VLÁKNA a TEXTIL

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Ročník 18.
2011

ISSN1335-0617

Indexed in:

Chemical Abstracts,

World Textile Abstracts

EMDASE

Elsevier Biobase

Elsevier GeoAbstracts

Fibres and Textiles (2) 2011
Vlákna a textil (2) 2011

Content

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STUDY OF TRANSPLANAR HEAT TRANSFER IN MULTILAYER TEXTILE STRUCTURES

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Abstract: *This work presents the results of investigation of thermal properties of individual textiles, their packages and functional multilayer composites. The thermal properties: thermal resistance, thermal conductivity and thermal absorptivity were investigated. We have studied the relation between thermal properties of individual textiles and properties of packages and multilayer composites that make up from these textiles. Comparison between the experimental and theoretical values of the thermal properties of packages is submitted for consideration.*
Key words: *textile materials and packages, functional multilayer composites, heat transfer*

1 INTRODUCTION

In our previous works [1–3] we developed method of designing multilayer textile composites for technical application. This method consists in the bonding of individual textiles in one multilayer structure. Such composites consist of textiles with various functional properties, different structures and different fibrous composition. We suppose that the creation of multilayer textile composites is one of the effective ways of control the water and heat transfer properties in textile systems.
The aim of this work is the investigation and comparison of the thermal properties of individual textiles, their packages and properties of multilayer composites for establishing a relation between their thermal properties.
Usually thermal properties are characterized by thermal conductivity, thermal resistance, thermal diffusion coefficient and a thermal capacity. L. Hes proposed a new parameter – thermal absorptivity, which characterizes human thermal sensations at a contact with textile [4]. This parameter was marked “*b*”, $W{\cdot}s^{1/2}/m^2{\cdot}K$. All these characteristics can determine on device ALAMBETA.

2 EXPERIMENTAL

2.1 Textile materials

It was chosen eight modern individual textiles, which differ by their structure, raw composition and physical properties (Table 1). In this table is given the thermal properties too.
For investigation two groups of multilayer packages (Table 2) and two groups of multilayer textile composites (TCM) (Table 3) were obtained. Packages and composites had identical composition, but multilayer packages were obtained by simple layering of individual textiles in one multilayer structure without bonding. For textile composites receiving the individual textiles were bonded through the use of two-sided adhesive web “Sharnet” (Bostik Findley, Ltd., England).

Table 1 Structural and thermal properties of individual textile materials (φ = 65 %, t = 25°C)

Code of individual textile materials	Raw composition [%]	Thickness h [mm]	Heat flow density $q\cdot10^3$ [W·m ^{2}]	Thermal resistance $R\cdot10^3$ [$W^{-1}\cdot K\cdot m^2$]	Thermal conductivity $\lambda\cdot10^3$ [$W\cdot m^{-1}\cdot K^{-1}$]	Thermal diffusion coefficient $a\cdot10^6$, [$m^2\cdot s^{-1}$]	Thermal absorptivity b [$W\cdot s^{1/2}/m^2\cdot K$]
Sa	PP – 100	0.69	1.45	15.1	45.6	0.138	123
Sp	Cotton – 33 PES – 67	0.76	1.59	12.7	59.9	0.149	155
Al*	PP – 60 Cotton – 40	1.55	0.86 1.33	29.0 29.2	53.5 53.7	0.290 0.246	100 130
El	Viscose – 100	0.84	1.93	11.1	76.0	0.091	253
Pq	Cotton – 100	0.82	1.69	12.4	65.9	0.150	171
Li	Linen – 50 Cotton – 50	1.38	1.33	20.2	68.2	0.145	180
Lu	PES – 100	0.34	1.72	8.6	39.8	0.063	159
BA	PES – 100	0.32	1.90	7.6	42.6	0.045	201
+**	EVA – 100	0.20	1.94	7.9 (4 layers)	25.3 (4 layers)	0.026 (4 layers)	157 (4 layers)

* – two layers knitting fabric
** – two-side adhesive web “Sharnet”

The textile composites were prepared on laboratory equipment. The optimal bonding conditions: the bond line temperature – 130°C, the pressure applied – 0.05 MPa and the exposure time under heat and pressure – 15 sec. These bonding conditions provide the required bonding fastness.

2.2 Research Methods

The thermal properties of individual textiles, their packages and functional multilayer composites were measured on ALAMBETA device (temperature difference of 10°C (temperature of top heated plate was 34°C) and pressure (200 Pa)) [5].

The measurement were provided under the condition φ = 65 %, t = 25°C.

3 RESULTS AND DISCUSSION

3.1 Thermal properties of individual textiles

Investigated textiles are characterized by a range of values of thermal properties (Table 1):

- thermal resistance (R) changes from $81.6\cdot10^{-3}$ to $90.2\cdot10^{-3}$ $W^{-1}\cdot K\cdot m^2$;
- thermal conductivity (λ) changes from $51.4\cdot10^{-3}$ to $58.7\cdot10^{-3}$ $W\cdot m^{-1}\cdot K^{-1}$;
- peak heat flow density (q) changes from $1.22\cdot10^{-3}$ to $1.58\cdot10^{-3}$ $W\cdot m^{-2}$;
- thermal diffusion coefficient (a) changes from $0.128\cdot10^{-6}$ to $0.205\cdot10^{-6}$ $m^2\cdot s^{-1}$;
- thermal absorptivity (b) changes from 119 to 157 $W\cdot s^{1/2}m^{-2}\cdot K^{-1}$

These data enables studied the relation between thermal properties of individual textiles and properties of packages and multilayer composites.

3.2 Thermal properties of multilayer packages and composites

Experimental data of thermal properties of multilayer packages are presented in Table 2 and for multilayer textile composites in Table 3.

Table 2 Structural and thermal properties of multilayer packages (φ = 65 %, t = 25°C)

Code of packages	Composition of packages*	Thickness h [mm]	Heat flow density $q\cdot10^3$ [W·m^{-2}]	Thermal resistance $R\cdot10^3$ [W^{-1}·K·m^2]	Thermal conductivity $\lambda\cdot10^3$ [W·m^{-1}·K^{-1}]	Thermal diffusion coefficient $a\cdot10^6$ [m^2·s^{-1}]	Thermal absorptivity b [W·s$^{1/2}$/m^2·K]
I group							
1	Sa+Al+El +Lu+BA	4.55	1.22	83.6	54.6	0.205	122
2	Sa+Al+Pq +Lu+BA	4.48	1.29	87.1	51.4	0.188	119
3	Sa+Al+Li +Lu+BA	5.28	1.45	90.2	58.8	0.184	137
II group							
4	Sp+Al+El +Lu+BA	4.58	1.58	81.6	56.2	0.128	157
5	Sp+Al+Pq +Lu+BA	4.54	1.50	81.7	55.5	0.151	143
6	Sp+Al+Li +Lu+BA	5.06	1.50	86.3	58.7	0.165	145

*(packages were obtained by simple layering of individual textiles in one multilayer structure without bonding)

Table 3 Structural and thermal properties of multilayer textile composite materials (φ = 65 %, t = 25°C)

Code of TCM	Composition of TCM	Thickness h [mm]	Heat flow density $q\cdot10^3$ [W·m^{-2}]	Thermal resistance $R\cdot10^3$ [W^{-1}·K·m^2]	Thermal conductivity $\lambda\cdot10^3$ [W·m^{-1}·K^{-1}]	Thermal diffusion coefficient $a\cdot10^6$ [m^2·s^{-1}]	Thermal absorptivity b [W·s$^{1/2}$/m^2·K]
I group							
1	Sa+Al+El+Lu+BA	2.93	1.84	36.2	81.2	0.157	205
2	Sa+Al+Pq+Lu+BA	2.92	1.79	37.7	76.4	0.145	201
3	Sa+Al+Li+Lu+BA	3.04	1.75	38.3	79.5	0.150	205
II group							
4	Sp+Al+El+Lu+BA	3.03	1.81	35.0	86.5	0.120	232
5	Sp+Al+Pq+Lu+BA	3.20	1.89	39.6	79.8	0.124	227
6	Sp+Al+Li+Lu+BA	3.43	1.80	43.9	78.2	0.131	216

Given below diagrams (Figure 1) are demonstrating differences between thermal properties of packages and composites.

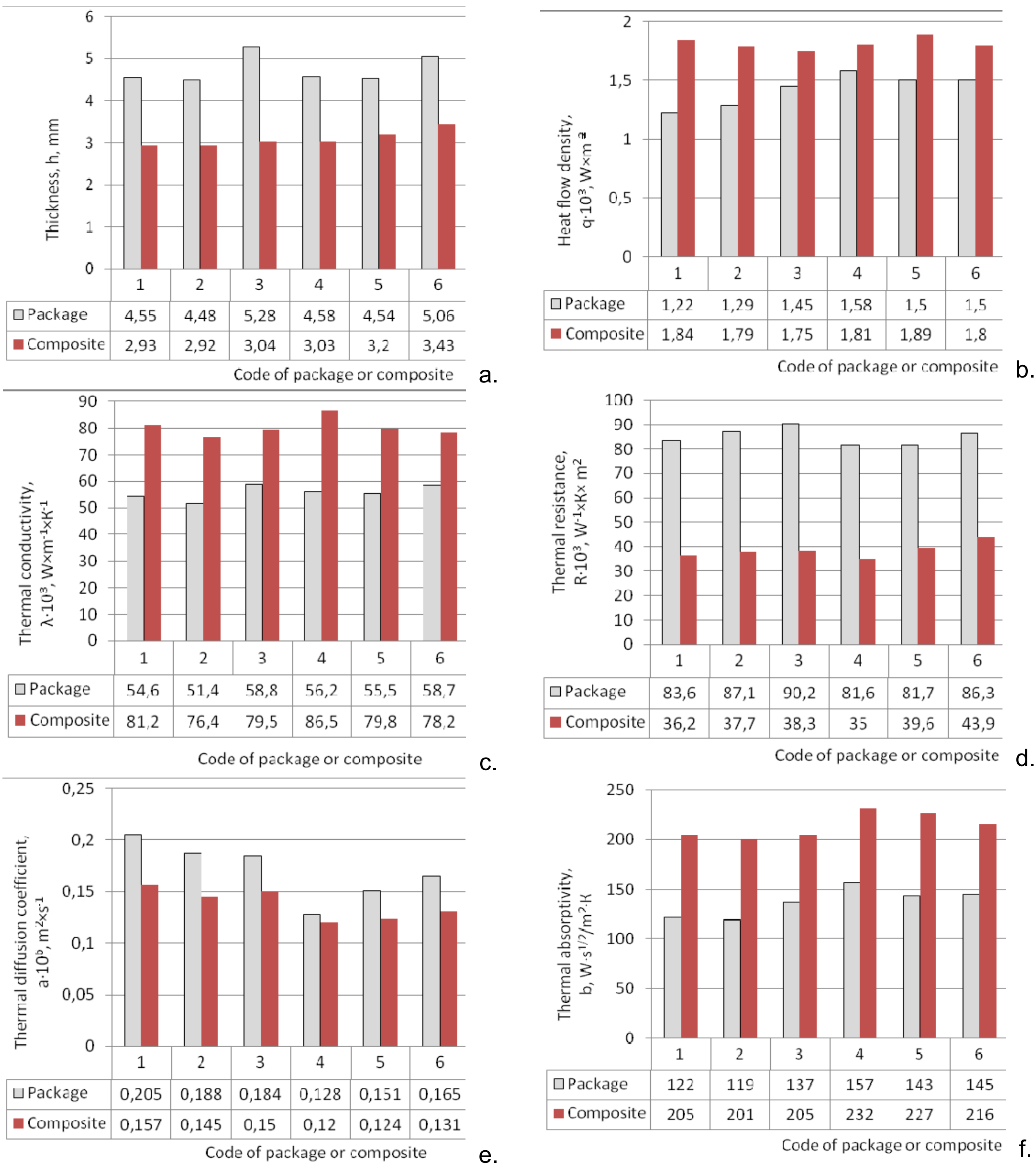

Figure 1 Heat transfer properties of multilayer packages and multilayer textile composites

As shown in Figure 1 thermal property of multilayer textile composites differ from thermal properties of multilayer packages. During thermal bonding (due to action of a heat and pressure) the air layers and thickness of TCM decreases, and contact areas between fibres and surfaces of textiles increase. It leads to decrease thermal insulation characteristics of TCM and to increase of their ability to conduct heat.

The analysis of data specifies influence of packages and composites structure on their numerical values of thermal properties.

The analysis of thermal properties of TCM (Table 3) I and II groups (composites differ of type of the first layer) has shown that thermal resistance (*R*) of textiles with the top layer «Sp» is higher as a result of their increased thickness. Thermal conductivity (λ) and thermal diffusion coefficient (*a*) of these composites practically does not differ among themselves. Use in the third layer of textiles «El», «Pq» or «Li» does not make essential changes in thermal properties of multilayer materials because very close numerical values of individual textiles (Table 1).

