaznic) were more influenced by a smaller amount of ink. It is also clear that at very small type sizes, uppercase letters are more legible than lowercase letters.

While comparing the influence of a different number of washes (fig. 5), it can be seen that the differences in *TTD* on the prints printed with a various number of ink layers (L_1 – L_3) were smaller after the second wash. After the third wash, the prints printed with three layers of ink (L_3) stabilised.

Colorimetric properties of prints

The analysed achromatic K 100 and K 40 intensity fields were made with the prints of pure black ink with three different numbers of ink layers at direct printing.

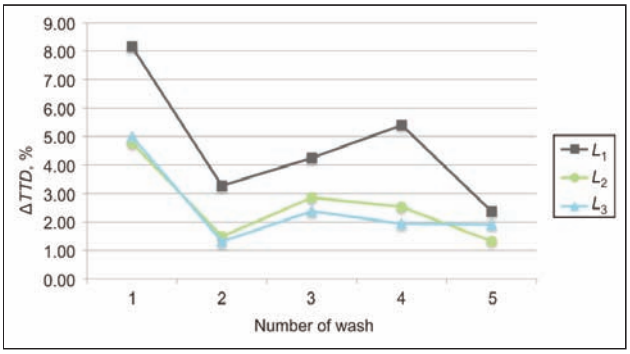
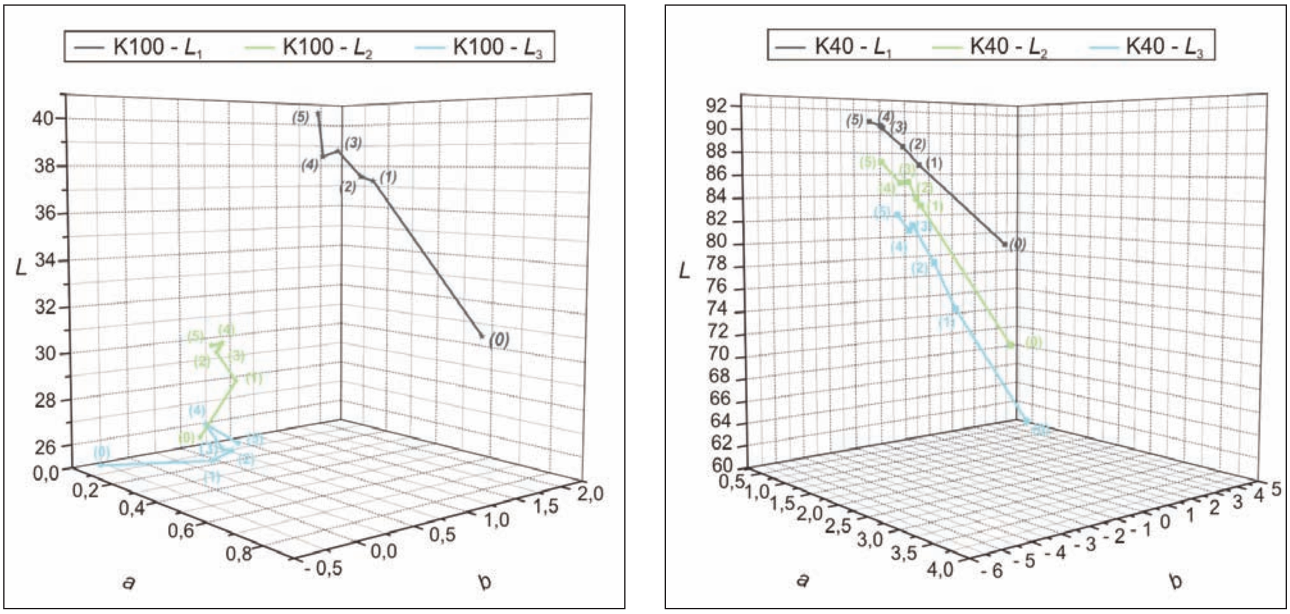


Fig. 5. Average differences in *TTD* after each of five washes printed with all three different layers of ink ($L_1– L_3$)

Figure 6 shows the CIE L*a*b* values of spectrophotometric measurements of the prints before and after the washes. In tables 5 and 6, the differences in colour (ΔE_{00}), lightness (ΔL_{00}), chromaticity (ΔC_{00}) and hue (ΔH_{00}) are given for the prints (K 100, K 40) after a different number of washes.

By applying different layers of UV drying ink ($L_1 – L_3$), the colour degradation of black (K 100) dyed cotton prints considerably decreased (fig. 6, table 5). After the first washing process, the samples showed the largest colour changes. In further washing processes, the degradation process slowed down, yet it still remained visible. The standard black prints (L_1) underwent a great colour change during the experimental washing (ΔE > 5.00), which rapidly decreased with the increased application of black ink. With three



a *b*

Fig. 6. CIE L*a*b* values of prints with different layers of ink (L_1– L_3), before washing (0) and after different number of washes (1–5): *a* – K 100; *b* – K 40

Table 5

COLORIMETRIC DIFFERENCES IN K 100 PRINTS OF DIFFERENT INK LAYERS L_3 - L_3, AFTER EACH OF FIVE WASHES

	Colorimetric differences in K 100 prints	ΔE_{00}	ΔL_{00}	ΔC_{00}	ΔH_{00}
L_1 (K 100)	K 0 wash – K 1 wash	5.52	–5.42	0.82	0.6
	K 0 wash – K 2 wash	5.71	–5.57	0.89	0.88
	K 0 wash – K 3 wash	6.59	–6.38	0.93	1.32
	K 0 wash – K 4 wash	6.43	–6.20	0.97	1.38
	K 0 wash – K 5 wash	7.73	–7.44	0.78	1.92
L_2 (K 100)	K 0 wash – K 1 wash	2.40	–2.37	–0.21	0.31
	K 0 wash – K 2 wash	3.34	–3.31	–0.16	0.39
	K 0 wash – K 3 wash	3.60	–3.56	–0.24	0.48
	K 0 wash – K 4 wash	3.80	–3.78	–0.28	0.52
	K 0 wash – K 5 wash	4.12	–7.44	–0.53	0.76
L_3 (K 100)	K 0 wash – K 1 wash	0.73	–0.27	–0.12	–0.67
	K 0 wash – K 2 wash	1.09	–0.79	–0.23	–0.71
	K 0 wash – K 3 wash	1.10	–0.87	–0.19	–0.65
	K 0 wash – K 4 wash	1.96	–1.88	–0.20	–0.53
	K 0 wash – K 5 wash	1.60	–1.42	–0.34	–0.65

Table 6

COLORIMETRIC DIFFERENCES IN K 40 PRINTS OF DIFFERENT INK LAYERS L_3 - L_3, AFTER EACH OF FIVE WASHES

	Colorimetric differences in K 100 prints	ΔE_{00}	ΔL_{00}	ΔC_{00}	ΔH_{00}
L_1 (K 40)	K 0 wash – K 1 wash	4.40	–5.45	1.99	4.59
	K 0 wash – K 2 wash	8.84	–6.48	1.15	5.90
	K 0 wash – K 3 wash	10.43	–7.42	–0.07	7.33
	K 0 wash – K 4 wash	10.66	–7.51	–0.31	7.56
	K 0 wash – K 5 wash	11.26	–7.66	–0.96	8.19
L_2 (K 40)	K 0 wash – K 1 wash	11.59	–10.54	1.48	4.60
	K 0 wash – K 2 wash	12.15	–10.98	1.15	5.08
	K 0 wash – K 3 wash	13.46	–11.99	0.29	6.12
	K 0 wash – K 4 wash	13.75	–11.95	–0.35	6.78
	K 0 wash – K 5 wash	15.11	–13.05	–1.10	7.54
L_3 (K 40)	K 0 wash – K 1 wash	10.73	–10.05	2.04	3.14
	K 0 wash – K 2 wash	14.16	–13.30	1.56	4.61
	K 0 wash – K 3 wash	16.91	–15.75	0.50	6.15
	K 0 wash – K 4 wash	16.83	–15.49	0.10	6.58
	K 0 wash – K 5 wash	17.95	–16.44	–0.48	7.20

layers of ink (L_3), a minimal aberration, scarcely visible to the naked eye (ΔE < 2.00), was achieved. The change of lightness resulted primarily in the mentioned colour changes. The prints with a standard ink layer (L_1) became lighter and lighter (values on the coordinate L^* increased). The only exception was the prints with three layers of ink (L_3), at which the process stabilised after the fourth washing (lightness did not increase any more). Minor changes were visible on the coordinates a^* and b^*. On the prints with one and two layers of ink (L_1, L_2), the changes were visible in the chromaticity decrease and on the coordinates a^* and b^*, where the tones neared the ideal achromatic axis. The application of three layers of ink (L_3) led at the beginning to the print which was the nearest to the achromatic axis; however, the greatest chromatic change appeared (the change on the coordinates a^* and b^*) after the first experimental washing. During the further washing processes, the black tones again neared the ideal achromatic axis.

In the reproduction, the most complicated area was that of 40% screen value, where the printing elements were the most sensitive to the increased application of ink. In the relation to prints with K 100, the K 40 prints had much more intensive colour changes after the first washing (fig. 6, table 6). In this connection, the prints printed with a thicker ink layer had much more expressed colour changes which increased with further experimental washing processes.

The colour analysis of prints showed that the changes were more intensive in lightness. The difference in lightness was smaller than on the prints with one ink layer (L_1) in the relation to those with two or three ink layers (L_2, L_3). The relation of lightness and ink thickness was proportional. The changes of chromaticity parameters (ΔC) behaved completely different. The textile samples printed with only one ink layer (L_1) had a greater difference than the samples printed with more ink layers (L_2, L_3). The changes on the coordinate b^* were much more substantial than the ones on the coordinate a^*. In other words, the appeared colour changes were in the direction of violet blue.

CONCLUSIONS

Print fastness is influenced by the application of ink. The application of a larger amount of ink is more suitable for direct printing onto a fabric, resulting in better print fastness. The prints made with direct printing (inkjet) and one layer of ink cannot boast of the best fastness. The best fastness was measured at the prints made with three or at least two layers of ink, respectively. Furthermore, the used printing technology does not enable precise printing of smaller graphic elements, e.g., thin strokes and serifs at smaller letter sizes, and complex textile care symbols. The smallest size of simple symbols for textile care should be 4.50 · 4.50 mm, whereas more complex symbols have to be larger in size. To ensure suitable visibility and recognition of symbols even after several washes, it is recommended that the symbols not be smaller than 6.00 · 6.00 mm. The biggest difference in the fastness of prints after a different number of washes was measured at smaller type sizes (6 and 8 pt). The most substantial difference in the typographic tonal density was measured at the transitional typeface, which has the thinnest thick stroke among the tested typefaces. Therefore, the use of sans-serif typefaces and uppercase letters instead of lowercase letters is recommended for smaller type sizes.

To achieve suitable visibility of textile care symbols printed with the inkjet printing technology, special attention has to be paid to the symbol size in connection with the applied amount of ink.

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DOCUMENTARE

Confecții textile

AȚĂ DE CUSUT CU CARACTERISTICI ANTIINSECTE ŞI ANTIMICROBIENE

Prima aţă de cusut şi primele fermoare cu proprietăți antiinsecte au fost lansate de către producătorul de aţă industrială şi materiale textile de larg consum ***Coats Plc.***, din Uxbridge/UK.

Compania a dezvoltat *Coats Insectiban*, un tratament chimic antiploşniţe, care se aplică pe aţa de cusut şi pe fermoarele, destinate confecționării saltelelor pentru pat. Acest tratament este bazat pe extracte şi uleiuri vegetale.

Deoarece ploşniţele se cuibăresc în cusăturile şi chingile saltelelor ori în diferite spații ale mobilierului, unde își depun ouăle, aţa de cusut şi fermoarele tratate chimic vor ajuta la controlul infestărilor, chiar dacă ţesătura şi alte elemente ale lenjeriei de pat nu au fost supuse acestui tratament.

Coats Plc. a lansat, de asemenea, o nouă gamă de aţe de cusut cu proprietăți antimicrobiene, care inhibă dezvoltarea microbilor şi a bacteriilor, în jurul cusăturilor. Aţele de cusut cu proprietăţi antibacteriene şi antifungice vor fi comercializate sub denumirea *Coats Protect*.

Tratamentul inovator aplicat aței de cusut oferă o protecţie maximă împotriva microbilor şi creează o "zonă de inhibiţie", care ajută la prevenirea dezvoltării bacteriilor şi agenţilor patogeni, ce generează pete şi un miros neplăcut în jurul cusăturii.

Melliand International, mai 2013, p. 68

Notch size and loading rate on the tensile behavior of woven fabric reinforced flexible composite with symmetrical double edge notch

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REZUMAT – ABSTRACT

Efectul dimensiunii canelurilor şi a vitezei de încărcare asupra rezistenţei la tracţiune a materialelor compozite flexibile, ranforsate cu ţesături, care prezintă caneluri simetrice cu margine dublă

Pentru a stabili efectul înălţimii canelurii şi a vitezei de alungire asupra comportamentului la tracţiune al materialelor compozite flexibile, ranforsate cu ţesături, în acest articol au fost studiate experimental atât mecanismul ruperii şi rezistenţa la tracţiune a materialelor compozite flexibile, ranforsate cu ţesături finite, cât şi efectele dimensiunii canelurii şi ale vitezei de alungire asupra proprietăţilor de rezistenţă la tracţiune a epruvetelor cu caneluri. Rezultatele arată că materialele compozite flexibile, ranforsate cu ţesături, sunt influenţate de înălţimea canelurii şi de viteza de alungire. Aceste rezultate joacă un rol important în evaluarea comportamentului la tracţiune şi a duratei de viaţă a materialelor compozite flexibile, ranforsate cu ţesături care prezintă caneluri cu margine dublă.

Cuvinte-cheie: materiale compozite flexibile, ţesătură, comportament la tracţiune, canelură cu margine dublă

Notch size and loading rate on the tensile behavior of woven fabric reinforced flexible composite with symmetrical double edge notch

In order to investigate the effects of high notch ratio and loading rate on the tensile behavior of woven fabric reinforced flexible composites, in this study, fracture mechanism and tensile strength of finite woven fabric-reinforced flexible composite materials with a through-the-thickness symmetrical located double edge notches is experimentally investigated, and the effects of notch size, loading rate on the tensile properties of notched specimen are analyzed. The results show that the woven fabric reinforced flexible composites exhibit notch sensitivity and loading rate dependent, these results play an important role in predicting strength and evaluating the lifetime of textile reinforced flexible composite materials with double edge notches.

Key-words: flexible composites, woven fabric, tensile behavior; double edge notch

Textile-reinforced flexible composites, usually called coated fabrics or laminated fabrics in textile industry, have been widely used in many engineering structures due to their excellent mechanical proprieties. Now days, the flexible composites have been widely applied in many fields, i.e. civil engineering, architecture, aerospace engineering and other inflatable structures [1] – [3]. In the practical use of the flexible composite structure, some geometrical discontinuities like cut-outs and holes are necessary for some functions, such as joining of riveted and bolted joints, and the failure of notched components is governed by the stressed in the vicinity of the crack tip [4]. Due to redistribution of stress around the discontinuity area and the no-homogeneous and anisotropic nature of textile reinforced flexible composites, the stress–strain relation of notched composite is very complicated. Therefore, the study of strength and fracture of notched composites will play an important role for better designing and evaluating lifetime of composite structures.

