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Efficiency representing geometrical structure of plain woven fabrics in tactile rendering technology: a psychophysical study

RUITAO JIANG XIN DING

REZUMAT – ABSTRACT

Eficienţa structurii geometrice a ţesăturilor plane în tehnologia tactilă: studiu psihofizic

Dezvoltarea de textile virtuale necesită cunoaşterea urgentă a relației psihofizice dintre parametrii de construcție a ţesăturii și senzațiile tactile. Pentru a analiza această relaţie psihofizică, studiul se concentrează pe cuantificarea percepției tactile a modificărilor minore ale parametrilor de construcție (densitatea firului de bătătură și diametrul firului de bătătură) ai caracteristicilor țesăturilor plane prin metoda de estimare a magnitudinii și metoda de comparație prin perechi. Se calculează pragul de discriminare și fracțiunea Weber. Experimentele arată că atât rugozitatea percepută, cât şi senzaţia de tuşeu moale scad odată cu creşterea desimii firelor de bătătură și a diametrului firelor de bătătură. Fracția lui Weber pentru desimea firelor de bătătură este 0,0997 pentru rugozitate și 0,1066 pentru tuşeul moale, iar pentru diametrul firelor, 0,0494 pentru rugozitate și respectiv 0,0334 pentru tuşeul moale. S-a ajuns la concluzia că diametrul firelor de bătătură a fost mult susceptibil de a domina percepția tactilă în comparaţie cu desimea firelor de bătătură.

Cuvinte-cheie: desimea firelor de bătătură, diametrul firelor de bătătură, rugozitate, tuşeu moale, fracţia lui Weber

Efficiency representing geometrical structure of plain woven fabrics in tactile rendering technology: a psychophysical study

The development of virtual textile has an urgent need to know the psychophysical relationship between fabric construction parameters and tactile sensations. To insight into the psychophysical relationship, this research focuses on quantifying the tactile perception of minor changes in constructional parameters (weft yarn density and weft yarn diameter) of plain fabrics by the magnitude estimation method and the paired comparison method. In addition, the discrimination threshold and the Weber fraction are calculated, respectively. Experiments show that both perceived roughness and softness sensation decrease with an increase of weft density and weft yarn diameter. The Weber fraction for weft density is 0.0997 in roughness and 0.1066 in softness, for yarn diameter 0.0494 in roughness and 0.0334 in softness, respectively. It was concluded that weft yarn diameter was more likely to dominate tactile sense than weft density.

Keywords: weft density, weft yarn diameter, roughness, softness, weber fraction

INTRODUCTION

With the development of online shopping, the virtual rendering techniques of textiles have dramatically developed during the last two decades [1]. Nowadays, to simulate virtual textiles in real time, virtual reality systems which **aim** to reproduce the feeling of touching a cloth surface with fingertips have been researched [2, 3]. In virtual reality systems, **modelling** the physical **behaviour** of textiles and tactile properties feedback are both based on the physical properties of real textiles. Meanwhile, the algorithm expense cost for virtual reality systems is high and the real-time rendering efficiency is low. When the tactile rendering device performance is limited, the solution is to decrease feature space of physical properties of real textiles and **defines** strategies to reduce haptic information complexity, as well as to remain the necessary features for the generation of typical tactile textures. In this sense, it is very important to know how human is sensitive to main features of textiles by bare fingertip, i.e. the psychophysical properties. This study will focus on the capability of human in perceiving the structural features of plain woven fabrics, i.e. the relationship between constructional parameters and tactile properties.

On the other hand, the quantitative psychophysical relationship is still not clear, though a considerable volume of research outcomes have been reported on relationships between constructional parameters and the fabric's tactile quality. For example, Behmann in 1990 stated that the subjective perception of textiles was related to the textile construction parameters [4]. By researching fabrics which are made of air jet yarns and ring spun yarns, respectively, Behery found that the compression properties and shearing properties are mainly controlled by fabric weave and thread density [5]. And also, many negative properties especially surface harshness might be improved by choosing an appropriate weave (e.g. twill or satin weaves) [6]. Furthermore, Koc et al. also investigated the effect of fabric constructional parameters (weft yarn density, weft yarn diameter and pattern) on textile surface friction concluded that with both increasing weft yarn density and weft yarn diameter, coefficient of friction increases at the same time plain weave yielded higher coefficient of friction than twill weave [7]. On the basis, Mooneghi et al obtained the

evidence that there are significant relationships between weft density and surface roughness [8]. However, qualitative studies were not sufficient to represent the tactile properties of fabrics, there was no systematic conclusions about the quantitative relationship between fabric constructional parameters and the psychosocial physical properties (e.g. roughness and softness).

In this research, two sets of plain woven fabrics, with respect to two basic construction parameters, i.e. weft yarn density and weft yarn diameter were designed to capture the psychophysical relationship between basic fabric construction parameters and typical tactile sensations by the magnitude estimation methods and the paired comparison method, and the Weber fraction was calculated.

EXPERIMENTAL WORK

Materials

In this study, plain fabrics which were industrially produced by means of LT102 type rapier loom were shown in table 1. The fabrics were cut into 20 cm × 20 cm squares and stereoscopic microscope images were shown in figure 1.

Evaluation conditions

Tests were performed in standard atmosphere (20 ± 2°C and 65 ± 5% relative humidity) and fabrics were preconditioned for 24 h before evaluation. The sensory evaluation method that refers to AATCC Guidelines for the Subjective: Evaluation of Fabric Hand at the same time Sensory Analysis Methodology Magnitude Estimation (GB/T 19547-2004) has been used to evaluate experiment's data [9]. The subjects were eighteen men and twelve women, aged from 18 to 24, most of them were textile background.

Research Method

Before experiment, fabrics were randomly put on a smooth table. Subjects entered into the lab ahead of thirty minutes, and then touched successively and gave the score of roughness and softness (the score of reference sample is 50). In addition, in a forced-choice procedure, subjects were asked to compare any two fabrics to rank them from smoother to rougher and softer to harder, respectively, in subsequent intervals corresponding to the reference and comparison stimulus. The order of presentation of the reference and the comparison varied in a pseudo-random fashion between trials. To obtain reliable results, strict controlled procedures have been implemented and the evaluation has been performed in blind conditions. Each sample was measured three times.

In order to avoid that each assessor's score coordinate system is different, the data of experiment was normalized and we used Grubbs tests to reject the abnormal value to avoid assessors that were affected by accidental factors in subjective experiment such as fatigue etc. Additionally, a multivariate analysis of variance was computed to test the validity and reproducibility of experiments (significance level of 5%). The results of three experiments were listed in table 2, for roughness and softness sensation, the three experiments of weft density (p=0.85 and p=0.59) are no significant difference at the level 0.05, similarly, the three experiments of weft yarn diameter (p=0.77 and p=0.9) are also no significant difference. The method of magnitude estimation was used to qualitative analyse the relationship between tactile sensation and constructional parameters. On the other side, the methods of paired comparison and

Table 1

CONSTRUCTIONAL PARAMETERS OF WOVEN FABRIC

Fabric No.	Warp × Weft density (yarns/cm)	Count (Nm)	Diameter (μm)	Compression loading energy (%)
1	28×16	27×27	240	0.32
2	28×18	27×27	240	0.38
3	28×20	27×27	240	0.39
4	28×22	27×27	240	0.40
5	28×24	27×27	240	0.41
6	28×24	27×17	305	0.39
7	28×24	27×21	278	0.38
8	28×24	27×24	258	0.34
9	28×24	27×27	240	0.31
10	28×24	27×36	210	0.29

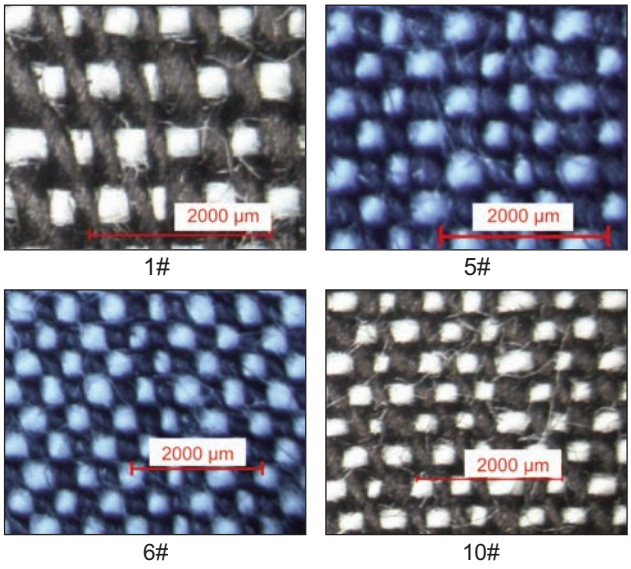

Fig. 1. Stereoscopic microscope images of fabrics (20 times)

Table 2

THE SIGNIFICANCE OF THREE EXPERIMENTS BETWEEN TYPICAL TACTILE SENSATION AND TWO CONSTRUCTIONAL PARAMETERS

Significance	Roughness sensation	Softness sensation
Weft density	0.85	0.59
Weft yarn diameter	0.77	0.9

psychometric functions which fitted with a cumulative Gaussian function were used to calculate the Just Noticeable Difference(JND) of roughness and softness sensations that were affected by weft density and weft yarn diameter, respectively [10].

We modelled the responses of each participant using psychometric functions, and the followed models are used:

$$\Phi^{-1}[P(Y_j=1)]=\beta_0+\beta_1 x \qquad (1)$$

In a given trial j, $Y_j=1$ if the participant reports that the fabric was softer in the comparison with the reference and $Y_j = 0$ otherwise. $P(Y_j=1)$ is the probability of perceiving a softer fabric in the comparison and Φ^{-1} is the probit transform of this probability. On the right side of the equation, x is the physical property of the textiles in the comparison stimulus and β_0, β_1 are the intercept and the slope of the linearized equation, respectively. The point of subjective equality (PSE = $-\beta_0/\beta_1$) is an estimate for the accuracy of the percept. Next, the analysis was extended to the whole population ($n=30$) with a generalized linear mixed model GLMM [11, 12]. The GLMM is similar to the psychometric function, with the advantage of allowing the analysis of clustered data-as in our case the collection of repeated responses in several participants. The PSE and the 95% confidence interval are estimated in the two experimental conditions.

RESULTS AND DISCUSSION

When human fingertip touches plain woven fabric surfaces, the variance of surface properties from different constructional parameters implies different mechanical interaction between plain fabrics and finger pulp, the change of tactile stimulus intensity can lead to full tactile quality. This section will firstly report the effect of constructional parameters on tactile roughness and tactile softness sensation, and then the psychometric properties will be presented.

Weft yarn density effect

When weft yarn densities increased from 16, 18, 20, 22 to 24 picks/cm, the perception of roughness and softness steadily decreases with the gradually increasing of weft yarn density, as shown in figure 2. This result can be attributed to an increase in the contact area and the number of yarn intersection points per unit area. As the weft yarn density increases, more material is filled in the gaps so that we get more uniform stimuli when touching the fabric. According to the conclusion of Weber, roughness sensation decreased with the figure getting uniform stimuli, so this result fits very well with the conclusion of Weber's [13]. Additionally, it has been observed that when the weft density is increased, the softness sensation decreases. With the increase of weft density, fabric tightness increased leading to the difficulty of deforming, Bergmann found that softness was proportional to fabric's deformation [14]. Therefore, a decrease in perception of softness as the weft density is increasing.

Weft yarn diameter effect

Figure 3 plotted the relationship between weft yarn diameter and roughness sensation and softness sensation. It is illustrated that softness sensation decreases linearly with the increasing weft yarn diameter. The result can be attributed to finer yarns yield smoother surface than thicker yarns that the relative elastic modulus of fabrics which are composed of finer yarns is low [15]. For roughness sensation, it's an interesting phenomenon. When the yarn diameter is 240 μm, the subjects feel rougher than other yarn diameter. As the yarn diameter continues to increase, the roughness sensation decreased but marginally increased at 305 μm. Fabrics constructed with coarse yarns yield more uniform surface than finer yarns since intersection points of yarns between two adjacent yarns are smaller, so the general trend is as the yarn diameter increases, the roughness sensation decreases.

Weber fraction

Here, the main physical properties consisting of weft density and weft yarn diameter were assumed as the physical stimulus, and their discriminability was calculated and compared by two psychometric parame-

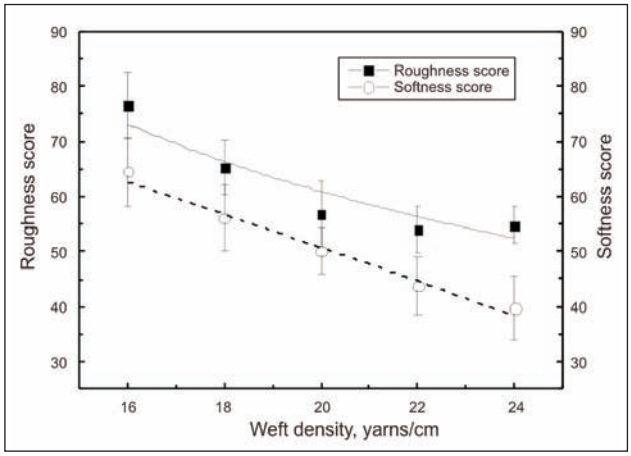

Fig. 2. Effect of weft density on sensory evaluation

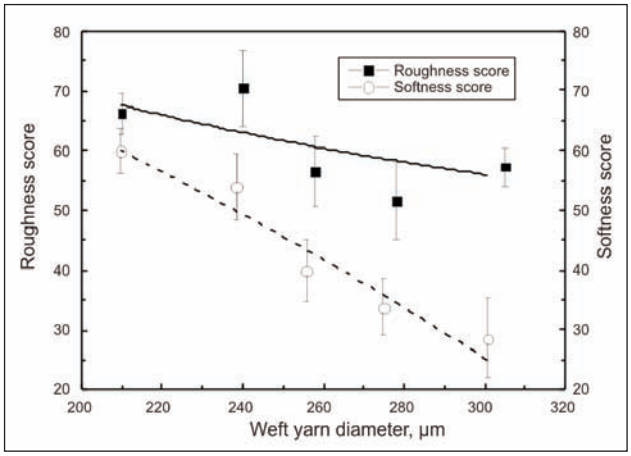

Fig. 3. Effect of weft yarn diameter on sensory evaluation

Table 3

CORRECT RATE OF PAIRED COMPARISON IN ROUGHNESS SENSATION AND SOFTNESS SENSATION FOR DIFFERENT CONSTRUCTIONAL DIAMETERS										
Weft density (yarns/cm)	**Correct rate of paired comparison**									
	Roughness sensation/Softness sensation									
	16		**18**		**20**		**22**		**24**	
16	-	-	0.83	0.86	0.94	0.81	0.92	0.94	0.97	0.92
18	-	-	-	-	0.92	0.83	0.94	0.86	0.89	0.97
20	-	-	-	-	-	-	0.64	0.75	0.47	0.89
22	-	-	-	-	-	-	-	-	0.58	0.53
24	-	-	-	-	-	-	-	-	-	-
Weft yarn diameter (μm)	**Correct rate of paired comparison**									
	Roughness sensation/Softness sensation									
	210		**240**		**258**		**278**		**305**	
210	-	-	0.53	0.92	0.86	0.94	0.89	0.97	0.86	0.97
240	-	-	-	-	0.83	0.86	0.92	0.89	0.94	0.94
258	-	-	-	-	-	-	0.83	0.86	0.58	0.94
278	-	-	-	-	-	-	-	-	0.36	0.81
305	-	-	-	-	-	-	-	-	-	-

* Accuracy rate of paired comparison about roughness sensation and softness sensation based on the results of the magnitude estimation method.

Table 4

JND AND WEBER FRACTION FOR MAIN PHYSICAL PARAMETER				
	JND		**Weber fraction**	
	Roughness sensation	**Softness sensation**	**Roughness sensation**	**Softness sensation**
Weft density	1.5952	1.9195	0.0997	0.1066
Weft yarn diameter	10.3785	7.0232	0.0494	0.0334

ters, namely the Just Noticeable Difference (JND) and the Weber fraction. Table 3 showed that the correct rate of paired comparison in roughness sensation and softness sensation for different constructional parameters. Apparently, it is easy for the subjects to discriminate the nuance of roughness sensation and softness sensation as touched different fabric samples.

From the psychometric function fitting to the correct percent in a two-alternative forced-choice task and the relevant physical stimulus, the calculated psychometric parameter values were listed in table 4 that revealed a quantitative difference in the discriminability and the detectability. For weft yarn density, the Weber fraction of roughness sensation is less than that of softness, meaning that people can easier sense the difference of roughness than softness when we add a slightly smaller number at the same weft density condition. When weft yarn diameter varies, the Weber fraction of roughness sensation is larger than that of softness sensation, it just contrary to weft density's. On the other hand, the Weber fraction of weft yarn diameter, whether roughness sensation or softness sensation, is smaller than weft density, that is to say, the tactility is more easily affected by yarn property than weaving process.

CONCLUSIONS

In this article, the psychophysical relationship between basic fabric construction parameters and typical tactile sensations were discussed by the sensory analysis method. The obtained results show that the variety of weft yarn densities and weft yarn diameters have a significant effect on the tactile sensory. The detailed conclusions were summarized below:

1. The perceptions of roughness and softness steadily decrease with a gradually increase of weft yarn density and yarn diameter.

2. The Weber fraction of weft density is 0.0997 in roughness sensation and 0.1066 in softness sensation. Obviously, the weft density's contribution to roughness sensation is greater than softness sensation. For weft yarn diameter, the Weber fraction is 0.0494 in roughness sensation and 0.0334 in softness sensation, contrary to what the phenomenon weft density told us, so it can draw a conclusion that weft yarn diameter has a great influence on softness sensation.

3. With respect to the detectability, the Weber fraction of weft yarn diameter is smaller than weft density, in other words, the change of weft yarn diameter is more likely to cause the difference of tactile. So the property of weft yarn was superior to weft density to affect the difference of tactile. With the guidance of the results, the technique of virtual textiles could reproduce exactly tactile sense and textile industries could design more comfortable products by adjusting process parameters.

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Key factors affecting binding tightness between two components of PTT/PET side-by-side filaments

ZHULI YANG FUMEI WANG BUGAO XU

REZUMAT – ABSTRACT

Factori cheie care influenţează etanşeitatea legăturii dintre două componente ale filamentelor PTT/PET de tip side-by-side

S-a raportat faptul că elasticitatea filamentului PTT/PET (politrimetilen tereftalat/polietilen tereftalat) s-a redus foarte mult după un tratament alcalin puternic din cauza separării celor două componente alăturate. În scopul determinării cauzei principale a acestui fenomen, au fost utilizate rezonanţa magnetică nucleară (^{13}C-RMN) și calorimetria diferențială de baleiaj (DSC), pentru a analiza compoziția materialului, microscopul electronic de baleiaj (SEM), cu scopul de a observa morfologia interfacială dintre cele două componente. S-a constatat că un factor-cheie care a afectat etanșeitatea legăturii dintre două componente ale filamentelor PTT/PET de tip side-by-side a fost cantitatea de copoliesteri produsă în interfață, deoarece legăturile covalente ale copoliesterului pot consolida foarte mult legătura. În procesul de filare, locul și timpul au influențat generarea copoliesterului pentru contactul direct al fluidelor PTT şi PET. Producția de copoliesteri s-a modificat după tratamentul termic și s-a mărit la tratamentul cu o tempertură de 100–120°C. Legarea a două componente în filament cu mai puțin copolimer s-a redus în mediul alcalin extrem în timpul proceselor de vopsire și finisare, ceea ce a condus la pierderea elasticității filamentului.

Cuvinte-cheie: filament PTT/PET side-by-side, modificarea esterului, copoliester, forţă de legare interfacială, tratament termic

Key factors affecting binding tightness between two components of PTT/PET side-by-side filaments

It has been reported that the elasticity of PTT/PET (polytrimethylene terephthalate /polyethylene terephthalate) filament was reduced dramatically after a strong alkali treatment because of the separation of the two side-by-side components. In order to determine the main cause of this phenomenon, we used Nuclear Magnetic Resonance (^{13}C-NMR) and Differential Scanning Calorimetry (DSC) to analyse the material composition, Scanning Electron Microscope (SEM) to observe the interfacial morphology between the two components. It was found that a key factor that affected the binding tightness between two components in PTT/PET side-by-side filaments was the amount of copolyesters produced in the interface because covalent bonds of copolyester can greatly strengthen the binding. In the spinning process, the location and the time for the PTT and PET fluids to contact directly influenced the generation of the copolyester. The production of copolyesters changed after heat treatment and maximized when treated at a temperature of 100–120°C. The binding of two components in filament with less copolymer was weakened in the extreme alkaline environment during the dyeing and finishing processes, leading to the loss of filament elasticity.

Keywords: PTT/PET side-by-side filament, ester interchange, copolyester, interfacial binding force, heat treatment

INTRODUCTION

The PTT/PET (polytrimethylene terephthalate/polyethylene terephthalate) side-by-side filament is a conjugated fiber manufactured by jetting and merging two melting polymers from the same spinneret [1–2]. Known as an elastomultiester, large crimps in PTT/PET filaments take shape after heat treatment because of the differential shrinkage of PTT and PET components [3]. The high helical crimps bring exceptionally good stretch and elastic recovery to PTT/PET yarns and fabrics [4]. However, the side-by-side components could split when the binding force between the two components was weakened in the finishing process, resulting in the disappearance of three-dimensional crimps. In a previous experiment, it was found accidently that two components of one PTT/PET filament separated after alkali treatment and this filament lost its helical crimps compared to other two similar filaments [5]. Therefore, it is necessary to investigate the binding tightness between two components in PTT/PET filaments.

Most polymers are thermodynamically immiscible due to different structures and they can only adhere together through secondary bond forces, with no covalent bonding, which limited the mechanical properties of these polymer blends [6]. Crystallisable polymers were thought to be incompatible [7–8]. However, PTT and PET are aromatic polyesters with similar chemical structures, and thus their solution blends are miscible in amorphous areas and partially miscible in crystalline regions [9–10]. It has been a broad interest to study trans-esterification reaction in polyester blends [11–12]. In general, ester exchange reaction in polyester blends readily takes place near and above the melting points, producing block copolymers at first and random copolymers with the passage of time [13–14]. These studies were based

on the condition in which polyesters fully blended. In the process of side-by-side filament spinning, two polyesters are extruded from the same spinneret and drawn with two components parallel arranged. The generation of copolyester in melt-mixing interface and their influences on filament properties has not been reported.

In this study, qualitative judgment of copolyester in PTT/PET filaments, the interfacial morphology between the two components and the thermal properties of copolyester will be investigated through nuclear magnetic resonance analysis, scanning electron microscope and differential scanning calorimetry analysis to explain this phenomenon.

EXPERIMENTAL WORK

Materials and Method

Three commercially available PTT/PET filaments were selected for this study. The basic parameters of these filaments were listed in table 1. The three filaments had the same total fineness but different numbers of monofilaments, cross-section shapes, volume ratios and production processes. Filament C was the one found to have two splitting components in previous experiment.

^{13}C-NMR of the PTT/PET filaments was measured by a NMR spectrometer (Bruker Avance 400) at 100.6 MHz. The samples used for the ^{13}C-NMR measurement were prepared by dissolving 100 mg PTT/PET filament in 0.6 ml deuterated trifluoroaectic acid.

The thermal properties of the PTT/PET filaments were measured using DSC (Perkin-Elmer Pyris 1). About 5 mg samples were heated at a rate of 10°C/min under nitrogen from 40°C to 300°C.

The cross-section slices of the PTT/PET filaments were cut by Hardy's cross-sectional device (Y172) and the morphology of the cross sections were observed using scanning electron microscope (Hitachi, SEM TM3000).

Table 1

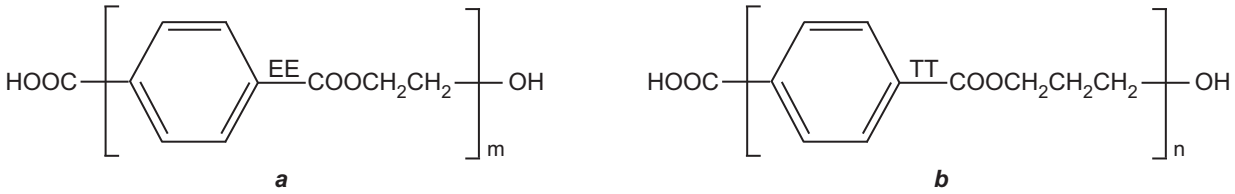
SPECIFICATIONS OF FILAMENT YARNS			
Fibre properties	**Values**		
Label	A	B	C
Structure	FDY	FDY	DTY
Fineness, (Tex)	16.67	16.67	16.67
Monofilament number, nr.	64	48	72
Cross section	Pear-shaped	Dog-bond-shaped	Dog-bond-shaped
Volume ratio,%	50/50	50/50	40/60

FDY: full draw yarn; DTY: draw texturing yarn.

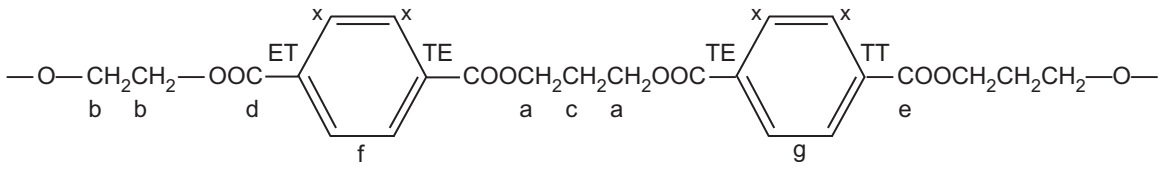
RESULTS AND DISSCUSSION

Ester exchange reaction

Normally, there are two basic molecular interactions in the interface of polymer blends. One relies on covalent bonds and the other depends on secondary bond forces, such as Van der Waals force and hydrophobic interaction [15]. In PTT/PET bi-component filament, PTT and PET components were adhered together mainly by Van der Waals force. Scheme 1 shows the molecular structures of PET and PTT. During the spinning process, two polyesters in the molten state are miscible and molecular chains entangled with each other in the contact area. There are free carboxyl and a free hydroxyl as the end groups in PTT and PET structures. In melted state, the thermal degradation made more ester group break. And the residual catalyst in the condensation polymerization can markedly promote the transesterification [16]. Then ester interaction happens between the two melting components after enough contact and the two parallel components are adhered together also by covalent bonds whose binding strength is much higher than that of secondary bonds. In fact, this copolymer is a kind of by-product and other such side reactions also happen in the spinning process [17]. The chance of ester exchange between the two components is much more than other side reactions. Scheme 2 shows the possible copolyester after the interaction between the two components.



Sche. 1. Molecular structure of PET and PTT: *a* – PET; *b* – PTT



Sche. 2. The molecular structure of possible copolyster

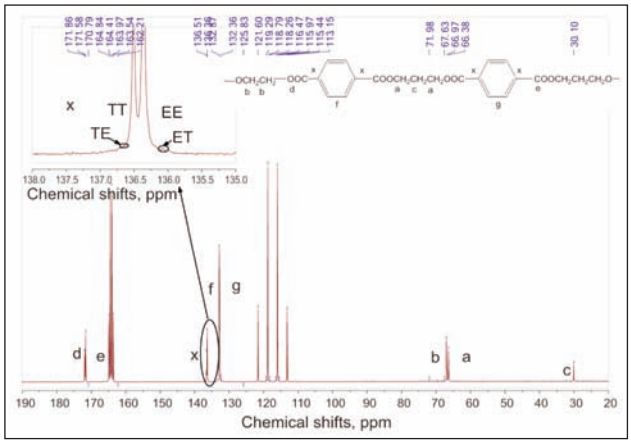


Fig. 1. ^{13}C-NMR spectrum of Filament A

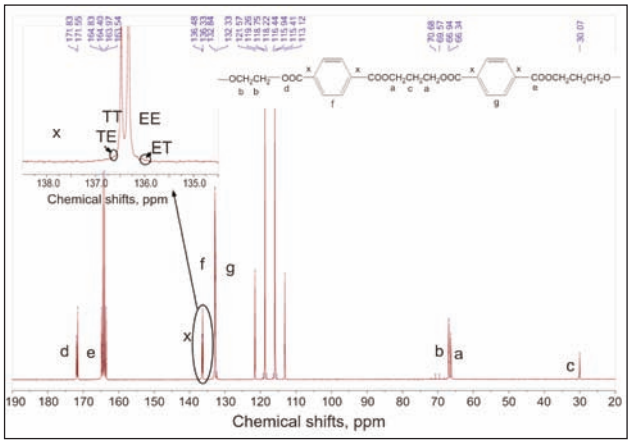


Fig. 2. ^{13}C-NMR spectrum of Filament C

^{13}C-NMR analysis

Nuclear magnetic resonance analysis is one of the effective methods to identify and quantitatively analyse organic molecular structures [18]. Different chemical shifts in an NMR spectrum can identify different groups. Because Filaments A and B have the similar spectra of ^{13}C-NMR, only the spectra of Filaments A and C were shown in figure 1 and figure 2.