As described in [4] important role belongs to a parameter «thermal absorptivity» at hand estimation of thermal comfort of TCM. For the characteristic of this parameter the type of the top layer is defining, namely, character of its surface and fibrous structure. Investigations are show that «thermal absorptivity» increases on 50 ÷ 70 % for all TCMs. The reason of this effect is decrease roughness of textile surface of the first layer after thermal bonding. Decrease of a surface roughness of TCM lead to increase of actual area of contact between a human body and textiles, and, so, the surface of a material becomes colder to the touch.

We have made an attempt to compare the experimental and calculated data of thermal properties. The results are given in Table 4.

The calculated data of thermal properties of packages at a stationary condition were full filed using concept of thermal conductivity of flat multilayer wall [6].

Data from Table 1 and following formulas have been used for calculation:

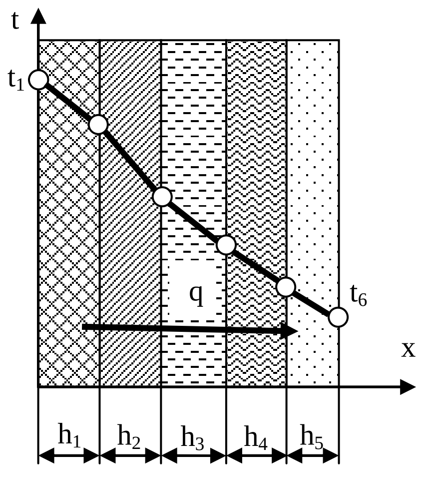

Figure 2 Model of heat transfer in multilayer wall (5-layer)

Peak heat flow density of multilayer package:

$$q_p = \frac{t_1 - t_{n+1}}{\sum_{i=1}^{n} \frac{h_i}{\lambda_i}}$$

Thermal conductivity of multilayer package:

$$\lambda_p = \frac{\sum_{i=1}^{n} h_i}{\sum_{i=1}^{n} \frac{h_i}{\lambda_i}}$$

Thermal resistance of multilayer package:

$$R_p = \sum_{i=1}^{n} R_i$$

Thickness of multilayer package:

$$H_p = \sum_{i=1}^{n} h_i$$

t_1 – outside temperature of first layer (in experiment t_1=35°C)
t_{n+1} – outside temperature of last layer (in experiment t_{n+1}=25°C)
h_i – layer thickness
λ_i – thermal conductivity of layer
R_i – thermal resistance of layer
n – layer number

Table 4 Comparison data of the experimental and calculated values of the thermal properties of packages (φ = 65 %, t = 25°C)

Code of packages	Composition of packages	Thickness of package H_p [mm]		Thermal resistance $R_p \cdot 10^3$ [$W^{-1} \cdot K \cdot m^2$]		Thermal conductivity $\lambda_p \cdot 10^3$ [$W \cdot m^{-1} \cdot K^{-1}$]	
		experimental	calculated	experimental	calculated	experimental	calculated
I group							
1	Sa+Al+El+Lu+BA	4.55	3.94	83.6	79.5	54.6	49.6
2	Sa+Al+Pq+Lu+BA	4.48	3.92	87.1	80.8	51.4	48.5
3	Sa+Al+Li+Lu+BA	5.28	4.48	90.2	88.6	58.8	50.6
II group							
4	Sp+Al+El+Lu+BA	4.58	4.01	81.6	77.1	56.2	52.0
5	Sp+Al+Pq+Lu+BA	4.54	3.99	81.7	78.4	55.5	50.9
6	Sp+Al+Li+Lu+BA	5.06	4.55	86.3	86.2	58.7	52.8

The analysis of data has shown that experimental values differ from calculated on 1÷13 % (the variation at measurement on device ALAMBETA made up 1÷10 %). Experimental data of thickness, thermal resistance and thermal conductivity of multilayer package are higher than calculated data. It is explained by limitations of the multilayer wall theory. The theory assumes ideal thermal contact between smooth surfaces of layers – layers closely fit to each other and have the same temperature on contact surfaces of different layers. However textiles have a rough surface and their ideal fit contact is impossible. The air layers are formed between textile layers. As is well known the thermal conductivity of air is small (λ_{air} = 0.02553 W/m·K). Presence even of very thin air layers leads to decrease in thermal conductivity of multilayer packages. This phenomenon is observed in multilayered packages too (Table 4). Thus, use of the multilayer wall theory for a prediction of thermal conductivity of multilayer textile packages is advisable, however it is necessary to pay attention to contact fit between layers. But the multilayer wall theory [6] is not valid for calculation of thermal properties of multilayer textile composites.

4 CONCLUSION

The study of the heat transfer properties of individual textiles, their packages and multilayer composites leads to the following conclusions:

1. Thermal properties of multilayer packages at a stationary condition can be described using concept of thermal conductivity of flat multilayer wall. Comparison of experimental and calculated data shown that the results are very similar. In the same time the multilayer wall theory can't be used for multilayer textile composites.
2. The thermal properties of multilayer packages and textile composites depend on the initial materials' characteristics and receiving condition of TCM.
3. The thermal absorptivity, peak heat flow density and the subjective thermal contact feeling characterising the textile thermal comfort of TCM is depending of type of the top layer (roughness or smoothness of its surface and fibrous composition).

Acknowledgement: *This work was carried out with the support of the International Visegrad Fund*

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ŠTÚDIUM TRANSROVINNÉHO PRESTUPU TEPLA VO VIACVRSTVOVÝCH TEXTILNÝCH ŠTRUKTÚRACH

The translation of article
Study of transplanar heat transfer in multilayer textile structures

Abstrakt: Táto práca prezentuje výsledky štúdia termických vlastností jednotlivých textílií, ich návinov a funkčných viacvrstvových kompozitov. Boli hodnotené tieto termické vlastnosti: tepelný odpor, tepelná vodivosť a tepelná absorptivita. Študoval sa vzťah medzi termickými vlastnosťami jednotlivých textílií a vlastnosťami návinu a viacvrstvových kompozitov vytvorených z týchto textílií. Porovnanie medzi experimentálnymi a teoretickými hodnotami termických vlastností návinov je uvedené.

This contribution was presented at the 6th Central European Conference 2010,
13-14th September 2010, in Bratislava, Slovak Republic.

THE EVALUATION OF THE SEQUESTRATION CAPACITY OF AGENTS BASED ON COPOLYMERS OF ACRYLIC ACID WITH MONO- TO OLIGOSACCHARIDES IN WASHING PROCESS

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Abstract: *Sequestrate agents based on high-molecular polymeric polycarboxylates are recently used, but they aren't biodegradable. Therefore the research is focused to obtain biodegradable sequestrates based copolymers of acrylic acid with mono- to oligosaccharides. The structure of prepared samples of dextrin – acrylic acid was confirmed by IR and ^{1}H-NMR spectra. Sequestration capacity was measured at 20°C and 98°C at different pH-values. The prepared samples were tested at model washing conditions. After twenty times repeated washing in hard water 22°dH, 30 min at 90°C was determined the contain of ash and calcium ion. Washing process was also performed with addition of sodium perboritane. The image of fabric after the model washing was evaluated by scanning electron microscope. This sequestrate agents may have wide application for textile industry.*

Key words: *sequestrate agents on polymer-basis, sequestration capacity, copolymers of acrylic acid with saccharides*

1 INTRODUCTION

Textile auxiliary agents (hereafter TAA) are possible to define as compounds produced by chemical way and their mixtures. These mixtures make easy, speed up, improve or enable at all a technological treatment and are used at production and textile finishing.

Textile auxiliary agents based on natural polymers (starch, cellulose) have been used in textile finishing already very long time ago. They apply mainly at sizing, stiffening and filling finish and as thickening agents, etc. The significance is in their good biodegradability and the important reality is as well as in the obtaining from recent raw materials.

Noted advantages lead chemical research to use natural raw materials for preparation of textile auxiliary agents and apply in non-traditional areas.

The sequestrate agents (hereafter SA) are one of TAA. Those are the most frequently used as a component of detergents, then in the areas of textile finishing (mainly in a pre-treatment) but in further areas, e.g. dyeing cellulose materials or water softening.

It is well-known, that water plays irreplaceable role in textile industry. A textile production is dependent on water and sufficiency of water with good quality is a basic precondition for textile plants. Water is almost the only solvent, which is used at textile industry for washing and dissolution of finishing agents, dyes and sizes and also for steam production.

An adverse effect of alkaline earth metal ions (Ca^{2+}, Mg^{2+}), which make water hardness or effect of heavy metal ions (Fe^{3+}, Cu^{3+}, Mn^{3+}) on fundamental processes of textile industry is generally known. An important property of sequestrates is disabling of $CaCO_3$ precipitation. This slightly soluble compound can be deposited at high temperature as water stone on equipment and affect its functioning, temperature regime etc. Beside of it, $CaCO_3$ can be deposited on treated textile, which now has a rough handle. It affects an efficiency of TAA and a run of other textile finishing processes. Beside $CaCO_3$, a negative effect can have calcium silicate, which is created at water glass presence.

Moreover, that the alkaline earth metal cations or heavy metal cations got into bath with insufficiently treated plant water, they are contained as well in technical chemicals and the treated material. Therefore the usage of sequestrates is recommended even in pre-treatment.
An increasing pressure on cleanness of wasted water and use of biodegradable washing components and finishing baths of textile productions leads to new opinions on recently used sequestrates. With respect to environment protection a consumption of pentasodium triphosphate was primarily limited, which has suitable properties, but stimulates a creation of water eutrophication. Some Western Europe countries prohibited its use at all. Sequestrates on polymeric basis became its substitution in detergents. They are mostly sodium salt of acrylic acid event. copolymers of acrylic acid with maleic anhydride or homopolymer of maleic anhydride (Umastat Q) [1] etc. Polymeric sequestrates, of course, do not create a water eutrophication and it is possible to remove them from wasted water on cleaning equipments with a high yield, but they are not biodegradable and stocked-up in cleaning sludge. Therefore there is an effort to develop and produce biodegradable polymers with sequestrate effect. They are mostly copolymers of acrylic acid with suitable monomers, which represent biodegradable places in the created copolymer. Vinyl acetate (vinyl alcohol after hydrolysis) [2-6] or monosaccharides, oligosaccharides or polysaccharides [7-17] are used as the above mentioned monomer. These copolymers are used as sequestering agents, complexing agents, cobuilders in laundry detergents in textile finishing [8, 12-17].

2 EXPERIMENT

2.1 Sequestrate agents preparation

The samples were prepared by grafting oligosaccharides (dextrin) with acrylic acid. For preparation of samples the radical polymerization of acrylic acid and dextrine was used in addition of H_2O_2 as catalyst at 85°C.
The structure of prepared samples was confirmed by IR and ^{1}H-NMR spectra. Infrared spectra were measured as Nujol mulls in KBr cuvette on a Perkin-Elmer 684 spectrophotometer in the region 4000-350 cm^{-1}. ^{1}H-NMR spectra were measured in D_20 on instrument Bruker AYX 360 at frequency 360.17 MHz.

2.2 Evaluation of dry matter and sequestration capacity

Dry matter was evaluated after drying of precise weight amount of a sample to constant weight at 80°C.
The sequestration capacity was evaluated at prepared agents and it was compared with commercial sequestrate agents. The sequestration capacity was evaluated to Ca^{2+} ions by precipitating opacity titration - so called Hampshire test, at 20°C and 98°C at a range of pH-values 9 to 12.
A solution of $CaCl_2.6H_2O$ was selected as a volumetric solution. The equivalence point was determined by measuring of absorbance of created opacity at waving length 650 nm, in cell 1 cm - (Spectrophotometer Spekol 11 - Carl Zeiss) and consequent evaluation of measured dependences.

2.3 Sequestrate agent efficiencies at model washing condition

Prepared polymeric agents were determined at model washing condition. Model detergent consists of anion active and nonionogenic tenside, and further common components as water glass, carboxymethylcellulose, sodium carbonate and sodium sulphate [18]. Determined sequestrates were added into this base mixture. Washing material was 20 grams of cotton textile, bath ratio 1:10.
After twenty times repeated washing in the hard water 22°dH (German degrees of hardness), 30 min at 90°C was determined, the contain of ash and calcium ion. After 20x repeated washing the textile was incinerated in a platinum crucible and the amount of Ca^{2+} was evaluated in ash. Titration of chelaton III (13.270g/l) was made [19].

The image of fabric after the model washing was evaluated by scanning electron microscope.

3 RESULT AND DISCUSSION

All synthesises are realizable at normal conditions, starting monomers are easy available. The advantage is the use of water as solvent. This water solution is ready for further use.

The structure of prepared samples was confirmed by IR and ^{1}H-NMR spectra - Figures 1, 2.