In practice, the tension strength with notch is an important parameter for textile reinforced composites, since it is can be a limiting factor in design. It is also difficult to characterize and predict through analytical or numerical methods since there exists a wide variation in experimental results depending on testing configuration [5], [6].

This paper deals with the mechanical behaviour of flexible composites reinforced by woven fabrics for tents and outdoors purpose, and aim at experimental investigate the relationship of notch strength and notch size within high notch size ratio. Therefore, the effect of loading rate on the notch strength was also investigated.

MATERIALS AND EXPERIMENTAL PROCEDURE

The double edge notch tensile (DENT) specimens were made from plain weave polyester woven fabrics with a PVC coating. Yarn count was 111.11 tex (1 000 denier) and fabric count was 16 × 15 /inch. The thickness and density are 0.52 mm and 670 g/m^2, respectively. All cracks were made with a fresh razor blade. Figure 1 shows the geometries of the double edge notched tensile (DENT) specimen and the loading

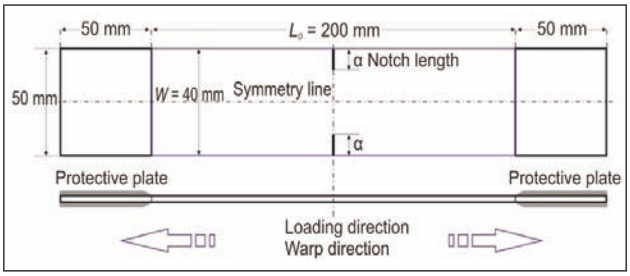

Fig. 1. Geometry of the tested specimens

loading of specimen blunted the notch tip, and the plastic zone continues until the elliptical shape is fully developed. Up to a certain amount of specimen extension, the matrix cracks were imitated at the tip of notch, the warp fibres bridge the crack propagation and for the cracks to extend the stored elastic energy must do work for shearing the matrix parallel to warp and weft fibres. And then, with applied load increasing, yarn breaking occurs near the notch tip when the load reaches a critical level (fig. 2 – *3*). For all notched specimens, crack propagates parallel to

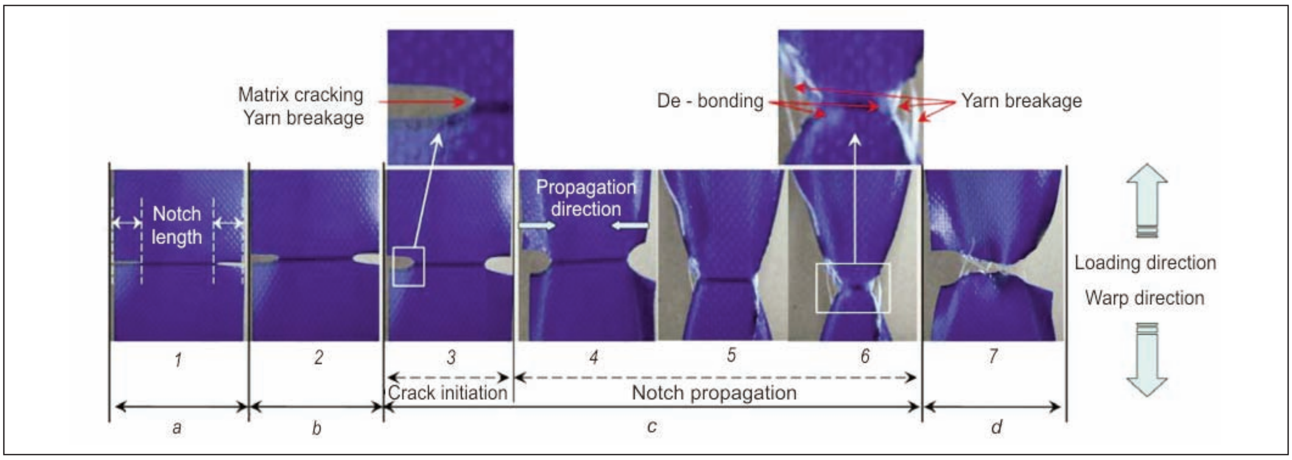

Fig. 2. Tensile fracture process of double edge notched specimen:
a – initial stage; *b* – notch initiation; *c* – crack initiation and notch propagation; *d* – final failure

condition. In this test, the size and width of the specimens was kept constant, while the pre-notch size and loading rate varied. The following test conditions are considered in the test: one is to change notch size 2 α when the loading rate υ remains constant, i. e. *υ* = 5 mm/min., 2 α = 0, 2, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42 and 46 mm, respectively. The other is to change the loading rate when the notch size remains constant, i. e. 2 α = 22 mm, *υ* = 5, 10, 50, 100 and 200 mm/min. For each case, three identical specimens are tested and the results are average with the standard deviation indicated.

After installation of each specimen, tests were carried out on a universal mechanical tensile test machine at room temperature. The specimens were uniformly loaded in tension to fracture. During each test, relationship between load and corresponding displacement were continuously recorded in time by an automatic data acquisition system using a microcomputer.

RESULTS AND DISCUSSIONS

Fracture mechanism of notched specimens

A typical notched specimen that fails around the notch can be seen for a notch size of 22 mm notched specimen in figure 2. Based on observation, the damage progressive process can be divided into following stages, i.e. initial stage, notch opening, crack initiation and notch propagation, and final failure.

When the load applied increases, it is observed that the progressive elliptic plastic zone near the tip of initial notch developed (fig. 2 - *2*), which indicate the the fill direction and in a progressive mode. During the process of notch propagation, warp yarns in the plain woven fabric gradually failed in tension (fig. 2 - *7*).

TENSILE CURVES OF NOTCHED SPECIMENS

Figure 3 illustrates load-displacement diagrams of DENT specimens under various notch sizes. Based on the shape of tensile curves, the conclusion can be drawn that the failure model can be described by brutal and progressive models depended on initial notch size. For smooth specimens and notched specimens with short notch size, the failure model is described as “brutal”, it occurs suddenly without obvious notch

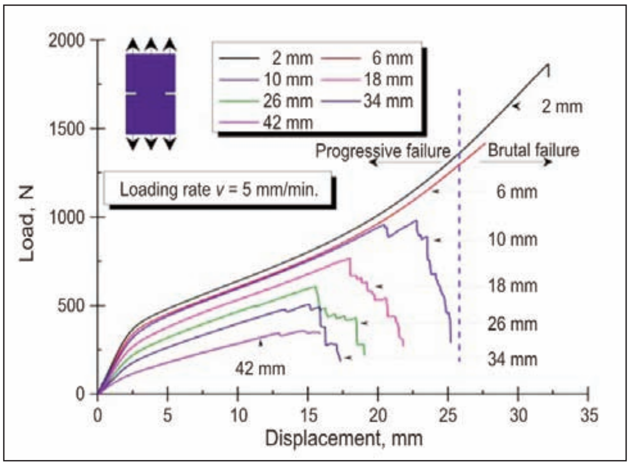

Fig. 3. Typical load displacement curves for notched specimens under various notch sizes

Table 1

NOTCHED GROSS-AND NET-SECTION STRENGTH FOR CONSTANT LOADING SPEED UNDER VARIOUS NOTCH SIZES				
Notch size, mm	**Gross-section strength**		**Net-section strength**	
	Average value, N/mm^2	***CV***, %	***Average value***, N/mm^2	***CV***, %
0 mm	93.38	7.79	93.38	7.79
2 mm	66.82	7.25	69.60	7.55
6 mm	49.44	5.29	56.18	6.01
10 mm	41.70	3.11	52.12	3.89
14 mm	34.97	0.71	48.58	0.99
18 mm	30.67	0.94	47.93	1.47
22 mm	24.78	1.08	44.26	1.93
26 mm	24.02	0.48	50.04	1.00
30 mm	20.82	1.53	52.06	3.83
34 mm	19.46	1.81	60.81	5.65
38 mm	16.23	1.12	67.62	4.67
42 mm	12.88	0.79	80.51	4.94
46 mm	7.18	0.52	89.70	6.55

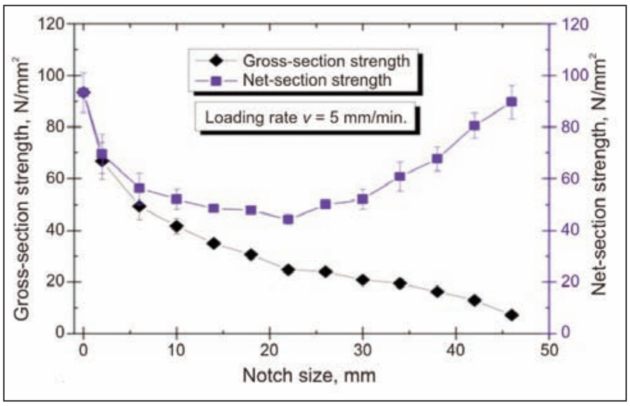

Fig. 4. Gross-section strength and net-section strength for constant loading speed under various notch sizes

propagation. And for longer notch size specimens, the failure model is described as "progressive", initial notch propagates alternately on each side. The figure 3 also show that the tensile curves during notch propagation exhibiting obvious multi-peaks characteristics. It is observed that the maximum force supported by a sample decrease with the increase of the initial crack size. This is due to the fact that the number of cracked yarns increase when crack size increase. The results in figure 3 also indicate the material behave a non-linear manner up to a tensile load before notch propagation at the tip of notch.

Influence of notch size on tensile strength

Average gross- and net-section strengths for each notch size are summarized in table 1 and figure 4. The gross-and net-section strength were calculated using the equations (1) and (2), respectively.

$$S_G = \frac{F_{threshold}}{W \times t} \quad (1)$$

$$S_N = \frac{F_{threshold}}{(W - 2\alpha) \times t} \quad (2)$$

Due to tensile curves of notched specimens exhibiting obvious multi-peaks characteristics, the threshold force of notch propagation $F_{threshold}$ was determined, based on the method proposed in previous paper [2]. Figure 4 show that the gross-section strength is reduced by the presence of increasing notch sizes, which indicates the tensile strength of the tested material, is sensitive to the presence of edge notches. A 92.31% reduction in gross-section tensile strength is observed for a notch size 46 mm compared with the un-notched specimen. The net-section strength is reduced from 93.38 to 44.26 from notch size of 0 mm to 22 mm, but no further reduction is observed as the notch size increase to 46 mm. This critical notch size will be influenced by specimen boundaries, which have an effect on the stress intensity factor, and therefore only applicable to the current data set.

Influence of loading rate on tensile strength

The notched net-section strength is summarized in table 2. The net-section strength is plotted in figure 5. Based on figure 5, it can be drawn that the net-section strength increases with increasing of loading tare, which indicate that the notched woven fabric reinforced flexible composite exhibiting rate sensitivity. By analyzing from the net-section strength and loading rate, it can be found that the relationship of net-section strength and loading rate can be expressed by the equation (3).

$$S_N = 44.26 + 3.28214\,(\upsilon - 5)^{0.18993} \quad R^2 = 0.97421$$
$$5 \text{ mm/min} \le \upsilon \le 200 \text{ mm/min} \quad (3)$$

Table 1

NET-SECTION STRENGTH FOR CONSTANT NOTCH SIZE UNDER VARIOUS LOADING SPEEDS (Notch size 2 α = 22 mm)			
Loading speed, mm/min.	**Experimental strength**		**Predicted strength**, N/mm^2
	Average value, N/mm^2	***CV***, %	
5	44.26	1.93	44.26
10	48.91	2.31	48.72
50	50.83	1.10	51.02
100	51.83	1.14	52.05
200	53.44	2.95	53.19

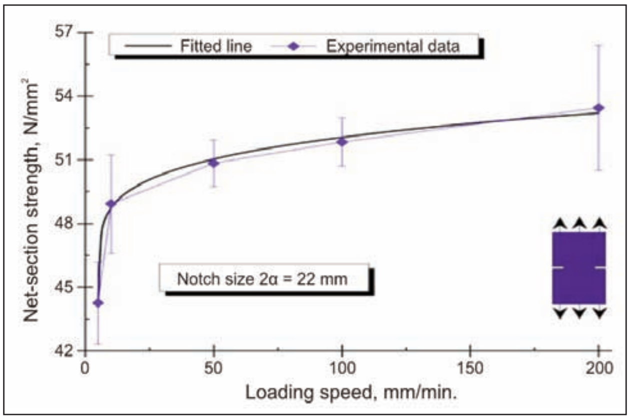

Fig. 5. Net-section strength for constant notch size under various loading speeds

CONCLUSIONS

In this experimental investigation, the effects of notch size and loading rate on the tensile behaviour of a woven fabric reinforced flexible composite are investigated. The experiment results show that the woven fabric reinforced flexible composite exhibit notch sensitivity and the notched specimens exhibit rate sensitivity. For specimens with shorter notch size, the failure model can be described as brutal, and for specimens with longer size, described as progressive.

ACKNOWLEDGMENT

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Development of new processes intended to obtain fireproof non-asbestos textiles covered with nanodispersions based on modified polychloroprene elastomers

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REZUMAT – ABSTRACT

Dezvoltarea de noi procese destinate realizării textilelor nonazbest rezistente la foc, acoperite cu nanodispersii pe bază de elastomeri policloroprenici modificați

Lucrarea prezintă rezultatele cercetărilor efectuate în scopul obținerii unor materiale ecologice, destinate fabricării de ambalaje etanșeizate, membrane, furtunuri, carcase, perdele și echipamente, care asigură protecție termică contra temperaturilor ridicate și izolare în zonele cu pericol de incendiu. Aceste materiale au fost realizate dintr-un suport textil ignifugat și un material polimeric de acoperire. Suportul textil este realizat din materiale textile ignifugate, cu diferite structuri și grosimi, obținute din fibre acrilice supuse unui tratament care le conferă rezistență termică. Ca materiale de acoperire s-au folosit compuși elastomerici termorezistenți – cloropren compoundat cu negru de fum HAF și clorură de stibiu. Pentru obținerea unor nanodispersii apoase ecologice performante, destinate acoperirilor textile ignifuge, a fost îmbunătățită aderența policloroprenului, prin grefarea chimică a latexului policloroprenic Dispercoll C 84 cu metacrilat de metil, în prezența peroxidului de benzoil, folosit ca inițiator. Materialele nonazbest obținute posedă proprietăți ignifuge și rezistență chimică și termică.

Cuvinte-cheie: textile ignifugate, protecție termică, policloropren grefat chimic, nanodispersii

Development of new processes intended to obtain fireproof non-asbestos textiles covered with nanodispersions based on modified polychloroprene elastomers

The paper presents the results of investigations carried out to obtain some environmentally friendly materials for thermal protection and insulation intended to be used in the manufacture of air-tight packings, membranes, sleeves, protective cases and curtains, protective equipment for high temperature and fire hazard areas. Such materials were made from a fireproofed textile support and a covering polymer material. The textile support was a fireproof fabric of a variety of textures and thicknesses obtained from heat-resistant acryl fibres. Heat-resistant elastomer compounds such as chloroprene compounded with HAF carbon black and antimony chloride were used as covering materials. High performance environmentally friendly aqueous nanodispersions for coating fireproof textiles were obtained by improving the polychloroprene adherence by chemical grafting of polychloroprene latex Dispercoll C 84 with methyl methacrylate in the presence of benzoyl peroxide as initiator. The resulting non-asbestos materials are heat and chemical-resistant, and fireproof.