According to the chemical structure of aromatic polyester, carbon atoms can be divided into six categories as shown in scheme 2. The resonance peaks in the spectra were assigned as follows: at 66.3 ppm for the propanediol 1, 3-carbon of PTT (a), at 66.9 ppm for the ethylene carbon of PET (b), 30.1 ppm for the propanediol 2-carbon of PTT (c), 171 ppm for the carboxyl carbon atom of the phenyl group (d and e), 132 ppm for the 2, 3, 5, 6 carbon atom of the phenyl group (f and g), 136 ppm for the 1, 4-carbon of the phenyl group(x). The resonance peaks of CF3COOD appeared at 113.12–121.57 ppm and at 163.54–164.83 ppm.

Figure 3 shows a close-up view of the characteristic peaks of the copolyesters at the upper left corner of the spectra. Two strong resonance peaks of EE and TT are the 1, 4-carbon of the phenyl group in PTT and PET. Two smaller peaks near 136.1 ppm and 136.6 ppm indicate the existence of TE and ET copolyesters [19]. They are the evidence that ester interchange reaction takes place in the interface of two components. Compared with the peaks of PET and PTT in the ^{13}C-NMR spectra, the intensity of copolyester is much lower. That is because the ester exchange reaction only occurs in the interface and the contact time for two melting components is short. So the production of copolymer is very little.

Both Filaments A and C contain copolyesters, but the height and area of copolymers in Filament A are larger than those in Filament C. The integrated areas of Filament A are 1.52 and 0.66. The integrated areas of Filament B are 1.32 and 0.52. However, the integrated areas of Filament C are 0.88 and 0.32. The intensity of NMR is represented by the area of the absorption peak [20]. So the copolymer produced in Filament C is less than that in filament A and B.

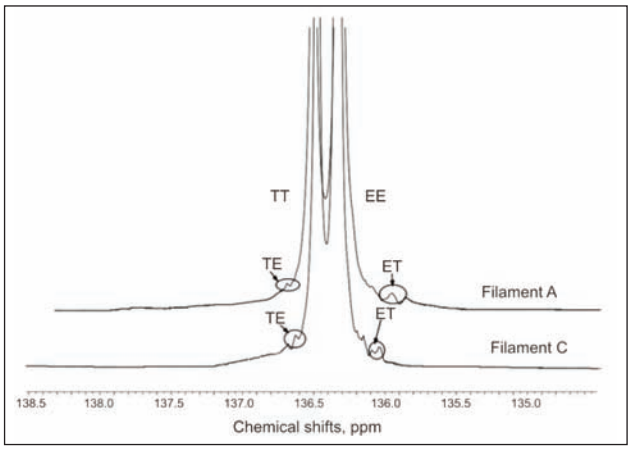


Fig. 3. The spectra of copolyester

DSC Analysis

The ^{13}C-NMR method has determined the existence of copolyester. DSC was adopted to examine whether copolyester would affect the thermal properties of PTT/PET side-by-side filaments.

As shown in figure 4, the DSC curves of the three PTT/PET filaments appeared to be similar. The

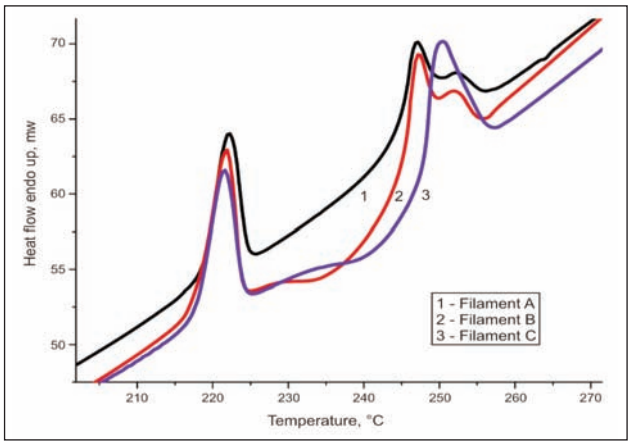


Fig. 4. DSC curves of PTT/PET filaments

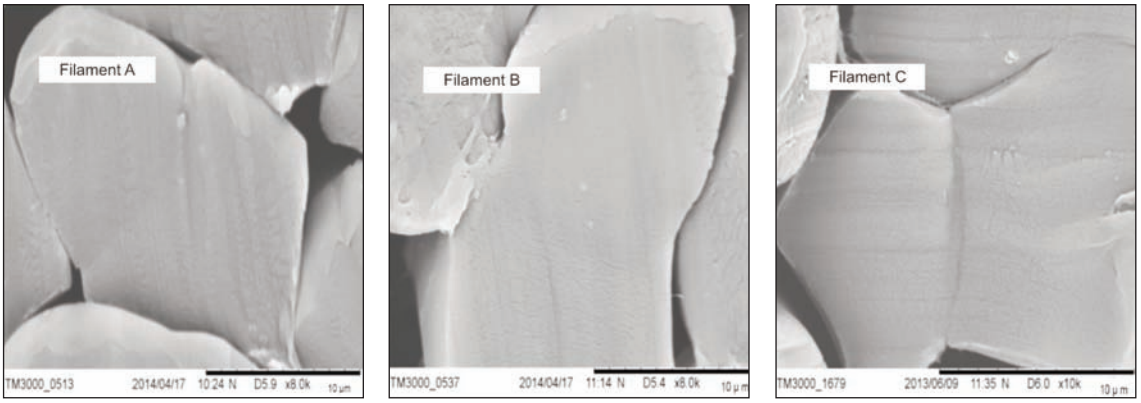


Fig. 5. SEM image of interfacial configuration

endothermic melting peak of the PTT component is located at the temperature range of 221–222 °C and the endothermic melting peak of the PET component is at the temperature range of 246–250 °C. According to Flory, the melting point of copolyester locates between PTT and PET [21, 22]. But there is no apparent melting peak for copolyesters between PTT and PET components in DSC curve. Because the amount of copolyesters is so little that it cannot crystallize. However, there is a small peak at 252 °C on both DSC curves of Filaments A and B. The small peak is the endothermic melting peak of secondary crystallization [23, 24]. It was reported that the crystallization rate of PTT is faster than that of PET [25]. So in PTT/PET bi-component filament, PTT component crystallizes firstly and follows the PET component. But the copolyester in the interface can retard the crystallization of PET component. In Filament A and B, there is relatively more copolyester, so the copolyester has a stronger effect on crystallization of PET and then the secondary crystallization appears. In Filament C, since there was no enthalpy of secondary crystallization detected in the interface of the two components in Filament C, the amount of copolyesters is negligible. Therefore, the absence of secondary crystallizes in Filament C also indicates a smaller amount of copolymers.

SEM image

Extruded from a twin screw extruder, PTT and PET component melts meet in the spinneret and were drafted into a filament quickly. Without blending, the two components should remain independent and bilateral distributions in the fibres, exhibiting an interface in the cross-section. Analysis from the ^{13}C-NMR spectra and DSC curves show that there is relatively more copolyester in the interface of Filaments A and B. However, Filament C which components separated easily in previous experiment produced less copolyester. The interfacial configuration of the three PTT/PET bi-component filaments was further explored through the interfacial morphology images taken by SEM.

As seen in figure 5, cross-sections of the three filaments have interfaces between the two components, but the separating line in the cross sections of Filament C is more apparent in the image, amplifying it by a factor of 10,000. The cross-sections of Filaments A and B cut by the blade are smooth and the boundaries are almost seamless. That is because of the adherence of the copolymers in the interface. On the other hand, the cross sections of Filament C have distinct separating boundaries because the two independent components are combined together mainly by secondary binding forces.

The reason for this discrepancy in interfacial configuration is that in the spinning process of Filaments A and B, two melting polymers met earlier in the channel and had more contact time in the molten state, thus more ester interchange occurred. For Filament C, most likely because of later contacting between the two components, the temperature was lower and the viscosity of component melts was higher, which caused little copolyester produced.

Heat treatment and copolyester

Heat treatment is the means to impart crimps in PTT/PET side-by-side filaments due to the differential shrinkage ratio of the two components. But the heat treatment may alter the copolymers as well. To investigate the relationship between the copolyester and the heat treatment temperature, three PTT/PET filaments were heated at the temperature range of 80, 100, 120 and 140°C for 5 minutes respectively and then tested by DSC to examine changes in the amount of copolyesters.

Figure 6 presents the DSC curves of three PTT/PET filaments after different heat treatments. Table 2 lists the melting points and enthalpies of each component corresponding to different heat treatment conditions. As shown in figure 6 (a) and table 2, the melting peak of the secondary crystallization in Filament A become a little higher and broader with the increase of temperature. The melting enthalpy increases to the maximum at the temperature of 120°C and then drops as the temperature continues to go up. That may be because of the effect of secondary crystallization. When the temperature rises, the activation energy of esterification reaction increases and the rising temperature accelerates the reaction. But esterification reaction is an exothermal process and the reaction

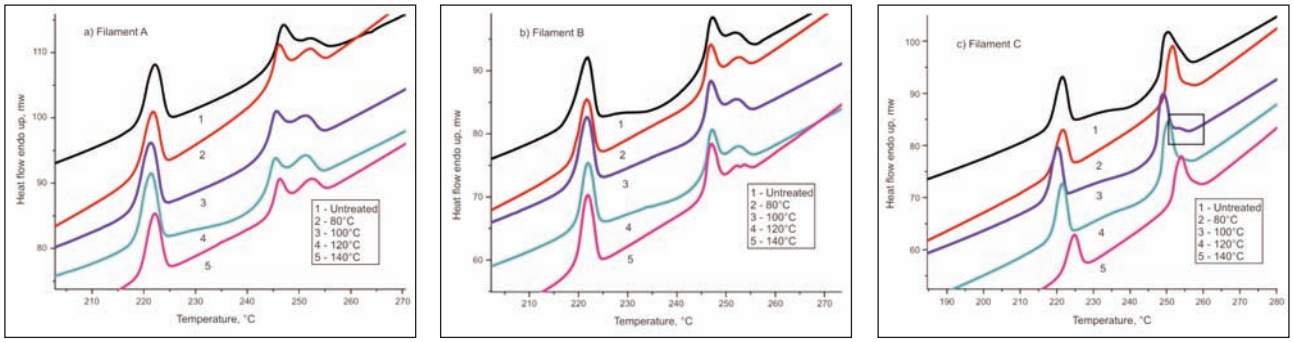


Fig. 6. DSC curves of three PTT/PET filaments after different heat treatment

is suppressed by the higher temperature. Thus, the reaction slows down and the production of copolyester decreases as the temperature increases.

As shown in figure 6 (b), the melting peaks of Filament B changes slightly. Like Filament A, the melting enthalpy of Filament B gets to the maximum after the 120°C heat treatment, but the enthalpy value is lower than that of Filament A. That is because the cross-section shape of Filament B is slender and has a short interface boundary (see in figure 5). This indicates that the different cross-sections of filament also have influence on the production of copolymer.

From figure 6 (c), it can be seen that without a heat treatment, there is no melting peak of secondary crystallization. After the heat treatment, the peak of PET component narrows down and both peaks of the two components shift leftward slightly at a temperature of 120°C. In this case, a small melting peak of secondary crystallization appears at 253°C. As the heat temperature goes above 120°C, the melting peak disappears and the melting peaks of PTT and PET shift to their original position. This side-fact further proves the existence of copolymer. The melting temperature of PET and PTT decreases slightly as the increase of the copolymer content. According to Flory, the decrease of the melting point is due to the decrease in the chemical potential of the crystalline phase in the two phase system [8].

Filament structure and copolyester

It is noted in table 1 that Filaments A and B are the full draw yarn (FDY), while filament C is the draw texturing yarn (DTY) which heated more times in the hot box at the temperature of 155–165°C during the spinning process [26]. To explore whether the hot box heating had destroyed the copolymers, filaments A and B were tested by DSC after heat treatment at the temperature of 160–180°C. The results of DSC in table 2 and figure 7 show that the amounts of secondary crystallization in Filaments A and B decreased slightly but not as little as that of Filament C. This indicates that the processing of DTY is not the cause of low copolyester content from sides.

Figure 7 shows the relationship between the heating temperature and the melting enthalpy of secondary crystallization in Filaments A and B. The result at the temperature of 0°C came from the samples without

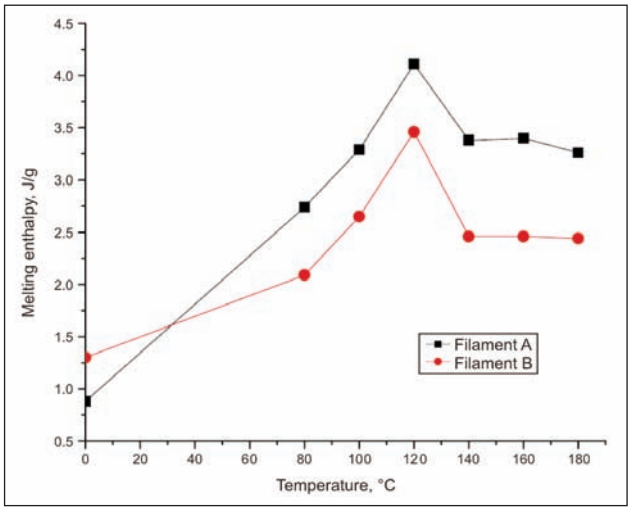


Fig. 7. Relationship between the heating temperature and the melting enthalpy of secondary crystallization

heating treatment. After heat treatment, the amounts of enthalpy increased dramatically. With the increase of the heating temperature in the range of 80–120°C, the enthalpy rises to reach the maximum at 120°C. In the range of 140–180°C, the enthalpy stays relatively stable. The more secondary crystallization means more copolymers generated in the interface. The highest content of copolyesters at 120°C yields the maximal binding tightness between the two components. The PTT/PET side-by-side filaments obtained the optimum elastic elongation after heat treatment at a temperature in 100~120°C [27]. Whether there is a connection between the copolyester and better elasticity, it needs a further explore in future work.

Fabrics are often subjected to various dry-heat treatments (e.g., pre-setting and heat-setting) and wet-heat treatments (such as high-temperature and high-pressure dyeing and alkali peeling). Due to the larger differences in thermal contraction, PTT and PET components are disposed side-by-side in one cross-section and high-frequency helical crimps takes shapes. While shrinking along the axial, shear forces generate in the interface between two components and components with weaker binding would split easily. In addition, swelling and corrosion could happen in components if immersed in a strong alkali solution. If there are not enough copolyesters in the interface, the two side-by-side components would separate

Table 2

MELTING POINTS AND ENTHALPIES OF EACH COMPONENT							
Samples	**Temperature** (°C)	**Melting points** (°C)			**Melting enthalpy** ($J \cdot g^{-1}$)		
		PTT	**PET**	**Copolymer**	**PTT**	**PET**	**Copolymer**
Filament A	Untreated	221.93	246.83	252.73	19.75	20.43	0.88
	80	221.63	246.21	252.10	18.57	21.63	2.74
	100	221.30	245.54	251.77	20.72	23.43	3.29
	120	221.33	245.25	251.47	22.35	24.27	4.11
	140	221.99	246.24	252.47	18.89	16.77	3.38
	160	222.20	247.68	252.93	20.61	22.64	3.40
	180	222.04	247.34	252.59	20.39	21.29	3.26
Filament B	Untreated	221.92	247.15	252.39	25.08	26.16	1.30
	80	221.65	246.88	252.45	20.78	20.00	2.09
	100	221.64	246.87	252.44	22.28	21.03	2.65
	120	222.00	247.22	252.79	20.57	22.34	3.46
	140	221.98	246.89	252.13	18.89	16.07	2.46
	160	222.52	248.33	253.91	21.97	19.93	2.46
	180	222.01	247.80	253.06	19.01	20.27	2.44
Filament C	Untreated	221.62	250.12	——	21.43	30.98	——
	80	221.66	251.46	——	16.78	20.45	——
	100	220.33	248.84	253.75	22.41	26.68	0.13
	120	221.34	250.49	——	19.61	25.27	——
	140	224.61	253.76	——	15.99	21.78	——

because of corrosion of alkali. Then the structure of helical crimps disappears and its elasticity loses.

To avoid the separation, there are two critical steps in the spinning and finishing processes which can facilitate copolymer generation in the interface of the PTT/PET filament. Firstly, the spinning parameters need to be adjusted to allow two melts to maintain the contact as long as possible before cooling. Secondly, the dyeing and finishing temperature needs to be set between 100~120°C, the amounts of copolyester increase and the combine fastness is the best.

CONCLUSIONS

This paper explored the key factor that affected the binding tightness of the two components in PTT/PET side-by-side filaments. The quantity of copolyesters generated in the interface of the two components played a main role in binding the two components. During the spinning process, more copolyesters can be produced if two melting polyesters maintain longer contact time.

The copolymers allow PTT and PET components to be adhered together through covalent bonds, enhancing the binding tightness. The quantities of copolyester can be increased by controlling the heat treatment within the temperature range of 100~120°C. A strong alkali solution can weaken the binding of the components because of the corrosion.

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Effect of ozonation process on dyeing of polyamide fabrics with a natural dye: walnut rind

RIZA ATAV OSMAN NAMIRTI

REZUMAT – ABSTRACT

Efectul procesului de ozonizare asupra vopsirii ţesăturilor de poliamidă cu colorant natural din coaja de nucă

În ultimii ani, preocuparea pentru mediul înconjurător a creat un interes tot mai mare asupra coloranţilor naturali. Pe lângă fibrele naturale, fibrele sintetice pot fi, de asemenea, vopsite cu coloranți naturali. În studiul anterior, a fost examinată capacitatea de vopsire a țesăturilor din poliamidă cu coajă de ceapă albă. Scopul acestui studiu a fost de a determina efectele procesului de ozonizare asupra capacităţii de vopsire a ţesăturilor din poliamidă cu colorant natural din coajă de nucă. În acest scop, a fost efectuată optimizarea pre-tratamentului de ozonizare. În conformitate cu rezultatele experimentale, s-a constatat că pre-tratamentul de ozonizare a îmbunătățit capacitatea de vopsire a ţesăturilor de poliamidă cu colorant natural din coajă de nucă și s-au obținut valori foarte bune ale rezistenţei vopsirii.

Cuvinte-cheie: poliamidă, ozonizare, colorant natural, nucă, rezistenţa vopsirii

Effect of ozonation process on dyeing of polyamide fabrics with a natural dye: walnut rind

In recent years, concern for the environment has created an increasing interest in natural dyes. Besides natural fibers synthetic fibers can also be dyed with natural dyes. In our previous study, we have examined the dyeability of polyamide fabrics with white onion skin. The aim of this study was to determine the effects of ozonation process on dyeability of polyamide fabrics with walnut rind as a natural dye. For this purpose optimization of ozonation pretreatment was performed. According to the experimental results, it was determined that ozonation pretreatment improved the dyeability of polyamide fabrics with walnut rind and very good fastness values were obtained.

Keywords: Polyamide, ozonation, natural dye, walnut, fastness

INTRODUCTION

Polyamide fibers have a large share of the worldwide market of synthetic fibers [1]. Polyamides are principally obtained by two types of chemical reactions: by polycondensation of diamines with dicarboxylic acids (Polyamide 6,6), or by autopolycondensation of amino acids (or their lactams) (Polyamide 6) [2]. Polar -NH_2 and -COOH end-groups, and the amide NH-CO groups present inside the polyamide fibers and on their surfaces, may interact with dye chemically [3]. In recent years, concern for the environment has created an increasing interest in natural dyes [4]. Synthetic fibers can also be dyed with natural dyes. Polyamide fibers are the most easily dyeable synthetic fibers with natural dyes due to having similar structure with wool [5]. Although there are lots of studies on dyeing of wool fibers with natural dyes, there are limited articles in literature on dyeing of polyamide fibers with natural dyes [6–9].

One of the alternatives which cause superficial changes on fiber is the ozonation process. Ozone is one of the strongest oxidizing agents and has strong tendency to react with almost any organic substance as well as with water [10]. ***Lee et al.***, have shown that polymer surface of the nylon 6 fibers were easily oxidized by the ozone-gas treatment. Water penetration of the nylon 6 fabric was accelerated considerably by the treatment. Both moisture regain and water absorption increased a little with treatment [11].

In our previous study, we have examined the dyeability of polyamide with white onion skin [9]. The aim of this study is to examine the effect of ozonation process on dyeability of polyamide with walnut rind.

EXPERIMENTAL PART

- **Material:** In this study, polyamide/lycra plain knitted fabric (supreme) was used. All experiments were carried out by using pure water.
- **Ozone treatment:** The ozonation process was carried out in laboratory scale equipment. Ozone was generated from dried air in the Degrémont Technologies LAB2B corona discharge type ozone generator with a capacity of 1 g/h and was bubbled into applicator by means of a diffuser. The applicator was a two necked round-bottom flask.

The polyamide/lycra fabrics were ozonated at 20–25°C for a specific period of time. The initial mass of fabric, prior to impregnation and ozone treatment, was the same for each experiment. To optimize the ozone treatment, fabrics were treated at different wet pick-up values (0–50–100%), ozone treatment time (1–2–3 min.) and *p*H values (5–7–9).

- **Natural Dye:** Walnut (*Juglans regia*) rind was used as a natural dye. The reason of choosing walnut rind among hundreds of plants is its ease of accessibility that could be important for its applications in textile industry. Furthermore, a waste is being utilized by using walnut rind. In many literatures it

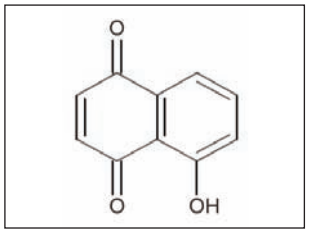

Fig. 1. Chemical formula of C.I. Natural Brown 7 [12]

is identified as a natural dye plant which includes juglone and gives brown color. Chemical structure of dye (C.I. Natural Brown 7) obtained from walnut rind is 5-hydroxy-naphthoquinone and its chemical structure is given in figure 1 [12].

- **Preparation of extract dye solution:** 100 g. plant samples were soaked in 2 L water. Subsequently the solution was heated to boiling temperature and boiled for 0.5 hour and afterwards filtered with gause fabric. Then this filtrated solution was used as dyeing liquor.
- **Dyeing with natural dyes:** 100 mL of filtrated and diluted dye extract was used to provide the liquor to good ratio of 20:1 for 5 g. material. Dyeings were carried out at extract solution's own *p*H value (*p*H 5.7). Dyeing experiments were performed on Termal HT Dyeing Machine according to the dyeing graph given in figure 2.

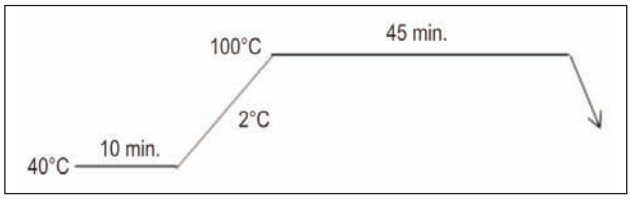

Fig. 2. Dyeing graph used in experiments

- **Color measurements:** CIE L*a*b* color values and reflectance (*R*%) values of dyed samples were measured with Gretag Macbeth E700 (D 65/10°) and color yield (*K/S*) values of dyed samples were calculated by Kubelka Munk equation:

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

where:

R is reflectance value in maximum absorption wave length (nm);

K – absorption coefficient;

S – scattering coefficient.

- **Fastness tests:** The washing fastness was determined at 40°C according to ISO 105 C06 standard. Dry and wet rubbing fastnesses of samples were assessed according to ISO 105-X12 standard.
- **IR spectroscopic analysis:** In order to determine the effect of ozonation treatment on the functional groups of polyamide fibers, fabrics were subjected to Fourier transform infrared analysis. FT-IR spectrophotometer, model Vertex 70 ATR, made by Buriker was used over the range 500–4000 cm^{-1}.
- **Microscopic analysis:** In order to determine the effect of ozonation treatment on the surface morphology of polyamide fibers, scanning electron microscope (SEM) analysis was carried out. Quanta FEG 250 scanning electron microscope (FEI, Netherland) was employed for imaging at 5000X magnification.
- **Bursting strength tests:** Un-treated and ozonated fabric samples were subjected to the bursting strength tests according to the ISO 13938-2 pneumatic method.

RESULTS AND DISCUSSIONS

Optimization of the ozonation treatment

Color yield results of untreated and ozonated (at different conditions) fabrics are given in figure 3.

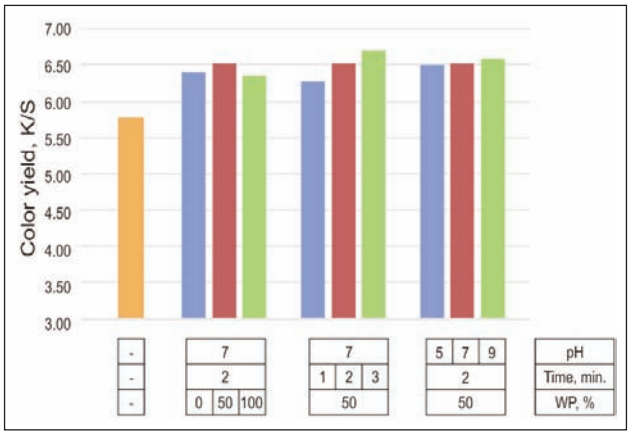

Fig. 3. Color yield values of untreated and ozonated fabrics

Effect of moisture content on the ozonation efficiency

To investigate the effect of moisture content on the ozonation efficiency of polyamide fiber, the ozone treatment time was set at 2 minutes and the *p*H of the impregnation liquor was set at *p*H 7. At these conditions fibers were impregnated in three different wet pick-up (WP) values (0, 50, and 100%).

It can be seen from figure 3 that color yield of ozonated fabric increased with the rise in the WP up to 50%. After that point, further increase in the WP caused a decrease in the color yield. ***Prabaharan and Rao*** have suggested a model in order to explain this phenomenon. According to this model it can be said that for ozonation to take place, water should be present inside of the fiber. However the quantity of water present has a definite effect on the rate of reaction. In the presence of water ozone can act effectively. If excess water is present ozone also reacts with this excess water and so all ozone molecules are not available for reaction with the reaction site in the fiber [13]. From these results, it can be concluded that the WP of fibers during the ozonation processes has an important effect on the subsequent dyeability of the fiber. Hence, it is recommended to ozonate polyamide material in 50% WP for obtaining optimum effect.

Effect of ozonation *p*H on the ozonation efficiency

The other parameter that affects the ozonation efficiency is the *p*H of the liquor used in the impregnation.

To investigate the effect of impregnation liquor pH on the ozonation efficiency of polyamide material, treatment time and WP were set at 2 minutes and 50% respectively. At these conditions ozonation was carried out at three different pH values; *p*H 5 (adjusted with CH_3COOH), *p*H 7, and *p*H 9 (adjusted with Na_2CO_3).

According to the results given in figure 3, it can be said that the color yield of ozonated polyamide fabric did not significantly affected by *p*H. For this reason, it can be recommended to ozonate polyamide fiber in neutral pH which does not require acid/alkali usage.

Effect of ozonation time on the ozonation efficiency

Another parameter that affects the ozonation efficiency is the time of ozonation. To investigate the effect of time on the ozonation efficiency of polyamide material, *p*H and WP were set at 7 and 50% respectively. At these conditions ozonation was carried out at three different time durations (1–2–3 min.).

From figure 3 it can be seen that the color yield of polyamide fabric increased with the time. It is important to note that during experimental studies yellowing and fiber damage was observed with the further increase in ozonation time from 3 min. For this reason durations more than 3 min. were not included in the experimental set-up. According to these results it can be said that optimum ozonation time for polyamide material is 3 minutes.

Determination of the effect of ozonation process on color and fastness properties

Color yield and CIE L*a*b* values of untreated and ozonated (at optimum conditions: *p*H 7, WP: 50%, 3 min.) polyamide/lycra fabrics are given in table 1.

From the results given in table 1, it can be seen that the color yield of the ozonated fabric is greater than the untreated fabric. ***Sargunamani and Selvakumar*** determined that ozonated silk samples have higher amino group content than control samples due to the breakage of peptide backbone. Based on this fact, they have proposed an oxidation mechanism which accounts for the introduction of amino groups in the chemical structure of silk [14]. As polyamide macromolecules also consist of amides joined by peptide bonds, possibly similar reactions could occur when polyamide macromolecules are exposed to ozone gas as shown in figure 4.

As it can be seen from the reactions given in figure 4, structure of polyamide fibers loosened after ozonation process due to breakage of peptide linkages. Furthermore new functional amino end-groups are formed which means fibers will be able to bind more anionic dye molecules. This case represents why ozonated sample is dyed darker than untreated sample.

From table 1, it can also be seen that the differences in a* and b* values of the color obtained in untreated and ozonated fibers are small. If L* values are examined, it can be seen that L* values of ozonated fibers are lower than the untreated fibers. L* value is the value of lightness-darkness and the decrease of L* value shows that the color gets darker.

Washing and rubbing fastness values of untreated and ozonated fabrics are given in table 2.

When table 2 is examined, it can be seen that there aren't any differences in washing and rubbing fastness values of the untreated and ozonated fabrics.