Figure 1 Infrared absorption spectrum of model sample (No. 1) – grafted dextrin of acrylic acid after dialysis

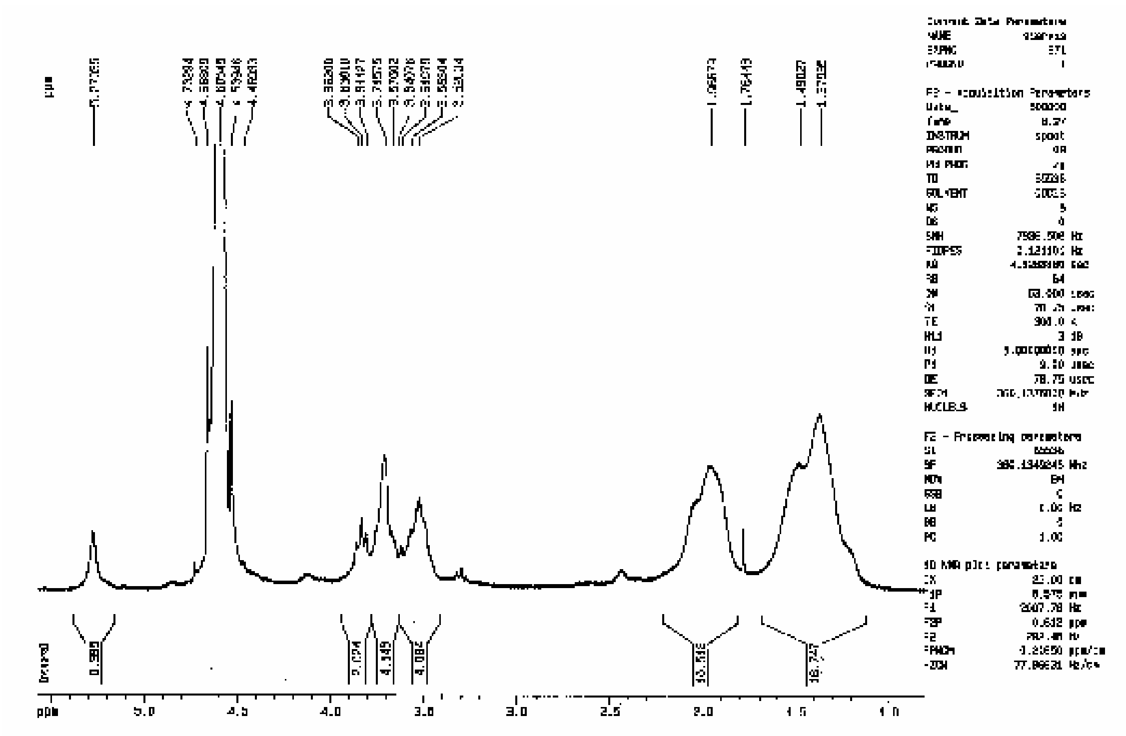

Figure 2 NMR–^{1}H–spectrum of model sample (No. 1) of grafted dextrin of acrylic acid after dialysis

Polymer cleaned by dialysis (membrane filtration) gives IR spectra with visible absorption band in a range belonging to hydroxyl groups (1000 –1100 cm^{-1}), (Figure 1). Similarly NMR spectra give signals of –OH groups of glucopyranose units (3.5 ppm), (Figure 2).
The sequestration capacity was evaluated at prepared agents and it was compared with commercial sequestrate agents. The sequestration efficiency decreases with increasing temperature. The measured values of sequestration at 98°C show 80-95% sequestration capacity at 20°C (Table 1). If the sequestration capacity is evaluated in relation to pH value, the sequestration linearly goes up with increasing pH-value. The above-mentioned behaviour of sequestration effect was confirmed at prepared samples, as well as commercial agents (Figures 3, 4).

Table 1 Values of dry matter and sequestration capacity

Sample (molar ratio of dextrine:acrylic acid)	**Dry matter [wt.%]**	**Sequestration capacity [mg Ca^{2+}/1g dry matter]**		**pH**
		20°C	98°C	
1 (1:24)	25.33	274.00	257.00	12.5
2 (1:12)	26.06	244.32	236.49	12.5
3 (1:6)	28.71	223.69	203.79	12.5
4 (1:12)	50.72	214.70	209.59	12.5
5	-	225.52	221.04	12.0
6	-	189.38	146.60	12.0

Samples 1 – 4 grafting dextrine of acrylic acid (different molar ratio)
Samle 4 change of process of neutralization
Sample 5 commercial SA on based copolymer acrylic acid – maleic anhydride – Sokalan CP-5
Sample 6 pentasodium triphosphate

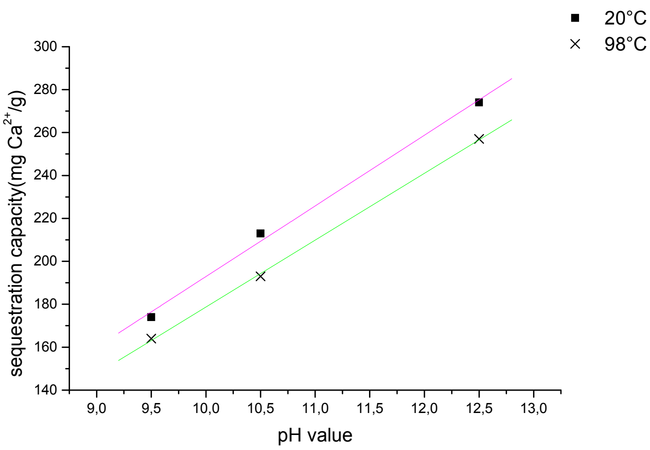

Figure 3 Dependence of sequestration capacity Ca^{2+} on pH value at 20°C and 98°C for sample No.1 (acrylic acid – dextrine)

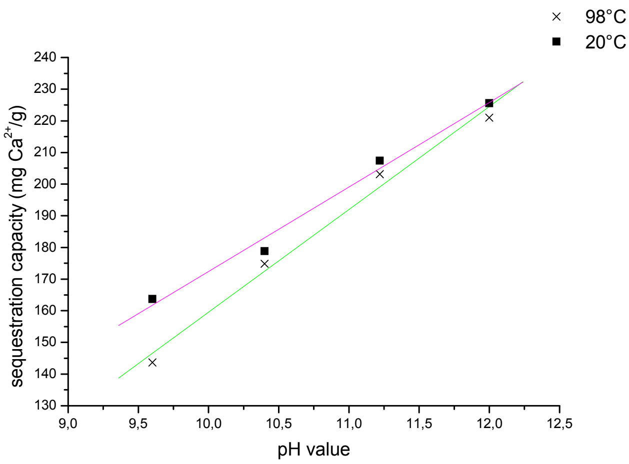

Figure 4 Dependence of sequestration capacity Ca^{2+} on pH value at 20°C and 98°C for sample No.5 (Sokalan CP-5)

Due to the fact the significant part of the world production of sequestrate agents is used at manufacture of detergents and cleaning agents, the prepared samples were tested at model washing conditions. After 20x repeated washing the textile was incinerated and the amount of Ca^{2+} was evaluated in ash (Table2).
Washing process was also performed with addition of sodium perborate for the determination of unfavourable influence of oxidizing substance on sequestration capacity (Table 2, Figure 5).
The image of fabric after the model washing was evaluated by scanning electron

microscope. If sequestrate is not used during washing process or as reason of its low sequestration capacity, the deposits are created, which are evident on Figures 6, 7.

Table 2 Content of ash and calcium ion in cotton textile after twenty times repeated washing in hard water 22°dH with model detergent

Sample	**Ash content [wt. %]**	**Content of Ca^{2+} [g/1 kg]**	**Ash content [wt. %]**	**Content of Ca^{2+} [g/1 kg]**
	Washing process without sodium perborate		Washing process with sodium perborate	
Without sequestrate	2.760	**7.835**	3.340	**8.619**
1	0.103	**0.356**	-	**-**
2	0.101	**0.271**	0.096	**0.639**
3	0.108	**0.585**	-	**-**
4	0.101	**0.177**	0.097	**0.461**
5	0.120	**0.273**	0.098	**0.779**

Samples 1 – 4 grafting dextrine of acrylic acid (different molar ratio)
Sample 5 commercial SA on based copolymer acrylic acid – maleic anhydride – Sokalan CP-5

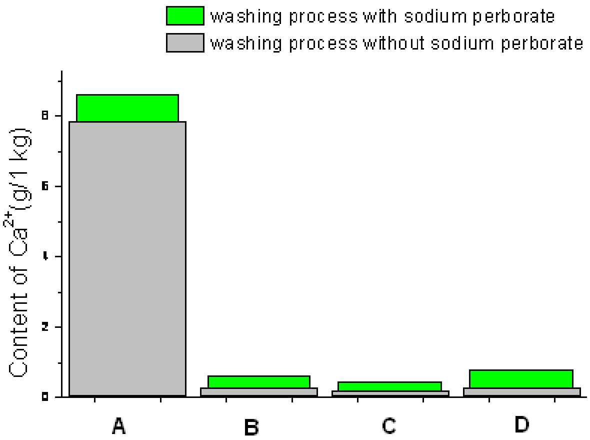

Figure 5 Influence of sodium perborate in washing bath to amount Ca^{2+}
A - washing process without sequestrate agent
B - washing process with model sample No. 2
C - washing process with model sample No. 4
D - washing process with commercial sequestrate agent

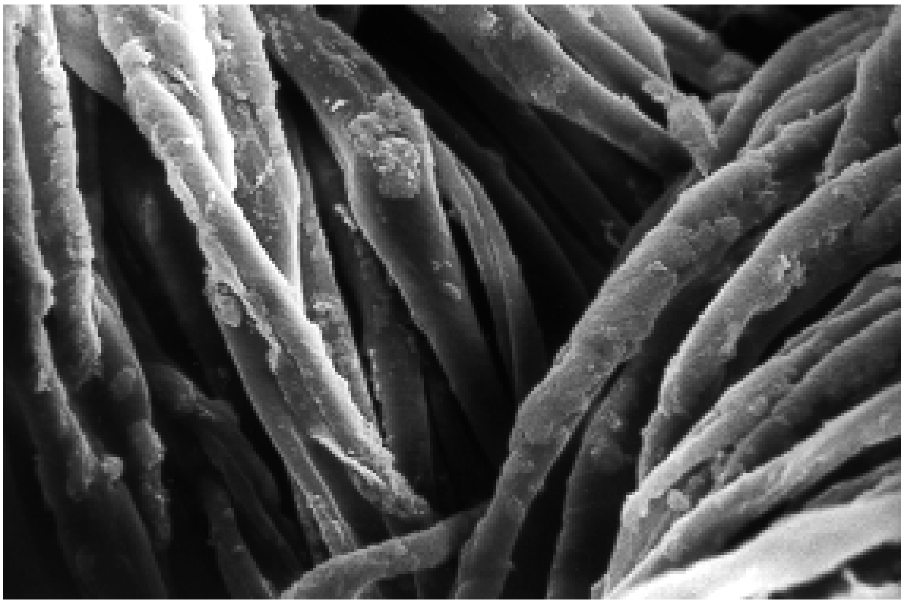

Figure 6 Picture of fibre surface of cotton textile washed without sequestrate agent with model detergent (enlargement 500x)

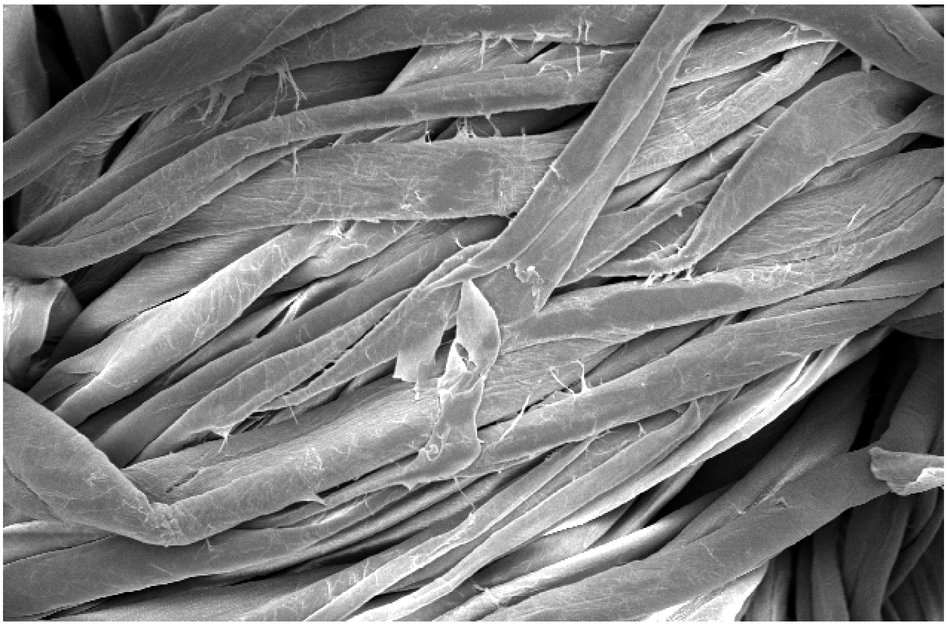

Figure 7 Picture of fibre surface of cotton textile washed at model condition with sequestrate agent – sample No. 1 – without sodium perborate (enlargement 500x)

4 CONCLUSION

Recently, the main trend of development of sequestrate agents on polymer base is determined by efforts to prepare environmentally friendly sequestrate. That means to move attention from sodium salts of classical homopolymers of acrylic acid and maleic anhydride event. from mentioned monomers to the biodegradable sequestrates. Model sequestrate agents are possible to use to many detergents, event. as textile auxiliary agents in textile finishing.