Key-words: fireproofed textIle, thermal protection, chemically grafted polychloroprene, nanodispersions

Clothes are no longer used only for protection against atmospheric factors; sometimes they cannot offer an adequate protection and, in these cases, special clothing is needed (IPE), made from special materials [1], [2].

Individual protective equipment (IPE) influences the process of human body temperature rendering; depending on the insulating degree/type they can reduce the thermal flux from/to the body. So, in addition to the required specific protective properties, they also have to respect hygienic demands.

Protection of human body against fire and heat it is a very important matter nowadays. Asbestos based materials, usually used for this type of protection are harmful for health due to their carcinogenic effect. Because of that, developments of new materials which are non-asbestos and have properties to be used for fire and heat insulation are state-of-art research activities [3] – [5].

Protection of human body against fire and heat means individual equipments resistant to heat, fire, melt metals, boiling water, water vapours etc. but also comfortable for wearer.

Textiles covered with heat-resistant and fireproof elastomers are used largely in many industry sectors such as: aeronautics, shipbuilding, metallurgy, chemical and petrochemical industries, oil equipment construction, energetics, machine industry, building materials etc. Such covered textiles are used in the manufacture of air-tight packings, membranes, sleeves, protective cases and curtains, conveyor and drive belts, protective and safety equipment (gloves, aprons, helmets etc.) for high temperature (250°C) and fire hazard areas.

Such materials have been obtained both in the Romania and abroad from elastomer covered asbestos fabrics or 'marsit' plates of pressed elastomer bound asbestos fibres. Because the asbestos is required to be replaced with new environmentally friendly materials which have been emerging in the last years in the world, the Romanian industry has been directed to the 'marsit' type materials and manufacture of materials made up of textiles covered with heat-resistant elastomers with the textile support made up of imported fibres – natural fibres (cotton) and synthetic fibres (polyamide, polyesters, aramide fibres, silicon fibres, glass fibres etc.). A large range of elastomers have been used as cover materials, such as: natural rubber (NR), nitrile rubber (NBR), chloroprene rubber (CR), butadiene rubber (BR), styrene-butadiene rubber (SBR), silicon rubber (VMQ, PVMQ, MQ, PMQ), ethylene-propylene elastomer (EPDM), butyl rubber (IIR), isoprene rubber (IR), fluorosilicon (FMQ), fluorocarbon (VITON) etc. [6], [7]. These elastomers can be filled with such materials as fillers (carbon black), vulcanizing agents, protective agents like as antioxidants, plasticizers (mineral oil, esters), particular auxiliaries such as dyes (pigments), antistatic agents, fireproofing agents. There is a variety of techniques for textile support covering by elastomer: immersion, lamination, calendaring, dyeing, printing etc. The resulted materials have not shown always good enough heat-resistance and fire-resistance and have shown low flexibilities, therefore, they could not cover the whole range of thermal protection and insulation materials. These materials also were obtained from imported high cost fibres, so that some sectors have been faced with troubles in finding low cost heat resistant material substitutes.

In this paper were develop on advanced non-asbestos textile material coating with nanodispersions based on modified polychloroprene elastomers which can be used successfully in air-tight packings and thermal protection is made up of heat-resistant acryl fibres (precursors for the carbon fibre manufacture).

EXPERİMENTAL PART

Materials used

The fabric is made up of heat-fast (fireproof) acrylic fibres of varying textures and thickness, which are technical fibres for particular use.

Three types of fabrics of different weights and weavings, namely Startex S 350, Startex S 500 and Startex S 250, made by SC ICEFS SA Savinesti noted 3, 5, 6, have been selected for trials.

These fabrics were covered with nanodispersions based on modified polychloroprene elastomers. Polychloroprene latex Dispercoll C 84 (A0) with 55% polychloropren (Bayer, Germany) as polymer; raw polychloropren Denka A 20 as control sample (Du Pont, Franta), methyl methacrylate (Merck, Germany) as monomer; benzoyl peroxide as initiator and dodecylmercaptan as inhibitor (both Sigma-Aldrich Chemie, Germany), aqueous zinc oxide dispersion (active substance 93-95%) – Borchers VP 9802 as cross-linking agent and to consume the hydrochloric acid eliminated during reaction; aqueous silica dispersion 30–31%, average particle size 9 nm (Dispercoll S 3030) as thickener; diphenylamine derivative emulsion 50% – Rhenofıt DDA – 50 EM as antioxidant (the last three Bayer, Germany), triethanolamine as dispersion and *p*H stabilizer (Merck, Germany), natural resin colophony (Caroco Comimex SRL, Bulgaria) as adherence improver, and Desmodur RE – triphenyl methane triisocyanate 27% in ethyl acetate as cross-linking agent (Bayer, Germany) were used.

Procedure used

The grafting equipment consists of a three-neck flask equipped with agitator, thermometer, heated thermo-regulated nest and vacuum pump (capacity – 5 m^3/hour).

The polychloropren latex was introduced into the flask and the agitator and refrigerator were adapted. Heating and agitation were started and the grafting agent was introduced during 1/2 hour. The initiator was introduced when the temperature reached 80°C, the vacuum pump was adapted and the mixture was kept under stirring for 5 hours. The pressure into the reaction vessel was 5 mm Hg. Then the reaction inhibitor was introduced, while the heating and stirring were maintained for 1 hour. After cooling, the rest of the ingredients were added gradually during 1/2 hour. The receipts from table 1 were used and the dispersion A resulted.

The dispersions were characterized by the percentage of solids, free monomer and polymethyl-metacrylate, flowing time through Ford cup and *p*H. The obtained values are given in table 2.

Table 1

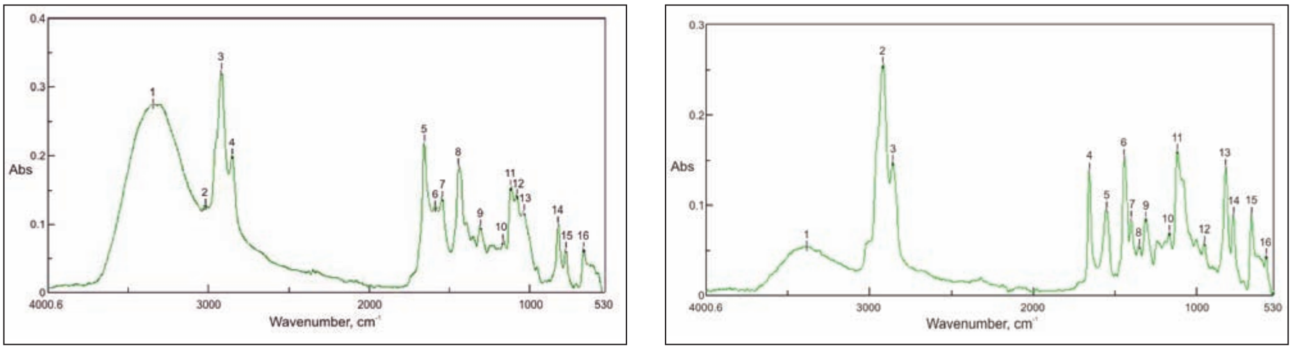
RECEİPTS FOR THE ADHESİVE DİSPERSİONS OBTAİNED BY CHEMİCAL GRAFTİNG

Component, g/dispersion	*A*
Dispercoll C 84	442.48
Methyl methacrylate	18.15
Triethanolamine	6.05
Benzoyl peroxide	0.61
Dodecylmercaptan	1.22
Borchers VP 9802	9.69
Rhenofit DDA 50	6.05
Dispercoll S 3030	6.05
Demineralized water	9.69
TOTAL	500

Table 2

CHARACTERİSTİCS OF DİSPERSİONS *A*

Characteristic/dispersion	*A*
% solids	57.84
% free monomer	0.05
% polymethylmethacrylate	0.00
Flowing time ford cup, s	24
*p*H	13



a *b*

Fig. 1. FT-IR spectra of films obtained from:
a – raw polychloroprene; *b* – Dispercoll C 84 – A0

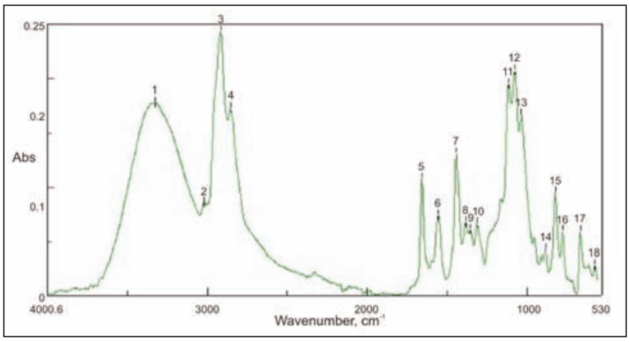


Fig. 2. FT-IR spectra of films obtained from dispersion A

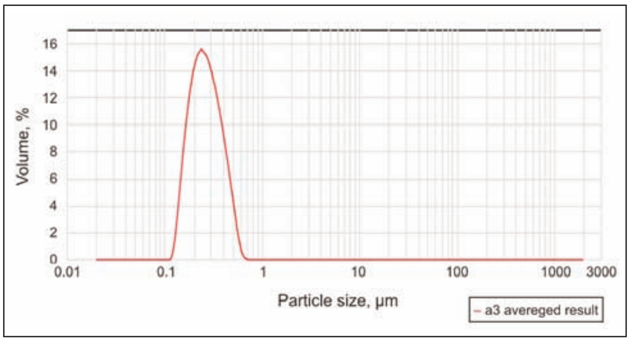


Fig. 3. Particle size distribution curves for A dispersion

The dispersions obtained by chemical grafting of polychloropren latex are stable for 30 to 40 days but the technology is time and money consuming. They can be re-dispersed by gentle mixing.

FT-IR spectra of the films obtained from Dispercoll C 84 and dispersion A were recorded within the spectral range 4 000 – 530 cm^{-1}. The spectrum of raw polychloropren rubber film was also recorded for comparison.

The FT-IR spectra of raw polychloropren rubber film and that obtained from A0 dispersion were compared with those from literature or instrument library. The two spectra look very similar each other, as can be seen in figures 1 *a, b,* as well as with those from the date base.

The bands of the spectrum from the figure 3 have the following assignments: 2 900 cm^{-1} (*i*) – n(CH_2) asymmetric, 2 820 cm^{-1} (*w*) – *v*(CH_2) symmetric, 1 640 cm^{-1} (*i*) – *v*(C=CH), 1 555 cm^{-1} (*i*) – *v*(C=CH), 1280 cm^{-1} (*w*) (CH_2)*r*, 1 100 cm^{-1} – C-Cl, 989 cm^{-1} (*w*) – C-C, 825 cm^{-1} (*i*) CH in C=CH trans, 600 cm^{-1} (*i*) – C-Cl, where *i* is intense, *w* – weak, *v* – valence vibration and *r* – wagging in plane vibration [8], [9].

But some new weak bands can be seen in the spectrum from the figure 1 *b*: 1 150 cm^{-1} and in the range 550 – 650 cm^{-1} that can be assigned to some vibrations of C-Cl bonds and to the additive introduced.

The FT-IR spectra of the films obtained from the dispersions in which the polychloroprene was grafted with the amounts of methyl methacrylate specified in table 1, shown in figure 2, present significant modifications of the intensity of some bands characteristic to polychloroprene, bands specific to polymethylmethacrylate grafts appear and two new weak bands can be seen at 650 and 530 cm^{-1}, respectively.

Thus, the bands assigned to C-Cl (1 100 cm^{-1}) and -C=CH- (1 555 and 825 cm^{-1}) decrease in intensity, their decreasing depending on the amount of methyl methacrylate (the higher the amount of monomer the less intense the bands), the bands characteristic to polymethylmethacrylate at 1 740 cm^{-1} (*v*C=O) stretching), 842 cm^{-1} (-C-O-C)- and 530 cm^{-1} (-C-CO-O-) [10], [11] and the new bands at 650 and 550 cm^{-1} can be seen.

The weakening of the polychloroprene bands assigned to -C-Cl and -C=CH- groups may be due to the grafting of methyl methacrylate chains onto the polychloroprene backbones [12, 13]. This supposition is supported by the absence of the monomer and polymethylmethacrylate into the dispersions A1 – A3, as table 2 shows.

Knowing of particle size and particle size distribution is very important, giving information on stability and viscosity of disperse systems, their optical properties, as well as on the kinetic aspects of emulsion polymerization or preparation of some composite materials [14], [15].

Particle size distribution

The Malvern instrument used is able to measure a large range of particle size [16[, [17]. The particle size distributin curves for the dispersion from table 1 are presented superposed in figure 3 to facilitate comparison. The figure shows that both the initial dispersion and those modified by chemical grafting with increasing amounts of methyl methacrylate present unimodal distribution of particle size.

The values of standard points to read the distribution characteristics for the dispersions A0 and A are given in table 3.

The analysis of figure 3 and table 3 reveals that the grafting increases the particle size and particle size distribution, both becoming higher when the amount of methyl methacrylate increases. Thus, the lower limit of the particle size displaces from 102 nm for dispersion A0 to 120 nm for dispersion A, while the upper one increases from 380 for A0 to 630 nm in the case of A.

SEM image of the cross section of the film obtained from Dispercoll C 84 (A0), presented in figure 4 *b*, emphasize a lamellar structure, with the components of the fillers finely dispersed inside. Instead, the SEM images of cross sections of the films obtained from the other three dispersions, in which the polychloropren was chemically grafted with methyl methacrylate, have completely different aspects (fig. 4 *a*: they show a morphology of biphasic type consisting from spheroid particles distributed within a matrix with less evident lamellar morphology, the number of particles increasing with the amount of methyl methacrylate.

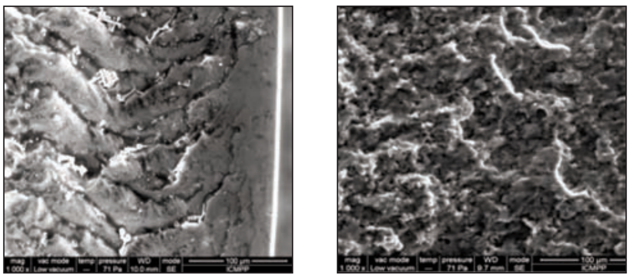
This dispersion was introduced by slight shaking fireproofing materials like as chlorinated paraffin, antimony trioxide and crosslink agents (CA3, CA5, CA6).

Rubber film covering was performed by means of a gauged doctor knife, with 4 different rubber-coating consistencies for every solution as follows:

- a 120 µm thick layer on a side + a 120 µm thick layer on the other side of fabric;
- a 120 µm thick layer on a side + a 300 µm thick layer on the other side of fabric;
- a 300 µm thick layer on a side + a 300 µm thick layer on the other side of fabric;

Table 3

VALUES OF THE STANDARD POİNTS TO READ THE DİSTRİBUTİON CHARACTERİSTİCS FOR DİSPERSİON *A*			
Dispersion	***D*(*v*, 0.1)**, nm	***D*(*v*, 0.5)**, nm	***D*(*v*, 0.9)**, nm
Dispercoll C 84 A0	132	181	259
A	168	260	426



a *b*

Fig. 4. SEM images of cross sections of films obtained from dispersions A0-A: *a* – A0, 1000X ; *b* – A, 1000X

- a 120 µm thick layer + a 300 µm thick layer on a side + a 120 µm thick layer on the other side of fabric.