Table 1

COLOR YIELD AND CIE L*a*b* VALUES OF DYED SAMPLES

Sample	L*	a*	b*	C	h	K/S
Untreated	51,75	7,01	7,11	9,98	45,38	5,76
Ozonated	49,45	6,89	7,24	9,99	46,43	6,71

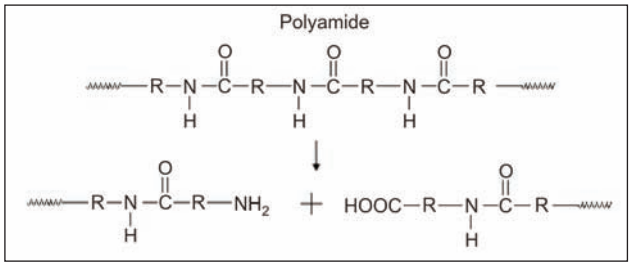

Fig. 4. Breakage of amide linkages

Table 2

WASHING AND RUBBING FASTNESS VALUES OF DYED SAMPLES

Sample	Washing Fastness						Rubbing Fastness	
	WO	PAC	PES	PA	CO	CA	Dry	Wet
untreated	5	5	5	5	5	5	5	5
ozonated	5	5	5	5	5	5	5	5

Determination of the effect of ozonation process on polyamide fibers

In order to determine the effect of ozonation treatment on the functional groups of polyamide fibers, fabrics were subjected to Fourier transform infrared

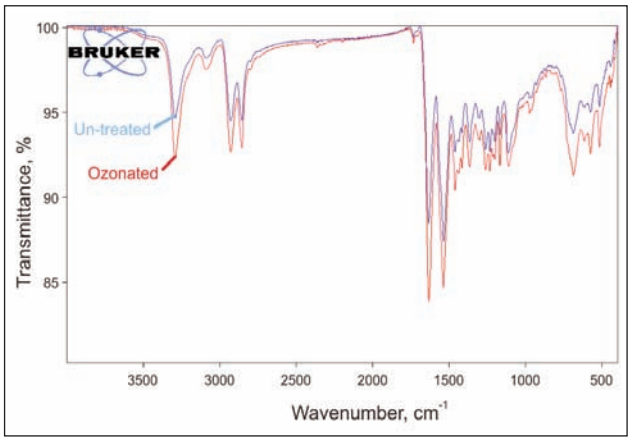

Fig. 5. FT-IR of un-treated and ozonated samples

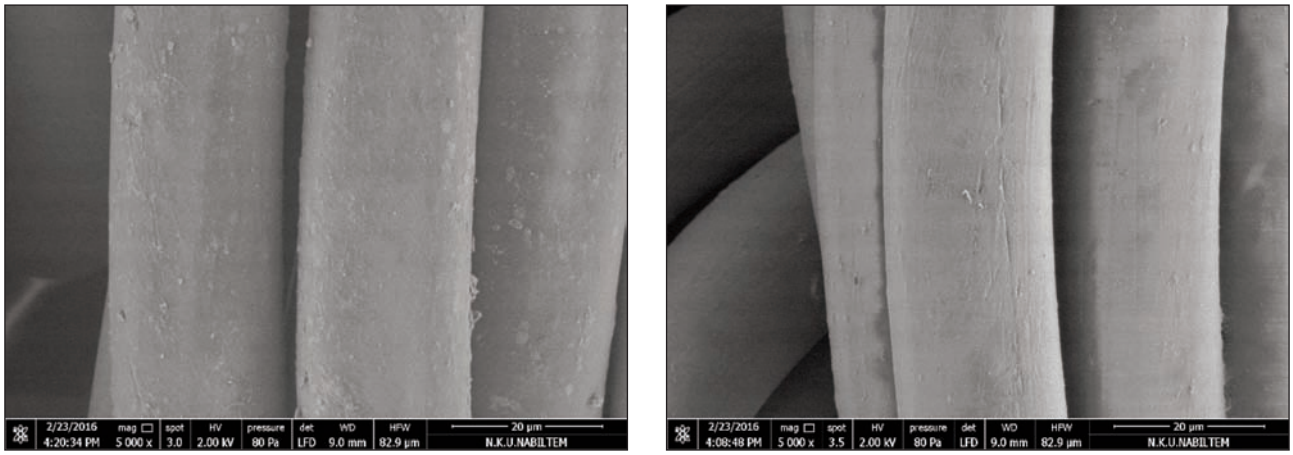

Fig. 6. SEM photographs of un-treated (on the left) and ozonated (on the right) samples at 5000X magnification

analysis. Results of un-treated and ozonated samples are given in figure 5.

The peaks at region of 1675–1620 cm^{-1} and also 1560–1520 cm^{-1} correspond to the N–C=O and C–N–H vibrations, respectively in the amide group, and are usually identified as amide I and amide II. The broad band centered about 3300 cm^{-1} is usually regarded as a complex band, as a result of overlapping occurring with the deformation stretching vibration of the OH group of water, and the NH group of polyamide. The transmittance at 3291 cm^{-1}, which is assigned to free and hydrogen-bonded NH stretching modes, and the peaks at region 1675–1620 cm^{-1} and also 1560–1520 cm^{-1} correspond to the amide I and amide II decreased after ozonation [15]. In other words after ozonation additional free amino groups occurred in fiber structure. These results explain why dye-uptake is increased after ozonation treatment.

In order to determine the effect of ozonation treatment on the surface morphology of polyamide fibers, scanning electron microscope (SEM) analysis was carried out. SEM photographs of un-treated and ozonated samples are given in figure 6.

From SEM images given in figure 6, it can be seen that there is no significant change in the surface structure of polyamide fibers after ozonation treatment.

Bursting did not occur in both of un-treated and ozonated fabric samples during bursting strength tests carried out according to the ISO 13938-2 pneumatic method. This indicates that ozonation process does not cause important damage in fabric structure.

CONCLUSIONS

In this study, an AOX free pretreatment is suggested for improving the dyeability of polyamide fabrics. The optimum conditions of ozonation process were determined as WP 50%, *p*H 7 and 3 min. According to the experimental results, it can be concluded that the color yield obtained in dyeing could be increased by applying ozonation to polyamide fabric prior to dyeing process without affecting the color nuance and fastness properties negatively.

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IImprovement of air-flow field in melt-blowing processing

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HUADONG ZHANG
TIANYI LU
XINHOU WANG

REZUMAT – ABSTRACT

Îmbunătăţirea câmpului cu flux de aer în prelucrarea neţesutelor filate din topitură

În conformitate cu analiza aerotermodinamicii şi analiza caracteristicilor de turbulenţă ar putea exista câţiva factori negativi în ceea ce priveşte rezistenţa ulterioară a fibrei filate din topitură. În acest studiu, câmpurile cu flux de aer din matriţele uzate au fost îmbunătăţite şi au fost proiectate noi matriţe de acoperire cu piese de stabilizare internă. Prin utilizarea modelului Reynolds Stress, câmpurile cu flux de aer pentru noile matriţe au fost studiate utilizând simularea numerică, iar lucrarea a fost validată cu ajutorul datelor de măsurare în laborator. Rezultatele simulării arată că piesele de stabilizare internă sunt utile pentru a reduce viteza negativă în zona de recirculare, a mări viteza medie descendentă pe linia centrală, a reduce temperatura pe linia centrală și de a face fluxul de aer din apropierea duzei mai lin. În plus, experimentul de simulare arată că noua matriţă de acoperire cu piesele stabilizatoare interioare poate ajuta la fabricarea de fibre mai fine.

Cuvinte-cheie: *filare din topitură, matriţă de acoperire, câmp cu flux de aer, simulare numerică*

Improvement of air-flow field in melt-blowing processing

According to the aerothermodynamics analysis and turbulence characteristics analysis there might be some adverse factors on the further attenuation of the melt-blowing fiber. In this study, the air-flow fields from the blunt dies were improved and new slot dies with inner stabilizing pieces were designed. Utilizing Reynolds Stress Model, the air-flow fields for the new dies were studied using numerical simulation and the work was validated with the laboratory measurement data. The simulation results reveal that the inner stabilizing pieces is helpful to decrease the negative velocity in the recirculation zone, enhance the downward centerline mean velocity, slow the centerline temperature decay and make the air-flow near the nose piece smoother. In addition, the simulation experiment shows that the new slot die with inner stabilizing pieces can manufacture finer fibers.

Keywords: melt-blowing, slot die, air-flow field, inner stabilizing pieces, numerical simulation

INTRODUCTION

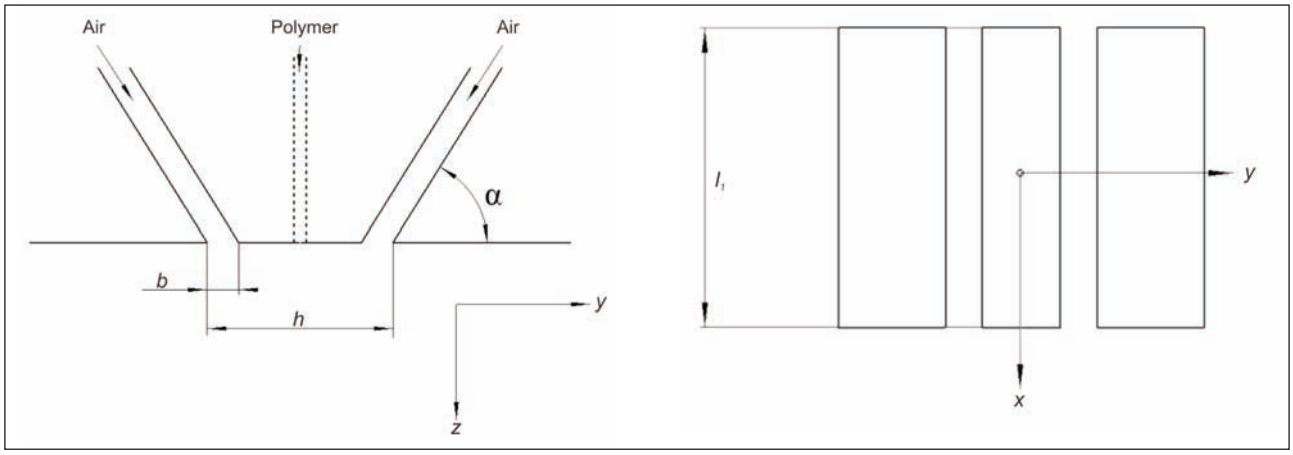
It is a short productive process for non-woven fabric in the melt-blowing. In the manufacturing process, the raw polymer materials are delivered into the container, melt by heating and then extruded from the spinneret. The polymer streams are fast drafted by high-velocity hot airflow from the jet holes, are collected on the steel screen and finally, form melt-blowing nonwoven. The melt-blowing products are composed of ultrafine fibers and they have many applications in the areas including healthcare, apparel and filtration.

The hot jets created by the melt-blowing dies have a significant impact on the fiber diameter and the fiber structure. The melt-blowing air-flow fields have been studied using experimental method or computational fluid dynamics (CFD) approach by many researchers. Shambaugh and his co-workers examined the velocity fields and the temperature fields of the single-orifice dies [1–4]. Xie and Zeng also measured the air-flow field from a single-hole slot die [5].

CFD have been employed to computer the melt-blowing air-flow fields because of its some advantages. Comparing to experimental methods, the CFD approach is easy to obtain the velocity information and the temperature information near the die. Moreover, using CFD can save the experimental tests cost and the measurement time expense. With CFD technology, Shambaugh, etc. simulated the flow field from the slot dies and the annular dies and their simulation results were validated with the laboratory measurement data [6–8]. Chen, etc. studied the effects of the blunt die geometry on the melt-blowing flow field under the condition of the subsonic velocity. Shambaugh and his co-workers analyzed the flow field from the Schwarz melt-blowing die [9–10]. Some researchers investigated the melt-blowing flow field from Laval nozzles using CFD [11].

It is a short productive process for non-woven fabric in the melt-blowing. The blunt die is a common slot die often used in industry (figure 1). However, for the blunt dies, there are several negative factors which limit the further fiber thinner [12].

Through the aerothermodynamics analysis and turbulence characteristics analysis, in the air-flow field from the blunt die there are some adverse factors on the further attenuation of the fiber. First of all, the research result showed that the recirculation zone which is close to the die surface exists in the air-flow fields for the slot die [6]. In this region there is full of eddy flow which is called the separation vortex and



a *b*

Fig. 1. Detailed schematic of a blunt die: *a* – cross sectional view; *b* – view of the face of the die

result from the sudden enlargement of the slots. According to the turbulence theory, there should be a typical flow loss in this case. In the recirculation zone, the polymer fiber might be subjected to reverse velocities that push it back toward the die [12].

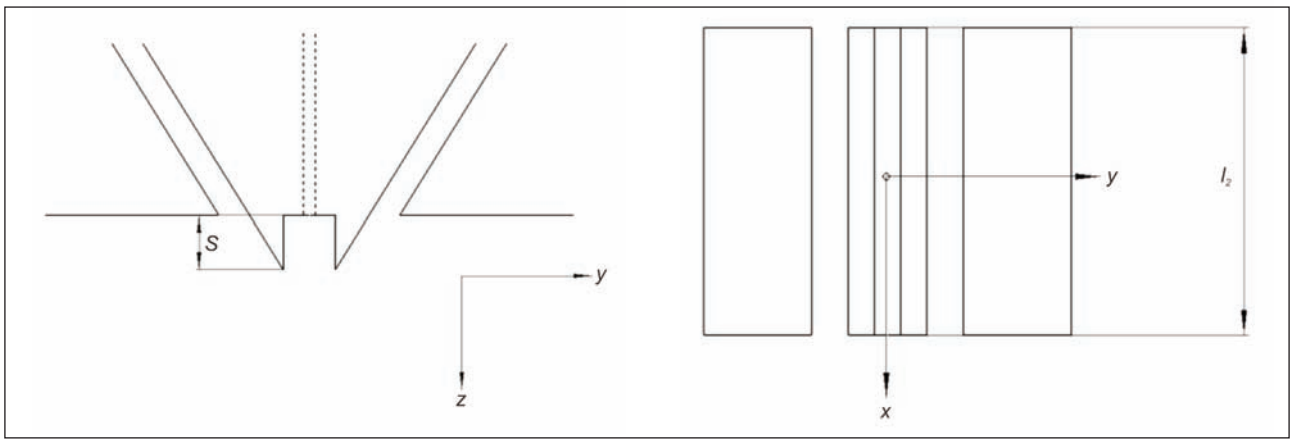
Secondly, the partial kinetic energy loss of the jets is resulted from the interaction between the jet and ambient air. In other word, this is because the lateral diffusion of the jets. In the interaction the exchanges of mass, momentum and energy occur between the stream and the nearby gas. When the width of gas jets increases, the speed value of the core section of the jets becomes smaller and then more and more gas parcels are entrained. Though the mass of the streams increases, the kinetic energy of the jets becomes smaller.

Last but not the least, due to the required use of a large quantity of hot air in the melt-blowing production process energy consumption is particularly huge and the centerline temperature of the air-flow decays rapidly [3]. If the temperature decay and the velocity decay can be lowered, the jet not only will attenuate the molten polymer into finer fiber, the gas consumption and the heat energy consumption but also will be greatly reduced.

In this work, the flow fields of several new modified slot dies were studied utilizing CFD approach and these simulation results were validated with the measurement data. A primary goal is to investigate the effects that different designs and sizes for the slot dies with inner stabilizing pieces have on the air-flow field and to lay the foundation to manufacture and industrialize the aerodynamically superior die.

NEW MODIFIED DIES WITH INNER STABILIZING PIECES

The blunt die with the traditional structure, was used to compare new die, which is the corresponding modified dies with two stabilizing pieces (figure 2). The stabilizing pieces on the inner sides are the extended parts of the external end of the nose piece and their angle relative to the face of the die are the same to the one that the jet makes with the die face. The cross-section of the inner stabilizing piece is a right triangle and the bottom width of the inner stabilizing pieces varies with the height.



a *b*

Fig. 2. Detailed schematic of a new modified die: *a* – cross sectional view; *b* – view of the face of the die

The slot angles making with the die face for the three blunt die (i.e., die 1, die 2 and die 3) are 45°, 50° and 60°, respectively, which are the same to the corresponding new dies. The slot width and the length between the outer ends of the air nozzles for the two kinds of die heads are 0.65 mm and 3.32 mm, respectively, which are usual in industry. The heights of the inner stabilizing piece for four corresponding new die with different slot angles are set 0.810 mm, 0.965 mm and 1.403 mm.

NUMERICAL COMPUTATION AND EXPERIMENTAL VERIFICATION

Calculation domain and grid generation

Modeling a half-symmetry of the bidimensional plane air-flow field for a slot die is reasonable [6]. Figure 3 provided the computational domain of a common blunt die, which was developed on the basis of the experiments discussed later and identical with the our previous study [12].

AB was the inlet of the calculation region, and CD and ED are the outlets of the computational region. OC was set the symmetrical boundary, which can decrease much simulation time.

The structured grids with large size for the slot dies were obtained in Gambit and the adaptive mesh refinement was employed in FLUENT 6.3.26. For the two kinds of slot dies, the grid generations were all the same to those in previous work [6].

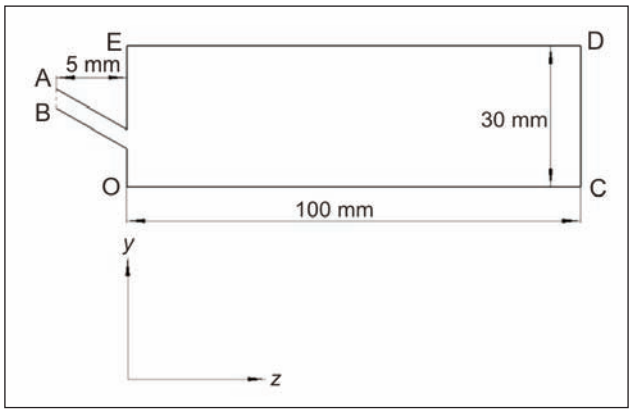


Fig. 3. Computational domain used in the simulation

Turbulence modeling and simulation parameters

In this work, AB was designated as a pressure inlet boundary and under an absolutely pressures of 1.1 atm, which is the reason why the air jet was considered to be compressible. The static temperature of the hot air at the entrance was 390 K. CD and ED were designated as pressure outlets under atmospheric condition. The air nozzle walls and the die face were designated as nonslip walls and their static temperature were 470 K. The hydraulic diameters and turbulence specifications of the inlet boundary and the outlets boundary referred to the previous studies 2. Meantime, RSM is used in simulation for the blunt dies and modified die.

Experimental verification

A blunt die was manufactured and its flow field was examined used a hot-wire anemometer in our work. The slot angle α is 60° and the slot length l1 is 1.2×10^{-2} m. The slot width b and the length h are 1.3×10^{-3} m and 6.64×10^{-3} m, respectively, and the sizes are twice of that in Shambaugh's study based on the similarity principle [6].

The experimental setup is shown schematically in previous study [13]. The Compressed air in the plastic tube was under a condition that the pressure was 0.05 MPa and the temperature was at about 310 K was compressed into the slot dies.

Figure 4 provides the numerical computation data and the measurement results in different location of the air-flow field. Figure 4 presents that the velocity along the central line predicted using numerical simulation agreed quantitatively with that for the experiments. Therefore the simulation results are accurate and reliable.

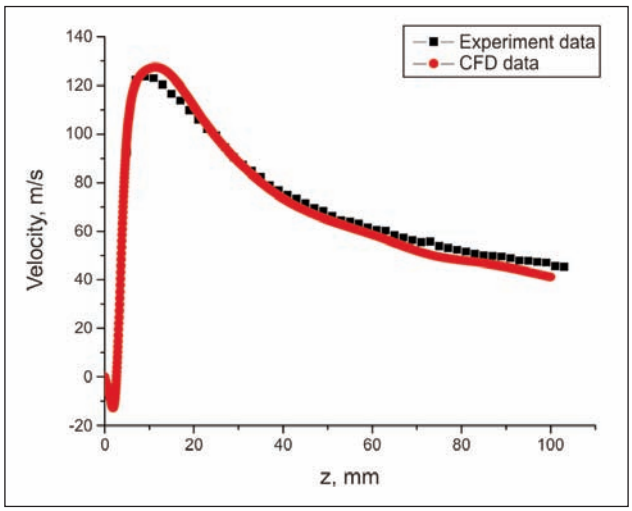


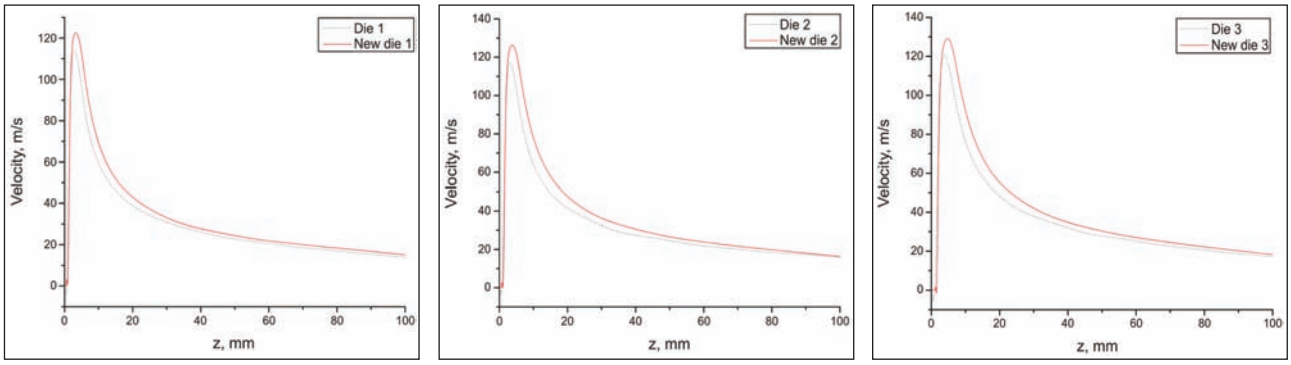
Fig. 4. Comparison of centerline velocity as predicted by CFD with measured centerline velocity

RESULTS AND DISCUSSION

Velocities in the centerline

The mean velocity along the centerline in the air flow field was employed as an evaluation standard for the attenuation of the melt-blowing fibers. The reason is that during drawing, the motion trail of the polymer stream is mainly within the region along the centerline of the flow field. In addition, the mean centerline velocity is larger, the drawing is faster and the diameter of the final fiber is thinner [14].

Figure 5 presents the centerline velocity for the blunt dies and new slot dies with different slot angles. In figure 5, the curves show that the reverse velocities near the die face for the modified slot die are much lower than the ones for these corresponding blunt dies. In the region where the velocity is the same to the drawing direction of the melt-bowing, the centerline velocities of the modified slot dies are basically greater than that of these corresponding blunt dies. Especially, when $z < 1.5$ cm the velocity differences



a *b* *c*

Fig. 5. Centerline velocity profile of the two kinds of dies:
a – die 1 and new die 1; *b* – die 2 and new die 2; *c* – die 3 and new die 3

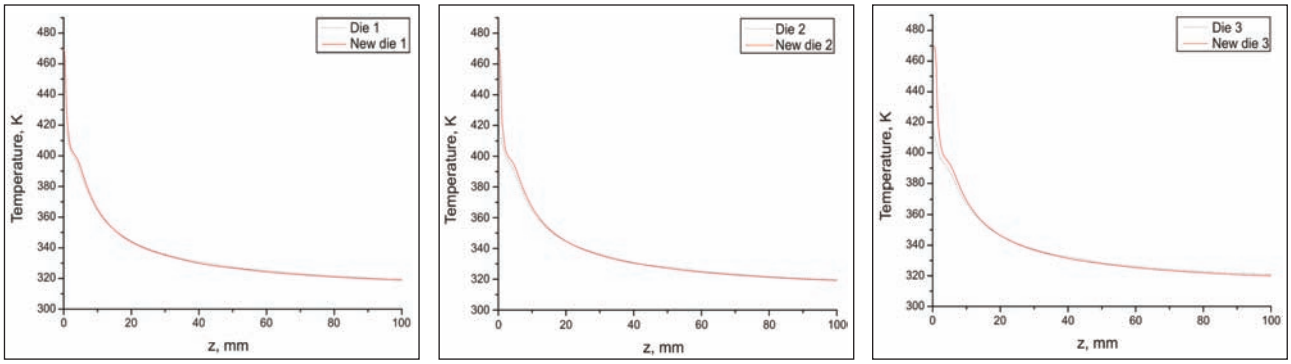
between the new dies and the corresponding blunt dies are much higher than that in the more distant region away from the die face. On the basis of the study, the key diameter decrease of the melt-blowing fiber was in a small area from z = 0 mm to z = 15 mm [14]. And in the other region, the fiber diameter almost made no change. So the simulation results reveal that modified slot dies with different slot angles have speed advantage on the drawing compared with blunt dies and should contribute to produce the thinner melt-blowing fibers.

Static temperatures in the centerline

Figure 6 gives the curves of the centerline temperatures for two types of slot dies with different slot angles. In the range between z = 0 mm and z = 10 mm, the centerline static temperatures for the new dies are higher than the corresponding blunt dies. And particularly near the die face the difference value of the static temperatures for two types of slot dies is larger. The new slot dies with different slot angles can reduce the centerline temperature degradation and obtain higher temperature in the main drawing region than the blunt die. When the flow-field temperature is higher, it is helpful to keep the melt-blowing fiber under flow conditions and reduce the viscosity of the polymer stream, which can play an important part on the distribution of the melt-blowing fiber diameter [15]. Thus the thinner melt-blowing fiber can be obtained as a result of higher flow-field temperature and these new slot dies it is expected to obtain thinner fibers for these new slot dies [14]. Moreover, a lot of air a huge temperature is employed in the manufacturing process and the heat consumption is quite high. And the new slot dies have speed and temperature advantage and the potential of energy saving is great.

Turbulent kinetic energies in the centerline

Figure 7 shows the centerline turbulent kinetic energies in the airflow fields for the several die heads with different slot angles. For these modified dies the turbulent kinetic energy start at the position z = 0 mm and is clearly different from that of the corresponding blunt die. For the two kinds of dies, the position for the maximum of turbulent kinetic energy comes earlier comparing with that for the peak value of the velocity (figure 5 and figure 7). In the region near the die, the turbulent kinetic energy along the centerline for the new modified die is much weaker than that of the corresponding blunt die. The velocity fluctuations can be evaluated using the turbulent kinetic energy which should be small along the centerline in the melt-blowing. If the centerline velocity fluctuations are very strong, it takes harmful effects to production in the melt-blowing. In addition, if the centerline turbulent



a *b* *c*

Fig. 6. Centerline temperature profile of the two kinds of dies:
a – die 1 and new die 1; *b* – die 2 and new die 2; *c* – die 3 and new die 3

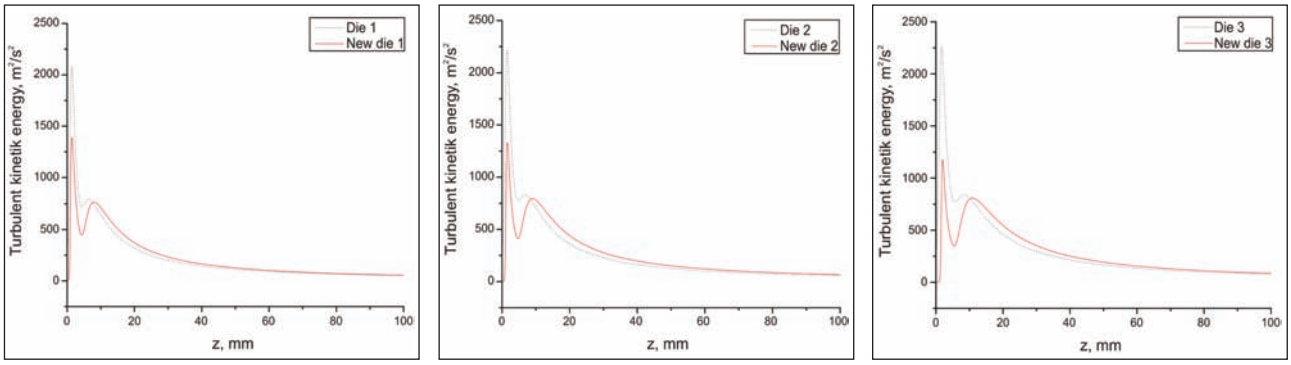


Fig. 7. Turbulent kinetic energy profiles in the centerline for the two kinds of dies: *a* – die 1 and new die 1; *b* – die 2 and new die 2; *c* – die 3 and new die 3

kinetic energy is great, it can intensify the whipping of the melt-blowing and can cause the associated defects [16].

Prediction with Mathematical Model

The pioneering work on melt-blowing mathematical modeling was done by Uyttendaele and Shambaugh [17]. Their one-dimensional model can predict the similar profiles for fiber diameter with the complex models and it doesn't need too much computer resources. In this work, Uyttendaele and Shambaugh's model is employed to predict the fiber diameter of melt blown nonwovens produced by the common slot die and the corresponding new die with inner stabilizing pieces [18–19].

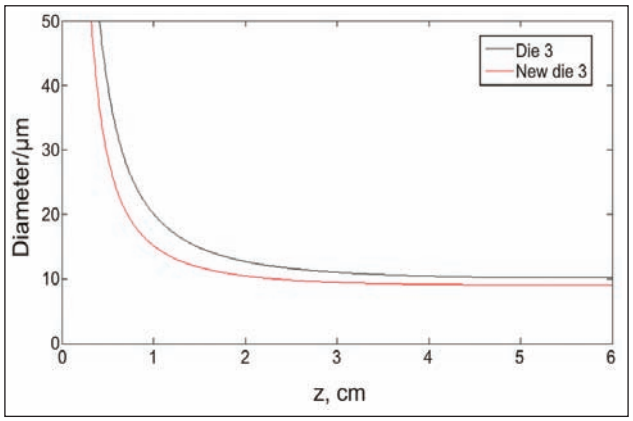


Fig. 8. The predicted diameter profile for the blunt die and the new die

With the aid of numerical simulations of the air jet flow field, the distribution of the *z*-component of air velocity v_z along the *z*-axis can be obtained. The drawing model of polymers is solved by using a fourth order Runge-Kutta method. The blunt die and the new die have the initial air pressure velocity of 1.3 atm, the initial air temperature of 310 °C, and the initial polymer temperature of 260 °C.