Their sequestrate capacity is comparable with used commercial products at the same conditions. Positive effect of model sequestrates were confirmed at conditions of model washing and as well as at presence of sodium perborate and washing of soiling fabric.

IR spectra of cleaned products show absorption band typical for hydroxyl groups, which confirms the presence of saccharidic part. Also, in ^{1}H-NMR-spectra is possible to see peaks belonging to this component, mainly at prepared sequestrate agents with dextrine.

Samples containing saccharidic part also show optimal course of evaluation of biochemical oxygen demand and increased biodegradability can be awaited.

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HODNOCENÍ SEKVESTRAČNÍHO ÚČINKU PROSTŘEDKŮ NA BÁZI KOPOLYMERU KYSELINY AKRYLOVÉ S MONO- AŽ OLIGOSACHARIDY V PROCESU PRANÍ

Translation of the article

The evaluation of the sequestration capacity of agents based on copolymers of acrylic acid with mono- to oligosaccharides in washing process

Sekvestrační prostředky jsou nejčastěji užívány jako součást detergentů (pracích a čistících prostředků), dále v oblasti chemického zušlechťování textilií (především v procesu předúprav - bělení), ale i v dalších oblastech např. barvení celulosových materiálů nebo změkčování vody. Rostoucí tlak na čistotu odpadních vod a používání biodegradabilních komponent pracích a zušlechťovacích lázní textilních výrob vede k přehodnocování názorů na dosud používané sekvestranty. Existuje snaha vyvinout a vyrobit biodegradabilní polymerní sekvestrační prostředky. Jedná se převážně o kopolymery kyseliny akrylové s vhodným monomerem, který pak představuje ve vzniklém kopolymeru biodegradabilní místa. Jako tento monomer je užíván vinylacetát (po hydrolýze vinylalkohol) nebo monosacharidy, oligosacharidy, popř. polysacharidy.

Práce se zabývá studiem vzorků připravených na bázi kopolymeru kyselina akrylová – dextrin. Struktura vzorků byla hodnocena pomocí IR a ^{1}H-NMR spekter. Sekvestrační kapacita byla stanovena vůči iontům Ca^{2+} srážecí zákalovou titrací (Hampshirským testem), a to při 20 a 98°C a v rozmezí hodnot pH 9 až 12. Dále bylo provedeno modelové praní v tvrdé

vodě 22°dH (německých stupňů tvrdosti). Praní bylo provedeno také s přídavkem peroxohydrátu boritanu sodného.
Pro posouzení vlivu sekvestračního prostředku na omezení tvorby vápenných úsad při praní byly pořízeny snímky povrchu vláken bavlněné tkaniny pomocí elektronového rastrovacího mikroskopu.
Vývojové sekvestrační prostředky by bylo možné použít do různých typů pracích prostředků, event. jako textilní pomocné prostředky v textilním zušlechťování.

THE EFFECT OF APPLYING EXTENSION ON ELASTIC KNITTED FABRIC'S EVAPORATION RESISTANCE

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Abstract: *In this research, the evaporation resistance Ret [m^2Pa/W] for knitted fabrics made from different core elastic ratios have been investigated; this fabric have been extended to different levels and the evaporation resistance have been measured under these variation of extensions. It was found, that the evaporation resistance for the knitted fabric from elastic core yarn under study decreased with the increase of extension in the course direction.*
Key words*: Evaporation resistance, Clothing comfort, Elastic core yarns, Permetest, Knitted fabrics.*

1 INTRODUCTION

Moisture transport through textiles is one of the factors that influence the thermo physiological comfort of the human being. The moisture can be transferred through a textile material in the form of vapors and liquids. The analysis of the scientific literature shows high and constant interest to a problem of reliable determination of vapor permeability and the evaporation resistance properties of the textile materials [1 – 5].
The task of clothing is, beside fashionable embodiment and expression, the protection against harmful environmental stresses including the climatic conditions. On this account, well being, health and productivity of humans largely depends on clothing. Humans usually wear clothing all day long - even in bed we are surrounded by textiles - therefore it is often characterized as a "second skin". Except in tropical latitudes, a person needs constant protect to avoid simply freezing [6]. So we can tell that the thermal properties are among the most important features of textiles [7-8].
The human body converts the energy provided by food into work and heat, depending mainly on the level of activity.
The main part of the moisture transfer occurs through the skin, since the skin is usually largely covered with clothing, the moisture release of the human body is strongly influenced by the heat and moisture transfer through clothing [9, 10].

2 METHODS

2.1 Apparatus

The Permetest instrument enables the determination of relative WVP [%] and evaporation resistance Ret [m^2Pa/W] of dry and wet fabrics within 3 -5 minutes (Figure 1).

Figure1 Permetest

Measuring head of this small Skin Model is covered by a resistant semi-permeable foil, which avoids the liquid water transport from the measuring system into the sample. Cooling heat flow caused by water evaporation from the thin porous layer is quickly recorded by a special computer evaluated sensing system. In terms of heat transfer this instrument presents the model of real human skin. Given by a new concept of measurement, which enables distinguishing small changes of water amount absorbed in the fabric during unsteady state of diffusion and to record e.g. the heat of sorption, very good measurement reproducibility was achieved, with CV often under 3%. The instrument provides all kinds of measurements similar to the ISO Standard 11092 and the results are evaluated by identical procedure as required in this standard. The correlation coefficient of measurements related to the ISO Standard SKINMODEL exceeds 0.9. The results are treated statistically, displayed and recorded for next use [11].

When the results of measurement should be expressed in terms of the water vapor resistance Ret [m^2Pa/W] according to the ISO 11092 Standard, then the following relationship is applied:

$$Ret = (pwsat - pwo)(1/qo - 1/qs) = C(100 - \varphi)(1/qo - 1/qs) \quad (1)$$

Where, qs and qo mean heat loses of moist measuring head in free state and covered by a sample. The values of water vapor partial pressures pwsat and pwo in Pascals in this equation represent the water vapor saturate partial pressure valid for the temperature of the air in the measuring laboratory to 22-25°C, and the partial water vapor pressure in the laboratory air. The constant C will be determined by the calibration procedure. Special hydrophobic polypropylene reference fabric for this purpose is used with the instrument.

Besides the water vapor resistance, also the relative water vapor permeability of the textile sample pwv can be determined by the instrument. This practical parameter is given by the relation:

$$pwv\ [\%] = 100\ qs/qo \quad (2)$$

2.2 Test samples

The transport of heat and moisture through fabrics is one of the major concerns in the design of functional clothing such as sports wear. In the clothing research field, researchers usually assess the transport of heat and moisture through fabrics by using a sweating hot plate [12-15]. But here permetest was used to evaluate the evaporation resistance for the elastic fabrics which have been manufactured to achieve some requirements that other fabrics cannot achieve. The use of elastic yarn has resulted in fabrics that fit better on the body like a second skin and have good shape retention without any deformation throughout the life of the garment.

In this work three elastic knitted Rib 1x1 constructed fabrics with different Lycra ratios were used to measure the evaporation resistance [m^2Pa/W] under different extensions as will be mentioned. Elastic core yarn was used to produce this knitted fabric. Lycra was used as the core and the outer layer (sheath) was cotton. The core: sheath ratios for the three different types were: 8% Lycra: 92% cotton, 6% Lycra: 94% cotton and 4% Lycra: 96% cotton. The count of the yarn for producing this fabric was 30 English count for all of the three different fabrics. A special frame was manufactured to obtain the different extensions for the used fabric (Figure 2)

Different ratios of extension were applied in the course direction, 10%, 20%, 30%, 40% and 50% from the original length. At each extension of the fabric, the evaporation resistance was measured. Three different tests were held for each extension and the mean value was calculated.

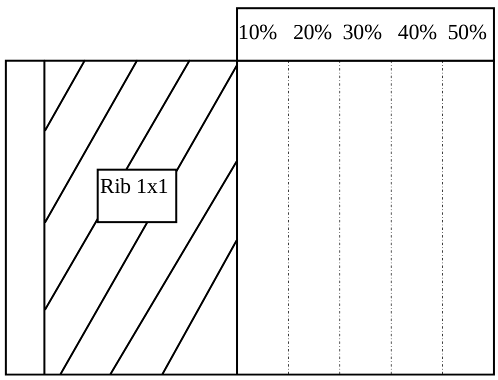

Figure 2 Extension frame

3. RESULTS AND DISCUSSION

Elastic Core yarns have become established in many new application areas. They are used in sports wear, leisure garments and children's wear, in high quality outer wear, in functional clothes and in technical products. Core yarn can be either elastic or rigid filament which is covered with natural or synthetic fibers. It is an ingenious idea as elastic or rigid material can be produced without sacrificing the texture or quality of traditional fibers. This is probably why its use in the textile sector is becoming more and more popular.

In this work the evaporation resistance of a Rib 1x1 knitted elastic fabric was measured with applying different degrees of extension from 10% to 50% and the water evaporation resistance [Ret] was measured at each extension. Table 1 shows the variation in the evaporation resistance at each level of extension for the different samples.

Table 1 Ret at different extensions

Ext	Ret [m^2Pa/W] 4%	Ret [m^2Pa/W] 6%	Ret [m^2Pa/W] 8%
0%	4.18	4.53	4.83
10%	3.81	4.18	4.46
20%	3.67	3.82	4.19
30%	3.25	3.46	3.56
40%	3.19	3.38	3.47
50%	3.12	3.27	3.38

It is obvious from the results that applying different extensions for the Rib 1x1 elastic knitted fabric has an obvious effect on the evaporation resistance. As we can see from Figure 3 that the evaporation resistance for the measured fabrics decreases by the increase of the extension for all the different samples with the different Lycra ratios 4%, 6%, 8%. Table 2 shows the Ret change percent ,i.e. We can say that the evaporative resistance [m^2Pa/W] in the Lycra 4% decreased by 25.35% when applying 50% extension from the relaxed position, while decreased by 27.8% in Lycra 6% and by 30% in Lycra 8% at the same extension percent.

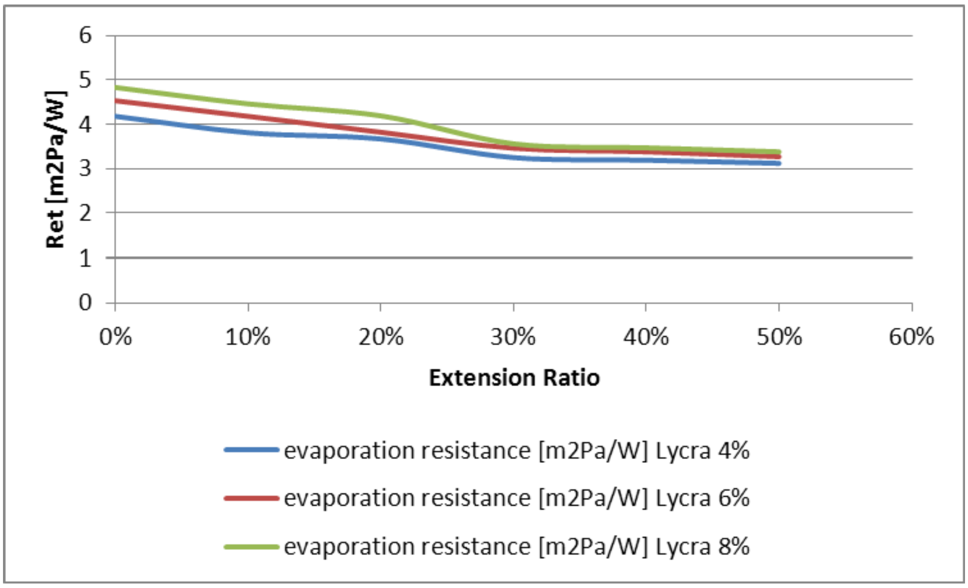

Figure 3 Ret change in Lycra 4%, 6%, 8%

Table 2 The Ret decrease percent

Change % of Ret [m2Pa/W]			
Extension	**Lycra 4%**	**Lycra 6%**	**Lycra 8%**
0%	0	0	0
10%	8.8516	7.7262	7.6604
20%	12.200	15.673	13.250
30%	22.248	23.620	26.294
40%	23.684	25.386	28.157
50%	25.358	27.814	30.020