Lamination **was** performed after the solvent removal by evaporation when the coated solution layer did not adhered to the hand any more (after about 20–30 minutes based on the drying temperature) [18], [19], [20].

Crosslinking and whole solvent removal by evaporation were conducted in an oven at 70°C for 4 hours. From the trials some elastomer covered fabrics have resulted which were subjected to physical-mechanical tests according to the standards in force. The film covering was also observed at a stereomicroscope, and the pictures of the uncoated and coated fabrics are shown below.

RESULTS AND DISCUSSIONS

The fabrics coated with elastomer films were subjected to tests for physical-mechanical characterization as such and after the accelerated ageing (72 hours at 70°C).

Three types of textile supports of different mass were used in the study, as follows (fig. 5):

- STARTEX S 350: 332,15 g/m^2;
- STARTEX S 500: 638,06 g/m^2;
- STARTEX S 250: 259,92 g/m^2.

To measure the amount of rubber coated onto 1 m^2 of fabric, the coated textile supports were weighted and the uncoated fabric weights were then subtracted from.

The data in the table have revealed that the amount of the rubber coated onto 1 m^2 is dependent on the fabric thickness, which in turn is dependent directly on uncoated fabric weight (table 4).

By considering the data in the two tables the following conclusions have been drawn:

- The strength characteristics of textile supports coated with elastomer films are dependent on the fabric fiber direction, being higher in the warp than in the weft;
- Tensile strength is dependent on the type of the covered elastomer both in the warp and weft, as follows: nitrile rubber > chloroprene rubber > chlorobutyl rubber;
- Based on the textile support used, the best results have been obtained with the support no. 5

Table 4

WEİGHT OF THE COATED RUBBER			
Sample		**Weight of the fabric coated with an elastomer film**, g/m^2	**Weight of the coated rubber**, g/m^2
Chloroprene rubber	CA3	504.36	175.54
	CA5	809.58	163.50
	CA6	615.24	355.32

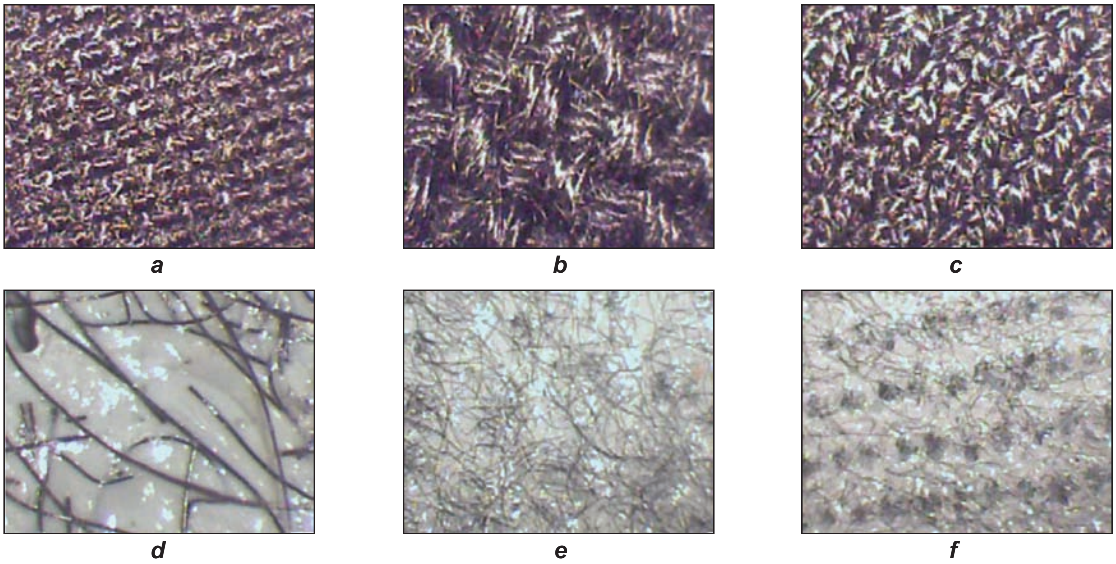


Fig. 5. *a* – Startex S 350 fabric; *b* – Startex S 500 fabric; *c* – Startex S 250 fabric; *d* – Startex S 350 fabric coated with a film of A elastomer dispersion; *e* – Startex S 500 fabric coated with a film of A elastomer dispersion; *f* – Startex S 250 fabric coated with a film of A elastomer

(638 g/m^2), followed by the supports no. 6 (332.15 g/m^2) and no. 3 (259.95 g/m^2), the material strength resulting more from that of the textile support than of the elastomer film;

- Where after the accelerated ageing (72 hours at 70°C) a slight increase in tensile strength was observed, this is due to the elastomer film self-curing action that have been going on over the time, particularly at high temperatures (70°C).

Analyzing the data in the tables 5 and 6 is observed as follows:

- Strength characteristics of textile substrates coated with elastomeric films are influenced by the fabrics wire directions, being higher in the warp to weft;
- Also, the tensile strength in the warp and weft depends on elastomer type used for coverage, their rankings is as such: chloroprene rubber;
- Depending on the support fabric type used, best results were obtained to support no. 2 (m = 638 g/m^2), followed by support no. 3 (m = 332.15 g/m^2) and no. 1 (m = 259.95 g/m^2), strength of materials is due mostly to textile support and less elastomeric film;
- Where, after accelerated aging (72 hours × 70°C) shows a slight increase in fracture strength values,

Table 5

CHARACTERISTICS OF TEXTILE SUPPORTS COATED IN WARP

Sample		**Strength**, N/5 cm			**Tensile strength**, %		
		Primary condition	***After the accelerated ageing***	***Variation, %***	***Primary condition***	***After the accelerated ageing***	***Variation, %***
Chloroprene rubber	CA3	790	865	+ 9.5	26.5	31	+ 16.9
	CA5	1 317.5	1 385	+ 5.1	31.5	33.5	+ 6.3
	CA6	750	745	– 0.7	12.5	19	+ 52

Table 6

CHARACTERİSTİCS OF TEXTİLE SUPPORTS COATED İN WEFT

Sample		**Strength**, N/5 cm			**Tensile strength**, %		
		Primary condition	***After the accelerated ageing***	***Variation, %***	***Primary condition***	***After the accelerated ageing***	***Variation, %***
Chloroprene rubber	CA3	340	470	+ 38.2	15	13	– 13.3
	CA5	745	815	+ 9.4	26.5	28.5	+ 7.5
	CA6	590	520	– 11	26	22	– 15.4

Table 7

RESISTANCE TO HEAT FOR NON ASBESTOS RUBBER FABRIC				
Sample type	**Specimen**	**Contact tempeature**, °C	**Threshold time**, s	**Average threshold time**, s
CA3	8	100	34.8	34.36
	8	100	34.2	
	8	100	34.1	
CA3	9	250	9.6	9.5
	9	250	9.1	
	9	250	9.8	
CA5	8	100	38.2	40.9
	8	100	44.4	
	8	100	40.1	
CA5	9	250	11.2	10.7
	9	250	10.6	
	9	250	10.5	
CA6	8	100	39.8	41.4
	8	100	43.3	
	8	100	41.3	
CA6	9	250	11.2	11.26
	9	250	11.1	
	9	250	11.5	

Table 8

FLASH DETERMINATION FOR NON ASBESTOS RUBBER FABRIC					
Sample	**Exposure time**, s	**Duration of flame persistence**, s	**Duration of residual glow**, s	**Duration of smoke evolution**,s	**Comments**
CA3	10	0	0	21	– specimen does not deform; – in the contact with flame hole is not forming; – charred area does not reach the top
CA5	10	55	11	17	– specimen does not deform; – in the contact with flame hole is not forming; – charred area reach the top
CA6	10	3	4	22	– specimen does not deform; – in the contact with flame hole is not forming; – charred area does not reach the top

Table 9

RESISTANCE TO HEAT FOR NON ASBESTOS RUBBER FABRIC							
Sample	**Specimen**	**Incident heat flux density**, Q_O, kW/m^2	**Sampling area**	**Rise time of the temperature for the inside**		**RHTI** Q_O, **average value**, t_{24}, s	**Comments**
				12°, (t_{12}), s	24°, (t_{24}), s		
CA3	2	19.85	central	12.0	20.6	20.35	– smoke release – slightly scorched rubber layer
	3		at 20 cm of edge	12.2	20.1		
	4	40.81	central	7.9	12.5	12.15	– smoke release – textile discolouring – rubber carbonization
	5		at 20 cm of edge	7.2	11.8		
CA5	2	19.85	central	12.4	21.6	21.7	– smoke release – slightly scorched rubber layer
	3		at 20 cm of edge	12.1	21.8		
	4	40.81	central	7.5	12.8	12.6	– smoke release – textile discolouring – rubber carbonization
	5		at 20 cm of edge	7.3	12.4		
CA6	2	19.85	central	12.3	20.8	20.65	– smoke release – slightly scorched rubber layer
	3		at 20 cm of edge	11.9	20.5		
	4	40.81	central	7.4	12.7	12.9	– smoke release – rubber carbonization
	5		at 20 cm of edge	8.2	13.1		

this phenomenon is due to self curing the elastomeric film that continues over time, especially at higher temperature (70°C).

As resistance to repeated flexion, it is assured by textile supports, wich presents a very good value of over 100 000 of flexion.

Resulting material were physical-mechanical tested and also in terms of resistance to temperature by the following tests:

– determination of heat resistance - determination of heat transmission through contact;
– determination of flash - fire behavior;
– resistance to heat-resistance to radiant heat.

The results of determinations are shown below:

- *Determination of heat resistance - determination of heat transmission by contact:* Test method: 6.4/ EN 407:2005, EN 702:2003; Apparatus: equipment for determining thermal transmission through contact - type L - DITTC 500 (table 7);
- *Flash determination - fire behavior:* Test method: MIP method adapted from 6.3 EN 407:1997; Equipment: testing equipment regarding fire behavior Dr. Troitsch, stopwatch, measuring tape (table 8);
- *Resistance to heat - resistance to radiant heat:* Test method: ISO 6942:2003, Method B; Apparatus: equipment for determining L-RAD radiant heat (table 9).

Analyzing data from the tables is found that fabrics covered with polymer blends based on chloroprene nanodispersion show resistance to both high temperatures and open flame and also to temperature by contact or radiant heat. Specimens of chloroprene rubber-coated fabric are not deformed, in the contact with flame hole is not formeing, charred area does not reach the top, for which, combined with physical and mechanical data, was selected for testing products. Also been taken into account the easyness workability of mixtures based on chloroprene nanodispersion and economic effects arising from the use. Were selected both with and without carbon black to diversify production to the needs of future beneficiaries.

CONCLUSİONS

- New advanced materials – oriented systems with different functions – have recently developed for individual protective equipments (IPE) like gloves, aprons etc. and other thermal insulation items like tight garnishes, protective gaskets, covers and curtains etc. meant for high temperature working areas where there are thermal risks;
- New materials are based on woven fabrics covered with elastomer blends containing different fireproofing additives;
- Fireproofing and physical-mechanical characteristics of the new materials make them able to be used in thermal risk areas.

ACKNOWLEDGEMENTS

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DOCUMENTARE

Calitate

NOI SISTEME DE CERTIFICARE

Noul sistem de certificare a textilelor *STeP,* pentru o producţie durabilă, a fost lansat oficial pe 12 iunie 2013, odată cu prezentarea premiului *Oeko-Tex Sustainability Award.*

Oeko-Tex GmbH*,* din Frankfurt – Germania, a expus acest sistem, pentru prima oară, la Texprocess.

Premiul Oeko-Tex Sustainability Award a fost prezentat în cadrul categoriilor de management al mediului, management al calităţii, responsabilitate socială, management al siguranţei şi inovării produsului. Pentru fiecare categorie au fost nominalizate trei companii.

Noul instrument de certificare a textilelor „Sustainable Textile Production“ furnizează brandurilor, companiilor comerciale şi producătorilor din întreaga lume o opţiune pentru analiza modulară a tuturor activităţilor relevante dintr-o companie, cum ar fi managementul calităţii, utilizarea substanţelor chimice, protecţia mediului, managementul mediului, responsabilitatea socială şi sănătatea şi securitatea muncii.

Scopul certificării STeP este acela de a oferi unităţi de producţie care să sprijine ţintit optimizarea continuă a tehnologiilor de producţie şi a condiţiilor de muncă, în sensul unei mai bune protecţii a muncii, a siguranţei la locul de muncă şi a responsabilităţii sociale.

Evaluarea gradului în care companiile certificate STeP au un management durabil este făcută pe baza unei cereri, evaluarea desfăşurându-se online, iar auditul final al companiei are loc sub forma unui sistem gradual transparent, desfăşurat în trei etape. Certificatul STeP emis arată scorul total realizat, precum şi valorile individuale pentru fiecare companie, în procente.

Condiţia preliminară pentru certificarea STeP este conformitatea cu un număr minim de cerinţe, care urmează a fi verificate pe parcursul auditării unităţilor de producţie de către unul din institutele Oeko-Tex.

Certificările deja existente, de exemplu, ISO 9001, ISO 14001, SA 8000 sau OHSAS 18001, pot fi integrate fără probleme în certificarea STeP, astfel încât companiile nu trebuie să prezinte probe justificative de două ori.

Melliand International, mai 2013, p. 114

Developing original software designed to estimate consumption norms for textile products, using the method based on the sum of all rests

ALEX ANTEMIE
AUREL POPP
FLORENTINA HARNAGEA
PASCAL BRUNIAUX

REZUMAT – ABSTRACT

Dezvoltarea unei aplicaţii destinate estimării asistate de calculator a normei de consum pentru produsele textile, pe baza metodei de determinare a sumei tuturor deşeurilor

Estimarea corectă a consumului de materiale, încă din faza de proiectare a unui produs, reprezintă o etapă importantă, deoarece costurile cu materia primă constituie o cotă semnificativă din preţul de vânzare al unui produs. În timp, teoria specifică acestor produse precum şi industria confecţiilor au sugerat diverse metode de estimare a normei de consum. Ca şi contribuţie originală, articolul prezintă algoritmizarea metodei de estimare a consumului pe baza determinării sumei tuturor deşeurilor, parametrii specifici acestei metode şi influenţa modificării lor asupra valorii finale a normei de consum. Orientarea cercetării în acest scop este justificată de faptul că metoda în sine este cea mai complexă şi, totodată, poate furniza rezultate relevante, nefiind prezentă în programele de calculator actuale, destinate estimării consumului de materiale.

Cuvinte-cheie: estimare, textile, materiale, normă

Developing original software designed to estimate consumption norms for textile products, using the method based on the sum of all rests

Relevant material consumption estimation, since design stage for a product, is an important issue, because material's costs represent a significative percentage for the sale price of that product. Through time, the theory specific for these products, and also the manufacture sites suggested different methods for material norm estimation. This article presents, as an original contribution, algorithmics for an estimation method, so called the method based on all rests, with it's own parameters and how changing their values is refllected in the final value of the estimation process. Research focusing for this purpose is justified by the fact that this method is very complex and it can suggest relevant results, but it is not present in actual software sollutions.

Key-words: estimation, textiles, materials, norm

ACTUAL USAGE OF DIFFERENT ESTIMATION METHODS FOR TEXTILE PRODUCTS

Today there are several methods used to estimate needed material for manufacturing textile products; these methods had been developed by academics, or by technicians from manufacturing, focusing on design economical efficiency [1], [2].