Figure 8 shows the drawing process of the fiber for the two kinds of slot dies. As expected, the new die with inner stabilizing pieces can produce finer fibers under the same production conditions. It is reasonable because the new slot die will yield a faster air-velocity and a higher air temperature as just proved in the previous section.

CONCLUSIONS

In this study, the new modified slot dies with different sizes of inner stabilizing pieces and different slot angles were designed and studied. The flow fields for these new slot dies were simulated utilizing CFD and the RSM was used for turbulence simulation. Furthermore, the flow field of the blunt die was examined with a hot-wire anemometer and the simulation results were validated with the laboratory measurements. The numerical computation data and the measurement data at different positions reach a basic agreement.

The simulation results indicate that new modified dies with different slot angles can reduce the reverse velocity, increase the centerline-velocity peak value, decrease the centerline temperature degradation and weaken the centerline-velocity fluctuations near the spinneret orifice.

In addition, for the new modified dies, the results reveal that enhancing the height of the inner stabilizing piece, the mean velocities in the centerline become bigger, the centerline temperature decays more slowly, the peak value of the centerline turbulent kinetic energy close to the die face reduces more rapidly. However, only when the height of the inner stabilizing piece reaches certain extent, can the new die decrease the reverse velocity near the die. So to design and manufacture the aerodynamically superior melt-blowing die, the height of the inner stabilizing piece should be higher.

Using one-dimensional model, it proves that the new slot die with inner stabilizing pieces can manufacture finer fibers.

On the one hand, the new dies with inner stabilizing pieces are expected to remove the harmful effects to production and obtain thinner melt-blowing fibers. On the other hand, if one desires to get the same size of products while decreasing the heat consumption and air consumption in the melt-blowing, the new slot die should be more suitable.

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Optimization of oxygen plasma treatment to improve the dyeing of wool with grape leaves

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REZUMAT – ABSTRACT

Optimizarea tratamentului cu plasmă de oxigen pentru îmbunătăţirea vopsirii lânii cu colorant din frunze de viţă de vie

În acest studiu, fibrele de lână au fost vopsite cu colorant obţinut din frunzele de viţă de vie. Pentru a îmbunătăți capacitatea de vopsire, fibrele de lână au fost pre-tratate cu plasmă de oxigen. Metodologia suprafeţei de răspuns și proiectarea Box-Behnken au fost utilizate pentru a studia și a optimiza tratamentul cu plasmă, în scopul obținerii rezistenţei maxime a culorii după vopsirea probelor tratate cu plasmă şi extract apos de frunze de viţă de vie. Suprafața probelor brute și a celor tratate cu plasmă au fost, de asemenea, studiate prin microscopie electronică de baleiaj. Rezultatele au arătat că tratamentul cu plasmă a eliminat parțial solzii de pe suprafaţa fibrelor de lână și a îmbunătăţit pătrunderea colorantului natural în fibre. Puterea tratamentului cu plasmă a arătat cel mai ridicat efect asupra modificării fibrelor pentru condițiile optime de tratare, indicate.

Cuvinte-cheie: plasmă, colorant natural, lână, optimizare, RSM

Optimization of oxygen plasma treatment to improve the dyeing of wool with grape leaves

In this study, wool fibers were dyed using grape leaves. To improve the dyeability, wool fibers were pre-treated with oxygen plasma. Response surface methodology and Box-Behnken design were employed to study and optimize the plasma treatment with the aim of obtaining the maximum color strength after dyeing of the plasma treated samples with aqueous extract of grape leaves. The surface of the raw and plasma treated samples were also studied by scanning electron microscopy. The results revealed that plasma treatment has partially removed the surface scales of wool and enhanced the penetration of the natural dye into the fibers. Plasma treatment power showed the highest effect on the fiber modification and the optimum conditions for plasma treatment were indicated.

Keywords: plasma, natural dye, wool, optimization, RSM

INTRODUCTION

Natural dyes derived from roots, stems, barks, leaves, berries and flowers of various plants and bodies of some animals have been used since ancient times for dyeing of textiles [1]. By introduction of synthetic dyes to the market, the use of traditional natural dyes was reduced quickly. Due to some drawbacks associated with synthetic dyes, like environmental pollution and serious health hazards, recently there is a great tendency to revive the tradition of using safe, biodegradable, and eco-friendly natural dyes [2–7].

Natural dyes are obtained from renewable resources and they have no health hazards and some of them sometimes act as a health care product. The majority of natural colorants need metal mordants to dye wool fiber satisfactorily. Mordants are the substances capable of binding natural dyes to textile substrate [8]. The metal mordants mainly are considered as toxic and researchers are exploring for environmentally friendly alternatives to reduce or eliminate the use of metal mordants in natural dyeing recipes. Commonly studied approaches include the use of ecologically safe metal salts like alum and iron sulfates; use of natural oil products, tannins and other natural extracts from plants, besides the use of ultrasound in the dyeing process or gamma and UV radiations before the dyeing [9–13].

Wool, as a natural protein fiber, has a typical core-shell structure consisting of an inner protein core, cortex and surface shell, cuticle, consisting of several layers. The surface morphology of wool significantly influences the wool dyeing and finishing processes, since the hydrophobic nature of the cuticle and the high cross-linking density in the outermost fiber surface creates a barrier, which affects the sorption properties. Therefore, modifying the wool surface to improve the hydrophilicity and dyeability of the resulting goods is sometimes essential [14–16].

Low temperature plasma treatment, a water-free and clean process, provides a new alternative for surface modification of textile fibers. Plasma treatment can remove the hydrophobic surface layer and partially destroys the surface scales of wool fiber without affecting its bulk properties [3, 17]. Oxygen plasma treatment has a great influence on wettability of wool fibers and the plasma treated sample absorbs water very quickly and the water wicking is remarkably improved after plasma treatment [18]. This can increase the sorption of synthetic and natural dyes to wool fibers [3, 16, 19].

Grape is an important fruit crop grown all over the world and is a major source of alkaloids, alcoholic

compounds, flavonoids and polyphenols. Grapevine parts such as leaves contain high phenolic compounds too [20–21]. In this study, grape leaves which are a major waste generated in agricultural and food industries, were utilized for dyeing wool fibers. To increase the absorption of the coloring matter by the fibers, the wool fabric samples were treated with low temperature oxygen plasma at varying conditions. Response surface methodology was employed to determine the effect of plasma treatment factors on the color strength of the dyed samples and the optimum conditions for plasma treatment leading to the highest color strength of the dyed sample was obtained.

EXPERIMENTAL WORK

Materials and methods

Plain woven wool fabric (250 g/m^2) was supplied from Iran Merinos Textile Company, Iran, and was scoured with 1% non-ionic detergent (Ultravon CN, Ex-Ciba) at 50ºC for 30 min, then dried at ambient temperature.

Grape leaves, as the source of natural dye, were first washed and dried and then powdered. To prepare the original solution of the dye, each 100 g of powder was added to 1 liter of distilled water and boiled for 2 h and then filtered. Due to evaporation, the volume of the solution was reduces, so, the distilled water was added to the filtrate to reach the initial volume. The concentration of the resultant solution is 10% W/V.

Experimental Design: Design Expert software (version 7.0) was used for the design of experiments and statistical analysis of responses. In this study, the response surface methodology (RSM) and Box-Behnken design were applied to optimize the three important operating variables of the plasma treatment process. Preliminary studies were done to determine a practically feasible range for each factor prior to designing the experimental runs. The corresponding codes besides lower and higher values for each variable are listed in table 1.

Table 1

EXPERIMENTAL RANGES OF FACTORS				
Factor	**Name**	**Unit**	**Low Level**	**High Level**
A	Plasma Time	Sec	60	300
B	Oxygen Flow Rate	Sccm	20	200
C	Plasma Power	W	50	200

Box–Behnken is a response surface design, specially employed to require only three levels of factors. The total number of experiments ($N = 17$) in this study with three independent factors was obtained from the equation: $N = k^2 + k + cp$, where k is the number of factors ($= 3$) and cp is the number of center points of the design ($= 5$) [22]. To compare the plasma treated samples with a non-plasma-treated sample, sample no. 18 was added in which all plasma treatment factors are zero. P-value with 95% confidence level was considered for the selection or rejection of the model terms. To analyze the results, ANOVA was employed. Response surfaces were drawn to determine the individual and interactive effects of the process variables on the color strength of dyed samples.

Plasma Treatment: The wool fabric samples were pretreated using radio frequency (13.56 MHz) low pressure plasma equipment (Model: Junior Advanced, Europlasma, Belgium) with oxygen gas. The sample chamber was evacuated to 100 mTor and maintained at this pressure during process. Then, oxygen was introduced with a different flow rates. Plasma was generated at varying powers for a predefined time (according to the experimental design). Finally, atmospheric air was introduced into the chamber and the plasma treated sample was removed.

Dyeing: Dyeing of the samples was performed using 20% owf of the natural dye (L:G= 40:1, *p*H=5). The dyeing was started at 40°C and the temperature was raised to boil at the rate of 2°C per minute. Then the samples remained in that condition for 1 hour, and then rinsed and air dried.

Color strength measurements: the reflectance of dyed samples were measured on a Color-eye 7000A spectrophotometer using illuminant D65 and 10° standard observer. Color strength (K/S) of each dyed sample was calculated using kubelka-munk equation:

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

where: R is the observed reflectance, K – the absorption coefficient and S – the light scattering coefficient.

Scanning electron microscopy: Scanning electron micrographs were taken on a S-4160 field emission scanning electron microscope (FESEM) (Hitachi, Japan) to study the effect of plasma treatment on the surface structure of wool fibers.

RESULTS AND DISCUSSION

SEM investigations

The morphology of wool fibers was studied by scanning electron microscopy to investigate the effect of oxygen plasma treatment on surface structure of the fibers. These images were taken for understanding of the reason of better penetration of dye molecules into the wool fibers after plasma treatment. It can be clearly seen in figure 1 that after plasma treatment, the compact and intact scales of untreated wool fiber have been destroyed. This etching is due to the bombardment of the fibers surfaces by active species present in plasma. The removal of surface scales can increase the water and dye absorption of wool fibers [19, 23].

Model fitting and statistical analysis

The experimental conditions and color strengths (K/S) of the dyed samples are shown in table 2. The data were fitted to various models and their subsequent ANOVA are shown in table 3. The described process was most suitably described with quadratic

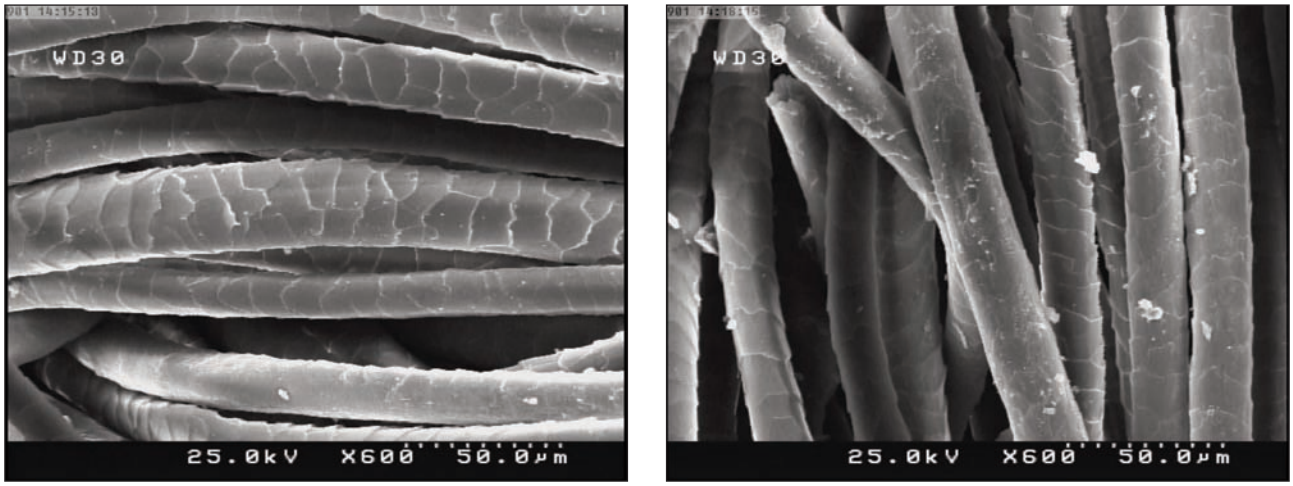

Fig. 1. SEM images of raw (left) and plasma treated (right) wool fibers (300 sec, 150 W, 100 Sccm)

model. The response data were analyzed by Design Expert software. The analysis of variance was applied to evaluate the significance of the effect of all variables and their interactions on the response.

Table 2

EXPERIMENTAL DESIGN OF PLASMA TREATMENT PROCEDURES AND RESPONSES

	Factor 1	Factor 2	Factor 3	Response
Run	A: Plasma Time (Sec)	B: Oxygen Flow Rate (Sccm)	C: Plasma Power (W)	K/S
1	300	20	125	2.9553
2	180	20	200	3.1103
3	180	110	125	3.1461
4	180	110	125	3.1168
5	180	20	50	2.4510
6	180	110	125	3.0593
7	180	200	200	3.1494
8	300	110	200	3.2646
9	60	200	125	2.9257
10	180	110	125	3.1298
11	180	200	50	2.7928
12	60	110	200	2.8231
13	300	200	125	3.6561
14	180	110	125	3.0688
15	300	110	50	3.0343
16	60	100	50	3.0066
17	60	20	125	2.9853
18	0	0	0	2.0862

P-values lower than 0.05 indicate that the model and the terms are statistically significant. If there are many insignificant model terms, model reduction can improve the model. In this study, model reduction was performed and some insignificant interactions of the variables were eliminated.

Table 4 shows the analysis of variance (ANOVA) results of the established model for responses. The model F-value of 13.01 implies that the model is significant and there is only a 0.02% chance that a "Model F-Value" of this large value could occur due to noise. Values of Prob>F less than 0.05 imply that the model terms are significant at the 95% confidence level, whereas the values greater than 0.1 are usually considered as insignificant. In this case A, B, C, AB, and C^2 are significant model terms. A high R^2 coefficient supported a satisfactory adjustment of the proposed model to the experimental.

The "Pred R-Squared" of 0.6390 was in reasonable agreement with the "Adj R-Squared" of 0.7793. "Adeq Precision" compares the range of predicted values at design points to the average prediction error. A ratio greater than 4 is desirable and indicates the suitable model selection [24]. In this case, the ratio of 16.004 indicates an adequate signal. This model can be used to navigate the design space.

Regression analysis of experimental data was performed and the model equation in terms of coded factors is as follows:

$$K/S = 3.13 + 0.16A + 0.14B + 0.15C + \\ + 0.15AB - 0.21C^2 \quad (2)$$

Table 3

ANOVA RESULTS OF THE FITTING THE EXPERIMENTAL DATA TO VARIOUS MODELS

Source Model	Sum of squares	Df	Mean Square	F Value	P value Prob > F	Std. Dev.	R-Squared	
Linear	0.57	10	0.057	39.19	0.0015	0.20	0.6810	
2FI	0.42	7	0.060	40.83	0.0015	.020	0.7664	
Quadratic	0.17	4	0.97	29.19	0.0032	0.15	0.9027	Suggested
Cubic	0.000	0				0.038	0.9968	aliased

Table 4

ANOVA RESULTS OF THE ESTABLISHED MODEL FOR RESPONSES

Factor	F-Value	P-Value
Model	13.01	0.0002
A: Plasma Time	9.59	0.0092
B: Oxygen Flow Rate	7.05	0.0210
C: Plasma Power	8.41	0.0133
AB	4.97	0.0456
C^2	11.33	0.0056

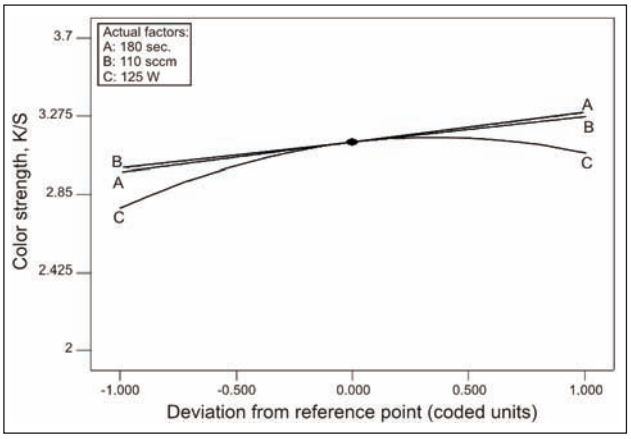

Fig. 2. Perturbation plot for K/S

The effects of parameters on color strength

To compare the effect of three factors on color strength of dyed samples, perturbation plot (figure 2) was drawn. This plot shows the effect of changing each factor on *K/S* while holding two other factors constant. The reference amounts of the factors to draw the plot are shown on it. A steep slope or curvature in the resulting trace indicates sensitivity of the response to that factor. From the curvature of the plot C, it can be concluded that the response is more sensitive to plasma power compared with other factors. The lower steep of the gas flow line shows less sensitivity of the color strength to change in this factor.

Figure 3 shows the individual and simultaneous effects of the plasma treatment factors on color

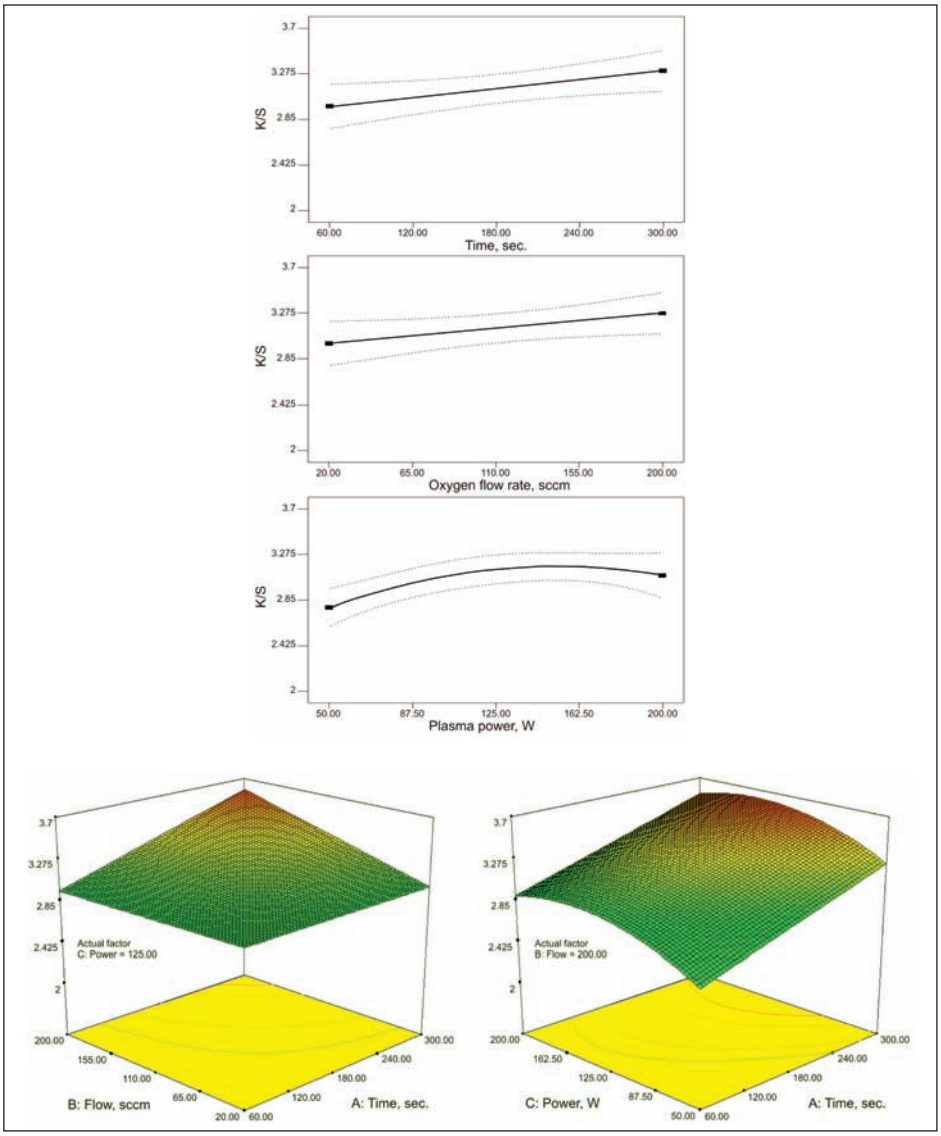

Fig. 3. The individual and simultaneous effects of each factor on color strength of dyed samples

Table 5

OPTIMAL CONDITIONS FOR THE PLASMA TREATMENT OF WOOL FIBERS TO OBTAIN MAXIMUM COLOR STRENGTH					
Plasma Time (Sec)	**Oxygen Flow Rate** (Sccm)	**Plasma Power** (W)	**Predicted K/S**	**Experimental K/S**	**Desirability**
300	200	150	3.61	3.67	0.973

strength of dyed samples. It can be seen that increasing all factors results in increasing the *K/S*, due to increasing the surface etching of wool scales leading to better penetration of dye molecules. The graph of *K/S* versus plasma power indicates that there is an optimum power (around 150 W) for highest effect on color strength. Using higher plasma power does not affect the *K/S* and the plot reaches a plateau.

Optimization of plasma treatment process

The maximum color strength was taken as the desired response and the optimal conditions for obtaining the maximum *K/S* were predicted using the optimization function of Design Expert software. All factors were selected to be "in the range". The optimized conditions are shown in table 5. Good agreement between the predicted *K/S* and the experimental value means that the empirical model derived from RSM can be used to adequately describe the relationship between the factors and response in this study.

CONCLUSION

In this study, the aqueous extract of grape leaves was used as a natural dye for dyeing of wool. To increase the sorption and penetration of the dye molecules, plasma treatment of wool fibers was considered as an environmentally friendly pre-treatment. The effects of three independent plasma treatment factors on the color strength of the dyed samples were statically studied using response surface methodology. The results showed that the *K/S* had the highest sensitivity to plasma power compared with other factors. Increasing all factors resulted in increasing the *K/S*, but there was an optimum plasma treatment power (around 150 W) for highest effect on color strength. The optimal conditions to obtain the highest color strength were derived from statistical data. Plasma pre-treatment can be a suitable approach to increase the uptake of natural dyes by wool fibers and lower the need for toxic mordants usually used in natural dyeing processes.

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Analysis of embroidery pattern influence on the working mode of "Happy" embroidery machine by using the vibration measurement technique

MARIUS ȘUTEU

REZUMAT – ABSTRACT

Analiza influenței modelului broderiei asupra regimului de lucru la mașina de brodat "Happy" prin tehnica măsurării vibraţiilor

Scopul prezentei lucrări este extinderea cercetărilor efectuate la mașina de brodat pe diferite modele de broderii, pentru a stabili dacă amplitudinea maximă a vibrațiilor se menține pe direcția de măsurare verticală Z și dacă regimul de lucru de 700 împunsături/minut se menţine la schimbarea direcției de brodare. După stabilirea regimului optim de lucru, cercetările experimentale au fost extinse şi pe alte modele de broderii, pentru a stabili dacă amplitudinea vibraţiilor pe direcţia de măsurare verticală Z (direcția de montare a senzorului) rămâne prioritară pentru analiză, adică dacă amplitudinea maximă a vibraţiilor se menţine pe direcţia de măsurare verticală Z şi dacă frecvenţa de lucru de 700 împunsături/minut se menţine la brodarea rectilinie, respectiv în curbă (la schimbarea direcţiei de brodare). În urma cercetărilor efectuate s-a stabilit că regimul optim de lucru este de 700 împunsături/minut. Materialul selecţionat pentru modelul broderiei a fost tercot (caracterizat prin stabilitate dimensională mare), iar lăţimea broderiei – 12 mm. Colectarea datelor s-a realizat în memoria analizorului IMPAQ, fiind ulterior transferate pe calculator în softul Data Explorer.

Cuvinte-cheie: măsurări de vibrații, lățimea materialului brodat, maşina de brodat, defecte, soft Data Explorer

Analysis of embroidery pattern influence on the working mode of "Happy" embroidery machine by using the vibration measurement technique

The purpose of this paper is to extend the research conducted on embroidery machine with different embroidery patterns, to determine if the maximum amplitude of vibrations remains on the vertical measuring direction Z and if the operating mode 700 stitches/minute is maintained when changing the embroidering direction. After determining the optimum operating mode, the experimental researches were extended on other embroidery patterns to determine if the amplitude of vibration in the vertical measuring direction Z (the mounting orientation of the sensor) remains a priority for analysis, ie if the maximum amplitude of vibration is maintained on the vertical measuring direction Z and if the operating frequency of 700 stitches/minute is maintained when making rectilinear embroidery or curved embroidery (to change the direction of embroidery). As a result of the research we determined that the optimal working mode is 700 stitches/minute. The fabric chosen for the embroidery pattern is terry cot (mainly because of high dimensional stability), and the width of embroidery is 12 mm. Data collection were made in the analyser memory IMPAQ, then being transferred to computer software Data Explorer.

Keywords: vibration measurement, embroidered fabric width, embroidery machine, faults, Data Explorer software

INTRODUCTION

In this paper the issue of increasing textile production quality and productivity is discussed. What is known for sure is that productivity is directly influenced by the main component parts of the equipment involved in technologies specific to the textile products sector. Modern solutions in the field of machinery intended for the textile products sector are elaborated and researched. To improve the specific components of these machines it is envisaged to increase the quality of the existing ones and in order to accomplish this research, theoretical and experimental studies are required [1].

The study presented in this paper has importance not only in terms of the influence of vibration on product quality but also in economic terms because a high level of vibration will lead to increased consumption of needles and thread, embroidery machine mechanisms wear and implicitly increased cost of production (this is one of the main factors that influence the development of production and exports of textile and clothing products) [2].

Fig. 1. Impaq analyser description [3]

Measurements were performed at S.C. CONFIDEX S.R.L Oradea. These were carried out in each measurement point by installing a vibration sensor in the three directions of the Cartesian coordinate system: longitudinal (axial X), transverse (Y horizontal), vertical (Z) as shown in figure 2.

Vibration measurements were performed with IMPAQ FFT spectrum analyser, manufactured by Benstone Instruments Inc. USA. IMPAQ which is a portable analyser with colour graphic display, keyboard and graphics display functions measured and analysed as shown in figure 1.

Vibration analysers include data analysis software that is installed on the PC. The program allows downloading and analysing data taken by software modules which are installed in the vibration analyzer. It also has the function of post data processing, simultaneous viewing of several types of charts and spectra, performing mathematical relations (+, –, *, /), integration, derivation, filters in real time etc. The best performing programs also have data export facilities in the following file types: UFF, BUFF, ASCII UFF, MATLAB, ASCII files (ex. MS Excel) and user-defined and automatic generation of technical reports according to the application studied, defining custom templates, saving in HTML, PDF, EXCEL and WORD formats.

Thus it can be concluded that the vibration analyser is ideal for use in all industrial fields.

To analyse and diagnose the embroidery machine faults were used:

– A vibrometer for vibration measurements to determine the global vibrations in order to establish the operating qualifier for the embroidery machine;
– Waveform and FFT analysis (frequency analysis of vibrations) in order to carry out waveform and frequency spectrograms on one or more channels. With these software frequency settings, measurement parameters, the number of mediations, etc. can be performed;
– Data Explorer software for analysing and interpreting the data measured with IMPAQ analyzer [3–6].

MODELING METHOD

The essential aim of the experimental part carried out with the embroidery machine consisted in extending the research on different embroidery patterns to determine if the maximum amplitude of vibrations remains on the vertical measuring direction Z and if optimal working mode established by the author at 700 stitches/minute is maintained when changing the embroidery direction. Determining this optimal working mode of 700 stitches/minute was introduced in a previous paper in the journal Textile Industry [3].

The machine on which these measurements were made is called HAPPY professional embroidery machine.

Data collection on Happy embroidery machine was carried out in the following fields of vibration: speed, displacement and acceleration. Data collection regarding vibration was performed with the help of transducers which took over the spectra of vibration and turned them into electrical information that were subsequently transmitted to the data collection system. Depending on the evaluated vibration parameter, the transducers can evaluate amplitudes of vibration, speeds of vibration or acceleration of vibration.

After collecting data on the embroidery machine and transferring them on the computer that works with the application Data Explorer, the stage of fault analysis and diagnosis has come [4].

The measuring direction shown below is vertical Z (mounting orientation sensor) fabric-terry cot and embroidery width is 12 mm as shown in figure 2.