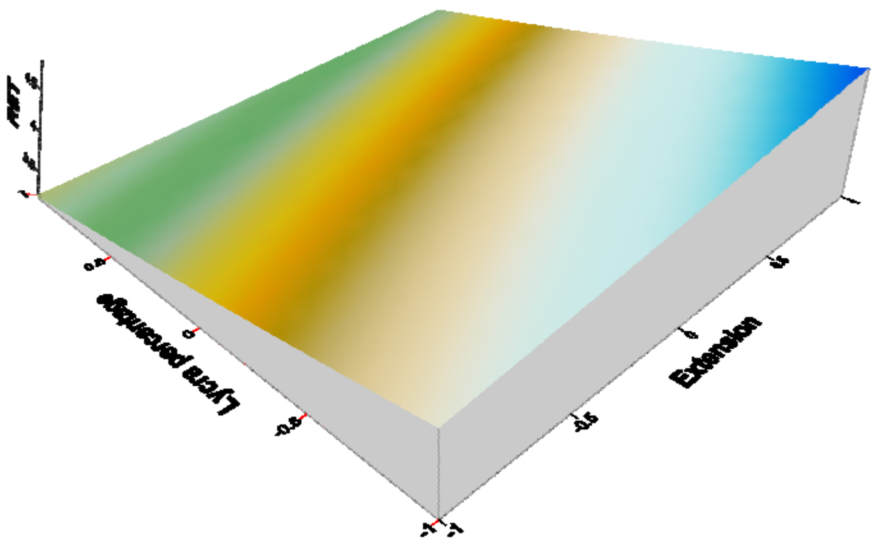

Figure 4 Effect of the interaction of different extensions and Lycra percentage on Ret [m^{2}Pa/W]

Applying mathematical treatment the next equation was obtained:

$$z=3.8+0.24x-0.58y+0.01x^2+0.03y^2-0.09xy \quad (3)$$

where: Z = Ret, X = Lycra, Y = Extension ratio.

Figure 4 shows the effect of the interaction between the different Lycra ratios and the different extension applied for the elastic knitted fabric on the evaporation resistance for these fabrics and it also shows that the evaporation resistance increases with the increase of the Lycra ratio at each of the extensions levels as observed from equation (1). It is obvious from the R^2 = 99.5539%, that when applying various extensions in the course direction in all of the cases we notice significant effect on the evaporation resistance Ret [m^{2}Pa/W] for the fabrics made from core yarns with different elastic ratios as previously mentioned.

Concerning the water vapor permeability of these fabrics, and by using Fick's equation [16]:

$$W_d = \frac{1}{R_{et}.\phi T_m} \quad (4)$$

the rate of water vapor transfer for a fabric is directly proportional to the partial water vapor □p. It is a linear relationship to the vapor pressure, inversely proportional to the evaporation resistance R_{et} and □T_m which is the latent heat of vaporization of water at the temperature T_m of the measuring unit. We can count the approximate diffusion of water vapor transfer, i.e. when Ret [m^{2}Pa/W] for the 8% Lycra sample in the beginning of the extension (0%) was 4.83 [m^{2}Pa/W] and by applying the maximum extension (50%) the evaporation resistance was 3.38 [m^2Pa/W]. It was found that the water vapor permeability increased about 42% which is a significant increase for the water vapor permeability.

4 CONCLUSION

In this work it was noticed that the evaporation resistance of Rib 1x1 knitted fabrics made from elastic core yarns was obviously affected by applying different levels of extensions, by increasing the extension for the tested fabric. It was noticed that the evaporation resistance decreased, rapidly in the beginning and till a certain level – here it was about 30% - evaporation resistance was decreased slightly, it was nearly the same. Maybe it is due the change of the fabric construction and due to that the porous area in the fabric are nearly the same according to the different level of tension applied. It could be concluded that the tight elastic knitted fabric could lead to more comfort properties if it was used during practicing light activity. But when practicing heavy activity the comfort of these fabrics will decrease due to heavy sweat production, as it will be also difficult to get rid of this sweat in that liquid form and in this case the garment will stick to the body causing lake of comfort. It was also concluded that the evaporation resistance increase with the increase of the elastomer ratio in the fabric. These results could be applied in designing functional, more comfortable garments concerning the different dimensions of the body's different parts where we can apply different elastomer ratios and tightness to achieve the optimum comfort wear.

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VPLYV POUŽITÉHO PREDĹŽENIA NA VÝPARNÝ ODPOR ELASTICKÝCH PLETENÝCH TEXTÍLIÍ

The translation of article

The effect of applying extension on elastic knitted fabric's evaporation resistance

Abstrakt: V tomto příspěvku jsou uvedeny výsledky hodnocení výparného odpor Ret [m^2Pa/W] u pletených textilií vyrobených s různým obsahem elastánové jádrové příze, při definovaném roztažení textilie. Bylo zjištěno, že výparný odpor pleteniny se snižuje s rostoucím prodloužením a transport vlhkosti se zvyšuje až o 50%. Měření bylo provedeno pro různé složení testované pleteniny.

LINEAR MATHEMATICAL MODEL OF WATER UPTAKE PERPENDICULAR TO FABRIC PLANE

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Abstract: *The general approach to development of mathematical model of non-stationary water absorption by multilayered textile structures while plane water transfer and analytical linear model of water absorption and diffusion through individual textiles are offered. For simplification of its solution the diffusion coefficient was accepted constant. Unknown function of concentration is presented as infinite series which is product of two functions: one of function depends only on time; the second one depends only on concentration. We propose this approach to use at the decision of nonlinear model of water absorption.*

Key words: *mathematical model, water absorption, diffusion coefficient, multilayered textile structures*

1 INTRODUCTION

As perspective direction in innovative functional textiles development is considered the layering of fabrics of different capillary porosity and physical properties in one structure of a "sandwich" type. Obviously it is an effective way to control some textile performances, for example, heat and mass exchange processes. The layered textiles can be used for different field of application, such as separation and filtration materials for absorption of harmful and dangerous gases, particles, microbes; as building textiles (noise-isolation, interior textiles); medical textiles, etc [1-3].

Water and other liquids transfer perpendicular to fabrics plane is an important property for textiles of these applications. Creation of multilayered textile structures with predictable performances expect of knowledge of the each component properties and need of analytical model of water transport perpendicular to fabric plane in real conditions.

The task of the whole work consists of development of analytical model of water absorption and transport through multilayered textile structures (packages and composites).

In this paper it the general approach to development of mathematical model of non-stationary water absorption by multilayered textile structures while plane water transfer and analytical linear model of water absorption and diffusion through individual textiles are offered. This model will be used for construction and decision of non-linear equation of water transport and distribution in multilayered textile structures.

2 RESULTS AND DISCUSSION

First of all, we have investigated the process of water absorption by individual textile materials of different chemical composition and structure with using of device SORP-3 (developed in Textile-Research Institute, Poland, Lodz) [4]. Sorption properties and characteristic parameters were determined under condition of water uptake perpendicularly to plane of textiles [5].

One can define the kinetic of water sorption through some adjoining layers of different textiles, if information about change of the water concentration on the border of two textile layers is present. Thus for the first textile layer (the bottom one) which abuts upon water and through which water enters system, there is 100% concentration of water on this surface (Figure 1). At the same time an entrance water concentration for next layer is the concentration which got through the first layer and attained his opposite surface. This concentration is variable of times and, as a rule, cannot be determined experimentally. Determination of terms of entrances for the second and following layers in a multilayered structure requires construction of mathematical model of non-stationary water absorption perpendicularly of every layer planes.

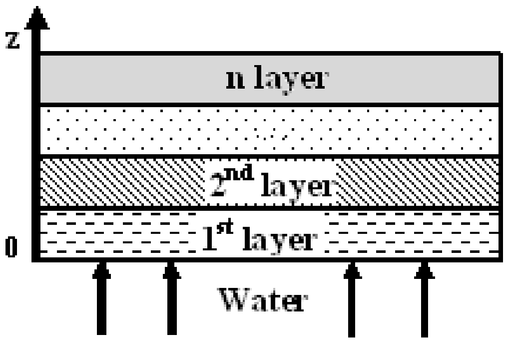

Figure1 Scheme of water absorption by multilayered textiles: *n* – number of textile layers; *z* – coordinate, perpendicular the plane of material (direction of water uptake); *t* – time.

We have developed a following general plan of the decision of equation of water sorption and distribution equations for multilayered textile structures.

1. Elaboration (construction) of the differential equation of water absorption by individual textiles which contains unknown absorption characteristics textiles. These characteristics depend on water content and absorption time.
2. Development of decision methods of the differential equation of water absorption and distribution all over textile thickness.
3. Choice and definition of relation between unknown textile characteristics which enter in the differential equation and experimental data.
4. Definition of water concentration on border between the first and second textile layers as function of time, in view of appointed experimental characteristics.
5. Construction of the equation of water absorption in each following layer in view of entrance concentration for each layer is function of time.
6. Development of methods of the decision of the equation for two, three and multilayered textiles.
7. Carrying out of numerical experiments for definition of water absorption characteristics by packages and composites.

We accept the following designations:
U – concentration of water in the certain point of layer;
Q – quantity of water which passes through a point;
z – dimensionless coordinate, perpendicular to the plane of material;
t – time;
D – coefficient of diffusion;
h – thickness of material.

If *U* is a concentration of water in the certain point of material, then at some distance *dz* from this point the concentration makes: *U+dU.* Quantity of water, which passes in times *dt* through a point *z* one can found as:

$$dQ = -D\frac{\partial U}{\partial z}dt$$

Then water quantity through all thickness is (a calculation is performed on unit of textile surface):

$$\Delta Q = U \cdot h$$

From this:

$$\Delta Q = \int_{z_1}^{z_2} \Delta U dz$$

Equation of water balance on a segment (z_1, z_2) for the interval of time (t_1, t_2) will:

$$\int_{t_1}^{t_2}\left(D(z_2)\frac{\partial U}{\partial z}(z_2,\tau) - D(z_1)\frac{\partial U}{\partial z}(z_1,\tau)\right)d\tau = \int_{z_1}^{z_2}\left(U(\xi,t_2) - U(\xi,t_1)\right)d\xi$$

The integration on variable limits t_1–t_2, z_1–z_2 is fulfilled. This result will be used in differential equation. For integration on variable limits we formal use the intermediate variables *τ* and *ξ*, which make the same physical sense, that *t* and *z* in a subintegral function.

This integral can be transformed, using a theorem about average and theorem about finite increments [6].

$$\frac{\partial}{\partial z}\left[D(z)\frac{\partial U}{\partial z}(z,t)\right]_{\substack{z=z_c,\\ t=t_c}}\cdot\Delta t\Delta z=\left[\frac{\partial U}{\partial t}\right]_{\substack{z=z_c,\\ t=t_c}}\Delta t\Delta z$$

where: z_c, z_c are intermediate points of the arbitrarily chosen intervals (t_1, t_2) and (z_1, z_2). From here we find

$$\frac{\partial}{\partial z}\left(D(z)\frac{\partial U}{\partial z}\right)\bigg|_{\substack{z=z_c,\\ t=t_c}}=\frac{\partial U}{\partial t}\bigg|_{\substack{z=z_c,\\ t=t_c}}$$

At (z_1, z_2) → z i (t_1, t_2) → t, we get equation of motion of water through the layer of material:

$$\frac{\partial U}{\partial t}=\frac{\partial}{\partial z}\left\{D(U,z)\frac{\partial U}{\partial z}\right\} \qquad (1)$$

As is generally known from many experimental researches [5, 7, 8], the coefficient of diffusion of liquid in porous bodies depends on the concentration of liquid. However for understanding and simplification of process of decision of equation (1), convectionally in the first approaching we accept the coefficient of diffusion as constant. Then differential equation is:

$$\frac{\partial U}{\partial t}=D\frac{\partial^2 U}{\partial z^2} \qquad (2)$$

For the decision of our task we have passed to the dimensionless coordinates:

- coordinate z changes from 0 to 1;
- concentration changes as a function of time from 1 on a surface of layer, which contacts with water, to some current quantity on its opposite surface.

The unknown concentration is presented as series which is product of two functions:

$$u=\sum_{i=1}^{\infty}V_i\cdot W_i \qquad (3)$$

where V_i – is a function of concentration which depends only on time;

W_i – function of concentration which depends only on a coordinate;

i – number of Fourier's series.

Taking into account the terms of boundary conditions, separate member of series function W which depends only on a coordinate, will presented as:

$$W_i=C_i\left(1-\sin\frac{\pi z(2i-1)}{2}\right) \qquad (4)$$

where C – constant, which appears during integration.