Generally, only one particular method is used for estimation, because each method presents a certain relevance and requires specific conditions, which involves that the personnel interested in norm estimation to use frequently the method that reflects best their interests, as follows:

- in theory (in the educational enviroment), it is prefered the method itself and how it works, and so the estimation process is exposed to help better understanding of the design process (by student, for example);
- in practice (in production), technicians prefer a method that provides a correct result within a very short period of time.

Method based on sum of all rests

This method is based on the medium value of nesting coefficients for all parts of one article, and on percentage values of common rests after the cutting:

- normally rests D_n – rests between cutted parts of same shape and size;
- marginal rests D_m – rests because of the differences between parts shape and material shape;
- pattern rests D_t – rests between parts with different shape;
- defects rests D_d – rests because of the need to go around material imperfections;
- bridge rests D_p – rests based on the distances between cutting dices.

From all methods, this is the most complex, because it takes into consideration design specific values, nesting coefficients, material quality index, cutting technology, material shape and size etc.

Method based on experimental cutting

After experimental (test) cutting, from the surface of used material and the surface of cutted parts can be calculated a cutting coefficient.

For example, if material surface is 200 dm^2 and parts surface is 152 dm^2, the value for the cutting coefficient will be equation (1):

$$I_f = \frac{\textit{Material surface}}{\textit{Parts surface}} = \frac{200}{152} = 1.315 \qquad (1)$$

Material estimation with experimental cutting involves multiplying the surface of all parts of an article S_n with the cutting coefficient I_f, estimation norm will be equation (2):

$$N_c = S_n \times I_f \qquad (2)$$

This method is recommended in practice to verify estimations values suggested by theoretical methods. Estimation accuracy increases with the cutted surface, but it is greatly influenced by batches, because materials with different fizical characteristics provide different results for the estimation method.

Today, design departments aren't always near cutting departments, which makes this method to lose ground.

Our approach

We studied the method of estimation based on sum of all rests during the elaboration of a doctoral, from Technical University "Ghe. Asachi" from Iasi (Romania), project that developed solutions for footwear CAD domain. We analized several estimation methods, and after we developed algorithmics for each one of them, so they can be implemented inside computer software.

This article presents criteria regarding algorithmics for the estimation method based on sum of all rests. The method itself is complex, because there are taken into account important aspects of the cutting process, but this complexity requires greater processing (computing) times than other metods. This method is not included in current software solutions, although it may provide relevant results, and therefore we developed an afferent algorithm. After a succesfully implementation of this method inside computer software, the duration of the estimation process has beed reduced sharply.

Following, will be presented the algorithm afferent for the method steps in a general manner, and not specific to a programming language, because a same algorithm can be successfully implemented in most existing programming languages. Algorithm steps are presented along with theoretical concepts of the method, aiming at implementing in a natural order all calculation steps. Later, after realizing an application able to estimate material consumption, we made estimations with different sets of parameters, to see how the outcome varies depending on method specific values. This study has the advantage that by using software applications, conclusions canquantifies more quickly, thus concluding on which parameters shows great power of decision and how relevant is the method itself. Finally, conclusions are presented and new directions for research are proposed.

EXPERIMENTAL PART

Algorithmics for the estimation method

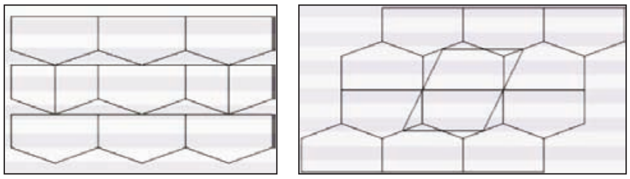
Specific algorithm for estimating material consumption by the method based on sum of all rests, must achieve the following requirements:

- calculate normal rest, D_n;
- calculation of defects rest, D_d;
- calculate marginal and pattern rests, $D_m + D_t$;
- calculation of bridges rest, D_p;
- calculation of material utilization factor, I_U;
- calculation of material consumption, N_c.

Calculate normal rest, Dn

Normal rests D_n is equal to 100 – A, where A is a nesting coefficient specific for all footwear parts. A reflects material usage, as shown in figure 1. Computing the medium value for A requires considering parts surface, because parts with greatest surface influence more this value than parts with low surface. This concept is taken into consideration, computing A relative to the specific nesting paralelogram for each part. Thus:

$$A\,[\%] = \frac{\textit{parts total area}}{\textit{paralelograms total area}} \times 100 = \frac{A_{set}\,[\mathrm{dm}^2]}{\textit{paralelograms total area}\,[\mathrm{dm}^2]} \times 100 \qquad (3)$$



a b

Fig. 1. Nesting layouts and material usage coefficient for different variants: *a* – 85%; *b* – 100%

Calculate parts total area, A_{set}

Set's area (total area for parts) is determined as the sum of individual areas of the parts (each contour area) multiplied by the demand in the pair. To determine the area of a shape, its required to obtain the corresponding discrete positions, determinated with a desired precision (accuracy). Considering the sequence of values (x_i, y_i) with i = 0 ... n, the area is given by equation (4):

$$S = \frac{1}{2}\sum_{i=0}^{n-1}(x_i\,y_{i+1} - x_{i+1}\,y_i)\,k^2_{px-mm} \qquad (4)$$

where:

k is equivalent scale for pixels and millimeters (working resolution).

Calculate paralelograms total area

Calculating this area requires finding the area for each parallelogram [3], associated with the nesting layout for one part; there are tried many variations of nesting, of which retains the parallelogram corresponding to the minimum area (nesting maximum factor) is described how to generate these nesting types.

Generating nesting variants

Variant 1. Parts are placed in vertical and horizontal rows; positions inside the final nesting layout resulting by translations *($k_{\Delta x}$, $k_{\Delta y}$)* (fig. 2) . Associated parallelogram area is the product of d_x and d_y.

Analytical nesting approach. Considering a part represented by a polygon P_1, with $w \times h$ overall bounding area, is building a second polygon P_2 obtained by translating the first polygon horizontally by the amount $d > w$, to avoid their premature intersection. If $d - w = d_w$ (*dw* is the added distance), the final distance for a proper contact of the two parts will be at most equal to d_w. To determine this value, the two polygons are intersected with a parallel beam of lines, whose height is at least equal to *h,* thus ensuring the beam fully intersects bought polygons (fig. 3). Origin C_f of this flow [1] can be considered as a simetric point for *A*, among origin *B.* Precision of the method is directly influenced by the distance *x* between two neighboring lines from the beam. It can be correlated distance *x* with height *h* of the part to distribute evenly all beam lines around part's surface. The condition is that *x* = [*h/n*]*,* where [*x*] is the integer part of number *x.*

Determination of contact distance d_w, is performed by comparing segments determinated by the beam between the two poligons (parts). Each line from the beam intersects with the two polygons, retaining for the polygon P_1 the point with the higher abscissa, and for the polygon P_2 the point with the smallest abscissa. Thus, for each line, is given a pair of points (*i, j*)*.* Finally, from all lengths of segments (*i, j*) the smallest distance is associated to d_w.

Considering the initial parts with zero rotation, $d_w = d_x$.

Determination of d_y is done similarly, except that the polygons are rotated with 90°, in the preferential direction (counterclockwise or clockwise).

After determination for values d_x, d_y, parts nesting can be achieved by translating them with the values determined by the axes of the coordinate system.

Variant 2. Parts are placed in vertical rows, with the observation that parts from neighboring rows are rotated by 180°. These strings are intertwined to obtain a higher nesting factor (fig. 4). Associated parallelogram area is the product of d_x and d_y.

Analytical nesting approach. Similar to the procedure described in variant *1*, is build a vertical row of parts *(P_1, P_2, P_3)*, distant from each other being d_y (determined above).

It builds a fourth part, rotated by 180°, positioned on the abscissa at a distance *d* > *w* from the vertical row, and on the ordinate midway between the center of parts P_1 and P_2. Analog to first nesting variant, is considered a beam of lines, with which is determinated the minimum distance d_{xi} (contact distqnce) for this position. The process is repeated for each intermidiate position of polygon P_4, translated to the positive direction of axis *OY*; the increment of translation *x,* is equal to the distance between neighboring lines from the beam. Thus, for each intermediate position occupied by the polygon P_4 there is a contact distance d_{xi} (fig. 5).

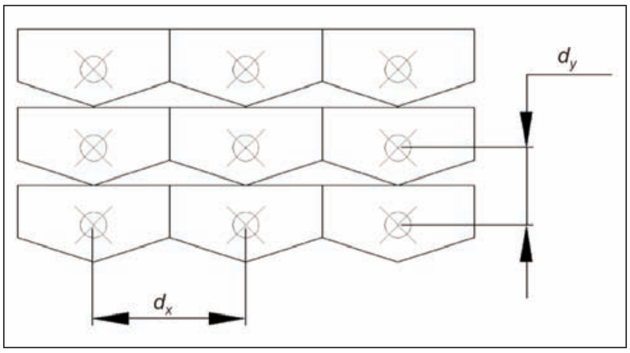


Fig. 2. Nesting layout no. 1

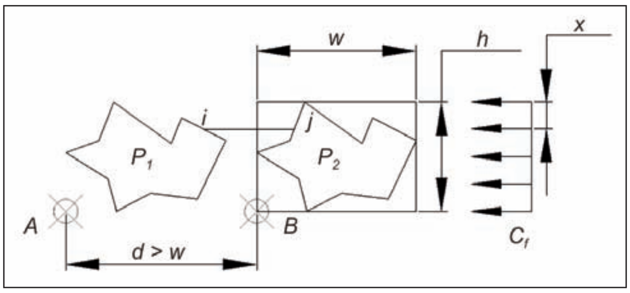


Fig. 3. Illustration of the calculation process

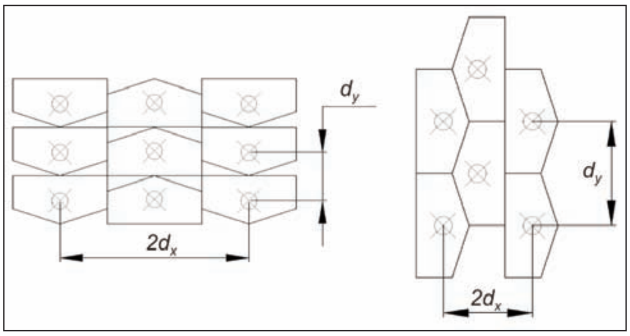


Fig. 4. Nesting layout no. 2

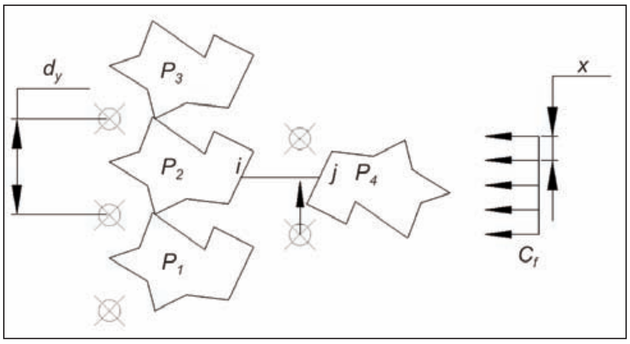


Fig. 5. Illustration of the calculation process

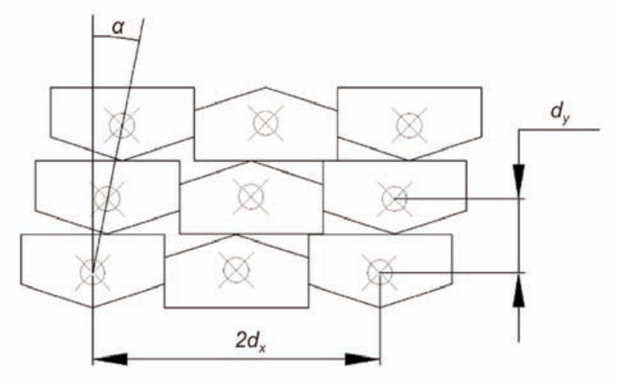


Fig. 6. Nesting layout no. 3

The final value d_x (the searched value) will be the minimum of all d_{xi} determined above. Accuracy is directly influenced by the translation increment of poligon P_4, which is equal to the beam linear density, *x*.

Variant 3. This version is derived from the above, indicating that the evolution sequence of parts (P_1, P_2, P_3), is not vertical, but away from the vertical by an angle α (fig. 6). d_x and d_y values determine methodology is the same as in variant 2, the difference in the number of different nesting layouts tested, which are corresponding to the angle α. Accuracy of these variant is influenced by same specifics as in variant 2, plus the increment of changing the angle α.

Calculation of defects rest, D_d

Material estimation methods are computed for 2nd quality class, so rests because of defects are ignored:

$$D_d = 0 \tag{5}$$

in the original computing process. For another quality class, defects rests D_d are computed using a quality index; considering N_c the material needed to manufacture footwear using 1st quality materials, N_{c^*} needed for manufacturing using 2nd quality material will be $N_{c^*} = N_c \times Q_i$, where Q_i is a quality index, with its values presented in table 1.

Table 1

QUALITY INDICES FOR DIFFERENT QUALITY CLASSES	
1st quality	Q_i = 0.97
2nd quality	Q_i = 1.00
3rd quality	Q_i = 1.04
4th quality	Q_i = 1.10

Calculate marginal and pattern rests $D_m + D_t$

Marginal and pattern rests $D_m + D_t$ depends on the size of surface factor F_s:

$$D_m + D_t = \frac{c_1}{\sqrt[4]{Fs}} + c_2 \tag{6}$$

where:

$$F_s = \frac{\text{Material surface}}{\text{Parts medium surface}} = \frac{M}{t_m} \tag{7}$$

Parts medium surface is:

$$t_m = \frac{\text{Parts total surface}}{\text{Parts total number}} \tag{8}$$

In the above relations, the only unknowns are *M*, c_1 and c_2, which are required from the user through the interface controller. The total area is already determined in the stage of calculating the normal rest, and total number of parts is how many parts are in the set.

Calculation of bridges rest, D_p

The percentage of bridge rest is:

$$D_p = \frac{P_{set}\,p}{2A_{set}} \times 100 \tag{9}$$

where:

P_{set} is the perimeter for all parts of the product (is determined as the sum of products of the perimeter of each part and demand in the product). The perimeter for a part is:

$$P = \sum_{i=0}^{n-1} d(A[x_i y_i], B[x_{i+1} y_{i+1}]) + d(A[x_0 y_0], A[x_n y_n]) \tag{10}$$

where:

P is in fact a sum of discrete approximation segments;

A_{set} – area for all parts of the product (determined above);

p – bridge size between patterns (this value is requested to the user through the application interface).

Footwear design academics sugest that D_p can be frequently ignored.

Calculation of material utilization factor, I_U

$$I_U = 100 - D \quad [\%] \tag{11}$$

where:

D is the sum of all rests (12):

$$D = D_n + (D_m + D_t) + D_d + D_p \quad [\%] \tag{12}$$

and how (13):

$$D_d = 0 \rightarrow D = D_n + (D_m + D_t) + D_p \quad [\%] \tag{13}$$

If also D_p is ignored then:

$$D = D_n + (D_m + D_t) \quad [\%] \tag{14}$$

Calculation of material consumption, N_c

Material consumption is (15):

$$N_c = \frac{A_{set}}{U} \times 100 \text{ [dm}^2\text{/article]} \tag{15}$$

where:

A_{set} is area for all parts of the product (determined above);

I_U – material utilization factor (determined above).