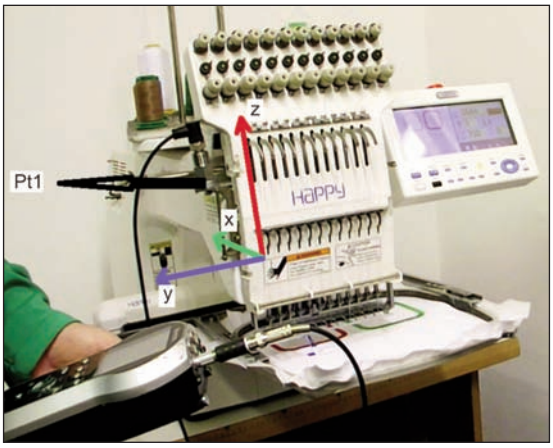


Fig. 2. The embroidery machine “HAPPY” [7] with vertically mounted sensor Z, terry cot fabric, embroidery width (12 mm) and coordinate axes

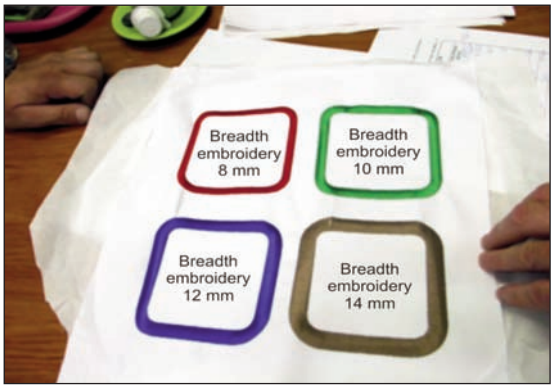


Fig. 3. Picture of the embroidery fabric (terry cot) with four widths of embroidery

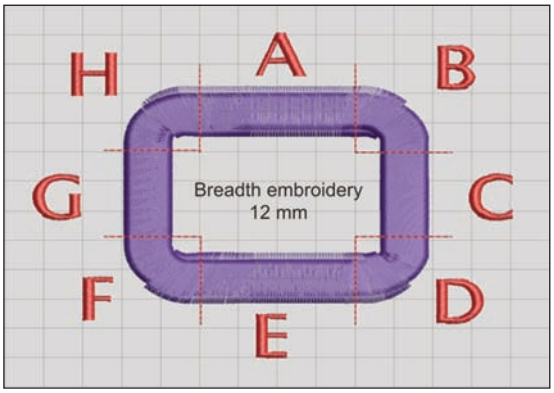
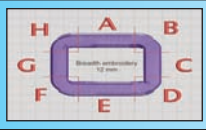


Fig. 4. The embroidery pattern (terry cot) with the analysed parts (A, B, C, D, E, F, G, H)

Table 1

VIBRATION AMPLITUDE DEPENDING ON THE OPERATING MODE WITH SENSOR ON THE VERTICAL Z (TERRY COT FABRIC EMBROIDERY WIDTH 12 mm)

	Amplitude of vibrations			Working frequency given by the machine
Embroidery parts *Mm*	**Velocity** *mm/s* [rms]	**Displacement** µ*m* [rms]	**Acceleration** *g* [rms]	**No. of** *stitches/minute*
A	14	180	0,7	750
B	7	115	0,5	550
C	9,5	80	0,7	750
D	7,2	90	0,5	550
E	14	180	0,7	750
F	8	100	0,4	550
G	10	80	0,7	750
H	6,8	87	0,46	550

RESULTS AND DISCUSSIONS

The amplitude of the vibrations recorded at the measuring point PT1 on the embroidery parts (A, B, C, D, E, F, G, H) is shown in table 1.

The amplitude of the vibration according to table 1 is greater in the rectilinear movement on the embroidery portions (A, C, E, G, shown in figure 4) and lower when changing the embroidery direction on the parts (B, D, F, H; shown in figure 4).

Based on table 1, diagrams were made: the amplitude of the velocity, the amplitude of the displacement and the amplitude of the acceleration based on the parts to be embroidered.

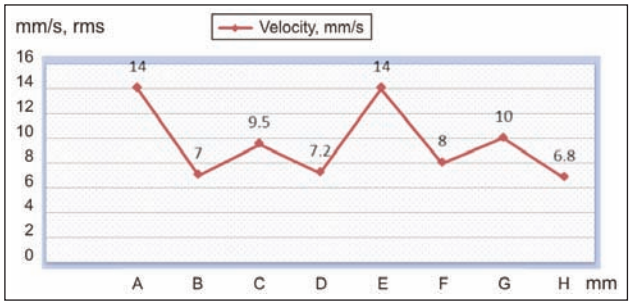


Fig. 5. Velocity amplitude according to the embroidery parts (sensor on vertical Z, terry cot fabric)

From figure 5 it can be seen that the magnitude of velocity in the two embroidery parts (A, E terry cot fabric) are equal, and the portions (B, D, F, H terry cot fabric) are approximately equal.

From figure 6 it can be seen that the amplitude of displacement on the embroidery portions (A, E terry cot fabric) are equal as well as the portions (C, G terry cot fabric).

The acceleration gives the impact *"metal on metal"* resulting in a linear acceleration on the embroidery portions (A, C, E, G, terry cot fabric) as well as on the embroidery portions (B, D, F, H terry cot fabric), as can be seen in figure 7.

The waveform and frequency spectrograms obtained for embroidery machine "HAPPY" recorded in the measuring point Pt1, on vertical measuring direction Z (the direction of mounting the sensor) on the embroidery portions (A, E terry cot fabric) are shown in figure 8.

The waveforms and frequency spectrograms obtained for the embroidery machine "HAPPY" recorded in the measuring point Pt1, on the vertical measuring direction Z, on the embroidery portions (B, D, terry cot fabric) are shown in figure 9.

The waveforms and the frequency spectrograms obtained for the embroidery machine "Happy" recorded

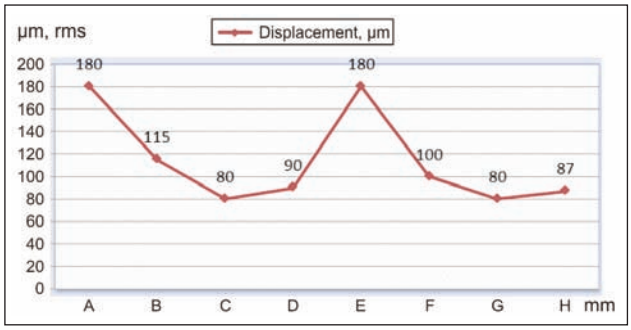


Fig. 6. Amplitude of displacement according to the embroidery parts (sensor on vertical Z, terry cot fabric)

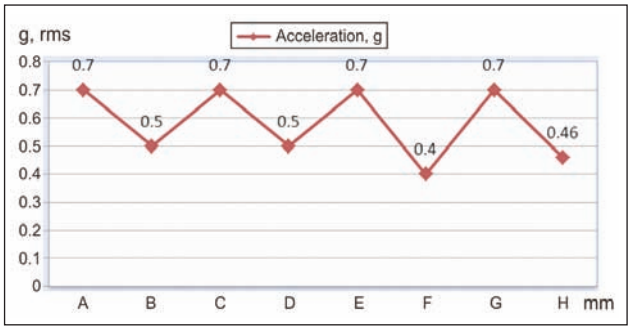


Fig. 7. Amplitude of acceleration according to the embroidery parts (sensor on vertical Z, terry cot fabric)

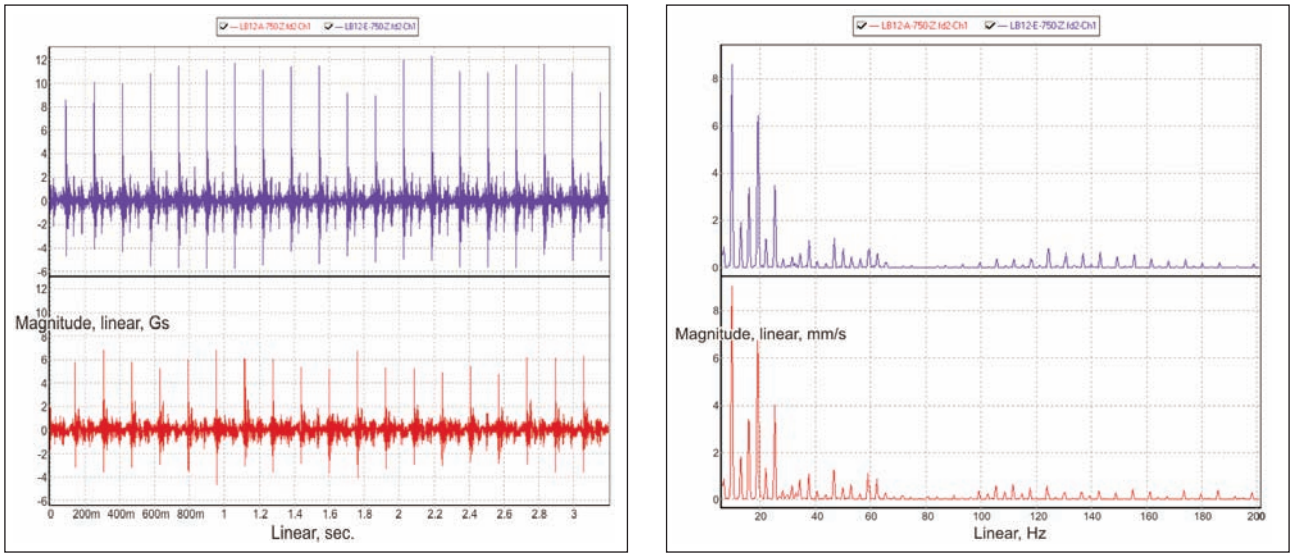


Fig. 8. Waveforms and frequency spectrograms recorded in the measuring point Pt1, on the vertical measuring direction Z, on the embroidery portions (A, E, terry cot fabric)

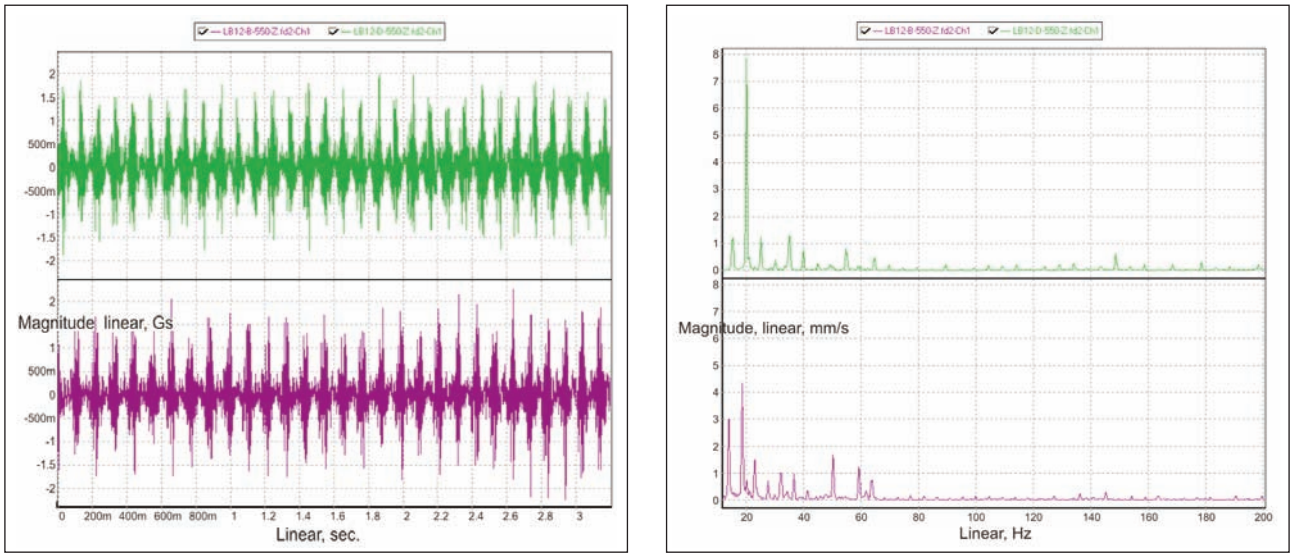


Fig. 9. The waveforms and frequency spectrograms recorded in the measuring point Pt1, on the vertical measuring direction Z, on the embroidery portions (B, D, terry cot fabric)

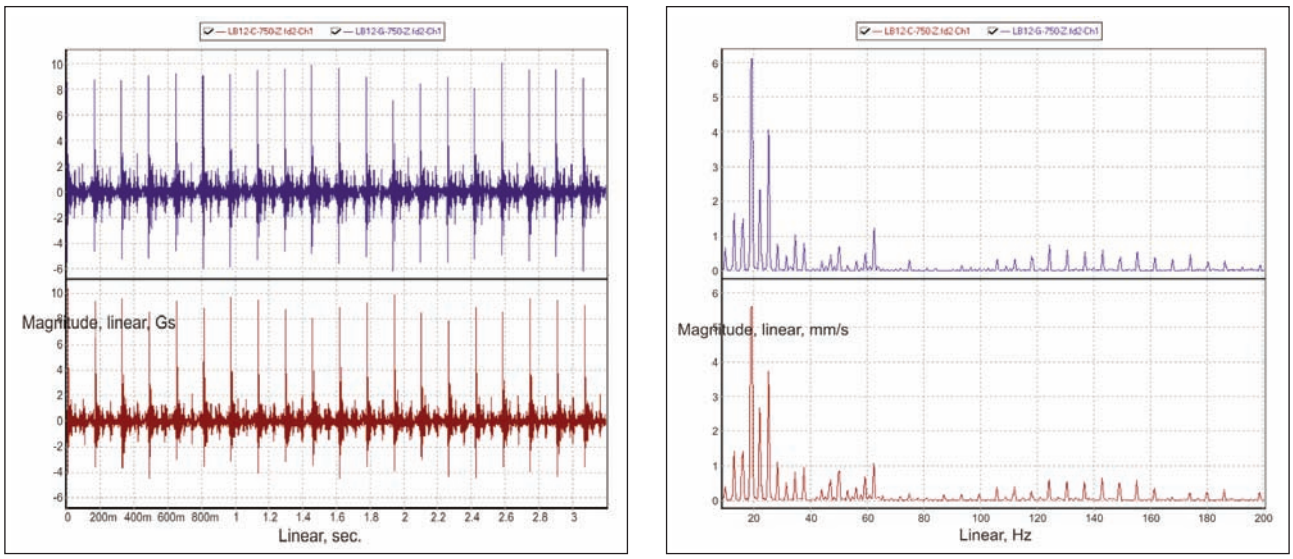


Fig. 10. The waveforms and the frequency spectrograms recorded in the measuring point Pt1, on the vertical measuring direction Z, on the embroidery portions (C, G, terry cot fabric)

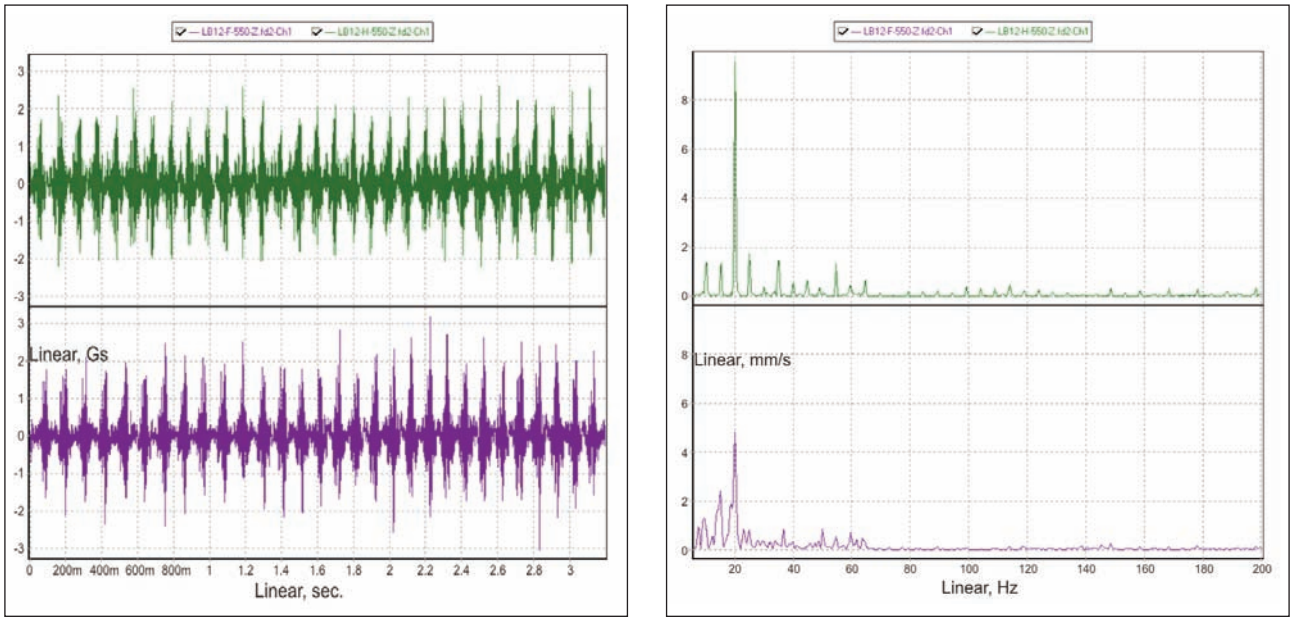


Fig. 11. The waveforms and the frequency spectrograms recorded in the measuring point Pt1, on the vertical measuring direction Z, on the embroidery portions (F, H, terry cot fabric)

in the measuring point Pt1, on the vertical measuring direction Z, on the embroidery portions (C, G, terry cot fabric) are shown in figure 10.

The waveforms and the frequency spectrograms obtained for the embroidery machine "Happy" recorded in the measuring point Pt1, on the vertical measuring direction Z, on the embroidery portions (F, H, terry cot fabric) are shown in figure 11.

By analyzing the frequency spectrum we can notice that, as a rule, the amplitude of 1x or 2x dominates the spectrum, this is because the driving engine speed occurs at 2x and at 1x sewing takes place (no sewing occurs at the same frequency). Upper harmonics 1x or 2x appear in different frequency spectrogram and are caused by the judders that occur in the transmission kinematic chain of the motion to make the embroidery.

CONCLUSIONS

From the research conducted it can be noticed that the amplitude of vibration on the embroidery portion (B, D, F, H, – terry cot fabric, figure 4) with sensor mounted on vertical Z decreases significantly compared to the embroidery portion (A, E, or C, G). This is due to the decrease in the frequency of the electric motor (frequency of embroidery) at the operating mode in a curve.

For sewing, embroidery machines, it is worth noting that there are no ISO standards from the point of view of the allowable vibrations level. Operating ratings are established by regulations of machine designers, and usually these values or the optimal operating modes are not specified in the technical book of the machine.

These vibration levels are not standardized because in practice there is a diverse range of sewing, embroidery, machines that can run to several working modes that can create large variations in amplitude vibration. This can be observed in the measuring direction (Z) of vibration amplitude where on the embroidery portion (A) the velocity amplitude is 14 mm/s and on the embroidery portion (B) the velocity amplitude is reduced by half, that is 7 mm/s.

In terms of choosing the optimum working mode it is well known that any large amplitude of vibrations leads to a decrease in the machine's reliability and the danger of breaking the thread.

Choosing the embroidery width was not coincidental, the research conducted by the author shows that up to a 10 mm width of embroidery according to the chosen model (figure 6) there are no differences in the working frequency.

At a width of 8 mm embroidery, 10 mm respectively, according to the chosen model (model shown in figure 3) the optimal working modes have been established.

At a width of 14 mm embroidery according to the chosen model shown in figure 3, the machine has a lower efficiency (the embroidery was not qualitative) it should be changed the sewing design (embroidery), respectively (embroidery width of 14 mm is divided into two passes).

Lately in more and more factories are implemented technological monitoring systems aimed at increasing the reliability and implicitly the quality. In this sense Happy Company took the first step and introduced needle contour frequency variation according to the radius of curvature and width of the embroidery. It might be said that it is a great achievement, in reality, this variation is performed very simply, in just 3 steps of frequency and it does not consider the thickness and density of the fabric, needle wear etc. and all these have an effect on vibrations. When performing the vibration measurement it is closely monitored the machine behaviour on the embroidered

contour. The novelty is that, theoretically, the continuous adaptive adjustment of the needle frequency could be adjusted with the help of an external calculator. The automatic access to the program has not yet been resolved, this is done only manually and at the beginning of the program. Provided that this level proposed in the paper could be implemented, in this case we could change the frequency on the contour in different modes: manual, automatic (online) in steps, continuous (adaptive), or by segmenting the program in several phases on the embroidered contour.

In this way the frequency along the embroidered curvature could be steered.

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Three dimensional online virtual apparel internet page application

BEKIR AKSOY MEHMET DAYIK

REZUMAT – ABSTRACT

Aplicaţie pe pagina de internet pentru îmbrăcăminte virtuală on-line tridimensională

Dezvoltările tehnologice care au apărut în mediile de modelare tridimensională amplifică în fiecare zi importanța îmbrăcămintei virtuale. În această lucrare, modele ale corpului uman având diferite dimensiuni, proiectate prin folosirea de software de proiectare a textilelor, au fost aşezate pe cămăşi de diferite dimensiuni prin utilizarea structurii Three.js, iar ulterior, aspectele reale ale acestor cămăşi, cum ar fi compactitatea, lărgimea sau potrivirea pe corp (drapabilitatea cămăşilor), au fost transferate tridimensional pe pagina de Internet prin utilizarea unui limbaj de programare Java. Caracteristicile de drapabilitate frontală, laterală și posterioară ale cămăşii au fost afișate prin rotirea la 360° a acestor aspecte reale transferate pe pagina de Internet. Accesarea unui aspect mai explicit al drapabilităţii cămăşii pe modelul de pe pagina de Internet a fost posibilă prin intermediul măririi prin zoom cu 10–40%.

Cuvinte-cheie: model tridimensional, programare Asp.Net, articol de îmbrăcăminte gata confecţionat

Three dimensional online virtual apparel internet page application

The technological developments occurred in three dimensional modeling environments enhance the importance of virtual apparel each passing day. In this paper, human body models having different sizes which were designed by employing textile design software were put on shirts of various sizes via utilizing three.js structure thereafter the realistic appearances of these shirts such as being tight, loose or well fitting (drapeability of shirts) were transferred to the Internet page three dimensionally by using java programming language. The frontal, lateral and posterior drapeability features of the shirt were displayed by rotating these transfered realistic appearances 360 degree on the Internet page. Accessing a more explicit appearance of the shirt's drapeability on the model at the Internet page was made possible via enabling zooming in by 10–40%.

Keywords: Three dimensional model, Asp.Net programming, ready made garment

INTRODUCTION

Today, people have to keep up with a quite intensive working life and have limited time, therefore, the use of electronic commerce via Internet increased considerably since 2000. At the beginning, the electronic commerce carried business on the sectors such as consumer electronics, computers, books and domestic appliances. As of today, for being able to access to more numbers of people in the society and offer higher quality, electronic commerce is evolved as a prime necessity for textile sector just like for all the other sectors. The utilization of the electronic commerce in the textile sector involves the two dimensional presentations of the textile product to the potential customers, by either displaying the photograph of the textile product or the photograph of the textile product on a mannequin. There are various studies investigating this subject in the literature. They suggested a solution which rendered possible a quick apparel design that enabled to try on the apparels, in conformity with the measurements and arrange the styles in a virtual environment via a CAD (Computer Aided Design) software [9]. Three dimensional body scanning technology application was developed which was capable of recognizing the body measurements for being able to fit the apparels on human body. In the study, after acquiring the individual's body measurements by three dimensional scanning technology, a virtual apparel rehearsal was carried out via Internet [4]. They tried to achieve a figure interpolation based three-dimensional parametric human body modelling tool. This tool, via utilizing the photographic images of the apparels and the synthesized images of the sizes through a three dimensional interface, created a putting on environment for the virtual sizes in computer environment [12].

One of the important factors, relating to putting on an apparel to a model in a virtual environment, is the degree of capability to display this put on apparel's drapeability. The capability of expressing this drapeability, depends on the fabric simulation to a greater extent. Because most of the bodies would be covered by the fabric, plaits occur at the contacting points between the fabric and the human body. The amplitude (spaciousness) of these occurred plaits tends to change depending on the distance at the contact point. It was detected that the most intensive fabric drapeability occurrence took place at the joining point of fabric and human body. Moreover, it was also observed that the amplitudes of these pleats were increased at the joining points in a direct proportion. The direction of the pleats tended to expose a parallel course with the points which were resistant to stretching.

MATERIAL AND METHOD

In this study, a three dimensional human model was created out of different body sizes. In the study, blank, xxsmall, xsmall, small, large, medium, xlarge and xxlarge size models were designed via employing design software. For designing the models, body measurements such as lower leg, upper leg, hips, belly, arm, chest, and neck were taken in to consideration. A sample shirt model was designed via employing design software and shirt patterns were created in computer environment. During shirt design, the patterns were generated in computer environment by considering the features such as collar, shoulder, arm, and cuff. The designed shirt was put on the model and then the appearances over the model were investigated in detail. Especially the fitting, pleats and the drapeability characteristics of the apparel on the mannequin were modelled. Well, loose or tight fitting, drapeability and pleat characteristics of the shirts for each body size on a three dimensional human model were designed and displayed over the model. Because of these acquired apparel images required excessive amount of storage place, it was necessary to reduce the file sizes of the prepared plain models and shirt attired models during transferring them to the Internet page. The sizes of the prepared models were reduced via saving hem as having OBJ (object) file extension which was supported by design software. Along with the creation of the above mentioned OBJ extended files, a MTL (Alias Material) extended file storing the path for the image files which were used by OBJ extended files was created. The OBJ and MTL file formats were red and transferred to the Internet environment by Hyper Text Markup Language supported Three.js project. A fitting room page was created that allowed the users to enter their body sizes for the models which were transferred to the İnternet page.

Fitting Room

An Internet page was prepared for the models which were generated via using Three.js project, and as seen in figure 1, a fitting room link was created for them.

Choosing the fitting room link would bring a screen to the Internet page that is similar to figure 2.

Zooming in/out at the fitting room

Zooming in/out to the fitting room placed model was carried out through three.js project via using the following codes: object.scale.set(0.1,0.1,0.1)

The code line enabled to display the three dimensional model with the desired ratio. In a similar way, it was possible to execute enlarge/reduce operations and also zoom in/out operations by using scale command:

```
object.scale.set(zoom == null || zoom == 0 ? "0.1" :
    (zoom / 100.0) ,
zoom == null || zoom == 0 ? "0.1" : (zoom / 100.0),
zoom == null || zoom == 0 ? "0.1" : (zoom / 100.0).
```

Fig. 1. Fitting room link for shirt category page

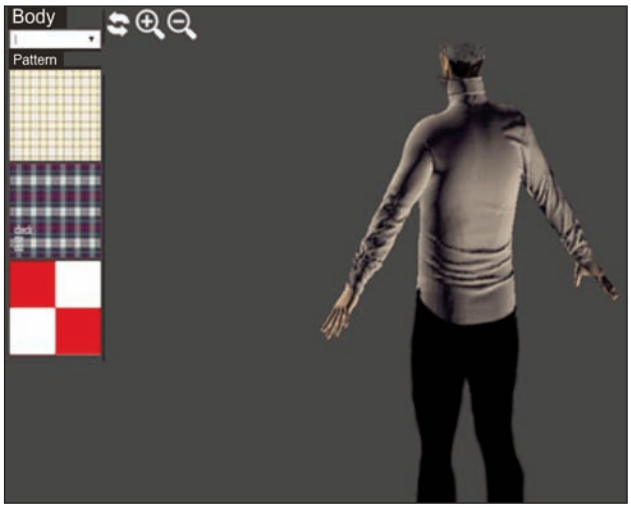

Fig. 2. Fitting room Internet page (with 20 % zooming in ratio)

The Zoom in/out value here was the user defined enlarge/reduce percentile ratio. The proposed scaling value was in 0-1 range, therefore, for achieving a 10% zoom in ratio it was necessary to submit a value of 0.1. Because of this, the related value was arranged as to be 10/100 when a user applied a 10% zoom in. We observed that the desired part of our model was failed to be displayed after executing the enlargement operation. Hence it was necessary to set the coordinates of y axis at the same time. For being able to achieve this,

object.position.y = [-70 + (-150 * (zoom - 10F) / 10F)] code line was used. Here, the zoom in/out value was a user defined one. It shifted the y coordinate of the model 150 pixels below for each 10% segment. Figure 2 shows 20% zoomed in and the figure 3 shows 40% zoomed in appearance of the fitting room placed model which was rendered via the prepared code structure.

Fitting room administrator operations

The designers were allowed to create shortcuts for being able to add shirt designs, apparel and apparel designs etc. on the Internet page, and the administrator was privileged to add such information to Internet page, thus, the users were enabled to view the shirt over the Internet page as being mounted on the model and rendered with different designs of choice. The prepared administrator operations home

Fig. 3. The 40% zoomed in appearance of shirt mounted model

page, as shown in figure 4, allows the user to be directed to the administrator page by entering personal TR Identity Number and Password information. The snapshot of the administrator home page, after entering TR Identity Number and Password information, and then pressing enter button, is shown in figure 5.

Choosing the add design link would bring the screen which is shown in figure 6.