It is needed to appoint a function which can be used for the decision of differential equations. For this purpose it is necessary to image the shape of function. If to take into account that on the exterior boundary of textile the water concentration is equal to "one", and on an opposite border equal to "zero", graphic representation of the unknown function can look like (Figure 2).

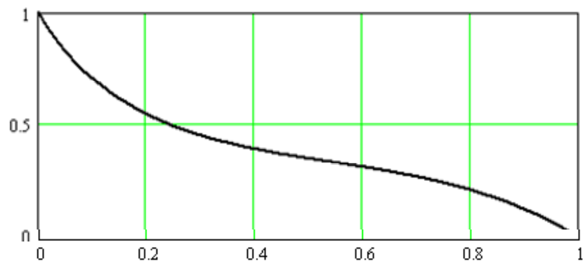

Figure 2 Graph of unknown function

For the decision of differential equations trigonometric functions are used. We shall choose a simple function

$$f(z)=\sin(\pi\cdot z).$$

Thus, the use of «π» causes change of argument interval from 0 to 1. We became the graph of this function (Figure 3), that does not look like an imaginary function (Figure 2). However if to take the half of this graph we get a function $f(z)=\sin(\frac{\pi\cdot z}{2})$,

the graph will look like (Figure 4).

On this basis, it is possible to build a function

$$f(z)=1-\sin(\frac{\pi\cdot z}{2}),$$

which is similar to imaginary. It is necessary to take the infinite series of functions which meet boundary conditions for the decision according to the Bubnov-Galerkin method [9, 10]. Taking into account such approach, one can find unknown functions

$$f(z)=1-\sin(\frac{i\cdot\pi\cdot z}{2}),$$

where "i" is a ordinal number (Figure 5).

At research of dependence for sinus with even and odd coefficients, we see a difference in the shape of function: for dependence

$$f(z) = 1 - \sin(\frac{i \cdot \pi \cdot z}{2})$$

with numbers 1, 3, 5 the graphs have a shape (Figure 6). The shape of these curves meets boundary conditions: on exterior boundary a concentration is equal 1, and on an opposite boundary is equal 0. For even members 2, 4, 6 the look of graphs does not meet the border conditions (Figure 7).

Hence, an unknown function must look like

$$f(z) = 1 - \sin(\frac{i \cdot \pi \cdot z}{2}),$$

where "*i*" – only odd members of series. For providing of direct call of odd numbers in the mathematical programs we will rewrite the separate series of our function as

$$f(x) = 1 - \sin\left(\frac{(2 \cdot i - 1) \cdot \pi \cdot z}{2}\right).$$

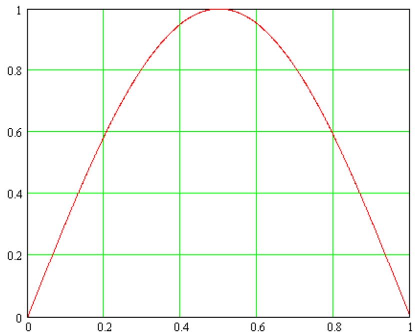

Figure 3 Graph of function $f(z) = \sin(\pi \cdot z)$

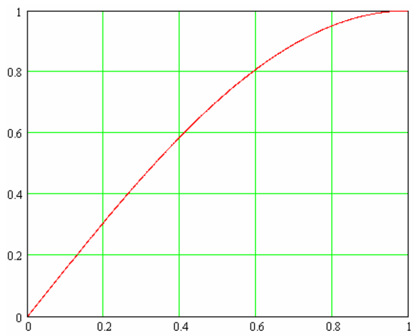

Figure 4 Graph of function $f(z) = \sin(\frac{\pi \cdot z}{2})$

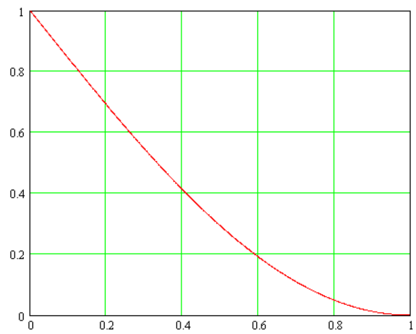

Figure 5 Graph of function $f(z) = 1 - \sin(\frac{i \cdot \pi \cdot z}{2})$

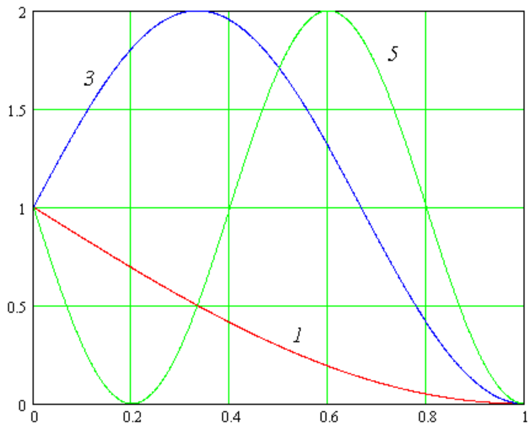

Figure 6 Graph of function $f(z) = 1 - \sin(\frac{i \cdot \pi \cdot z}{2})$ (for odd members i = 1, 3, 5)

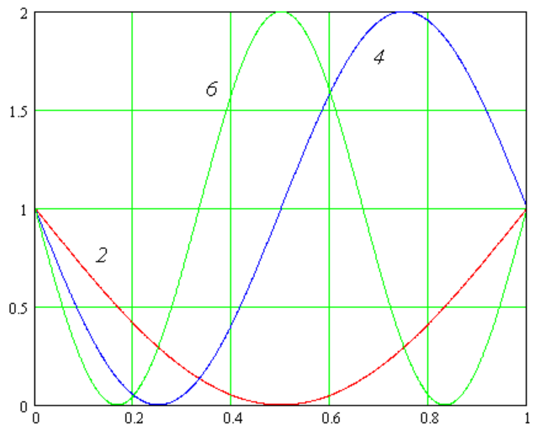

Figure 7 Graph of function $f(z) = 1 - \sin(\frac{i \cdot \pi \cdot z}{2})$ (for even members i = 2, 4, 6)

After a substitution in equation (3) and in initial differential equation (2), findings of derivative, reduction of similar, we get ordinary differential equation in relation to a function, which depends on time:

$$\frac{dV_i}{dt} = -\frac{D}{4}\cdot\pi^2\cdot(2i-1)V_i$$

This decision of this equation is [11]:

$$V = C_i e^{-\frac{D}{4}\pi^2(2i+1)^2 t} \qquad (5)$$

As a result general decision of equation (3) is

$$U = 1 - \sum_{i=0}^{\infty} C_i e^{-\frac{4}{D}\pi^2(2i-1)^2 t}\cdot\sin\left(\frac{\pi z(2i-1)}{2}\right) \qquad (6)$$

Unknown constants C_i can be found from an initial condition: in initial moment of time the concentration through all over layer is equal 0 (except a surface). This condition can be executed, if an infinite sum is expressed by function *U(z,0)*=0. Taking into account that at *t = 0* exponent with any multiplier is equal one, we get the Fourier series with unknown coefficients:

$$\sum_{i=0}^{\infty} C_i\cdot\sin\left(\frac{\pi z(2i-1)}{2}\right) = 1 \qquad (7)$$

After finding of coefficients C_i, we get the unknown Fourier series as [11]:

$$U = 1 - \sum_{i=0}^{\infty}\frac{4e^{-\frac{D}{4}\pi^2(2i-1)^2 t}\cdot\sin\left(\frac{\pi z(2i-1)}{2}\right)}{\pi(2i-1)} \qquad (8)$$

We will give to the coefficient of diffusion some arbitrary value and will build some graphs which represent a change the water concentration in material as a function of time (Figure 8).

Specific concentration through all over layer:

$$\bar{U}(t) = \int_0^1 U(z,t)dt \qquad (9)$$

After integration:

$$U(t) = \left.\left(z + \sum_{i=1}^{\infty}\frac{8e^{-\frac{D}{4}\pi^2(2i-1)^2 t}\cdot\cos\left(\frac{\pi z(2i-1)}{2}\right)}{\pi^2\cdot(2i-1)^2}\right)\right|_0^1 \qquad (10)$$

After putting the boundary we get equation of water adsorption by the textile layer:

$$U(t) = 1 - \sum_{i=1}^{\infty}\frac{8e^{-\frac{D}{4}\pi^2(2i-1)^2 t}}{\pi^2\cdot(2i-1)^2} \qquad (11)$$

and equation of concentration change through thickness (speed of adsorption):

$$\frac{dU}{dt} = \sum_{i=1}^{\infty} 2De^{-\frac{D}{4}\pi^2(2i-1)^2 t} \qquad (12)$$

A calculated curve absorption by layer of textile on time can be presented as graphic dependence (Figure 9), and the curve of speed of water adsorption is presented on a Figure 10 (a calculation is performed in the program MathCAD).

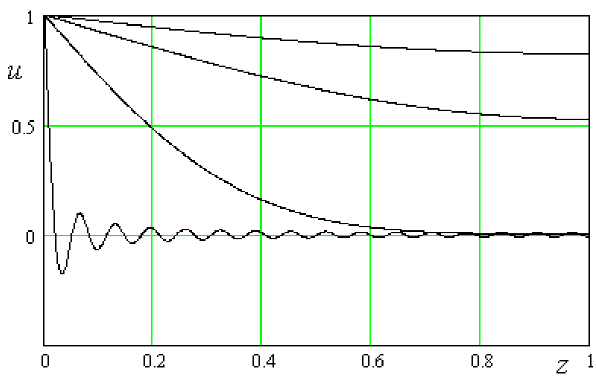

Figure 8 Dynamics of change of the water concentration through a thickness by constant coefficient of diffusion (initial data: *D* = const ≈1 s^{-1}; $t_1 < t_2 < t_3 < t_{max}$; *i* = 30)

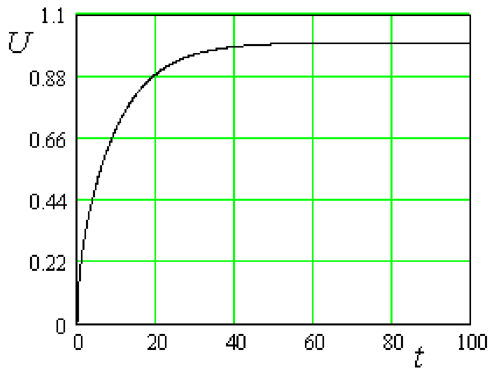

Figure 9 Water absorption with constant diffusion coefficient

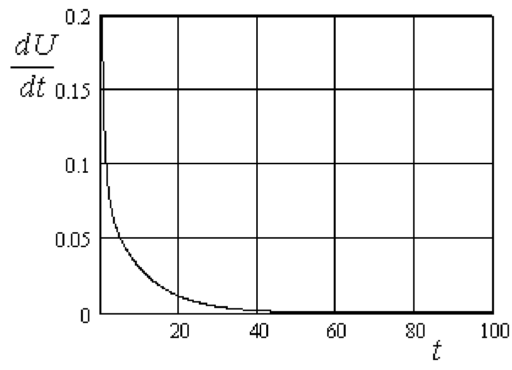

Figure 10 Speed of water absorption with constant diffusion coefficient

Comparison of calculated curves shape (Figure 9 and Figure10) with experimental curves [5, 7, 8] shows, that mathematical model with constant diffusion coefficient don't meets the real data. However we have done this assumption exceptionally in order to find the way of decision of equation of liquid motion taking into account non-linearity of process. Decisions of equation of liquid motion for a general case, when the diffusion coefficient depends on the amount of the accumulated liquid, will be presented in further work.

3 CONCLUSION

Linear equation of nonstationary process of water transfer perpendicularly to planes of material for a model with the constant diffusion coefficient is offered. An original artificial method, which consists of following assumption: the concentration of liquid in material appears as a series that is product of two functions: one of function depends only on time, other function – only on coordinate. The same way will be used for the decision of nonlinear equation which takes into account dependence of diffusion coefficient on the accumulated liquid concentration at any moment for the set point of material.

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LINEÁRNY MATEMATICKÝ MODEL PRÍJMU VODY KOLMO K PLOCHE TKANINY

The translation of article

Linear mathematical model of water uptake perpendicular to fabric plane

V tomto príspevku je prezentované stanovisko k vývoju matematického modelu nestacionárnej absorpcie vody plochou mnohovrstvovej textilnej štruktúry a analytický lineárny model absorpcie a difúzie vody cez jednotlivé textílie. Pre zjednodušenie riešenia bol difúzny koeficient považovaný za konštantu. Neznáma funkcia koncentrácie je uvedená ako nekonečný rad ako produkt dvoch funkcií: jedna funkcia je závislá iba na čase, druhá závisí iba od koncentrácie. Je navrhnuté riešenie použitím nelineárneho modelu absorpcie vody.