Consumption norm is calculated for 2nd material quality, for the medium number within the serie

Table 2

DIFFERENT ESTIMATION VALUES ACCORDING TO SPECIFIC $D_m + D_t$ PARAMETERS											
M, dm²	**75**	**100**	**125**	**150**	**175**	**200**	**225**	**250**	**275**	**300**	**c_1**	**c_2**
$D_{mt\_}1$, %	15.1	14.1	13.3	12.7	12.2	11.8	11.5	11.2	10.9	10.7	39	0
$D_{mt\_}2$, %	9.7	9.0	8.5	8.2	7.8	7.6	7.4	7.2	7.0	6.9	25	0
$D_{mt\_}3$, %	13.7	13.0	12.5	12.2	11.8	11.6	11.4	11.2	11.0	10.9	25	4
$D_{mt\_}4$, %	15.7	15.0	14.5	14.2	13.8	13.6	13.4	13.2	13.0	12.9	25	6

size. Consumption norm for other qualities can be determined by multiplying with the corresponding quality index Q_i.

Influence of methods specific parameters over the final estimation value

In the following, we will examine how different values of specific parameters for this method will affect the final result. This method has specific parameters for computing the next values:

– normal rest, D_n;

– marginal and pattern rests, $D_m + D_t$;

– bridges rest, D_p.

Also, quality directly influences the cutting, increasing consumption norm once the cutting surface expresses defects.

The influence of specific parameters for normal rest, D_n (16)

$$D_n = 100 - A \qquad (16)$$

where:

$$A = \frac{\textit{total parts area}}{\textit{total associated parallelogram area}} \times 100\ [\%] \qquad (17)$$

How total parts area is a constant, changing the value of D_n can be accomplished by obtaining different values for nesting associated parallelograms [4].

By modifying the nesting layout for different parts, we observed that larger area parts more easily influence the value for material estimation. Basically, to change D_n with *1* percent is sufficient for change the nesting value for the biggest part with 2%, while the same effect can be achieved by modifying the nesting for the smallest part with 7%.

In conclusion, parts with high surface must be subject to serios nesting, while nesting layouts for smallest parts can be tolerated wider.

The influence of specific parameters for marginal and pattern rests, $D_m + D_t = D_{mt}$ (18)

$$D_m + D_t = \frac{c_1}{\sqrt[4]{Fs}} + c_2 =$$

$$= \frac{c_1}{\sqrt[4]{\dfrac{\textit{Material surface}}{\textit{Parts medium surface}} = \dfrac{M}{t_m}}} + c_2 =$$

$$= \frac{c_1}{\sqrt[4]{\dfrac{M}{\dfrac{\textit{Parts total surface}}{\textit{Parts total number}}}}} + c_2 \qquad (18)$$

For the test article, $t_m = 12.7$ dm². The experimental data is shown in table 2.

After centralized data analysis, the following conclusions were made:

– whether the coefficients (c_1, c_2), D_{mt} percentage decreases as the average skin surface increases;

– up to the value $M = 200$ dm², D_{mt} decreases significantly, and as M exceeds the value of *200* dm², D_{mt} decreases with a smaller amount (~ 2%), so it may be considered value $M = 200$ dm² the mean surface suitable for cutting (for the test article);

– dependend the coefficients (c_1, c_2), D_{mt} increases as the coefficient increases.

Recommended values for the coefficients (c_1, c_2) are (39,0), specific to flexibile materials, while the others values are for rigid ones.

The influence of specific parameters bridges rest, D_p (19)

$$D_p = \frac{P_{set}\,p}{2A_{set}} \times 100 = pxk;\ [k = \frac{P_{set}}{2A_{set}} \times 100] \qquad (19)$$

where:

P_{set} is perimeter for all parts of the product (= 127.3 dm);

A_{set} – area for all parts of the product (= 114.16 dm²);

p – bridge size between patterns;

$k = 1.657$ mm^{-1}, we redefine k as $k^* = 1.5$ mm^{-1}.

An easy conclusion to note is that the D_p value increases relatively quickly with bridge p value (table 3), and so it is recommended to use as compact nesting solutions as possible.

Table 3

DIFFERENT BRIDGE REST VALUES FOR DIFFERENT, *p*				
P, mm	*5*	*7.5*	*10*	*12.5*
D_p, %	2.78	4.13	5.50	6.89

Implementing the algorithm inside a computer application

The algorithm developed for material estimation using the method based on the sum of all rests had

Table 4

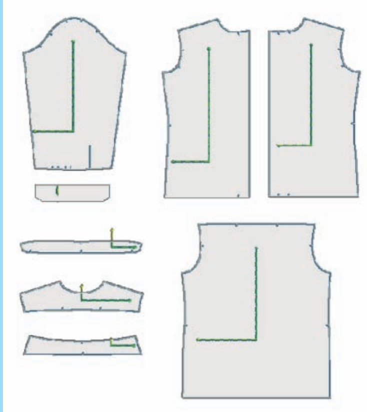
DISPLAYED INFORMATION FOR SELECTED PARTS									
No.	**Part, name**	**Parts, preview**	**Quantity**	**Part perimeter,** dm	**Product perimeter,** dm	**Part area,** dm^2	**Product area,** dm^2	**Nesting coefficient,** %
1	cuff		1	6.36	6.36	1.86	1.86	98
2	collar *1*		1	10	10	2.12	2.12	91
3	sleeve		2	17.35	34.7	19.47	38.94	80
4	reinforced back		1	11.38	11.38	4.16	4.16	70
5	back		1	25.06	25.06	37.78	37.78	92
6	face *1*		1	20.53	20.53	22.5	22.5	88
7	face 2		1	20.21	20.21	21.32	21.32	88
8	lapel/ collar *2*		1	10.38	10.38	2.71	2.71	77
			9	-	138.62		131.39	86.8

Fig. 7. Objects from computer interface through which the opeator can inpus specific values for methods parameters

been implemented inside the source-code for a computer application, resulting specialized software for estimations. The operator can set specific values for methods parameters through computer interface:

– medium material surface, *M*;
– coefficients c_1, c_2, specifics for D_{mt};
– bridge size *p*, specific for D_p, this value ca be varied inside the domain 10...30 mm.

The estimation process can also be done for some particular values, but it is important to use usual values, specific to the process itself. In this way, the teoretical results are constrained to conclusiv ones (fig. 7).

To perform estimation with our software, it is required to go through these next steps:

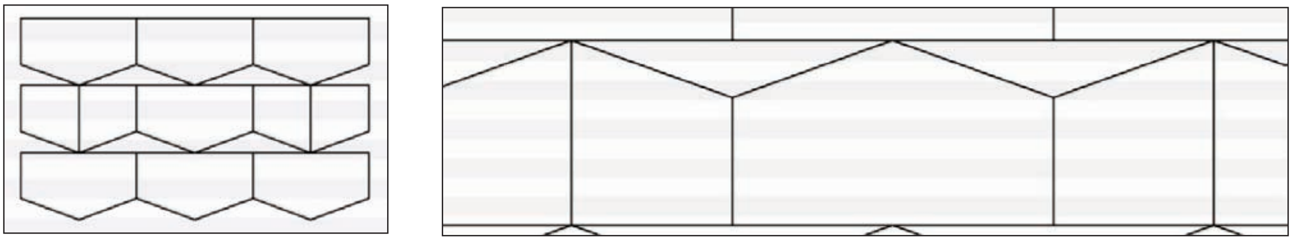
- *selecting a group of parts (eq article parts) and calling the estimation routine* – the software identifies automatically individual parts, so there is no need to predefine them. For each part, the software verifies if it has simmetry or not, and calculates afferent area and perimeter, using a conversion scale between pixels and milimeters. Parts identified as being simetric are rotated to a position which favors the estimation process;
- *setting required quantity for each part* – the operator can input these values through specific objects from the interface;
- *displaying characteristics for selected parts* – values computer at steps *1* and *2* are automatically tabled inside lists, as showed in table 4. For area and perimetes, there are two values; the first caracterizes the part, while the second – the product (article), their division being equal to the quantity required for each part inside the product. Thus, there had been identified 8 unique parts, with the total area of 131.39 dm^2 and the total perimeter of 138.62 dm;
- *setting process values* – through objects from computer interface, the operator can set values for material medium size *M*, bridge size *p*, and for the Dmt coefficients c_1 and c_2;
- *estimation process* – from all values presented at stept 1–4, considered input data, the software estimates consumption norm; there are performed nesting variants, from which are retained only those with superior material usage. The results from the estimation process, considered output data (table 5) are presented as text and image (fig. 8).

Images are generated through visual components, able to perform actions specific to vectorial/analitycal graphics and raster/visual effects (fig. 9). Images from this paper had been exported from the software by this component.

Once this application had been developed, there can be done several estimation for different articles, with

Table 5

OUTPUT INFORMATION FROM THE ESTIMATION PROCESS, DISPLAYED AS TEXT
Consumption norms for different quality materials
= =
N_c_cal_1 = 1.82 m^2/product
N_c_cal_2 = 1.88 m^2/product
N_c_cal_3 = 1.96 m^2/product
N_c_cal_4 = 2.07 m^2/product
= =
13.2% normal rest, D_n;
12.8% marginal and pattern rest, $D_m + D_t$;
4.0% bridge rest D_p;
70.0% material utilization factor, I_u



a *b*

Fig. 8. Output information from the estimation process, displayed as image (overall image and detail for a custom part):
a – nesting value = 85%; *b* – details (magnified area) allow a visual control on how parts are placed, because there can be better observed the contact area between them

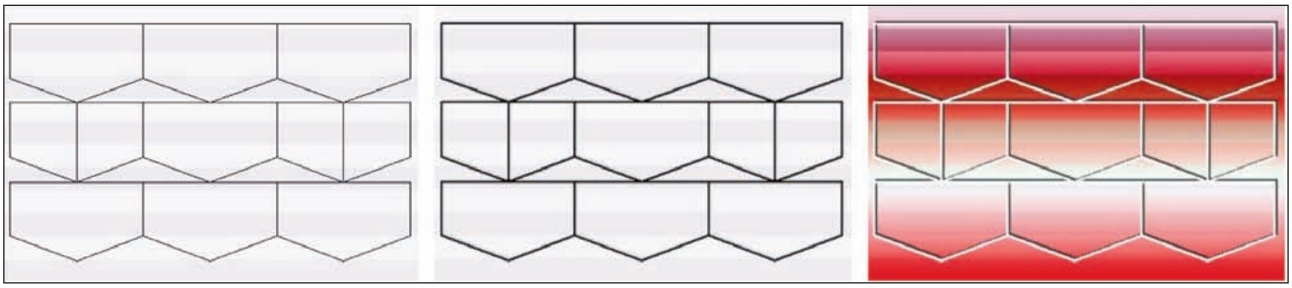


Fig. 9. Visual effect of the graphical component

different values for the method control parameters. Using different values for these parameters allow to obtain not a single value, but a probabilistic domain. It is important that the estimation process to be:

- *stable* – there should not be big differences between values estimated by different methods;
- *relevant* – differences between teoretical estimation and real values for material consumption shoud be easy to tolerate.

Presented software solutions and afferent algorithms had been developed by the author.

RESULTS AND DISCUSSIONS

- Developing an algorithm for the material estimation of textile articles, using the method based on the sum of all rests, represents an original contribution. The method itself is a complex one, which triggers important aspects from the cutting process, and thus is able to deliver relevant results.
- Proposed algorithm had been implemented inside the source code of a computer application, following original method's steps from specific theory. Thus, the duration of the estimation process had been drastically reduced, resulting an aplication to sustain the teoretical presentation of this method, and to favorize understanding of it's concept by technicians and researchers.
- The estimation method based on the sum of all rests has an analitycal character, because it delivers numerical results and graphical representations for computed parts nesting.
- The quality of this method can be established by comparing its results with results of other methods and with the real value for the material consumption of an article, when launched into production. Because of its complexity, the method delivers not a result, but a high probabilistic domain; also, in manufacturing there are fluctuations for materials consumption.

CONCLUSIONS

Adding a new method to computer assited technical design improves the stability of teoretical estimations regarding material consumption for textile products. If the estimation process is for a teoretical purpose, like a license project, than results can be larger tolerated than when estimated values are for manufacturing.

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DOCUMENTARE

Noi tehnologii

PRODUSE FĂRĂ CONŢINUT DE AMINOETILETANOLAMINĂ

Producătorul de substanţe chimice şi coloranţi pentru domeniul textil, ***Huntsman Textile Effects***, din Singapore, a lansat pe piață două noi produse, fără conținut de aminoetiletanolamină (AEEA), pentru doi dintre principalii emolienţi pe bază de silicon, utilizaţi în fabricarea confecţiilor şi a textilelor de interior.
Respectând legislaţia actualizată REACH, Huntsman a elaborat două noi produse, *Megasoft Jet-LF-01* şi *Megasoft Cec-01*, care reprezintă alternative fără conținut de aminoetiletanolamină la produsele deja existente, Megasoft Jet-LF şi Megasoft Cec.
Noile produse au acelaşi grad de emoliere ca şi precedentele şi, în plus, sunt compatibile cu diferite alte substanţe chimice utilizate, fiind mult mai atractive pentru clienţi.
Aceste realizări de ultimă generaţie se alătură noului produs *Sapamine CSN*, care înlocuieşte cu succes Sapamine CWS.

NOI ENZIME PENTRU CURĂȚAREA TEXTILELOR

Companiile ***DuPont Industrial Biosciences, Beloit*** și ***WI*** – din S.U.A., au elaborat noi soluţii pe bază de enzime pentru curăţarea şi biofinisarea ţesăturilor.
Formula lichidă foarte concentrată, *PrimaGreen Oxy*, îndepărtează peroxidul încă de la prima clătire, după albire, eliminând etapele ulterioare ale clătirii și economisind energie şi timp.
Având o gamă largă a activităţii *p*H-ului şi temperaturii, PrimaGreen Oxy are o stabilitate ridicată chiar și în prezenţa concentraţiilor ridicate de peroxid.
Primafast Gold HLS este un lichid folosit pentru biofinisarea unei game variate de ţesături din bumbac. Această enzimă oferă o curăţare superioară a ţesăturii, în condiţiile unui *p*H neutru, pentru toate tipurile de echipament de prelucrare. Curăţarea în condiţiile unui *p*H neutru permite combinarea etapelor de biofinisare şi de vopsire într-un proces cu o singură baie.

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The expansion potential of using sales promotion techniques in the Romanian garments industry

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REZUMAT – ABSTRACT

Posibilităţi de extindere a folosirii tehnicilor de promovare a vânzărilor în industria de confecţii îmbrăcăminte din România

Lucrarea îşi propune o prezentare generală a conceptului de promovare a vânzărilor, a complexității şi importanţei acestuia. Sunt descrise obiectivele promovării vânzărilor, tehnicile de promovare, publicitatea ca formă de comunicare şi de promovare a vânzărilor. De asemenea, articolul prezintă o analiză a modalităţilor de extindere a folosirii tehnicilor de promovare a vânzărilor. Analiza a fost realizată în urma unui studiu care urmăreşte evidenţierea tehnicilor de promovare a vânzărilor folosite preponderent de firmele din cadrul industriei de confecţii îmbrăcăminte din România, în contextul crizei economice mondiale. Este evidențiată necesitatea cunoaşterii şi conştientizării avantajelor folosirii şi extinderii tehnicilor de promovare a vânzărilor.