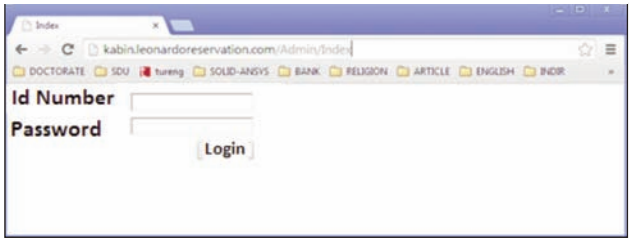

Fig. 4. Site administrator home page

Fig. 5. Site administrator home page

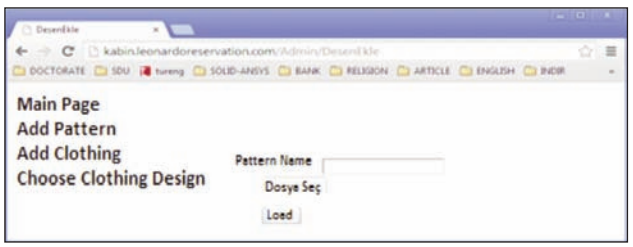

Fig. 6. Design adding page for the administrator

Fig. 7. Design selecting page for the administrator

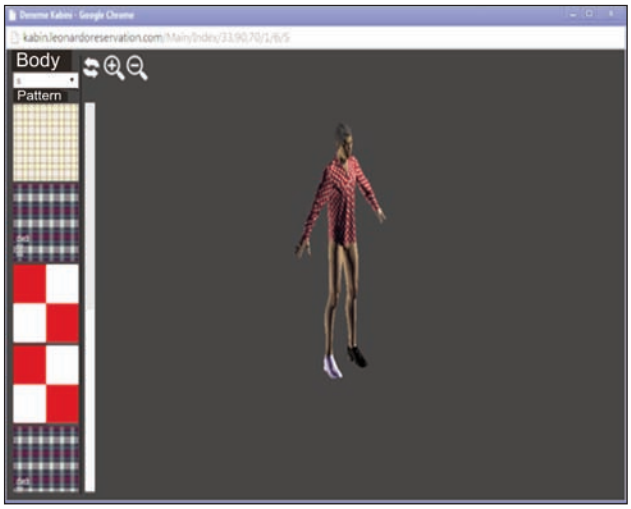

Fig. 8. The image of a design applied shirt

In this page, it was possible to select a design file from the saved ones the administrator's PC and add it to the database by clicking Select File button. The added designs were shown in figure 7.

For being able to apply any design, from ones that were displayed in the list to, the fitting room placed shirt, it was necessary select it within the page. By this way, it was defined which designs were to be applied on that apparel. An image belonging to a selected design was shown in figure 8.

In this study, blank, xxsmall, xsmall, small, large, medium, xlarge and xxlarge size three dimensional models were designed and put on with shirt correlatively with the literature. The acquired models, as being distinct from the previous studies, were transferred to an Internet page and the image of the model in the Internet page was subjected to zoom in/out operations in accordance with the defined ratios. Also, the put on shirt was allowed to be interchanged with a user selected design model.

RESULTS AND CONCLUSION

In this study, one of the important factors, relating to putting on an apparel to a model in a virtual environment, is the degree of capability to display this put on apparel's drapeability. For being able to exhibit this drapeability on the Internet page, it was achieved to

employ the models which were drawn by utilizing any commonly used three dimensional drawing software, instead of employing the Three.js project to draw three dimensional models. It was observed that the models which were transferred via Three.js project were offered a rapid performance increase in the Internet environment. Additionally, it was observed that the shirt put on models were streamed and displayed quite swiftly by Internet browsers such as Mozilla Firefox, Google Chrome, Internet Explorer, and Safari due to Three.js project has a rich java script library, In this study briefly, the image files which were created out of apparel put on models were converted to OBJ file format and their sizes were reduced and transferred to the Internet page while achieving zoom in/out functionality and also acquiring the three dimensional image of the shirts in accordance with user defined parameters.

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Differences in the clothing brand perception depending on generation

ALEXANDRU POPA CORINA PELAU

REZUMAT – ABSTRACT

Diferenţe în percepţia brandurilor de îmbrăcăminte în funcţie de generaţie

Una dintre cele mai mari provocări ale unei companii la ora actuală este de a convinge consumatorul să cumpere produsele proprii şi nu pe cele ale concurenţilor. Unul dintre elementele cheie care influenţează decizia de cumpărare este brandul unui produs şi caracteristicile asociate lui. Nu doar caracteristicile fizice precum calitatea, design-ul sau culoarea sunt definite de brand, ci şi asocieri cu imaginea, gradul de apreciere şi poziţia socială a persoanei care poartă brand-ul respectiv. În acest articol sunt prezentate rezultatele unei cercetări despre percepţia consumatorilor din generaţii diferite asupra brandurilor de îmbrăcăminte. Pentru fiecare grupă de vârstă sunt analizate motivele care determină cumpărarea de produse de îmbrăcăminte, importanţa brandului în decizia de cumpărare şi influenţa brandului asupra calităţii şi designului unui produs, precum şi impactul asupra nivelului de apreciere a persoanei care îl poartă. Cu ajutorul analizei contingenţei şi a calculului chi-pătrat, se determină dacă există o relaţie între vârstă şi aspectele menţionate. În cele mai multe cazuri s-a dovedit, cu o probabilitate de eroare mai mică sau mai mare, o dependenţă între variabile, demonstrând că există o diferenţă de percepţie de la o generaţie la alta şi în consecinţă un comportament diferit.

Cuvinte-cheie: brand, percepţia brandului, consumator, industria de îmbrăcăminte, generaţie

Differences in the clothing brand perception depending on generation

The biggest challenge of companies nowadays is to convince the consumer to buy its own products and not those of the competitor. One of the key issues determining the buying decision is the brand of a product and the characteristics associated to this brand. Not only the physical characteristics such as the quality, design, color are defined by the brand, but also associations related to the image, appreciation and social position of the person who wears a certain brand. In this article, there are presented the results of a research about the perception of consumers of different generations on clothing brands. For each age group there are analyzed the reasons which determine them to buy cloths, the importance of the garment brand in the buying decisions and the implications of the brand on the quality and design of the product as well as the impact on the degree of appreciation of the persons who wears it. With the help of the contingency analysis and the calculation of the chi-square it is determined if there is a relation between the age and the mentioned issues. In most of the cases there was proven, with a higher or lower probability of error, a dependence between the variables, showing that there is a different perception from one generation to another and therefore a different behavior.

Keywords: brand, brand perception, consumer, garment industry, generation

INTRODUCTION

In recent years the complexity of the buying decisions increased so that certain concepts have gained again the attention of researchers. The consumer is not obliged anymore to buy the products with the lowest price, but he passes a complex process of a buying decision, where both emotional and cognitive elements are involved and where the quality of the product and the personal satisfaction play an important role [1]. This happens because the purchased products and services are no longer just some goods which cover needs, but a way of being [2]. Thus the consumer buys products or services not only to have them, but also to define his personality, his image and even his position in society. All these extra-values of a product are given nowadays by the brand. Aaker defines the Brand Equity as all components linked to a brand that add value to it and contain the brand loyalty, the brand awareness, the perceived quality, the brand associations and other proprietary assets [3–4].

Brand awareness is one of the most important components for the existence of a brand [5]. Keller defines the brand awareness as the capability of a consumer to recall, to recognize and to link it to different associations [6]. If a consumer does not identify a certain brand as such, the value off the brand is cancelled. The brand association includes all thoughts, feelings, beliefs, experiences, images related to a certain brand [6–7]. They include product attributes, social attributes, trustworthiness, distinctiveness, and country of origin effect [5–6, 8–10]. The perceived quality is the evaluation and judgment of the consumer towards a product. It is usually a subjective construct as a consumer does not have access to all scientific attributes of a product [11]. Not less important is the attachment of a consumer to the brand quantified in this model by the brand loyalty and the willingness of a consumer to buy a certain product again and again [3].

In this article, based on the brand equity model of Aaker, there was analysed the perception of different age groups for the brand components in the clothing

industry. There were analysed the importance of a brand, the association of the brand with the quality and design of a product as well as the perceived influence on the image of a person.

RESEARCH METHODOLOGY

This article relies on a research which had as objective the perception of Romanian consumer on brand clothing, the associations of the brand and the influence it has on the consumer. In this article there is analysed the difference of perception of brand clothing depending on age. The survey was conducted in the period December 2013 – January 2014 on a sample chosen according to a certain quota. There were questioned 451 persons, with an equal distribution for gender and with different levels of income. All questions analysed in this article were multiple choice questions, the answer possibilities being indicated in the interpretations.

For the analysis of the results there were used the cross-tabling and contingency analysis. With the help of the cross table there was calculated the distribution of answers among the age groups for the five analysed questions. For each of the questions there was measured with the help of the SPSS program the chi square value in the contingency analysis. For each of the five questions the value of the chi square was compared to the existent statistics. These correspond to the Null-Hypothesis, which indicates the independence of the two variables for different degrees of freedom. If the chi square value is higher than the existent statistics, the Null-Hypothesis of the independence is cancelled and the probability of error can be measured depending on the value [12].

RESULTS OF RESEARCH

In this article there are analysed the results of the research regarding the brand perception and brand awareness for clothing depending on age. Most of the results show stronger brand awareness for the younger generations. In figure 1 there can be observed the reasons of the Romanian consumers to buy clothing. People older than 50 years rather buy clothing and they need something new, while younger people buy cloths when they see in the shops something they like. So, 58.7% of the people with ages between 50 and 65 years and 51.1% of the people older than 65 years have the preponderant reason for buying cloths the need of new cloths. This percentage decreases with the age, so that 40.4% of the people between 35 and 50 years and 34% of the people with ages between 20 and 35 years have the same behaviour. Only 26.3% of the people younger than 20 years have this type of behaviour. In opposition to this, the preponderant behaviour for young people is buying something they like. So 52.6% of the people younger than 20 years and 52.9% of the people with ages between 20 and 35 years has this type of behaviour.

Buying discounted products is also a significant buying factor for all generations. It can be observed that

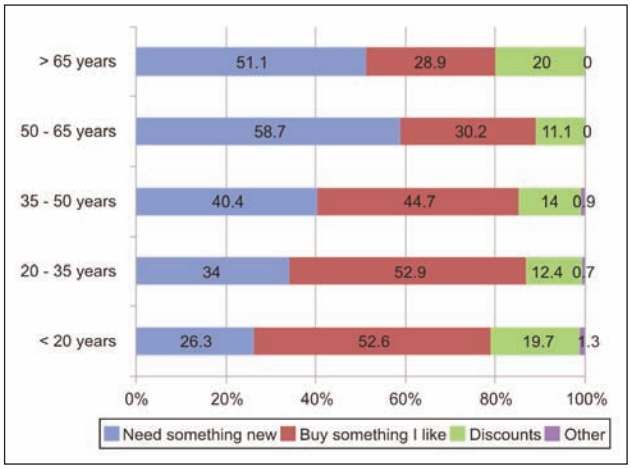

Fig. 1. Motives for buying clothing depending on age

people younger than 20 years (19.7%) and people older than 65 years (20%) are most sensitive at discounts. For the other generations with ages between 20 and 65 years the percentages of people who buy cloths when there are discounts, ranges between 11.1% and 14.0%. It is also interesting to observe that for the younger generations (younger than 50 years) there are also other few reasons for buying cloths, showing a diversifications and emancipation of the preferences and lifestyle of consumers, which should be taken in consideration by the garment industry.

In order to see if the relation between the age and the motives for buying clothes are valid, we applied the chi square test in the contingency analysis. For the relation between age and buying motives we obtained with the help of the SPSS program a chi square value of 29.4, having 12 = (5–1)*(4–1) degrees of freedom. As chi square = 29.4 > 26.22, it results that the Null-Hypotheses of the independence of the two variables is cancelled with a probability of error of 1%. Therefore it can be stated that the two variables are dependent.

In figure 2 there is analysed the importance of wearing brand clothing depending on age. As it can be observed the younger generations find it more important to wear brand clothes as older people. If in the generation younger than 20 years only 14.5% of the questioned people affirm that the band is not important, this percentage increases to 18.3% for the people with ages between 20 and 25 years and to 21.1% for the people with ages between 35 and 50 years. The percentage of people finding brands unimportant increases to 42.9% for the people with ages between 50 and 65 years and to 66.7% for the consumers older than 65 years. If we analyse the preponderant behaviour most generations consider that clothing brands are important or they take it in consideration. For the people younger than 65 years the people who take brands in consideration when choosing their outfit ranges between 39.5% and 44.4%, while for the people younger than 50 years the percentage of people who find brand important range between 29.4%

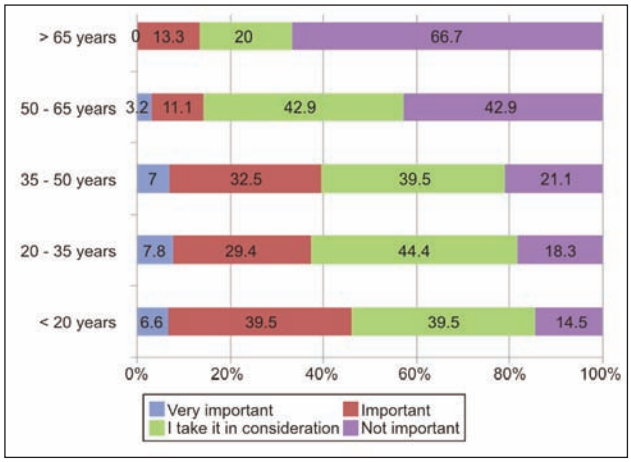

Fig. 2. The importance of wearing brand clothing depending on age

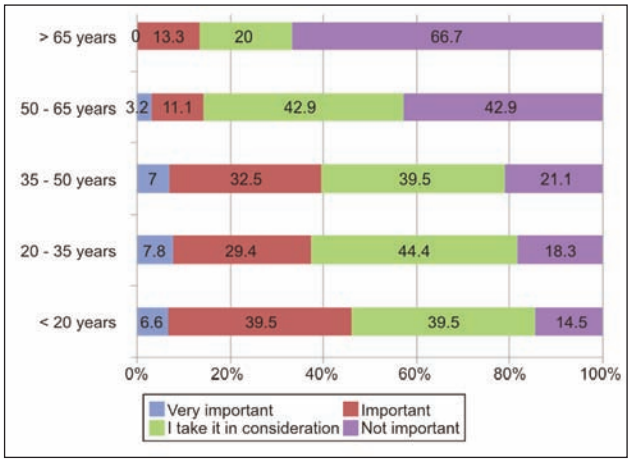

Fig. 3. Relation between brand and quality of product

and 39.5%. It is interesting to observe that the generation who finds clothing brands very important is the one with ages between 20 and 50 years. This result is confirmed also by other researches such as Kotler and Bliemel who state that the younger generations are more sensitive to marketing instruments (Kotler, Bliemel, 2001, pp. 325).

The results of the chi square test in the contingency analysis show a relation between the variables age and importance of clothing brand. The chi square test has a value of 70.2, at 12 = (5–1)*(4–1) of degree of freedom. As 70.2 > 32.91 it results that the Null-Hypothesis of the independence between the two variables is cancelled with a probability of error of 0.1%. Consequently the two variables are dependent.

In order to find an explanation why the consumers find the brand of the clothing they wear important, we measured the association of the brand with the quality of the product, the design of the product and the degree of appreciation of the persons who wear the brand. For the two physical characteristics of the product we used a 3 value scale, while for the qualitative characteristic we used a 5 values scale as it can be observed in figures 3, 4 and 5.

In figure 3, we can observe the results of the way in which the consumers agree or not to the affirmation “the brand cloths have a higher quality”, depending on age. As it was expected younger people rather agree with this affirmation than older people. 44.4% of the people older than 65 years and 27% of the people with ages between 50 and 65 years disagree with this affirmation, while the percentage ranges between 13.2% and 15.7% for the people younger than 50 years. The preponderant answer for the generations younger than 65 years is “in most of the cases”, having values between 52.6% and 58.8%. The highest percentage of consumers who see an obvious relation between brand and quality are the ones between 35 and 50 years (33.3%). This can be explained by the fact that in comparison to the younger generations who have a similar opinion, they have a better financial situation and more buying experience and can better appreciate the situation.

The chi square test for the relation between brand and quality of product has a value of 30.6. Having 8 = (3–1)*(5–1) degrees of freedom and chi square = 30.6 > 26.13, we cancelled the Null-Hypothesis of the independence of the two variables with a probability of error of 0.1%. Therefore the variables brand and quality are dependent so we can state that the Romanian consumer associates quality products with a brand.

In figure 4, there is analysed if the respondents agree to the affirmation by which the brand cloths have a better design than the others. In this case, again, the younger generations rather agree to the affirmation and it can be also observed that in all categories of respondents, they agree less to this affirmation than to the relation between brand and quality of product. As it can be observed most generations state that “in most of the cases” the brand cloths have also a better design. This answer has percentages ranging between 48.7% and 50.8%, with the exception of people older than 65 years, where only 33.3% agree with this answer. The percentage of people disagreeing to this affirmation ranges from 21.1% for the

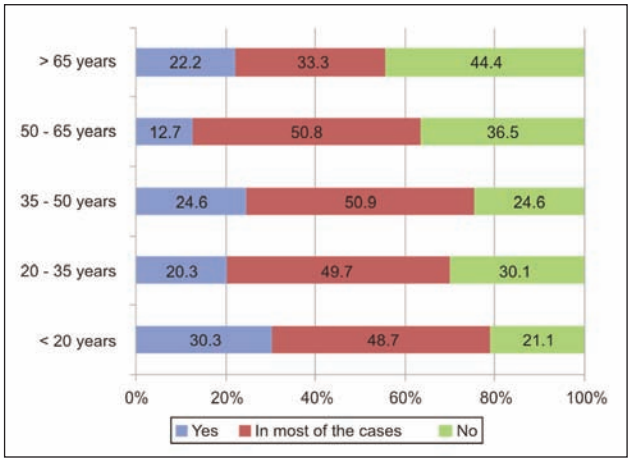

Fig. 4. Relation between brand and design of product

people younger than 20 years to 44.4% for the people older than 65 years. The generation who agrees most to this affirmation (30.3%) are the people younger than 20 years, while the percentage of respondents who totally agree to the relation between brand and design ranges between 12.7% (people between 50 and 65 years) and 24.6% (people between 35 and 50 years).
The chi square test for the relation between the existences of a brand and design has a value of 14.9 > 13.36, at 8 = (5–1)*(3–1) degrees of freedom. Therefore the Null-Hypothesis of the independence of the two variables is cancelled with a probability of error of 10%, being the highest probability of error from all analysis in this article. Therefore we can state that there is a relation between the two variables.
One of the most important characteristics of a brand nowadays, is the image it confers to the person using or wearing a brand. Therefore it was interesting to measure the relation between the degree of appreciation and wearing a certain brand. In figure 5 there is analysed the opinion of the consumers on the affirmation if they consider that they are more appreciated if they wear certain brand clothing.

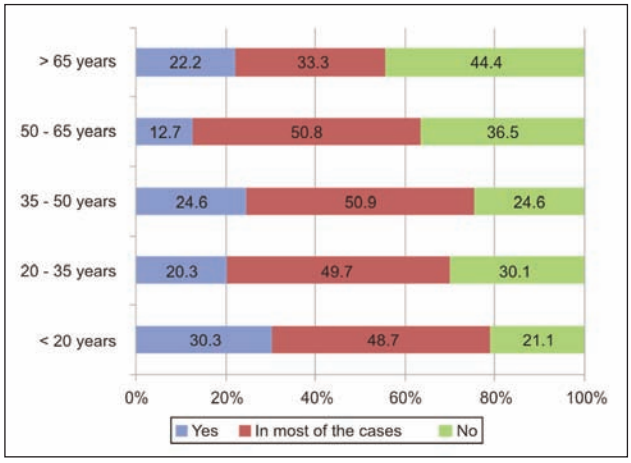

Fig. 5. Relation of appreciation and brand of clothing

As we can observe most of the consumers consider that there is a relation between wearing brand clothing and the degree of appreciation. The younger consumers consider that this relation is more frequent, in opposition to older people who are not that convinced about this relation. Therefore only 10.5% of the consumers younger than 20 years consider that there is no relation between the degree of appreciation and the brand, while this percentage increases to 19% of the people with ages between 20 and 35 years and 24.6% of the people with ages between 35 and 50%. 46.7% of the people older than 65 years and 33.3% of the people with ages between 50 and 65 years don't believe in this relation.
Most of the consumers think that only sometimes the brand affects the degree of appreciation. So the percentages of people doing so ranges between 26.7% and 38.1%, being higher for younger people. People younger than 50 years consider this relation as being very "often", ranging with percentages between 16.3% and 21.1%. This value is smaller for people with ages higher than 50 years, ranging from 2.2% for the people older than 65 years and 9.5% for the people with ages between 50 and 65 years.
The chi square value is 46.5 > 39.25, for 16 = (5–1)* (5–1) degrees of freedom. Therefore the Null-Hypothesis of the independence of the two variables can be cancelled with a probability of error of 0.1%. Therefore it can be stated that there is a relation between the degree of appreciation and the clothing brand people wear.

CONCLUSIONS

Despite the fact that most concepts related to the value and equity of a brand were developed in the '80s and '90s, their importance is more present than ever as competition and dynamics increased on most markets. The homogeneity and the comparability of the characteristics of products make the brand as one of the main differentiation factors in the buying decision. Consumers tend to buy the brands they know, relying on previous buying experiences and on the characteristics and associations of a brand.
The results of the research show that the importance of the brand increases for the younger generations. This can be explained as the psychological profile of young consumer indicate a higher influence of marketing communication on their behaviour in comparison to older and more experienced consumer. Different researches have shown that many of the behaviour patterns are formed in the young years of a consumer and therefore it is a period where is more likely to search and assimilate information form the medial and social environment. On the other hand there is also a change in the generations. Young generations are more exposed to mobile communication, media and the consumerism society than the older generations did. This overwhelming quantity of information, coming often as marketing campaigns of different brands, determine consumer to tend to buy brand clothing. As it was observed in this research, in most of the cases consumer associate the brand with a higher quality and therefore a reason enough to buy a clothing product. The results of the research point out the importance of having and developing and brand for the garment companies.
Considering the importance of brands, companies should focus on the development of efficient brand strategies. As it is known nowadays a brand strategy includes not only the communication strategy but also different elements such as the product portfolio and characteristics, the pricing strategy as well as the distribution channels. Therefore garment and clothing companies should develop collections of products according to the communicated brand values, a flexible pricing strategy and an exclusive distribution channels. Only by including all the key issues relevant for the consumers a garment company can achieve the long term success.

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Capabilities of SMEs in Romanian clothing industry

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REZUMAT – ABSTRACT

Capabilităţile IMM-urilor din industria de îmbrăcăminte din România

Industria de confecţii reprezintă un sector important al economiei româneşti, contribuind cu aproape 10% la valoarea exportului şi având o pondere de 3% în Produsul Naţional Brut. Deoarece majoritatea firmelor din acest sector este reprezentată de IMM-uri, devine critic pentru acestea să aplice noile abordări şi metodele de natură managerială în vederea generării de competitivitate pe pieţele locale şi internaţionale. Toate aceste realităţi apar în contextul schimbărilor radicale ce au loc la nivelul economiei odată cu trecerea la economia bazată pe cunoaştere. Lucrarea îşi propune să identifice conexiunile dintre strategia managerială abordată din perspectiva conceptului de capabilitate organizaţională şi noţiunile de schimbare şi performanţă în contextul societăţii bazate pe cunoaştere. În vederea atingerii obiectivelor propuse, s-a realizat o cercetare pe un eşantion de 79 de întreprinderi mici şi mijlocii din industria de confecţii, rezultatele obţinute sugerând o legătură directă între variabilele implicate.

Cuvinte-cheie: capabilităţi manageriale, schimbare, inovare, întreprinderi mici şi mijlocii

Capabilities of SMEs in Romanian clothing industry

The clothing industry represents an important sector of the economy in Romania, with 10% of export and 3% of GDP. Nearly 99% of companies active in this area are small and medium businesses. In order to generate competitiveness on local and international markets, it becomes vital for these types of enterprises to investigate new managerial approaches, methods and capabilities to sustain a high rate of growth and manage environmental challenges. We have to consider also that the economy undergoes a series of radical transformations which create conditions for appearance of knowledge-based economy. We try to analyse in this paper the connections between design management as a capability in connection with change and performance in context of knowledge based society. In order to achieve this task, we conducted a research based on 79 small and medium enterprises from clothing industry and results suggest positive, direct connections between involved variables.

Keywords: managerial capabilities, change, innovation, small and medium enterprises

INTRODUCTION

The clothing industry worldwide has become increasingly creative and innovative based on strong global competition and access to new fibres, materials and design [1]. In Romania, clothing industry is an example of "traditional sector" able to "redefine its identity" according to a new business model, adapted to the needs of knowledge economy by using new, unconventional technologies and materials. Pressures caused by the “global economic crisis and the extensive changes taking place, it obliges large, but also small companies to downsize with direct effect on employment and the qualifications required” [2]. The EU clothing industry has lost since 1996 to the present one third of the volume of production and jobs. The average index of industrial production growth in the past two years is 11.75% and the growth in turnover for Romanian companies in the field is 8%. After Vogler - Ludwig and Valente the main actors of change in European clothing industry are global competition, knowledge base, markets and environmental costs [3]. The competitiveness of European clothing industry has been hit in the past and in the future will be affected by the rise of these Asian countries and especially the rise of China in the field. In the European Union, by 2020, in the clothing industry there will be two groups of countries based on the capacity of organizations in the field to cope with change by integrating new knowledge into their products. A first group of countries will be that with the clothing industry based on products with high added value and differentiate due to the ability to integrate research results in the field, to innovate and to maintain or impose sustainable brands in the global market. The second group includes countries with industry based on costs as a result of the low level of wages and which will be increasingly affected by the pressure of competition with companies in other parts of the world. Unfortunately, Romania belongs today to this second category and to exit from the second group clothing SMEs must be able to respond adequately to changes occurred.

DESIGN MANAGEMENT CAPABILITIES

Management literature defines managerial design as a “key factor of firm performance” [4]. This is significant for small and medium businesses from clothing industry because it “can become a source of support for innovation and change” [5]. Design management refers to particular “management activities and

methods that are required to optimize and manage design processes" [6]. As a management field, design management "focuses on a complex of all visual manifestations of companies, brands and products, as well as on non-visual aspects relating to the design process as such, or to processes for product development, production, distribution, sales, delivery or service in order to create synergy between the creativity and business" [7].

The European Commission considers design management to be a "competence subordinated of innovation management, in recognition of the fact that companies need innovation capability to be able to respond to new market opportunities and threats" [8]. For our research it is important to clarify the links between managerial capability and organizational performance. In order to attain these objectives, we try to conceptualize managerial design as a capability which is capable to explain differences on performance in clothing industry between companies. Researchers argue that managerial "design capabilities have been considered without specifying the nature of the capability" [9]. Several authors investigate specific capabilities regarding organizational processes such as new product development, research and development or innovation [9–10]. Our research aims to present design management capabilities by extending the range considered by literature. We rely on explaining the peculiarities of the concept of design managerial capability in the clothing industry in order to explain differences in performance and innovation for small and medium sized firms in this industry. Since capabilities arise from knowledge, we examine the role of organizational knowledge as an antecedent of managerial design capability. First, we have to explain the concept of product design that is "the process by which a product is developed while taking into account any function, use and manufacture requirements" [12]. This implies the whole series of creative, technical, strategic and market aspects [13]. These requirements entail a complexity within the process which needs certain management processes and activities to support and sustain it. For this reason, there are scholars who are focusing in the design management highlighting it as a capability [14]. Many SMEs from clothing industry are still unaware of design as a strategic resource because of different types of barriers and problems such as limited human and financial resources, less formal or non-existent product development and innovation processes, lack of access to design resources or poor design understanding all of them making difficult the development and integration of managerial design in SMEs [15–16].

The current economic context makes clear the need for effective management design. Ceptureanu suggests how to change a SME in order to generate competitiveness [17]. We also studied the connection between change and innovation through Inno-Change model developed in 2015 by Ceptureanu [18]. We revise these concepts and adapt them to the capabilities literature by considering design management as a capability. Consequently, design management is conceptualized as a model composed of six factors which encompass many of the skills and activities underlined in the literature: a) resistance to change; b) change objectives, based on "process mapping" and design management capability; c) basic and specialized skills of human resources; d) stakeholder's involvement in the design process; e) organizational change; f) innovation skills [19].

KNOWLEDGE-BASED ECONOMY AND SMES

The concept of knowledge-based economy is widely used in a variety of contexts and with several meanings [20–21]. Initially, knowledge-based economy was addressed as the sum of high-tech and telecommunications industries. Nowadays, knowledge-based economy is addressed more broadly and is seen as broader than simply overall high-tech and telecommunications industries. "The necessity of knowledge management within the SMEs is the natural consequence of the society based on knowledge" [22]. In this context, the clothing industry represents a new area of interest for knowledge based economy. Process innovation and application of knowledge to generate new products or services, also occupies a central place in the literature devoted to the knowledge economy. However, more recent work tends to address broader concept, addressing not only innovation [23]. Florida emphasizes the key role of "social class creative" in generating competitive advantage [24]. As capabilities enable firms to integrate, build, and reconfigure internal and external competencies in order to address rapidly changing environments, we argue that different elements of Ceptureanu E. et al. model of change framework and Inno-Change model developed in 2015 by the same author: a) change objectives; b) promoters of change [17, 25]; c) stakeholders involvement, d) organizational change; e) innovation skills of employees; f) resistance to change; g) firm performance (figure 1).