This contribution was presented at the 6th Central European Conference 2010, 13-14th September 2010, in Bratislava, Slovak Republic.

Hodnotenie 11th World Textile Conference AUTEX 2011 konanej 8.-10. júna 2011 v Mulhouse, Francúzsko

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11. svetová textilná konferencia AUTEX 2011 sa konala pri príležitosti 150. výročia založenia textilnej školy v Mulhouse pod názvom „150 Years of Research and Innovation in Textile Science“ (150 rokov výskumu a inovácie v textilnej vede). Na konferencii sa zúčastnilo 316 odborníkov z 28 krajín celého sveta. Program bol zložený z plenárnych prednášok, prednášok v sekciách a z posterov. Odzneli tri plenárne prednášky:

1. Thomas EBBESEN: Nové vlastnosti nanoštruktúrovaných materiálov: potenciál a využitie.
2. Sima ASVADI: Inteligentné textílie, príležitosti a výzvy.
3. Stepan LOMOV: Textilné kompozity od nano ku makro: štruktúrna škála.

Prednášky a postery boli rozdelené do 14 sekcií:

- Sekcia A: Kompozity
- Sekcia B: Odevné strihy a modelovanie (dizajn)
- Sekcia C: Konečné úpravy a nanášanie
- Sekcia D: Pletenie
- Sekcia E: Medicínske textílie
- Sekcia F: Marketing
- Sekcia G: Nanotextílie
- Sekcia H + O: Polyméry + technické textílie
- Sekcia I + L: Trvalo udržateľný vývoj – eko-dizajn + Zvlákňovanie
- Sekcia J: Simulácia a modelovanie
- Sekcia K: Manažment
- Sekcia M: Inteligentné a funkčné textílie
- Sekcia N: Testovanie textílií
- Sekcia P: Tkanie

V rámci týchto sekcií odznelo spolu 152 prednášok a bolo uvedených 114 posterov.
Kladné stránky:

1. Účasť veľkého počtu odborníkov z mnohých krajín
2. Dodržiavanie časového harmonogramu prednášok v sekciách (možnosť prechodu zo sekcie do sekcie).
3. Návšteva Múzea potlače.

Záporné stránky:

1. Materiály z konferencie sú iba v tlačenej forme, formátu A4 – 2 ks hrubé zborníky + dodatok (spolu 1266 strán) a 3,6 kg !
2. Vyskytli sa aj podpriemerne pripravené prednášky.
3. Slabá účasť odborníkov zo Slovenska (ale aj z Českej republiky), 1 (+2).
4. Ukončenie konferencie v piatok po 17 h.

Pre ucelenú informáciu uvádzam kompletný zoznam prednášok a posterov, ktoré boli zaradené v programe konferencie. Všetky tri časti zborníka sú k dispozícii na oddelení vlákien a textilu ÚPM FCHPT.

Zoznam prednášok a posterov

Plenárne prednášky

- Thomas EBBESEN: Novel properties of nano structured materials: potential and application
- Sima ASVADI: Intelligent textiles, opportunities and challenge
- Stepan LOMOV: Textile composites from nano to macro: spannning structural scales

Sekcia A - Composites

- AMIOT Marion: Characterization of the internal architecture of nonwoven structures used as core materials in sandwich composites
- TOSKAS Georgios: Effect of carrying polyrner on organic-inorganic silica composite nanofibers
- WULFHORST Johannes: Substitution of powders by ultra short cut fibers for selective lasersintering (sls)

- KIM Yong: Projectile impact behavior of Z fiber reinforced laminar composites

Sekcia B - Clothing fashion and Design

- VURUSKAN Arzu: Analysing body shapes for clothing: using 2D images
- CICHOCKA Agnieszka:The fitting analysis of the clothes for health service as a part of human resources management
- ANEJA Arun: Seamless frontiers of apparel, textiles and fibers: an emerging paradigm
- BILEN Umut: The effects of seam parameters on the stiffness of wool and wool / PES blended
- ZAVEC PAVLINIC Daniela: Determination of optimal thermal insulation of the Slovene armed forces winter clothing ensemble
- UTKUN Emine: Evaluating sewability properties of reusable patient gowns

Sekcia B + P - Clothing fashion and Design + Weawing

- MAJIDI M.M.: Effect of stitch length of sewing on tensile strength. Properties of woven fabrics
- MOUSAZADEGAN Fatemeh: Effects of using interlinings on physical and mechanical properties of wind stoppers
- WITKOWSKA Beata: Evaluation of the biophisiological comfort in underwear garments for clothing microclimates selected zones
- PETRAK Slavenka: Computer design of textile and clothing collection - assumption of contemporary remote business
- MOUNTASIR Adil: Innovative manufacturing technology for three-dimensional woven spacer performs made of glass thermoplastic hybrid yarn for lightweight applications
- JUNAID Fadi: The measurement of weft velocity in air-jet weaving
- ZUPIN Ziva: Air permeability of monofilament woven fabrics

Sekcia C - Finishing treatment and Coating

- RADETIC Maja: Multifunctional properties of cotton fabrics modified with corona/air RF plasma and colloidal $TTiO_2$ nanoparticles
- YANG Charles Q.: Applications of Maleic acid and sodium hypophosphite as durable press finishing agents for cotton fabrics
- HEGEMANN Dirk: Potential of plasma technologies for the textile industry
- MIRO SPECOS Maria M.: Microencapsulated essential oils for mosquito repellent finishing of textiles
- VAJNHANDL Simona: Dyeing with Treated Waste Water
- HASABO Muhammad Ahmed: Development of cotton-Lyocell blended antimicrobial wipes
- LUKYANCHIKOVS Andrejs: Structural features of woven elastic bifurcated implant of aorta
- SPICKA Nina: Bleaching of cotton fabric with enzymatically generated hydrogen peroxide and bleach activator
- NOURBAKHSH Shirin: Nano TiO_2 deposition on different surface treated cotton fabric
- ALONGI Jenny: Sol-gel treatments for enhancing fire stability of cotton fabrics
- SINGH Ajay: Synthesis and characterization of hetearylazo disperse dyes derived from pyrazolones and fluorosulfonyl anilines
- BALCI Onur: Investigation of application of antibacterial agents with conventional and nano finishing chemicals in the same BATH
- TAYEBI Habib: Surface modification of polyester fabric by Corona discharge treatment: effects of Corona discharge treatment on adsorption isotherm of disperse orange 30
- SEMNANI Dariush: Improvement X-Ray prevention properties of 3D spacer fabric composite by lead powder deep printing
- SOLIMAN Ghada: Investigation into the application of dye scavengers in limiting cross-staining of cotton fabric with reactive dyes
- ABD EL-TALOUTH Jacklin Ibrahim: Achievement of different color tones using natural dye via burn-out printing style
- PAPADIA Simone: Comparison of two innovative processes for wool fabric coating based on plasma treatment
- PEILA Roberta: Quantitative analysis of a reactive β-cyclodextrin fixed onto cellulose substrates
- GIANSETTI Mirco: Field mapping for ultrasound application in dyeing process
- PELAEZ Felipe: Softening of figue fiber with enzymatic and chemical process

Sekcia D - Knitting

- KUCUKALI-OZTURK Merve: Spacer fabric design with enhanced acoustic properties
- ONAL Levent: Moisture management and wicking properties of knitted fabrics

- SANCHES Regina Aparecida: Design of experiments applied to the development of knitted fabrics
- TAMOUE Ferdinand: Investigation of yarn dimensional behavior in weft knitted pique structure and suitability to printing

Sekcia E - Medical Textiles

- ABBASIPOUR Mina: A review on the antibacterial properties of metal oxide nano-composites for textiles
- PAUL Roshan: Chitosan microspheres for antibacterial finishes
- RADU Cezar-doru: Biotextile to heal allergical contact dermatitis
- GARCIA Nuno: Resilient heart-beat detection algorithm for signals captured by smart textiles
- SKRIFVARS Mikael: Resorbable porous scaffolds fabricated via melt spinning and weaving of the fibres-novel means for engineering bone tissues

Sekcia F – Marketing

- MORAIS Carla Cristina: A design tool to identify and to measure the profile of a future sustainable conscious fashion customer
- KANAT Seher: Marketing strategies that are implemented in crisis period at clothing sector: turkish case
- TIEDT Tristan: Cognitive textile machines to improve process-and product-quality

Sekcia F+E - Marketing + Medical Textiles

- KANAT Seher: Differentiation strategies as a tool of rivalry in textile and clothing sector
- KOSZEWSKA Malgorzata: Social and eco-labels of textile and clothing goods - understanding and perceptions of polish consumers
- ABREU Maria José: The construction of an odour brand for children clothing
- PEREIRA Madalena: The attributes of e-commerce in fashion design products and the consumer buying behaviour
- YILDIZ Zehra: Investigation of the consumer ready-made preferences: a survey
- KANAT Seher: The effect of successful marketing strategies over enterprise performance: comparative situational analysis
- LAITALA Kirsi: Improving textile labelling SKRIFVARS Mikael: Resorbable porous scaffolds fabricated via melt spinning and weaving of the fibres-novel means for engineering bone tissues

Sekcia G – Nano Textiles

- YOUSEFZADEH Maryam: Improving mechanical properties of PAN/MWNT continuous electrospun yarn
- VALIPOUR Peiman: Nano TiO_2/ZnO antibacterial activity on polypropylene film
- ALMEIDA Luis: Development of standardization in the area of nanotechnologies
- CAROSIO Federico: Layer by layer assembly of smart-nanocoatings to enhance the flame retardancy of PET fabrics
- SEMNANI Dariush: A digital signal processing technique to measure the surface roughness of nanofibrous scaffolds
- AMIRI Parastoo: Electrospinning of cyclodextrin/poly (acrylonitrile-acrylic acid) and nanofibers characterizations
- VENUGOPAL Arun prasad: Properties of magnetic linear nanocomposite fibrous web
- KUTLU Bengi: Nanotechnological applications for improving appearance of fabrics
- VARESANO Alessio I : Continuous nanofibre production by multi-jet nozzle electrospinning on textile substrates
- NEZNAKOMOVA Margarita: Thermal barrier properties of multilayer textiles structures with nanofiber nonwoven membranes
- HONG Joo Hyung: The spinline behavior and web morphology in multinozzle electrospinning
- HEKMATI Amir: Multilayer structure of PA-6 electrospun nanowebs

Sekcia H + O - Polymer + Technical Textiles

- HUFENUS Rudolf: Fiber development by multicomponent melt-spinning
- SHAHVAZIYAN Mohammad: The study on physical properties of fibers produced from PP/PET/SEBs Ternary blends in tufting carpet
- El-GHEZAL JEGUIRIM Selsabil: Effect of polyamide 6.6 roving characteristics on their transverse compression behaviors
- TOMSIC Brigita: Efficiency of silver based antimicrobial finish on cellulose fibres: covalently versus physically bonded silver
- BISCHOF VUKUSIC Sandra: Preparation of zeolite coated cotton fabrics

- GHAZIMORADI Mehdi: A study on mechanical properties of multilayer fabrics used for military industry by c.1.m.
- SITVJENKINS Igors: Degradation of the camouflage pattern and textile of the field uniforms
- SOYASLAN Devrim: Electromagnetic shielding properties of some weft knitted structures
- WARNECKE Moritz: Analysis and evaluation of the potential of lignin as precursor material for carbon fiber production
- GRANCARIC Ana Marija: Radioacitivity of radon on cotton fabric - the influence of natural zeolites
- DURAN Deniz: Shielding characteristics of conductive woven fabrics
- KOTEK R.: Degradation of polypropylene nonwovens subjected to sterilization
- SCHNABEL Andreas: Increasing the off-plane properties of FRP-laminates with high performance fibers
- HARDIN Ian: The creation of graphene-coated textiles for innovative electrical and electronic applications
- VINEIS Claudia: Polypyrrole coating for antimicrobial textile

Section I+L - Sustainability – Eco-design + Spinning

- JERIC Tina: In-situ generation of H_2O_2 for decoloration purposes of textile wastewaters with UV light
- KARACIZMELI Izzettin Hakan: Waste reduction and quality improvement on yarn manufacturing process: a combination of six sigma methodology and knowledge based approach
- DALLEL Mohamed: Physical and mechanical characterization of Alfa (Stipa Tenacissima L.) fibres for textile applications
- STEINMANN Wilhelm: Melt spinning of electrically conductive bicomponent fibres: structure and electrical properties
- KARATAS Murat: Energy conservation in yarn manufacturing using six sigma methodology
- RAHNEV Ivelin: Spinning torsion influence on the boundary elasticity of single worsted yarns