Cuvinte-cheie: promovarea vânzărilor, publicitate, tehnici de promovare, dinamica afacerilor, industria românească de îmbrăcăminte

The expansion potential of using sales promotion techniques in the Romanian garments industry

The present research aims to offer a general presentation of the sales promotion concept, its complexity and importance. In addition, the article presents the objectives of sales promotion, promotional techniques, advertising as a form of communication and sales promotion. The article analyses the expansion potential of using sales promotional techniques through a study that highlights sales promotion techniques used primarily by firms operating in the garment industry in Romania, in the context of the global economic crisis. The paper underlines the need for knowledge and awareness of the advantages of using and expanding sales promotion techniques.

Key-words: sales promotion, advertising, promotional techniques, business dynamics, Romanian garment industry

Sales promotion practically covers heterogeneous marketing activities, many of which are applied empirically. From a theoretical point of view, research performed has mainly focused on the preoccupation of delimitating the position of sales promotion, compared to product and price policies on the one hand and advertising on the other.

Besides, if sales promotion is still often considered as "the poor cousin" of marketing, this is due to the difficulty in defining what it actually consists. L.F. Wegnez (1998) considers that sales promotion is frequently opposed to advertising, its active and effective role in economic development being neglected. Often, its image is reduced to that of a simple communication means, whereas it actually is primarily a part of business dynamics [1].

Moreover, among the classic authors that tried to identify the true role and place of sales promotion in the promotional mix is P. Lassègue (1972–1973), cited by P. L. Dubois and A. Jolibert (1994) [2]. In his approach, the author underlined the need to distinguish between two possibilities of defining the sales promotion concept: in a broader and narrower sense.

From a broader perspective, P. Lassègue considers that sales promotion is synonym with "trade dynamics", comprising all actions which can stimulate sales growth (including advertising, sales force and so on). This is in fact consistent with the Anglo-Saxon term of "promotion", included among the four variables of the marketing mix.

In a narrower sense, the author defines sales promotion as the "ensemble of techniques which render a fast but provisional growth in sales, by attributing an exceptional advantage to the distributors or consumers of a product". This classic definition was improved along with the evolution of the marketing concept. Hence, J. Lendrevie and D. Lindon (1997) infer that "a promotional operation consists in associating a product to a temporary advantage destined to facilitate its use, purchase and/or distribution" [3]. This implies the modification of the basic offer of the firm in order to propose a promotional temporary offer.

The quality of economic activity corroborated with the quality of communication and promotional activities help firms sell more, create new products, generate competition and finally provide more jobs.

Generalising promotion is necessary, as a result of consumer pressure. Confronted with dilution of purchasing power, given the background of the global economic crisis, more than ever consumers plan their purchases according to price levels, promotions and discounts [4], [5].

OBJECTIVES OF SALES PROMOTION AND CLASSIFICATION

M. J. Baker attributes the following specific marketing objectives to sales promotion [6]:

- winning a larger number of clients and their transformation into loyal users, usually by means of activities focused on growing the average quantity bought per purchase (for instance, through merchandising, price discounts); increasing the frequency of purchases for a given product (competitions, prizes); gaining new consumers (through games, direct rewards). Merchandising refers to the sale of goods in distinctly arranged spaces, by displaying the product offer regrouped by theme, which involves a new organisation of points of sale into consumption universes. These universes impulsively encourage sales by the very fact that they allow the consumers to discover the diversity and complementarity of the product offer;
- extending the products' distribution through a series of actions adapted to the points of sale; obtaining or increasing an assortment of merchandise; improving the presence of certain products in the sale mix;
- optimising inventory level by reducing inventory shortages; retail promotion; free samples;
- reducing sale fluctuations with the aim of maintaining an economic level of production and a regularisation of procurement;
- alleviating the effect of price increases by a series of techniques known as "price offers";
- generating a new interest for an existing product by competitions, games, partial or total repayment techniques.

There is a wide variety of sales promotion techniques. In an attempt to synthesise the extensive list of sales promotion means, J. Lendrevie and D. Lindon propose a classification into six categories [7]:

1. Free trial – free distribution of product samples (either to the consumer's home, or in stores, or in other places);
2. Temporary price discounts – a direct reduction in retail prices for a determined period of time; discount coupons, distributed to potential buyers by mail, press or in packaging; partial reimbursement of the product's price by presenting 'proof of purchase'; bulk discounts to listed price depending on the purchased quantity;
3. Gifts and rewards – direct rewards (a gift given directly with the purchased product); loyalty bonuses granted to consumers for several proofs of purchase;
4. Games and competitions – the competition may imply certain purchase commitments (for instance, the answer form must be accompanied by a proof of purchase); the contest contains questions which should not be too facile and should appeal to the participant's knowledge and intelligence (if the questions are too easy, the contest is considered a game);
5. Temporary merchandising – free sampling stalls (for food products) or new product demonstration stalls (for non-food products); shelf ends;
6. Sales promotion destined for distributors – gifts in kind or in cash, contests.

Another form of sales promotion is represented by salons, fairs and exhibitions. Regional, national or international, they may be excellent opportunities for a firm to make itself known, to promote its products and possibly carry out exchanges of goods.

Professional salons allow reaching an established target for a particular centre of interest. Fairs are markets with regular periodicity, organised in well delimited perimeters and concentrating a certain supply and demand for goods. The supply is presented in each participant's stall by samples, illustrative documents (catalogues, technical sheets, flyers, brochures etc.) referring to the issue of new products and the technical perfecting of their fabrication, with the aim of promoting and performing commercial transactions [8]. If well-orchestrated, a company's presence at exhibitions may render a gain in market share.

Among the most important fairs and international salons dedicated to the clothing industry with original collections we recall: Fashion SVP London (international sourcing fair, biannual, launched in 2011 as a section of the renowned London Off-Price Show – industry fair with inventory items and collections of clothes and footwear). Within Fashion SVP London, production surpluses or cancelled orders are sold and new contacts are established, seeing that there is a high demand in the UK market for products from geographically close fast-fashion suppliers; Prêt-à-Porter Paris (biannual presentation platform for designers and firms with original brands desiring to enhance their visibility and to contact new buyers); Sixty Days Paris (fair launched in 2011, biannual, addressing fast-fashion producers). The name of the fair refers to the average frequency of inventory renewal. According to the French Fashion Institute, short term purchases represent almost 35% of the market demand, and their market share is constantly on the rise [9]); Fast Fashion Tour London (fair initiated in 2011 which took up the successfully implemented Parisian model of Zoom by Fatex, endeavouring to customise it for the British market. The fair has three sections: fabrics and apparel, subcontractors and private labels); Who's Next Paris (clothes design fair, biannual); Premium Messe Berlin (clothes design fair); Madrid International Fashion Fair (SIMM) – mainly addressed to producers with original brands; the International Lingerie Salon (SIL) Paris (notable global event dedicated to lingerie that celebrated 50 years since its first edition on January 2013); Mode City Paris International Salon (international fair dedicated to lingerie and bathing suits) and so on.

Among the most important fairs and international salons addressed primarily to producers processing under lohn system, we recall: Zoom by Fatex – Paris with two editions every year, reaching its 11th edition); Texprocess Frankfurt (the "Source it" section of the fair connects fashion brands to manufacturing companies) and so on.

Among international fairs, the following are financed from state budget sources: Premium Messe Berlin, Who's Next and The Bride Show Dubai (garment design fairs) and Zoom by Fatex Paris (fair for lohn processors).

In Romania, the main relevant exhibitions are: the TINIMTEX Clothing and Footwear Fair (organised by the Chamber of Commerce, Industry, Navigation and Agriculture of Constanţa, at its 57th edition, it takes place in Mamaia resort and reunites producers from Romania and Europe); the Confintex Clothing and Footwear Fair organised by S.C. ExpoConfintex S.A., the Federation of Unions in the Garment Industry (FEPAIUS) and the County Councils of the cities where the fairs are organised. Until 2009, Confintex took place in ten Romanian cities; however, starting with 2010, it is held in only three cities, namely: Mamaia, Braşov and Ploieşti. The highest number of participants has always been recorded in Mamaia. Given the economic crisis, not only the number of hosting cities has decreased, but also the number of participants, from around 200 firms to 100 in 2012; MODEXPO (international exhibition of contractors for clothing, textiles, leather and footwear) organised by Romexpo and reuniting producers throughout the country; children's clothes fairs held with mainly Romanian producers at Sala Polivalentă in Bucharest (Baby Expo), Romaero Băneasa (Baby Boom Show), Romexpo Bucharest (KIDEX), Centrul expoziţional Constanţa (KIDO). All these fairs host contests, prizes (lotteries for babies and pregnant women), games, product testing. The fair at Sala Polivalentă also provides medical assistance for children, pregnant women, mothers of new born babies etc. In Bucharest there are six such fairs per year, and those organised at Romaero and Sala Polivalentă benefit from TV advertising.

ADVERTISING – MEANS OF COMMUNICATION AND SALES PROMOTION TECHNIQUE

T. Purcărea and V. Ioan-Franc consider that sales promotion, as a ***general endeavour***, includes, for example, the communication of information on: the company, the brand, the product's composition, collective advertising, demonstrations, various exhibitions, sponsorships.

A consumer-oriented approach contains especially merchandising, price discounts, games and contests, sample distribution and any other promotional initiative at point of sale which are performed not only by distributors, but also by producers, importers, wholesalers.

A distributor-oriented approach is often highly diversified: the supply of advertising and promotion material at point of sale, competitions, gifts, rewards, financial contributions to individual or collective distributor activities [10].

Advertising, as means of communication and sales promotion, is not altruistic information, but a temptation to desiring and buying a product. Thus, advertising allows the company to transmit a message to potential buyers it does not enter in direct contact with. In fact, through advertising, the firm applies a push communication strategy having as main objective the creation of a brand image and notoriety capital [11].

Advertising must be appreciated from the point of view of its presumed influence on the consumer, depending on the channel used. TV is the most widespread and costly media available, with the most dramatic impact.

The written and especially electronic press are effective and economic means of advertising. Most readers consider written press announcements less aggressive than those on TV, also having the possibility of selecting the publications they trust.

As a mass promotional medium, the written press presents notable advantages: visualisation and argumentation – through illustration and text (the permanence of the written word enhances communication strength). Also, it has the benefit of offering better geographical direction to promotional activities – through target reader segments. The written press is also used as a 'carrier media support' in various promotional activities: sampling, discount coupons, flyers etc. inserted in specialised publications and so on.

Billboard advertising permits a highly notorious means of communication with limited content and lacking any real argumentative possibilities; it is used more for local impact campaigns than for large national actions.

On the other hand, famous advertising mediums such as TV, radio, newspapers etc. are successfully competed against by the Internet. The Internet showroom, the site in its simplest or complex form, aims at promoting the products and services of a firm.

Virtual showrooms are profitably used for electronic trade promotion. Most firms create increasingly complex websites, by using programs and dynamic page generation. The creation of a pleasant interface mainly constitutes the secret of a site's success [12].

STUDY ON SALE PROMOTION TECHNIQUES USED BY ROMANIAN FIRMS ACTIVATING IN THE GARMENT INDUSTRY AND THEIR EXPANSION PROSPECTS

In the present research, we set out to bring a substantial theoretic and pragmatic contribution in the studied domain. The necessity of examining sales promotion techniques used by Romanian firms in the garment industry and their expansion possibilities is justified by the increase in the number of firms with original brands. The fact that Romanian textile companies mainly operated in lohn system starting with 1991 did not make a critical preoccupation out of elaborating and using sales promotion techniques. From 2006, Romanian lohn operators have significantly diminished. Given the global economic crisis, their number continued to decrease, leading to the design and production of own brands and to the need of operating with instruments of the marketing mix appropriate to, and also constrained by the new socio-economic conditions.

At the same time, firms still operating in lohn and full-product exporters supported by lohn processing are also compelled to attract and maintain clientele.

In order to obtain valid information on sales promotion techniques and their expansion potential for Romanian firms operating in the garments industry, we performed an opinion survey among them. The survey consisted in a questionnaire distributed to the managers of the analysed firms. The present research follows four main objectives:

Objective 1: The identification of production specificities showing sales promotion techniques' characteristics used by Romanian firms in the garments sector;

Objective 2: The identification of sales promotion techniques used preponderantly by Romanian textile firms;

Objective 3: The identification of the current status of correspondence between the promotion techniques used and companies' performance;

Objective 4: The description of future development directions for using sales promotion techniques for Romanian firms in the garments industry.

The questions were structured into three sections:

I. General information on the analysed firms

This section contains general questions on identification, address, the development region the firm belongs to, size judging by number of employees, capital structure, and product destination.

The sample of firms researched

The questionnaire-based investigation was performed on 176 firms operating in women's, men's and children's clothing industry from all development regions of Romania and refers to the year 2012. Details on the territorial structure of the sample investigated are presented in table 1.

Presentation of general information on the companies in the sample

Considering capital structure, out of the 176 firms, 17 are mixed companies with foreign capital, and 159 are firms with local capital (fig. 1). The structure of the companies by number of employees is presented in table 2.

It can be observed that the percentage of micro-enterprises within the analysed sample is of 48.30%, of small enterprises of 30.68%, of medium-sized entities of 19.32% and of large companies of 1.70% (fig. 2).

By destination of products, among the 176 firms, 114 are involved in exports, the other 62 addressing the internal market with their own brands. Out of the 114 exporting firms, 71 export their entire production

Table 1

SAMPLE DISTRIBUTION BY DEVELOPMENT REGIONS			
No.	**Development region**	**No. of firms analysed**	**Percentage, %**
1	North-West	22	12.50
2	North-East	23	13.07
3	West	20	11.36
4	Centre	35	19.89
5	South-West	12	6.82
6	South-East	20	11.36
7	South	29	16.48
8	Bucharest and Ilfov	15	8.52
Total		**176**	**100**

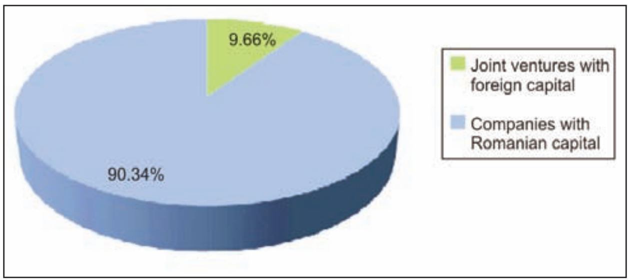

Fig. 1. Structure of the sample by capital type

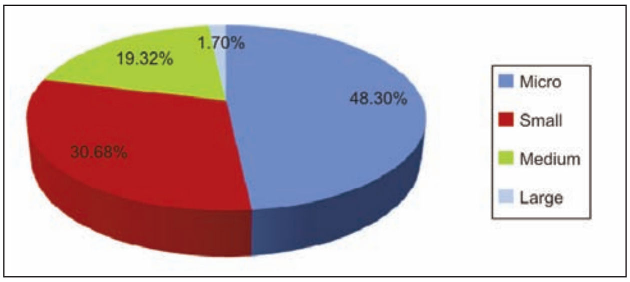

Fig. 2. Structure of the companies by the number of employees

Table 2

COMPANY STRUCTURE BY NUMBER OF EMPLOYEES				
Total	**Large** (over 250 employees)	**Medium** (50-249 employees)	**Small** (10-49 employees)	**Micro-enterprise** (1-9 employees)
176	3	34	54	85

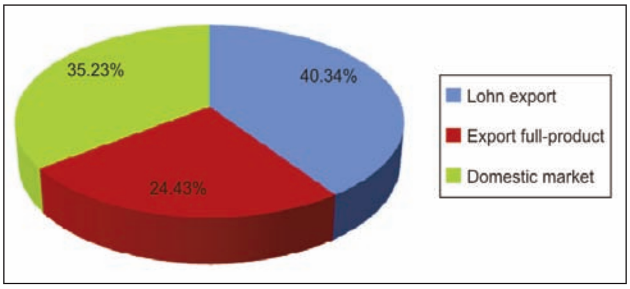

Fig. 3. Product destination

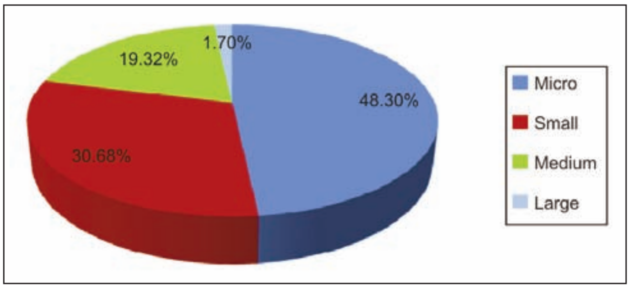

Fig. 4. Acceptance level of expanding sales promotion techniques

through lohn, and 43 firms make full-product exports, whilst also being supported by lohn processing (fig. 3).