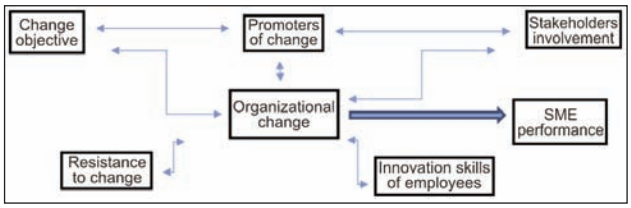

Fig. 1. Model involved in our research

Capabilities are based on the creation of knowledge and may represent an important source of competitive advantage for SMEs in clothing industry, since they allow the generation of unique organizational skills which are updated continuously [9, 25]. Another element we want to emphasize is innovation, which involves the generation and implementation of new ideas, processes and products. Knowledge organization involves the acquisition, dissemination and use of knowledge and therefore are strongly associated

Table 1

MAIN STATISTIC CHARACTERISTICS OF THE RESEARCH				
		Mean	**Standard deviation**	**Cronbach's alphas**
1	Organizational knowledge capability	4.7	0.8	-
2	Organizational change	5.02	1.1	0.6
3	Resistance to change	4.5	1.32	0.74
4	Human resource basic and specialized skills	4.9	1.18	0.72
5	Stakeholders involvement	4.6	1.04	0.78
6	Organizational change	4.7	1.11	0.67
7	Innovation practice and skills	4.95	0.98	0.8

Table 2

TEST RESULTS OF PARTIAL MEDIATION EFFECT OF DESIGN MANAGEMENT CAPABILITY		
Parameter	**Direct effect model R2 = 0.326**	**Partial mediation model R2 = 0.56**
Organization knowledge capability		
Innovation performance	0.51	0.02
Design management capabilities		0.64
Organizational innovation and change		
Organizational change score		0.67
Resistance to change		0.84
Human resource basic and specialized skills		0.73
Stakeholders involvement		0.6
Organizational change		0.84
Innovation practice and skills		0.77

with innovation performance [26–27].The literature shows a positive association between the dimensions of knowledge capability and product innovation [28]. However, knowledge capability could be not enough to achieve high levels of innovation performance in clothing industry because the firm needs to have other organizational capabilities. We argue that design management capability is necessary for achieving better innovation performance through organizational knowledge capability. Given that management design, as a capability, emerges from knowledge we suggest that organizational knowledge capability influences the small businesses of clothing industry design management capability, and the latter affects innovation.

METHODS AND RESULTS

Contributions found in the literature are of a mainly theoretical or empirical approach using methodologies based mostly on qualitative data. Therefore the outcome of literature review resulted in the extraction of the main ideas on management design capability in organizations that were used as variables in questionnaire design. The questionnaire was filled by entrepreneurs of clothing industry SMEs from Romania. In this sector SMEs "are the sources of innovation and economic advancement" [29]. Research variables have been translated into a common language accessible to most respondents. The response rate was 38%, being considered by specialists large enough to get relevant results [30]. Data collection was done by distributing questionnaires by telephone. Among the reasons that some representatives of organizations refused to participate in the conduct of the study we mention the lack of time and/or interest and policies relating to privacy within the organization. We acknowledge the disadvantages of the sample (i.e. analysis of a single sector) in terms of limiting generalizability but believe that they are outweighed by the advantages offered by this approach [31]. The fieldwork was conducted from October 2015 to January 2016. Items dealing with design management, innovation performance and organizational knowledge capabilities were addressed to entrepreneurs (table 1).

Table 2 shows a positive relationship between organizational knowledge and innovation. The results explain the strong link between design management capabilities interposing variable to stimulate the positive effect of the first two items listed [32]. We can determine that our study regarding the effect of management design capability on the relationship between organizational knowledge and innovation is consistent with Tippins and Sohi theory [33].

CONCLUSIONS

Our research on the impact of knowledge on innovation in SMEs in the Romanian clothing industry certainly establishes a direct link with innovation performance. This relationship is mediated by design management capabilities. The organizational knowledge can enhance the sustainable competitive advantages of SMEs in the Romanian clothing industry through design management capabilities. Consequently, a competitive advantage based on innovation in the clothing industry requires the development of organizational strategies based on knowledge organizational capability. Since "innovation is an important outcome of firm processes and has been shown to be critical to clothing firm performance, this research provides a more complete examination of the effects of organizational knowledge on innovation and offers an explanation to industry differences in company performance" [34]. Results suggest that innovation (both product and process) in the clothing industry requires action centred on organizational knowledge and design management.

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Ethics of the garment retail within the context of globalization and sustainable development

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REZUMAT – ABSTRACT

Etica retailului de îmbrăcăminte în contextul globalizării şi dezvoltării durabile

Industria şi retailul de îmbrăcăminte au fost supuse, în mod vizibil, la un proces de adaptare continuă la noile tendințe ale mediului de afaceri internațional, fiind confruntate cu numeroase provocări apărute din necesitatea de a satisface comportamentul polivalent al consumatorului, în continuă schimbare, și în căutarea de noutate și inovație. Clienții sunt în prezent mai greu de atras și menținut de către retaileri, decât au fost în trecut. Producătorii și retailerii din industria de îmbrăcăminte, încălțăminte, articole sportive etc. sunt tot mai mult constrânși de fenomenul globalizării, fiind forţaţi să se adapteze mai mult la cerințele și exigențele generațiilor de consumatori, să implementeze principiile etice în cadrul propriilor activități, dar și a celor ale partenerilor. În vederea analizei modului în care acești retaileri transpun normele etice în cadrul tuturor activităților din lanțul valoric, cât și principiile dezvoltării durabile, autorii au recurs la o cercetare calitativă, de explorare, în mediul de afaceri din România. Astfel, au fost intervievați reprezentanții retailerilor din diferite regiuni ale țării. Rezultatele evidenţiază stăpânirea principiilor etice și punerea în aplicare a unor măsuri care pot fi cuprinse în dezvoltarea durabilă în cadrul proceselor lanțului valoric. Implicațiile sale manageriale pot fi transpuse într-o strategie de ramură viabilă, care ar permite acestei industrii o mai bună poziționare la nivel regional și european. Teoretic, lucrarea de față pune în evidență legătura dintre dezvoltarea durabilă și principiile etice în contextul globalizării.

Cuvinte-cheie: globalizare economică, corporaţii multinaţionale, etica în afaceri, dezvoltare sustenabilă, industria de îmbrăcăminte şi comerţ

Ethics of the garment retail within the context of globalization and sustainable development

The garment industry and retail have been prominently submitted, to a continuous adaption process to the new tendencies of the international business environment, being confronted with numerous challenges emerged from the necessity to satisfy the consumer's polyvalent behavior, in continuous change and in search for novelty and innovation. Clients are nowadays harder to attract and maintain by retailers, than they used to be in the past. Producers and retailers from the fashion, footwear and sportswear industry are more constrained by globalization, being due to adapt even more to the demands and exigencies of the different generations of consumers, to implement ethical principles in both their activities and those of their partners'. In order to outline the means by which fashion, sportswear and footwear retailers transpose within all activities of the value chain ethical norms, as well as sustainable development principles, the authors have conducted a qualitative, exploratory research, within the Romanian business environment. Thus, retail representatives from different country regions have been interviewed. The results disclose a mastery of the ethical principles and the implementation of several measures that can be encompassed to sustainable development within the value chain. The managerial implications might be adequately transposed into a viable branch strategy which would allow this industry a better positioning on a regional and European level. Theoretically speaking, the present paper highlights the connection between sustainable development and ethical principles within the globalization.

Keywords: economic globalization, multinational corporations, business ethics, sustainable development, garment industry and trade

THE "SUSTAINABLE DEVELOPMENT – GLOBALIZATION" SYNERGY

When confronting ideas and features of the contemporary world, two major themes come more often to the fore: *globalization and sustainable development*. If on a conceptual level, these themes have enjoyed the attention of specialists, benefiting from due disambiguation and operationalizing possibilities, on a practical level – of the social-economic life – they benefit from a very different approach from one country or geographical region to another, from one field of knowledge to another. We share the opinion that only starting from the concrete casuistry of each field or economic branch, can generalizations with higher applicative valence be formulated on an *inductive basis*.

Sustainable development

The issue of sustainable development was a regularly recurring topic at the end of the 1980's [5, 11, 45]. However, sustainability (sustainable development) is not a wholly new concept, dating back to the forest industry. Von Carlowitz's treatise tackles the problems of *Sylvicultura Oeconomica* (The Economics of Forestry) and pinpoints the relationship between present and future forest exploitation [52]. According to the author, sustainable development in the field of forestry is a process capable of meeting the current needs without wasting the resources that should be

available for the future generations. The modern sustainable development principles were formulated at the Earth Summit in Rio de Janeiro and have been greatly improved since then [9]. In its reports, the World Bank drew attention to the danger of environmental degradation and its direct consequence: natural disasters [56–57]. For this reason, it is believed that there is no room for sustainable economy without the existence of a sustainable environment and/or business environment [27].

Growth of international economic and trade flows jeopardizes, to a certain extent, the smooth conduct of the human activity. Ecosystems, biodiversity, nature, flora and fauna are under real and immediate threat as they are in a relatively fragile balance and run the major risk of irreversible degradation [4]. The result thereof is the impossibility to ensure worldwide long-term economic growth because, in time, it would prevail over the regenerative capacity of nature [30]. Researchers have been drawing attention to the limits of economic growth for decades [31]. These limits were scientifically investigated over many years but it has been proven that the degradation of the "natural capital" entailed the creation of conditions that hinder economic growth. The climate changes that have occurred over the last decades led to a decline in the world's GDP by 5 to 10 per cent [49].

In the world's developed countries, leading organizations and their specialists are actively involved in developing strategies that integrate and accord with the society's medium and long-term economic, ecological and social interests. In Germany, the Council for Sustainable Development brings together 15 specialists from different fields, who wish to promote the German Code of Sustainability [16]. The positions taken on this topic are collected in a specific database. The Council explains and actively lobbies for sustainable development [1].

Globalization

A major challenge of the contemporary society and mankind, but also of the organizations that have a direct bearing on sustainable development, is *globalization.* A highly complex concept lacking a unanimously accepted definition, globalization is a multicausal process in which facts and events taking place in one area of the planet rapidly, continuously or simply punctually impact on societies and/or communities in other areas of the world. The communication outbreak exponentially facilitates the globalization phenomenon. Marshall McLuhan's well-known term "global village" captures the gist of this phenomenon which caused *homo oeconomicus* to cross the borders of his/her behavior and become *homo globalus* connected to news, technologies, innovation, novelty, mindful of the environmental issues, global society issues, issues of the community he/she is part of, respectively of the ones around him [3]. The 21st century individual very carefully makes shopping and/or consumption decisions, not just according to what he/she sees in a certain store, but also according to the behavior and actions of the favourite organization from other corners of the world, of the retailer he/she frequently shops from, of the producer of the brand he/she regularly purchases. The experience gained worldwide over the last decades has highlighted that globalization, despite its many positive aspects, fostered the emergence of factors hostile to sustainable development. Among these factors are the increased output and the growing consumption against a backdrop of unequal access of countries to economic resources, leading to constraints that are difficult to reconcile with the requirements and principles of sustainable development [54]. Aided by environmental degradation, globalization threatens the planet's food security, which might generate a major disaster at some point in the near future. For example, even if no major climate changes have occurred, the number of people affected by the lack of drinking water is expected to increase to about 5 billion in 2025 by comparison with only 1.7 billion in 2001 [25]. As a result of climate changes, growth of urbanization and exploitation of some natural resources, developing countries will lose about 11 per cent of agricultural land, having a detrimental effect on their industry and development of infrastructure [19]. Practically, globalization has also had negative effects on the environment, necessitating a readaptation and/or a rethinking not only of the ecosystem, but also of the adaptation strategy of the enterprises and organizations, following an ethical endeavor to sustainably adapt the market, the resources within the purchase, manufacturing/processing, marketing processes, etc. In order to overcome these challenges and secure a sustainable future for the planet, all countries must adopt development strategies that are compatible with "the naturalization process of globalization" [35]. Therefore, the concept of "sustainable development", defined by the World Commission on Environment and Development, must fall within the range of "global ecology", towards minimizing resource consumption, educating the population to understand the necessity to ensure access to resources for future generations as well, respectively to apply ethical principles to any activity [54].

The connection between globalization and sustainable development

The extent to which globalization and sustainable development are compatible (or not) is a matter requiring a careful approach. It is very possible that the two concepts are fully compatible. Waste, excessive consumption and pollution are reduced when more products and services (goods, ideas, rights and experiences) are produced with fewer resources. To a certain extent, this will make for sustainable economic growth of both national economies and companies capable of "capitalizing" on globalization and finding markets for their cost-effective production as well as markets with rich consumers or consumers who are willing to pay the prices charged by multinationals [23, 29]. Many multinationals perform environmental actions according to precise and clearly defined standards concerning the impact of their own

actions on the environment, by carefully monitoring and controlling pollution and by providing developing countries, regions or communities with technical assistance, with a view to promoting sustainable economic development that meets the environmental needs [26]. For example, the Deichmann Company carries out specific actions to minimize the impact of its activities on the environment. The company invests heavily in modern technologies which are intended to minimize the impact of administrative buildings and/or stores on the environment. As Deichmann uses solar-powered lighting, heat pumps to maintain the ambient comfort as well as energy-saving light bulbs, the company regards itself as one of the most innovative retailers in the garment industry. Its distribution centre in Bottrop (Germany), covering an area of 40,000 m^2, was ecologically certified by the German authorities as far back as ten years ago. In addition, the company is deeply interested in defining its own standards, which means that the various rules and regulations and the aspects concerning the environmental protection, ethical principles, etc., are included and carefully monitored within the manufacturing processes and the work procedures. The Deichmann standards may often be much more rigorous than the national ones in the field of purchase, production and/or distribution and marketing of finite materials and products [15].

GLOBALIZATION AND SUSTAINABLE DEVELOPMENT IN RELATION TO ETHICAL STANDARDS AND PRINCIPLES WITHIN THE ACTIVITIES OF RETAIL COMPANIES

The current debates on economic globalization increasingly focus on environmental protection as a sine qua non for achieving an organization's objectives concerning its social progress [42–43]. The current state of globalization of trade compels us to reconsider and reexamine more carefully the relation between this irreversible phenomenon and the environment [40].

The various facets of globalization which have given impetus to sustainable development, especially those that facilitate or are in direct connection with sustainable development, could not be clearly defined until now, nor has the level of interaction between the two concepts and the impact on one another been clearly established [42]. Globalization and economic globalization in particular have long been thought of as a cure-all for all of mankind's "sufferings" and/or of those related to environmental degradation. Consequently, many attributes were ascribed to globalization, starting with *liberalism* (elimination of movement restriction imposed on the main production factors), *universalism* (the rapid spread of ideas, experiences and technical knowledge across the world), *reconfiguration of geography* (in terms of shortening distances) and ending with *cost-benefit analyses*, in terms of highlighting the opportunities that can be maximized and the risks that must be avoided or mitigated [42]. As the years went by, it has been concluded that economic globalization offers obvious advantages for multinationals, in particular, and for the companies carrying out global activities, which are low-cost producers in Third World countries and sell at high prices in developed countries [40–42]. This is how the first ethical conflict arises, a conflict that must be solved by the parties involved in a harmonious way: how ethical it is to produce cheaply by "exploiting" the qualified workforce in poor countries and then sell at high prices in developed countries. In order to create scale economies, sometimes garment retailers not only purchase raw materials and other products from Taiwan, China, Bangladesh, Guatemala etc. but they also produce various garment articles in these countries where the hourly labour costs are extremely low. From an ethical point of view, such actions entail several challenges. As companies want to maximize their profits, they come into "conflict" with nature, putting the available resources under considerable pressure and reducing the environment's capacity to "treat" its wounds inflicted by society or the various private companies. Under such circumstances, the environment can no longer sustain a long-term growth of economy based on waste and/or unsustainable consumption of resources, fact that was highlighted by scientists as far back as the 1970's [21, 31]. Therefore, it has become increasingly obvious that mankind's future development depends on the condition of the environment.

In our opinion, by its very nature globalization can generate many externalities having significant sectoral ramifications. The costs of restoring the environment often exceed the production costs [34]. Due to the difficulties of solving the problems and challenges related to environmental protection and of eliminating the effects caused by different sorts of natural disasters, the experts believe that a *global environmental governance* should be created [47]. Despite the fact that the importance of the relationship between globalization, environment and following the ethical principles within the organization processes has been proven, it has not been clearly delineated how these dimensions interact with and influence each other as the specialty literature has only precariously dealt with this topic. For example, some authors emphasize the impact of globalization on the environment as well as how the latter determines the "direction and quality of globalization" [34]. The dynamic interaction between globalization and the environment is difficult to capture in all of its aspects. The "quality" of the environment, measured by the extent to which people affect and change it, has a strong bearing on the exploitation of the entire economic and social potential of globalization [33].

Today's companies must take additional measures to protect the environment and preserve, within the framework of a *holistic environmental governance,* the natural resources they exploit, and to implement ethical principles within their activities. H&M is a typical example of a company that successfully implements the environmental governance in retailing. In

cooperation with World Wide Fund for Nature (WWF), the company has been implementing for many years within its distribution chain a plan to use water in a sustainable way, which means the lowering of water consumption within all the processes of purchasing, manufacturing, transportation, distribution, marketing etc. (production of textile fibres for articles of clothing, clothing manufacture, dyeing and/or washing of textiles etc.). The company makes efforts to permanently apply ethical principles in the administration and conservation of water supplies, in the improvement of its actions' impact on the environment, in the water preservation from the bordering drainage basins in the areas where its production units are located, as well as from those of all its partners. The environmental governance and the necessity to follow several ethical principles in relation to local communities are constantly brought to the knowledge of employees and customers, as the only means by which one can develop a modern and effective distribution value chain [53]. Any reference to sustainable development is pointless and "empty" if there are no clear rules of conduct assumed by all actors involved and integrated into a code of standards and procedures capable of being defined as the "*ethics of globalization*".

THE ETHICS OF GLOBALIZATION AND MINIMIZING THE EMERGENCE RISK

The ethical conduct of an organization or individual involves actions falling into particular patterns, which the entire society accepts and considers natural. The ethical issues cover a very wide range of aspects which companies should take into consideration. The specialty literature has synthesized the knowledge concerning the ethical behaviour of organizations in the concept of "business ethics" [38]. In this new era of "business ethics", all decision-makers should become more responsible towards the society's demands and the needs of the environment [1].

The concept of "business ethics" involves a moral attitude and ethical judgment not only within interpersonal relations but also within the relations between society and nature. However, the connection between these components is not clearly defined. Surprisingly, individuals from different cultures or social environments tend to display similar moral attitudes towards international business practices as their reasoning in relation to nature continues to be based on specific, traditional values deeply embedded in the collective mind. Terms such as "right", "wrong", "moral", "immoral", "good", "bad" etc. have sometimes opposite meanings across cultures. However, a consensus has been reached at international level over some principles that underlie people's attitude to society, which are valid in every situation as common norms of conduct [40]. Among these is the respect for human dignity and for human rights. People's behavior towards natur varies considerably between individuals, communities, organizations and countries [17]. Companies of different sizes, operating in various fields, define their own standards of environmental protection, sustainability of products and services, ethical principles applied within their value chain and/or to the partners' activities, and adopt internal procedures and rules of conduct for employees with regard to the company's relationship with the environment, but also the degree in which its activities should be deemed ethical from a moral perspective towards the clients.

In order to combine the ethical aspects with their own sustainability strategies, H&M, Zara (Inditex), New Yorker and other fast fashion retailer have taken upon themselves to reduce by 2020 the use of chemicals for dyeing and/or bleaching garments [13, 50]. The electrical energy consumption within their networks must be minimized and/or streamlined, complementary to identifying new sources of renewable energy meant to transpose in practice the concept of "the eco-efficient store". Other aspects envisaged by this strategy refer to the use of innovative lighting systems, based on the predominant use of natural light and the rethinking of the heating/ventilation system etc. By their strategy based on ethical principles, some retailers have committed themselves to adopting the standards of sustainable consumption, to completely eliminating, by 2020, the use of chemicals in their manufacturing processes, but also in those of their partners [7–8]. This is how multinationals attempt to draw relatively closer to entire segments of consumers, the most sensitive being the young generation [2–39]. Companies cannot assume moral responsibilities alone as these are mainly the task of individuals [44]. Due to their highly complex activities conducted on the various international markets and extremely varied social, economic, political, legislative and cultural contexts, large concerns and organizations are faced with limited decision-making "autonomy" and have to adapt not only to the realities and interests of the served markets, but also to the purposes of the shareholders (ownership) [55]. Thus, the social obligations become extremely significant for these companies who eventually need to take them into account. Different fashion retailers include ethical principles within their social responsibility strategy. Through its own foundation "Help and Hope", the German retailer Kik promotes social, environmental, but also ethical actions and principles [22]. One of the ethical challenges faced by this textile retailer lies in its business philosophy. Kik is well-known for offering its different garment articles at very low, discount prices. For only two or three euros, the customer can purchase linen and even clothing products that are not sold at a discount [28]. Therefore, the question that arises here is to what extent the work done by the employees in Asian countries, especially in Bangladesh where the company runs most of its production units, is properly paid, to what extent it is ethical to make profit from extremely low paid work.

The companies assuming social responsibility in the context of globalization of purchase markets and/or outlets should be provided with an ethical and coherent answer to the challenges and problems about

respecting the rights of local communities, should propose viable solutions for the prevention of natural disasters, the identification of natural disasters scenarios, the refusal to endorse practices that run counter to the moral principles of society and of their own businesses [48].

Garment retailers are constantly concerned with providing a fair reward to their own employees involved in manufacturing, distribution, sale processes etc, as well as to the staff of their partners (suppliers, intermediary product factories etc.), in accordance with the regulations of each country, but also with the market conditions and work schedule of these employees [7]. Zara, C&A, H&M etc promote zero-tolerance towards the employment of children and young people, their involvement in activities that flout national regulations, as well as their exposure to health-threatening activities [6, 18].

For a better positioning on the market and in order to attract new consumers, multinationals can and should be permanently innovative, offer new performance and run cost-effectively. Long-term success on the market also comes from the consolidation of stable partnerships, focused on ethical principles, used for the society welfare. When defining the ethics of globalization, one has to take into account the fact that various international cultural environments have different perceptions of business practices. Economists and sociologists consider that some ethical norms must exist to regulate the relations between economic partners at international level as well as between these ones and the natural environment where most businesses are conducted [40].

In order to have companies adopt ethical conduct at a global level, some international organizations, such as the United Nations Organization, have attempted to lay down as clear as possible the general principles of business practice. Among these regulations are the United Nations Code of Conduct on Transnational Corporations, Guidelines for Multinational Corporations , Tripartite Declaration of Principles Concerning Multinational Enterprises and Social Policy, Anti-Corruption Convention etc. [24, 36–37, 51]. Despite these initiatives and the necessity to take highly important steps to define the business ethical practice in an increasingly globalized economy, the growing competition and the limited access to resources and markets question the companies' possibility and capacity to go by all such ethical norms. Multinationals find themselves more frequently unable to always abide by the ethical principles within the developed activities, especially due to the different legislation concerning business ethics between the states. In fact, an action, activity or measure can be deemed ethical in a country or region of the world while elsewhere a similar practice is condemned by society or legally prohibited [41]. A globally applicable code of ethics should be an instrument for assessing not only how an organization operates in a particular area, but also its capacity to protect its reputation among consumers and (human) society as a whole. Managers should be aware of the relevance of such a code of ethics, should understand its positive implications on the way in which consumers and/or target groups will perceive its organizational culture, the performance, the overall image and the brands of the company. Only the existence of an ethical code implemented at all organization levels will allow the company to reach the anticipated market succes, long-term benefiting from the positive contribution of the undertaken actions and strategies, thus managing to reach an adequate position on the market.

In order to differentiate the manner in which concepts, such as ethics in business, performance sustainability, globalization of relations between markets in the retail with garment articles, are perceived but mostly transposed in practical activity, *an exploratory research in the Romanian business retail with garment articles* has been conducted within the trade globalization context and the debates concerning the sustainable development of human society.

RESEARCH METHODOLOGY

The subject of investigation, taking the form of *qualitative, exploratory research* among representatives of the main garment article stores in Romania, focuses on the way in which the interviewees view sustainable development issues, on the degree of globalization of the intercompany relations, as well as on the degree of transposing the ethical principles in their own branch and within the processes of purchasing, processing (production), distribution or intrafirm marketing. The authors have also analysed the attitude of the respondents towards the production and marketing of garment articles in ethical conditions. The interviewees were store directors of several retailers in Cluj-Napoca and Bucharest. Only these two cities have been selected because they are the largest on the national scale and population size, according to the 2011 census: 1.883.425 inhabitants in Bucharest and 324.576 inhabitans in Cluj-Napoca [46]. The contact of the store directors has been done by the authors, following the „snowball" system. They initially contacted a significant number of possible representatives of the H&M, Zara, C&A, Debehams, Bigotti etc. type of retailers (approx. 100), to finally obtain 38 complete answers from the interviewees. Being an exploratory, qualitative research, this has not raised the issue of sample representativeness (specific aspect of a quantitative, direct research) but of revealing some pertinent answers to the hypotheses formulated during this investigation. In the case in which interest is shown to emphasizing precise, somewhat sensible aspects (the degree in which an organization truly applies the sustainable development and ethical principles etc.), but also to generating new ideas, respectively to clarifying some notions, the specialty literature recommends the use of one of the qualitative investigation methods [10, 12, 14].

Either referring to in-depth interview, focus group or projective techniques, these data collecting instruments are implemented on relatively small samples

of subjects, the resulted ideas and/or conclusions having a great generalization impact, due to the fact that the most representative persons in the investigated field have been interviewed. Conclusions can be used later on as starting points for prospective quantitative studies.

The *method* used for conducting the research was *the survey*, the *technique* employed was the *in-depth interview* and the *instrument* was the *discussion guide* (please find attached the conversation guide). The study was carried out in the form of face-to-face conversations with each interviewee, lasting between 25 and 30 minutes. The research was conducted from November to December 2015.

When forming these samples, the researchers took into consideration the retail chains for the distribution of different garment articles that have at least 10 subsidiaries (stores) on a national level. Identifying these store chains was possible by taking the inventory of the leaseholders from the retail centres having a total surface over 50.000 s.m. Thus, two malls have been identified for Cluj-Napoca, and five retail centres for Bucharest (table 1).

Table 1

RETAIL CENTRES IN THE STUDIED CITIES [32]

City	Name of the mall	Surface s.m.	No. of stores
Cluj-Napoca	Iulius Mall	155.000	190
	Polus Centre	62.000	200
Bucharest	AFI Palace Cotroceni	79.500	300
	Băneasa Commercial Park	105.000	120
	Grand Arena	50.000	180
	Militari Shopping	51.400	61
	Sun Plaza	81.000	130

The research attempted to meet the following *objectives*:

a) conceptual clarifications about the main keywords: *globalization* in the retail with garment articles, *sustainable development*, *business ethics*;
b) relationship between *current* and *long-term development* of one's own business; *factors* that *foster* and *factors* that *hinder* sustainable development;
c) the main *effects of globalization* on the field in which the interviewees work;
d) highlighting the main *ethical issues* faced by the retail garment sector in Romania, as opposed to the countries of origin.

Based on these objectives, the research set out to test the following *hypotheses*:

H1. interviewees, irrespective of the size of their store, have a clear understanding of the concepts of *globalization*, *sustainable development* and *business ethics*;
H2. most respondents regard the development of their own business based on clearly defined and/or shaped ethical principles within precise standards;
H3. interviewees are able to identify a wide range of *effects of globalization* in their own field of activity, these concurring to shape an ethical governance of the environment;
H4. the range of *ethical issues* approached by interviewees also covers the relation of the investigated companies with the environment, and interviewees are fully aware of this aspect.

The representatives of the investigated stores have experienced the Romanian market as a result of its intense adaptation within the last fifteen years. The long discussion with each of these representatives approached the general market situation, but also the way in which their own company is being adapted to the Romanian specific, in an open, frank but sometimes critical way. The respondents have been fully guaranteed of the privacy and anonymity of the provided answers, both in what concerns the identity of the interviewees and the ideas related to each chain.

RESEARCH FINDINGS

The globalization theme, especially the relation between one's own affairs and global exigencies, as well as the regional and/or the local ones imposed by this phenomenon have been adequately understood by the respondents, who have considered that the globalization of trade relations and the necessity to introduce one's company on different markets, not only the production ones (mainly Asian), but also the distribution ones (mainly European and North-American), represents a common feature/normality of the current situation, although it necessitates vast resources of coordination. The major difficulty of this approach lies in the adequate administration of the efforts to coordinate within one's own company, to understand the local cultures and/or the local specific, to adapt to national legislations, and also to care for the local communities. Actually, the respondents have indicated the fact that trade relations specific to the new millennium require the presence of any company that proclaims itself a „global player" on several markets from differet continents, and they need to follow more Levitt's postulate „think global, act local". Due to significant gaps and technological differences between the adapted markets, the intense competitive climate, and the free consumers who continuously change their action manner and/or shopping behavior, due to people's significant access to communication and information networks, due to the international migration of workforce, due to the major cost advantages that retailers have on the relatively cheap workforce markets, the respondents have considered that the liberalization of international trades and global flows of goods has allowed the increase and even the consolidation of the integration process of the national markets in the global economy, and has implicitly contributed to the increase of the company access to resources, capital, workforce. More interviewees have deepened the conceptual analysis,

highlighting a favorable attitude towards the international organizations and especially towards the global regulations which officially decide the international trades of the adapted sector (Agreement for textiles OMC 2000-2005; Multi-fibre agreement 1956-2000). Other interviewees have underlined the importance of outsourcing and/or moving production and/or some of the manufacturing processes from the economically developed states to the more attractive markets from the perspective of the workforce costs, but also of the access to some textile resources. Actually, the globalization of trade relations has favoured an activation of the garment sector, which manages to produce at precise standards and extremely low costs on the Asian markets, and to distribute goods for prices that ensure companies an increased capitalization and a turnover on the Asian markets. Some respondents have also mentioned the fact that, within the market adaptation endeavour, an increased attention is paid to trading products not only as global brands, but also as local and/or regional brands, thus companies trying to reach closer to the consumers' needs.