Sekcia J - Simulation and Modeling

- KORYCKI Ryszard: Modeling of heat transfer within clothing laminates
- SHAIKHZADEH-NAJAR Saeed: Simulation of breaking up of the fiber bundles in water using an analogous system
- DEHGHAN-MANSHADI Najmeh: Predicting bending rigidity of woven fabrics using fuzzy logic model
- SOMODI Željko: Numerical analysis of fabric drape as a problem of stable postbuckling state
- JMAL Hamdi: Quasi-static behavior study of polymer foams using memory fractional model and comparison between three industrial types of foams
- DARVISHZADEH Mehdi: Measurement of thermal diffusivity of polyester nonwovens using artificial intelligence
- MIGUEL Rui Alberto Lopes: Simulation of fabric weave shrinkage based on structural geometric models
- LAOURINE Ezzeddine: Characterization and simulation of permeability properties of woven fabrics for filtration and barrier use
- BEHERA B.K.: Prediction of bending property of woven fabrics using computational modeling
- UZMA Syed: Assessment of woven fabric porosity using Matlab
- RAWAL Amit: Modeling of bending rigidity of thermally bonded nonwoven structures
- HUBNER Matthias: Simulation-aided evaluation of textile structure drapeability; determining localized fixation methods to influence draping and structural stability
- RASHEED Abher: Study of pressure distribution on a car seat by using IR technology
- KYOSEV Yordan: Geometrical and mechanical modelling of spacer warp knitted structures
- DABIRYAN Hadi: Modeling of elastic deformation of warp knitted structures under uniaxial tension
- CURTO Joana Maria Rodrigues: Three dimensional polyamide-6 nanowebs modeling and simulation

Sekcia K+D - Supply Chain Management + Knitting

- ULUSKAN Meryem: Creating competitive advantage through quality in supply-chain management
- LEUNG SunneyY.S.: Enhancing cooperative negotiations in textile-apparel supply chain using agent-based technology

- DOS SANTOS SILVA Manuel José: An analysis of the recent developments in the textile and clothing supply chain
- MAPDAR Saumen: How the livehood & income increased in textile smes through reorientation of supply chain by cluster based approach ? - an indian case study"
- BILEN Umut:The effects of seam parameters on the stiffiness of wool and wool / PES blended
- VAEZ Mahdieh: Supply chain study in worsted industry to maximize total domestic added value consider in competitive advantage
- ONAL Levent: Moisture management and wicking properties of knitted fabrics

Sekcia M – Smart and Functional Textiles

- MILITKY Jiri: Electromagnetic shielding of hybrid fabrics
- ONDER Emel: Silver nanoparticle incorporated thermocapsules suitable for the development of thermally enhanced fabrics
- BAHADIR Senem Kursun: Multi-connection of miniaturized sonar sensors onto textile structure for obstacle detection
- OZEK H.Ziya: Electromagnetic shilding effectiveness of woven fabrics with silver coated nylon yams
- EHRMANN Andrea: Conductive knitted fabrics as textile sensors
- SCHWARZ Anne: A study on the lifetime behavior of elastic and electro-conductive hybrid yarns
- KECHICHE Mohamed: The development and characterization of conductive composite filaments
- SHAFI Arman: Analysis of signal transmission and electrical properties of embroidered circuit before and after washing
- SARIER Nihal: Manufacture of silver nanoparticle embedded chitosan and design of antimicrobial cotton fabrics
- ONOFREI Elena: The thermo-regulating effect of knitted fabrics incorporating PCMs
- KORYCKI Ryszard: Coupled heat and mass transfer within textronic structures
- LUCAS José Mendes: Development of textile substrates with magnetic properties
- KLEICKE Roland: Textile structures with integrated carbon based sensor networks for monitoring of filament reinforced composites
- SHANBEH Moshen: A novel method to produce textile-based heating elements using chrome-nickel metalic wires
- CURTEZA Antonella: Designing highly functional textile products for disabled people
- GRZELAKOWSKI Claire: Recent improvements in connecting electronic components to flexible textile structures
- CATARINO Andre: Biosignal monitoring implemented in a swimsuit for athlete performance evaluation
- FERREIRA Alexandre José: Monofilament composites with carbon nanotubes for textile sensor applications
- FRERE Yves: Fmart textiles obtained by grafting reloadable capsules

Sekcia N+M - Textile Testing + Smart and Functional Textiles

- BAUSSAN Eglantine: Comparative study of athletic socks regarding skin blisters formation during running
- XU Jun: A textile emergent fibers length measurement system based on camera vision and variable homograph
- ABOE Modeste: Within-bale variability study on cotton produced in Africa
- ROESSNER Daniel: Photo elasticity as a tool for the solid woven fabric deformation evaluation
- BOGUSLAWSKA: Effective water vapor permeability of wet functional fabrics determined by a new method
- ABREU Maria Jose: Effects of sportswear design on thermal comfort
- OPWIS Klaus: Oxidative in-situ deposition of PEDOT:PSS on textile substrates
- NOGUEIRA Clarinda: Comparison between French and Portuguese sensory evaluation applied on wool light fabrics Comparison between French and Portuguese sensory evaluation applied on wool light fabrics

Sekcia N - Textile Testing

- ERYURUK Selin Hanife: The effect of finishing processes on surface properties of wool fabrics
- ENKHTUYA D.: The study of discrimination analyses of cashmere characteristics
- DELITUNA Aslihan: Evaluation of reflective properties and surface characteristics of titanium dioxide coated woven fabrics

- SULAR Vildan: Development of a new testing instrument to simulate fabric bagging by artificial human elbow
- LAM Jimmy K. C.: Fabric hand on light weight summer knitted fabric
- BOCQUET Romain: Friction behavior of hairy textile fabrics. Contribution of adhesive and deformation forces
- CEJKA Vaclav: Contelon - structural analysis of textile yarns by the means of continual measurement of relative elongation
- JASINSKA Izabela: Pilling evaluation - standard and instrumental method of pilling evaluation
- EZAZSHAHABI Nazanin: Investigating the effect of fiber fineness on the poisson's ratio of microfiber polyester woven fabric
- ASGHARI Sara: Further study on roughness of worsted fabrics
- BARUQUE RAMOS Julia: Characterization of textile fibers from brazilian atlantic forest species

Posterové sekcie

- HASSON Messaa: Optimization of the heating of a thermal activated composite
- COLLAINE Anne: CBCM thermal and electrical properties identification and proposition for the control
- AYDIN Nurcan: Car seat fabrics' damages at seam line
- SHANBEH Mohsen: Effect of sewing parameters on tensile properties of seamed artificial leather after laundering process
- DOMJANIC Zaklina: Investigation of sewing needle damage
- MOUSAZADEGAN Fatemeh: Effect of seam type and parameters on fabric bending length
- KUZMICHEV Victor: Virtual design of system "body-clothes"
- PARK Junyoung: Reactive dyeing behaviors of cellulose/polyurethane blends containing amine-rich polyurethanes
- PETRINIC Irena: Flame retardant functionalization of blends
- DELITUNA Aslihan: Effects of alkali pre-treatment on weight-loss, color values and surface properties of polyester microfiber fabrics
- UNDRESCU Claudia: Water repellent cotton fabrics by ultraviolet curing and plasma treatment
- ATAV Riza: The use of ultrasound in dyeing of mohair fibers
- MIRJALILI Mohamed: Decolorisation treatment of wastewater containing reactive yellow I5 using herbal absorbent of wheat husk
- MIKUCIONIENE Davia: The problems in decorative finishing of weft-knitted articles
- MIKUCIONIENE Davia: Compression properties of knitted spacer orthopaedic supports
- MARMARALI Arzu: Application possibilities of 3D weft knitted spacer fabrics in composite structures
- CIESIELSKA- WROBEL Izabela Luiza: The analysis of the shielding efficiency of interlock structures
- TAKAMUNE Karina: Comparative study of the characteristics of knitted fabrics made of soybean and com fibers
- KHOFFI Foued: Polyester vascular grafts: textile structures and their elastic properties polyester vascular grafts: textile structures and their elastic properties
- POLLINI Mauro: Antibacterial silver-coated natural fibers to reduce nosocomial infections
- GRIGORIU Aurelia: Inclusion compounds of monochlorotriazinyl-B-cyclodextrin for UV protection of medical textiles
- ABBASIPOUR Mina: The Antibacterial property of treated sterile gauze with chitosan/Ag/ZnO nanocomposite
- MALINOWSKA- OLSZOWY Monika: Sources of innovative enterprises in the textile and clothing market
- ATAKAN Tumay: The factors that determine price policies of textile companies
- BRODA Jan: Structure and mechanical properties of fibrillated polypropylene fibres for reinforcement of concrete
- WULFHORST Johannes: Nanoparticles incorporated into meltspun filament yarns - dispersion orientation and high performance effects on the products abilities
- KRISTOFIC Michal: Composite compatibilized metallocene polypropylene fibres
- KALININ Eugeni N.: Dynamic model of impact on textile material during processing by pressure
- REINERS Priscilla: Evaluation of the human textile sensation using fuzzy logic
- YILDIZ Zehra: Modelling of seam strength and elongation at break values in poplin fabrics by using artificial neural network
- AKCAKOCA-KUMBASAR Perrin: Application of artificial neural network method on

decoloration of colored textile waste water by organoclay
- IRZMANSKA Emilia: Application of impedance plethysmography in a dynamic system for assessment of protective footwear users' comfort
- STOYANOV Borislav: Control of winding and unwinding processes of roll material
- AYATOLLIAHI Pegah: Predicting thermo physiological comfort of cotton fabrics using fuzzy logic model
- NAZARIAN Marzieh: Application of a fuzzy logic model for prediction of dimensional changes in knitted fabrics
- EL-GEIHENI Adel Salah: Progress in statistics of carded cotton yarns quality within the last half century
- MELKI Safi: Approach of wetting properties of hairy fabrics under stress
- YILDIRIM Kenan : Determinaton of paraffin amount on the yarn by using FTIR spectroscopy
- MOHAMMADI Vahid: The study on bending properties of cotton woven fabric in ultrasonic relaxation treatment
- SEAWRIGHT ALONSO Raquel: Microscopic and chemical characterization of textile fibers from brazilian malvaceae species
- ROGINA CAR Beti: Investigation of permeability to chemicals of protective fabrics
- KRANER Polona : Constructional problems of imbedding aerogel blankets into garments
- MASTEIKAITE Vitalija: Effect of fabric rigidity on the garment parts deformability
- DERAKHSHAN Javad: Studying the effect of fog and wind designs on decorative curtain fabric
- SACEVICIENE Virginija: The importance of materials mechanical properties investigation in product development processes
- BOR Arzu: Traditional and free designs of wedding gowns
- DOMJANIC Zaklina: Analysis of the fabrics for the manufacture of formal academic gowns
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- MOUSAZADEGAN Fatemeh: An overview of seam pucker
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- UTKUN Emine: Research on the body sizes of female university students: turkey Aegean Region case study
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- KARIMNEJAD Mohammadmehdi: Sodium hydroxide printing & investigation of dye adsorption on cotton fabric in different amount of NaOH & effect of nano TiO_2
- AKCA CAN Candan: The effect of different enzyme combinations on the garment properties under ultrasound energy the effect of different enzyme combinations on the garment properties under ultrasound energy
- AIMONE Francesco: Dying of aramids: a comparison between two industrial swelling agent
- SALIMPOUR Samera: Investigation of grafting mechanism of cotton fabric with poly (propylene imine) dendrimer nano-structure by using glutaric acid
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- CRONJE Lizl: Surface modification of poly (styrene-maleic anhydride) nanofibers to facilitate the binding of mycobacteria surface modification of poly (styrene-maleic anhydride) nanofibers to facilitate the binding of mycobacteria
- DAVODIROKNABADI Abolfazl: Coating of pa fabric using nano TiO_2 by electrospining of nano fibers
- VALIPOUR Peiman: Effect of nano silver particles on antibacterial properties of leather
- SEMNANI Dariush: Image processing technique to characterize the topology of electrospun scaffolds
- NEDJARI Salima: Nano fibres with nanoclay materials
- STANYS Sigitas: The formation of electrospun PVA mats using different type of electrodes
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- CARRION F.J.: Redeposition of impurities on wool fabric during washing with ecological surfactants and solvent microemulsion
- SIMONIC Marjana: Ozonation of colored wastewater generated after dyeing
- ATAV Riza : Comparison of the effectiveness of fenton and ozone processes in decolorization of reactive green 38
- ZONATTI Welton Fernando: Textile industrial ecology: recycling and (re) use of cotton fiber in the segments of the industry and fashion
- PIRES FERNANDES Ana Margarida: New materials and techniques applied to castelo branco embroidery in the textile and clothing design
- GONDOR Vera: Higher education marketing with quality management tools
- ALNAWASREH Waseem: The use of compressive shrinkage process to increase yarn elongation
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- AVRAM Petronela: The potential of wool in developing highly functional textile products
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- RATTFALT Linda: Electrical characterization of screen printed electrodes for ECG measurements
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