II. Information on current promotion techniques used by Romanian firms in the garments industry

The question set used in this section most directly serves the purpose of the research, since it seeks to identify respondents' opinions on the importance of using promotion techniques and their appropriateness in the current socio-economic context, the links between the processing form and the promotion techniques used, the identification of concrete promotion techniques used, as well as their correlation to the firms' performance, size, development area, difficulties in adopting the techniques.

On aspects regarding the analysed companies' increase in sales, gaining more customers and transforming them into loyal users, the answers received have revealed some managers' relatively high interest for using and extending sales promotion techniques. On the other hand, from analysing the replies received, one concludes that a relatively high number of managers do not give the appropriate credit to using, let alone extending these techniques. The latter category primarily invoked the large costs associated with using sales promotion techniques.

It is obvious that, in order to increase sales volumes in the context of the global economic crisis, managers and shareholders have to be aware of the necessity of appealing to various sales promotion techniques, appropriate to the current socio-economic context and capable of capturing increasingly sophisticated, reluctant and price-sensitive consumers' interest. The measure in which they manifested agreement with the assertion that 'extending the use of sales promotion techniques is one of the factors ensuring the success of the firm' is provided in figure 4.

The results reveal that:

- 51.70% of the respondents agree with the above affirmation, in clear or less categorical terms (total or partial agreement);
- 44.32% do not agree with the assertion (total or partial disagreement);
- 3.98% do not express any point of view.

From these answers we notice that a little over half of the investigated managers appreciate the role and importance of enhancing the use of sales promotion techniques for their firms. On the other hand, a significant number of managers (44%) do not perceive any connection between the success of their firms and the use of promotional techniques and their expansion. Moreover, these invoke the lack of financial resources in general and of those budgeted for promotional activities in particular. The correlation analysis between the awareness of the need of expanding sales promotion techniques and firm size is presented in table 3. In this context, the need to know a wide range of sales promotion techniques as well as to expand their use becomes apparent.

With regards to sales promotion techniques employed by full-product firms, out of the 43 analysed firms, 15 took part in Fashion SVP London: 2 large, both from the S - E region, 13 medium – 8 from N - W, 1 from N - E, 1 from the West, 2 from the

Table 3

CORRELATION ANALYSIS BETWEEN THE AWARENESS OF THE NEED OF EXPANDING SALES PROMOTION TECHNIQUES AND FIRM SIZE

Respondent firms	Micro 85	Small 54	Medium 34	Large 3
out of which:				
Total agreement	8	10	12	2
Partial agreement	26	21	11	1
Do not know/ cannot speculate	5	2	-	-
Partial disagreement	8	12	8	-
Total disagreement	38	9	3	-

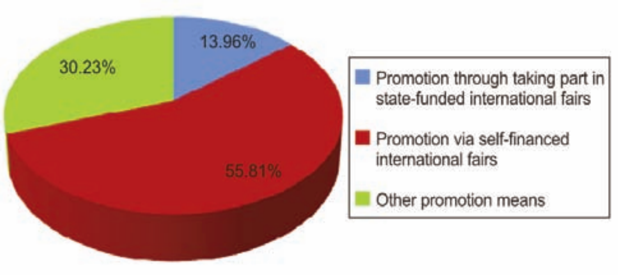

Fig. 5. Sales promotion techniques used by full-product exporters

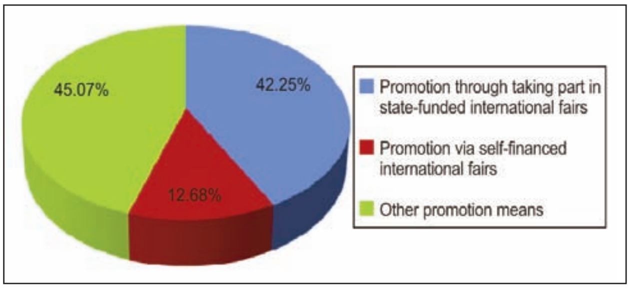

Fig. 6. Sales promotion techniques used by lohn processors

Centre and one from Bucharest - Ilfov; 3 firms in the Prêt-à-Porter Paris fair, all from Bucharest - Ilfov; 1 medium - sized from Bucharest - Ilfov went to Sixty Days in Paris; 2 companies to Fast Fashion Tour London (1 medium from N - W and a small one from S - E that exhibited in the private labels section); 5 firms sent their designer collections to Who's Next Paris (3 small central firms, 2 small from S - W and South respectively); 1 small firm from N - W sent its collection to Premium Messe Berlin; 2 medium firms from Bucharest - Ilfov participated in the Madrid International Fashion Fair (SIMM); 1 large lingerie and bathing suits company from N - W obtained notable awards at the International Lingerie Salon (SIL) and the Mode City Paris International Salon. In SIL, it launches new collections, makes creative stalls, organises 4 - 5 daily parades alongside well-known ballet troupes. At the Mode City salon, it received the creativity award, and one year claimed both the grand prize and the audience award. This firm is an atypically positive example for Romanian fashion in that it invests considerably in promotion, understanding the need for its presence in such events. The investment in presenting collections at a single event exceeds 200 000 euro. The rest of 13 full-product exporters not taking part in fairs argument that this technique is very costly relative to their financial power, seeing that they are micro- and small enterprises. These companies' managers hold that by acting on market niches (sports niche, occasion clothing for children, eco niche) they have traditional partners to whom they provide good value for money products and guarantees (for sportswear), a reason why they do not need promotion through fairs.

The 43 full-product exporters have official web-sites, most of which are for presentation purposes, and some also for commercial ends, varying from the spectacular (large, N - W firm) to the utilitarian and practical (medium, Bucharest - Ilfov firm). These firms also promote their products by means of online social networks (fig. 5).

On the issue of promotion techniques used by lohn-processors, out of the 71 analysed firms, 30 took part in the fair Zoom by Fatex (7 small Centre ones; 7 from S - E – 2 large, 1 medium, 3 small and 1 micro; 6 firms from Bucharest - Ilfov – 2 medium and 4 small; 5 small firms from N - E; 3 Southern firms – 1 medium and 2 small; 1 medium from N - W; 1 small from S - W); 9 firms went to Texprocess Frankfurt (3 medium from N - W; 4 medium from the West and 2 Central medium). Out of the 32 firms not participating in fairs, some invoke other means of establishing contacts (the use of intermediaries etc.), and the rest, the affiliation to one of the four Romanian textile-clothing clusters that ensure their representation especially in trade relations and the Export Council. All 71 companies have presentation web-sites (fig. 6).

With regards to promotional techniques used by companies addressing the domestic market, out of the 62 analysed firms, 7 medium-sized – 3 N - W, 2 Centre, 2 W – took part in Tinimtex; 4 firms (3 medium – 1 N - E, 1 N - W, 1 W; 1 small from Bucharest - Ilfov) went to Confintex (at least one edition of each in 2012 when the research was made) and 2 to Modexpo (both medium, 1 S, 1 S - E). From the 4 firms attending Confintex, 3 went to the fair organised in Mamaia and 1 in Braşov (Ploieşti was neglected). Turning to children's clothing fairs, 1 small firm from Bucharest - Ilfov went to Sala Polivalentă, 1 small N - E firm to Romaero, and none to Romexpo.

Other promotional techniques used by the firms focused on the domestic market are:

- 21 firms practice temporary price discounts: direct retail selling price reduction during a determined, seasonal period of time. In addition, 2 firms out of 21 participate in national fairs, and use at least two sales promotion techniques, with impact on their financial performance;
- 1 small Centre firm offers loyalty cards granting discounts to clients either from their first purchase, or after a given number or value of purchases. This firm thus uses a mix between the classical bonus point accumulation system and the percentage discount loyalty system depending on the level of accumulated sales (as you shop, besides the recorded points which transform into money, the card cumulates your purchases, and gradually pass you to a different level of appreciation, granting further discounts at any offer of the firm's products from its own stores and online shops);
- 1 medium sized firm in Bucharest - Ilfov gives voucher type gift cards storing from 100 to 300 lei, which the beneficiary may use for the purchase of products in the company's stores;
- 1 small children's clothing firm in Bucharest - Ilfov grants both loyalty cards and gift cards, issues a

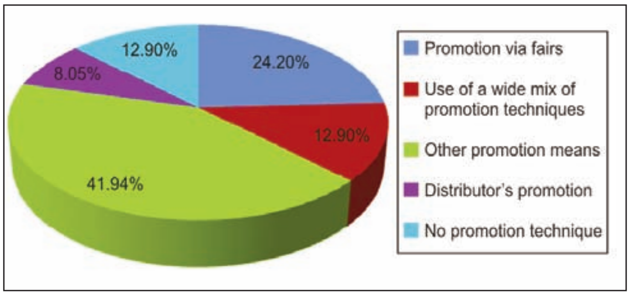

Fig. 7. Sales promotion techniques used by firms addressing the domestic market

newsletter, uses social networks, organises competitions in its stores and online. This firm too appeals to a varied mix of promotion techniques, a fact reflected in its performance;

– 1 medium firm from N - W also appeals to a varied mix of promotion techniques: collaborations with well-known artists (starting in 2008 with the couple Paula Seling-Radu Bucura, and providing Paula's stage attire at the 2010 edition of the Eurovision Song Contest in Oslo, Norway), collection releases where cultural figures are invited, radio advertising, posters, involvement in national and international fairs. Yet again, in the case of this firm, using a diverse mix of promotion techniques is reflected in the high financial performance of the firm;
– 1 micro-enterprise in Bucharest - Ilfov makes offers to its clients in the line of buy two get one free, small gifts upon the purchase of occasion clothes from its stores, such as apparel etc.;
– 3 firms organise promotional campaigns of Romanian products: 2 of them (one small and one medium) belong to the Romanian Textile Concept cluster revolving around the concept of 100% RO. These firms took part in the design of the 100% RO collections, organised in 2011 at the French Embassy and presented upon several of promoting Romania abroad. The third is a micro-enterprise from N - E which activates in the eco-niche for children and sells its products in packaging with "Made in Romania" prints. Moreover, the firm has invested in personalised bags with information on the benefits of organic cotton as well as in promotional banners it distributes to its partner stores for free. Consequently, these 3 firms use a wide range of sales promotion techniques, again reflected in their improved performance;
– only 3 firms in the Central region (2 medium, 1 small) distribute flyers and/or brochures;
– 1 small producer of pyjamas and house clothing in the N - E uses merchandising. The firm sells its products in spaces entitled Home Collection or Home Sweet Home, alongside bed linen, dishes, home decoration etc. The firm also attends national fairs, using at least two sales promotion techniques;
– 1 small firm in Bucharest - Ilfov provides the clothing for TV hosts, its name being mentioned by one of the hosts at the end of the show as well as in the show's credits;
– most firms have presentation web-sites, but less find e-commerce appealing, some use social networks.

Out of the 62 firms addressing the domestic market, 13 do not use any sales promotion technique, and 5 identify their distributors' price discounts and/or commercials as beneficial and sufficient (fig. 7).

III. Future directions of expansion in the use of promotion techniques for Romanian firms in the garments industry

This section is crucial since it presents the main future means of extending the use of promotion techniques for textile firms. Future expansion directions for the use of sales promotion techniques by Romanian firms activating in the garments industry:

– the knowledge and awareness of the advantages of using and extending sales promotion techniques by taking part in trainings, seminars, specialised workshops;
– the accessing of European funding (POS CCE), as well as government funding destined for the promotion of SMEs;
– the necessity for all firms to possess online presentation platforms conceived according to brand image, but also shifting to online sales. Informing clients about new products through social networks and newsletters is useful and economic;
– starting collaborations with firms in the four Romanian textile-garments clusters (the N-E ASTRICO Cluster, the Romanian Textile Concept – Bucharest - Ilfov, the Traditions Manufacture Future TMV Cluster in the S - E, the Transylvania Textile & Fashion Cluster – Centre) so as to promote and sell products, inasmuch as the study revealed an increased financial and logistic potential for the firms in the four respective development areas;
– the increase in the number of firms participating in specialised fairs;
– the necessity of generalising the elaboration of flyers, brochures, presentation catalogues, the multiplication of price discounts, the organisation of games and contests;
– the increase in the number of firms investing in promotional banners and other financially convenient advertising means (Internet commercials, radio ads);
– the distribution of samples (for instance, firms activating in the eco niche could distribute samples for free during six months to a panel of consumers and a panel of stores. For new born eco clothing articles, the consumer panel could be comprised of pregnant women, or the goods may be distributed in maternities; for adult eco clothing, the consumer panel could have patients in dermatology hospital wards, and for producers of medicinal stockings and/or stockings with gradual compression, the panels may be comprised of

patients in the orthopaedic section of hospitals, but also people with professions involving standing up most of the working hours. For correctly ascertaining consumption and consumers' education, the free distribution of samples in the first six months must be accompanied by studies on the implication of consuming these goods, studies performed every six months;

– raising awareness on the importance of expanding the use of sales promotion techniques for brand image creation, or in case of rebranding, raising awareness on the fact that the success or failure of the re-launched product depends on the appropriate use of these techniques.

CONCLUSIONS

The study has revealed the fact that exporting firms use sales promotion techniques more frequently than those addressing the domestic market. Furthermore, the study shows that large and medium-sized companies use a wider variety of promotion techniques, this situation being corroborated with their increased financial power and performance. Overall, firms in the regions N - W, Centre, S - E, Bucharest - Ilfov and N - E are those that more often use varied promotion techniques, appropriate to the current socio-economic context. In addition, the study has identified a significant number of garment company managers not aware of the importance of using sales promotion techniques (firms with short term strategies, risky in the context of their evolution in a turbulent, dynamic environment), but also a number of managers who do not use promotion techniques from lack of financial resources. On the other hand, the mere presence in virtual space (presentation sites and/or social networks) is far from being a sufficient technique for promoting sales. The paper identifies expansion directions for the use of promotion techniques by Romanian firms in the garments industry.

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