Sustainable development and especially the different measures concerning environmental protection, sustainable consumption, investments within communities in which retailers and/or their partners own production units, the access to cheap resources etc. is considered, by most respondents, a necessary right, the interviewees managing to provide a series of good practice examples within their own business, as well as to highlight the extent to which retailers not only take into consideration such aspects, but they also carefully follow their practical application. Certainly, the globalization of the markets and the access of retailers to the remotest consumers must take place only according to ethical principles. In this regard, all respondents have highlighted the fact that the implementation of clear standards of business behavior developed on ethical principles is aimed at within their own companies. Moreover, most respondents have considered that ethics must govern not only their processes, be they purchase, manufacturing, distribution, sale processes etc., but also the whole activity sector. By and large, we consider that the premises for the ***confirmation of the H1 hypothesis*** have been met.

Concerning *the business sustainable development,* based on ethical principles, clearly defined and/or shaped/included within precise standards, the situation is relatively complex, and the dispersion of respondents' answers is considerably higher. The difficulty to adequately shape this phenomenon arises from the fact that some of the retailers appeal to signing partnerships with different production companies, passing the indents to their partners. Thus, retailers do not have an extremely severe control over the way in which partner companies strictly respect and implement within their own activities, processes and strategies based on ethical principles similar to theirs. However, most respondents have declared that, generally speaking, partners within the value chain must sign declarations of goods conformity, as well as those concerning the application of several ethical norms of conduct and/or behavior within all processes, defined by some global organizations and specific to multi- and transnational companies (UN Code of Conduct on Transnational Companies, Guideliness for Multinational Corporations etc.). When retailers themselves appeal to the production in different Asian, South-American or European states, two thirds have declared that they have been striving to implement, within factories, clear standards concerning the use of workforce, the guarantee of labor security, the adequate staff remuneration (of course, in relation to the specific conditions of each national legislation, as well as of the activity sector), but this has not always proven to be successful. From the recorded answers, we can conclude that this attitude cannot be considered as unitary. Most of the retailers have declared to be preoccupied with encouraging local communities, where they hold several business units, with ethical education, through actions – indeed punctual – with corporate social responsibility and environmental protection etc. Extending the discussion on this subject with the respective respondents, the authors have concluded that the respective actions mainly aim at improving an image and not at a long-term, continuous objective, to improve the situation of the local population from the respective producing countries. The ethical principles are also implemented in what concerns the relations between the company's employees who are encouraged to promote an adequate behavior especially in the relation with the consumers and/or clients, but the nature of these measures has proven to be casual, without a long-term strategic orientation component. More than half of the respondents have honestly accentuated the fragmented nature of the measures undertaken to consequently promote ethical principles in production, trading and interrelation with the solicitors. Retailers have considered that there is a significant development potential and, especially, of future disambiguation, the interviewees accentuating the necessity to develop several standards of good practice. Corroborating the received answers, we appreciate that ***hypothesis H2 needs to be rejected.***

In what concerns identifying the consequences of globalization and the relation with applying the ethical principles to the garment trade, most respondents directly connect these effects with the increase of the competitive phenomenon. The gradual elimination of the lohn production was rather fortuitous, being caused by the competitive advantages in Romania's neighbouring countries, outside the EU, especially in countries where workforce qualification is high, but wages are still kept to a minimum level. In this sense, the respondents feel that, within their ethical conduct standards promoted by their companies, an important aspect is the extent to which sale prices are deemed to be "fair", based on the total production expenses, including workforce and purchase of goods. According to most interviewed persons, globalization is "translated" into the existence of some initiatives concerning the minimization of resource and raw

materials waste, thus somehow guaranteeing the possibility to globally implement an ethical governance regarding environmental protection. Moreover, the respondents consider that their own companies must not only be aware of the impact and consequences of their own actions on the environment, but also to permanently strive to minimize and improve the consequences exerted on nature and the whole natural environment by the activities of purchase, production and/or manufacturing, distribution and/or sale. Therefore, the investments supported by the modern technologies, the technological innovations at the level of raw materials and manufacturing processes, appealing to alternative sources of energy, making savings etc., represent relevant and representative elements in successfully implementing such an enterprise. These measures are meant to counteract with the negative effects of globalization in the garment retail sector, the respondents fully understanding the necessity to elaborate a clear strategy of ethical development and precise pursuit of ethical governance within their companies. As such, we consider that ***hypothesis H3 can be accepted.***

The respondents consider that the existing ethical principles, if implemented within their businesses, will guarantee a balanced development, in agreement with environmental protection, as there is a direct and immediate connection between these two aspects. Even if all respondents consider that their own companies should pay increased attention to the environmental protection, still, over two thirds of them declare that they are aware of the punctual existence of several issues and/or deficiencies. Even if not made public, these matters are treated higly serious by the company management, the consequences being to redefine the codes of conduct and to complete the existent standards, so that the occurrence of future situations may be avoided. From the received answers, we can conclude that most respondents have tried to appeal to global ecological governance, synergistically using and combining, within the sustainability strategy, orientation towards environmental protection, minimization of resource consumption, application and implementation of ethical principles within activities they directly undertake. This clearly shaped awareness of the respondents is meant to improve the impact on nature of the activities developed by their own companies. Overall, the received answers are meant to **confirm hypothesis H4**.

CONCLUSIONS

One cannot approach the target groups and assume the roles of a retailer in the current competitive environment without abiding by the “rules of the game” and adopting an ethical strategic thinking in line with the principles of sustainable development [20]. Adopting unethical behavior may have dire consequences for companies, such as serious economic and financial problems and the tarnishing of their image, reputation, social prestige and mostly trust enjoyed among customers [29]. The legal, social and/or economic risks of one’s business, along with the behavioral ones, interpreted as minimization of trust in company brands and/or products, have had adverse effects on the strategy of garment distribution companies. They generate significant costs in removing the consequences of unethical activities, superior to those concerning the consistent implementation of some ethical actions, in agreement with the global ecological governance within the company. To ensure the development of their own business, companies often overlook the importance and significance of the consequences of such governance, as well as of strictly applying their own ethical standards and/or some carefully shaped codes of conduct. The adverse effects that can occur as a consequence of some “mistakes” and/or “involuntary errors” can cause significant losses to the retailers. Whether we have in mind the minimization of the market share, profit, sales, cover costs, or the loss of the buyers’ trust in brands and products, minimization of their satisfaction concerning retailers, minimization of loyalty degree etc., avoiding to apply ethical principles within their own actions can cause severe impedings to the company, which might, in the long run, become irretrievable.

For the company functioning on sustainable development principles, it is highly necessary to have a strategic vision on the corporate level, based on solid, ethical principles, which would take into consideration a synergist and holistic relation to society, ecosystems, partners, employees, but mostly with the environment. The respect for ethical principles can probably play a predominant function, being the element that favors the business development or its decline.

The environmental protection policy involves finding the best solutions for a particular context, in accordance with the interests of all actors: concerns and multinationals, international organizations, local communities and civil society. The “best” way to follow in this context is not necessarily the most objective and the most ethical, but it has to be the right choice with minimal impact on the global future of mankind and of the area considered. The ethical dimension of such a course of action may generate different possibilities throughout the entire process of economic globalization.

The credibility of the entire global governance mostly depends on the proper harmonization of the interests of all partners involved in such negotiations and decisions, respectively. All opinions cannot be brought to uniformity as it can only be imposed by force. In the end, each interested party must be able to “give up” a small amount of their preference for the sake of the common “good” and make the best they can so that their decisions may adhere to the accepted ethical principles. Moreover, the actors involved must ensure that, in the long term, both they and all the other stakeholders strictly abide by the decisions made.

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Energy saving and efficiency tool for SMEs of the european textile industry

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REZUMAT – ABSTRACT

Instrument de economisire şi de eficientizare a energiei destinat IMM-urilor din industria europeană de textile

Eficiența și competitivitatea în sectorul de producţie a textilelor și îmbrăcămintei trebuie să țină seama de provocările energetice actuale și viitoare. Eficiența energetică este un subiect de importanță critică pentru industria de textile şi îmbrăcăminte, pentru alte sectoare și pentru societate în general. EURATEX a iniţiat Energy Made-to-Measure, o campanie de informare care se desfăşoară în perioada 2014–2016 pentru a sprijini peste 300 de companii din industria de textile și îmbrăcăminte, în special IMM-uri, să devină mai eficiente energetic. SET (Save Energy in Textile SMEs), un proiect de colaborare co-finanțat în cadrul Programului european pentru Energie Inteligentă Europa II, ajută companiile să înțeleagă consumul lor de energie și le permite să compare valorile de referință sectoriale în diferite procese de producție. SET a dezvoltat schema SET, ***Instrumentul de economisire şi eficienţă energetică,*** *un instrument gratuit personalizat pentru producătorii de textile. Schema SET este formată din 4 elemente: un software de sine stătător (instrument SET) pentru autoevaluare pe baza unei aplicaţii Excel; o componentă online (SET WEB) pentru benchmarking avansat și compararea performanțelor de-a lungul anilor; un document ghid pentru companii și prezentarea generală a stimulentelor financiare și a obligațiilor juridice în ceea ce priveşte eficiența energetică. Concepută special pentru întreprinderile mici și mijlocii (IMM-uri), Schema SET permite evaluarea consumului de energie și recomandă măsuri de reducere a acestuia. Înainte de a modifica procesele de producție ale companiei și de a face investiții pentru creșterea eficienței energetice, IMM-urile din industria textilă au nevoie să obţină diferite tipuri de informații, inclusiv contextul juridic, economic și particularitățile tehnice.*

Cuvinte-cheie: eficienţa energetică, industria textilă, instrument de economisire şi de eficientizare energetică, indici energetici, energy-made-to-measure

Energy saving and efficiency tool for SMEs of the european textile industry

Efficiency and competitiveness in textile and clothing manufacturing sector must take into account the current and future energy challenges. Energy efficiency is a subject of critical importance for the Textile & Clothing industry, for other sectors and for the society in general. EURATEX has initiated Energy Made-to-Measure, an information campaign running between 2014–2016 to empower over 300 textile & clothing companies, notably SMEs, to become more energy efficient. SET (Save Energy in Textile SMEs), a collaborative project co-funded within the European Programme Intelligent Energy Europe II helps companies to understand their energy consumption and allows them to compare the sector benchmarks in different production processes. SET has developed the SET Scheme, ***Energy Saving and Efficiency Tool,*** *a free of charge tool customized for textile manufacturers. The SET Scheme is made up of 4 elements: a stand-alone software (SET Tool) for self-assessment based on an Excel application; an on-line part (SET WEB) for advanced benchmarking and comparison of the performances across years; a guiding document for the companies and overview of financial incentives and legal obligations regarding energy efficiency. Designed specifically for small and medium enterprises (SMEs), the SET Scheme enables the evaluation of energy consumption and recommends measures to reduce the consumption. Prior to modifying the company's production processes and making investments to increase energy efficiency, textile SMEs need to get different type of information, including legal context, economic and technical peculiarities.*

Keywords: energy efficiency, textile industry, energy saving and efficiency tool, energy indices, energy made-to-measure

INTRODUCTION

All Textile and Clothing (T&C) companies are energy sensitive and energy consumption is an economic, environmental and competitiveness problem. Energy efficiency is becoming an urgent issue in the European T&C sector for several reasons: regulation for energy efficiency is becoming stricter; energy prices are increasing; staying competitive requires controlling and optimising energy cost. European T&C companies already strongly rationalized human resources. To further increase competitiveness, other sources need to be dealt with. Energy is a crucial one with still large potential, especially at SME level.

SET (Save Energy in Textile SMEs), a collaborative project co-funded within the European Programme Intelligent Energy Europe II by EASME (Executive Agency for Small and Medium-sized Enterprises), is launched to enable the European textile SMEs to improve their energy efficiency and achieve tangible and countable economic and resource-efficiency benefits [1]. The

consortium, co-ordinated by EURATEX, includes CITEVE (Portugal), DITF (Germany), ENEA (Italy), INCDTP (Romania), ATOK (Czech Republic), CENTEXBEL (Belgium), IVGT (Germany), TMT (Hungury). SET creates and deploys a unique **Energy Saving and Efficiency Tool (SET Scheme)** for SMEs of the European textile industry, **enables energy efficiency** for 150 companies by applying the tool at 50 companies premises, followed by training and assistance to further 100 companies, unlocks energy saving potential for **further** 350 companies and joins **the Energy Made-to-Measure (EM2M),** an information campaign lanunced and managed by the European Textile and Clothing Confederation (EURATEX) to provide Textile and Clothing manufacturers with tools, best practices and training to assess options and take informed decisions on energy efficiency measures [1].

EXPERIMENTAL WORK

A major outcome of the SET project is the **SET Scheme**, an Energy Saving and Efficiency Tool designed for textile companies to autonomously assess their energy consumption and performances in the production process, ultimately to improve their energy efficiency [2].

The SET Scheme (figure 1) is made up of 4 elements: a stand-alone software (SET Tool) for self-assessment based on an Excel application; an on-line part (SET WEB) for advanced benchmarking and comparison of the performances across years; a guiding document for the companies and overview of financial incentives and legal obligations regarding energy efficiency.

The **SET Tool** runs on a Microsoft Excel file and is used to collect the company data on energy consumption and production. Based on this input the tool calculates the company's energy index and offers a selection of best practices, return on investment etc. The **SET WEB** allows companies to benchmark, in strict confidentiality, its own energy performance data with data of comparable companies active in the same production processes. The **Guiding document** provides an overview of the data collection process and outcome. It is developed for companies' representatives to use and to be able to get the most from the energy efficiency tools [3].

In the SET project timeframe the SET Scheme application is supported by SET partners and is completed by a number of proposals to improve energy efficiency, taking into account the available financial support schemes and the legal framework [4–5].

SET Tool (figure 2) has a multi-step session approach and collects data of one factory related to one year.

In step 1 the application asks companies for basic yearly information about consumption and production and gives back as result some energy indices (energy cost/turnover, electrical consumption/turnover rate, electrical cost/turnover rate, thermal consumption/turnover rate, thermal cost/turnover rate) (figure 3) and some best practices (cross-cutting energy efficiency measures) [6].

In step 2 the company is asked for more detailed and monthly data and description of the technologies used (Yarn Production, Fabric Production and Finishing). A wider set of Best Practices is evaluated (also related to the kind of machines) and more data, diagrams and indices describing the energy uses are showed (Monthly production and Electrical/Thermal Consumption graph, Electrical/Thermal Consumption vs Production – regression graph, Specific Electrical/

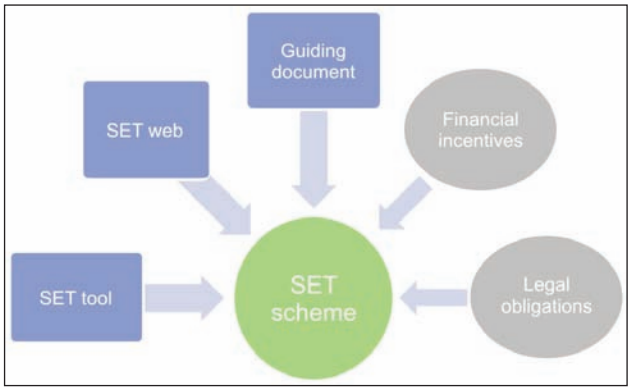

Fig. 1. Elements of SET Scheme

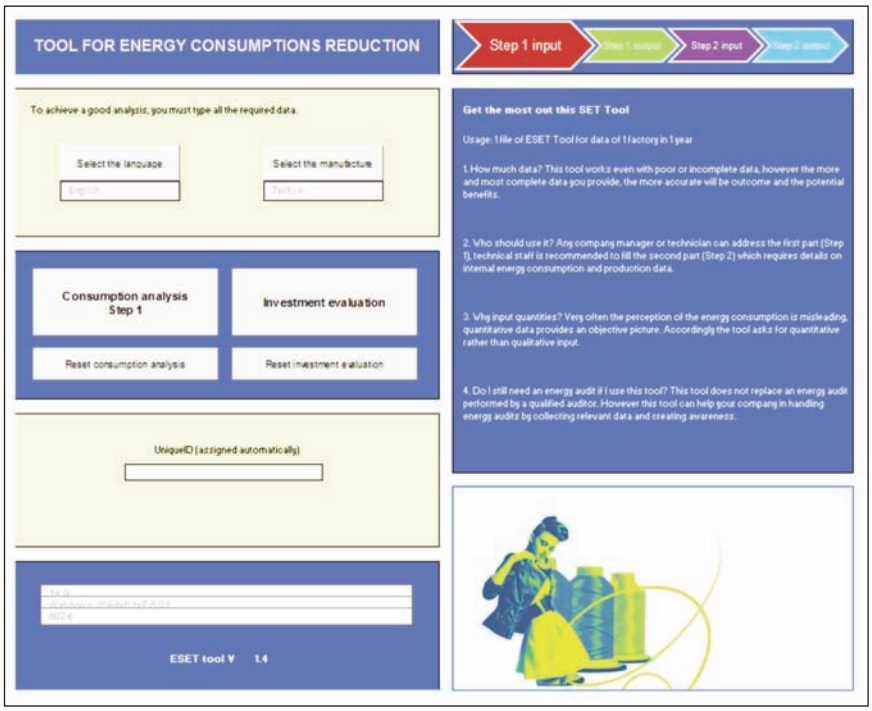

Fig. 2. SET Tool

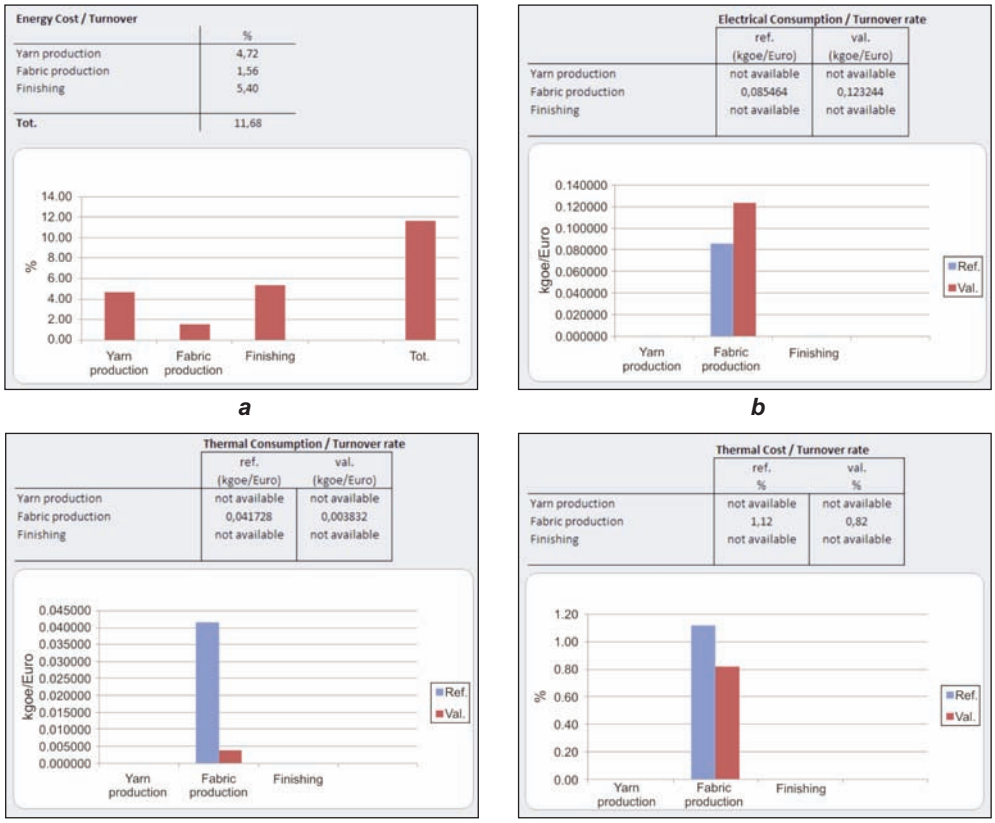

Fig. 3. Step1_Outputs – Global energy indices:
a – Energy Cost/Turnover; *b* – Electrical Consumption/Turnover rate; *c* – Thermal Consumption/Turnover; *d* – Thermal Cost/Turnover rate

Thermal Consumption vs Production-regression graph) (figure 4).

In step 3 detailed data from machines is asked to build an electrical and thermal model of the company (figure 5) to compare against the macro values and obtain the shares of energy for the different uses.

SET WEB

The SET WEB is based on a constantly updated database and is a service free of charge for companies which contribute by sending confidentially their own energy data. On the SET WEB the **company can:**

- Look at examples in the **demo** pages showing elaborations, graphs, benchmarks;
- **Compare** own factory's energy performance with those of similar European companies (figure 6);
- Forecast **models** for energy consumption based on own technologies and production;
- Compare own **progress** year by year.

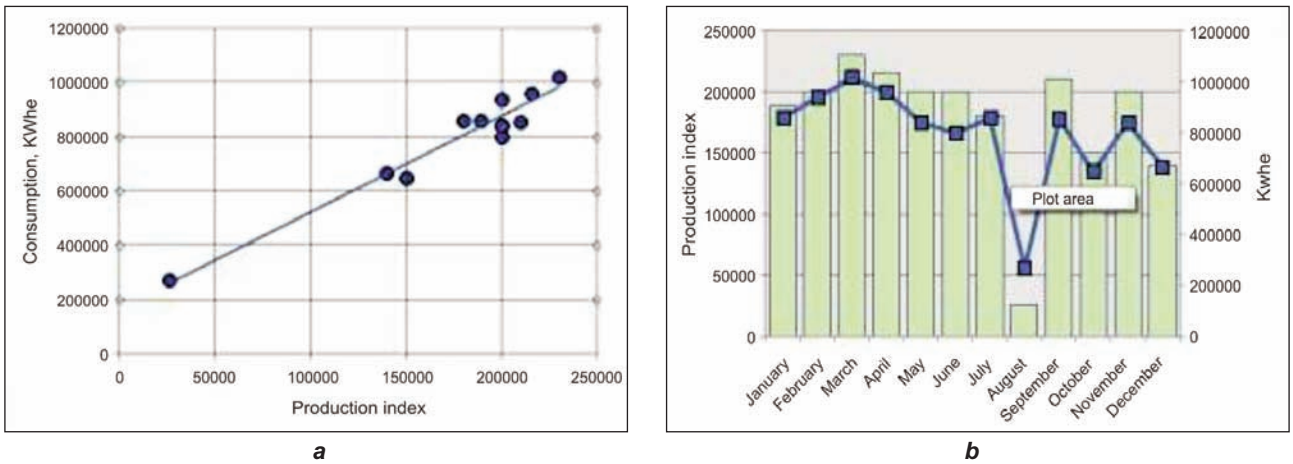

Fig. 4. Step2_Outputs – Monthly variation:
a – Electrical Consumption vs Production; *b* – Monthly Production and Electrical Consumption

1 – Insert percentage of electrical energy for production (not considering energy of auxiliary systems) and production;

2 – Data about your main production processes;

3 – The tool estimates your expected specific energy consumption (red circle) based on the information of point 2 and compares it with your real value (green circle).

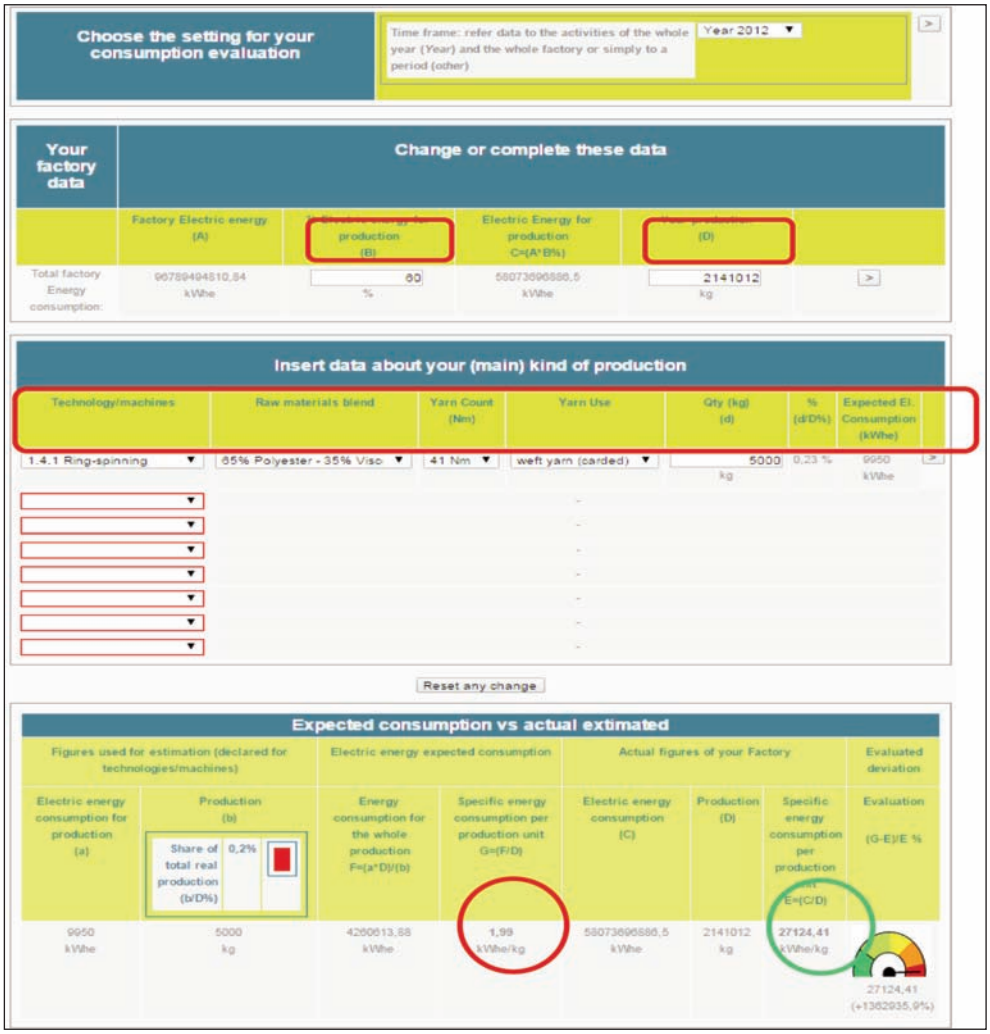

Fig. 5. Technology based model for Yarn production

a *b* *c*

Fig. 6: SET tool Web: Performance comparison:
a – Factory Turnover and Specific Energy Cost per Turnover by year;
b – Specific Energy Cost per Turnover; *c* – Specific Energy Cost per Production

RESULTS AND DISCUSSION

The SET Scheme, a self-assessment tool tailored on textile manufacturing processes has already been tested by over 50 companies selected along the three value creation steps: Yarn Production, Fabric production and Finishing, further 100 companies are planned to be supported in 2016. Application of SET tool on the companies was performed by the company itself with the help of SET partners. Based on the results of Application and Validation phases of SET Scheme there should be elaborated the Energy Consumption Rationalization Plan that contains the following items: Company characterization; Energy consumption and cost by type of energy (electrical and thermal); Energy indices provided the outputs of SET Tool; Energy efficiency measures; Estimated savings and investments for each energy consumption

of the selected measures; Estimation of energy consumption and energy indices after application of efficiency measures.
The implementation of a plan like this can be checked on a yearly basis using SET Tool instruments to evaluate company's progress on energy consumption, since the web application of the tool allows the storage and presentation of data from several years.
The SET Tool does not replace an energy audit performed by a qualified auditor. However this tool can help the company in handling energy audits by collecting relevant data and creating awareness.

CONCLUSIONS

Energy Saving and Efficiency Tool (SET Scheme) is a unique tool for SMEs to:

- Know and understand what legal obligations and financial incentives exist or are upcoming;
- What are the best practices in textile specific energy efficient measures;
- Evaluate energy consumption on specific textile processes;
- Calculate energy consumption per product;
- Benchmark the energy values;
- Get clear recommendation for energy efficiency measures;
- Evaluate the potential savings with recommended measures;
- Calculate economic profitability and the ROI (Return on Investment) of energy efficiency investments.

The SET project plans to support 150 European Textile SMEs to assess and effectively launch measures to reduce costs and become more competitive thanks to energy efficiency. Also, 350 European Textiles SMEs will receive all necessary elements (both technical and non-technical) to evaluate their options and to make well-informed decisions.
Prior to modifying the company's production processes and making investments to increase energy efficiency, textile SMEs need to get different type of information, including legal context, economic and technical peculiarities.

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Erratum

The correct names of the authors of the article published in vol. 67, no. 3, pp. 210–213 entitled "*Textile manufacturers' decisions optimization using informational energy modelling*" are:

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