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Content

Obsah

RESEARCH OF SOME PHYSICAL AND MECHANICAL CHARACTERISTICS OF SUITING FABRICS FOR DESIGNING THE CLOTHES

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Abstract: *The main physical and mechanical characteristics that have an effect on the shape and design of the clothes are thickness, surface density, rigidity and drapeability of the fabric. Experimentally, according to the standardized methods, were identified the main physical and mechanical characteristics of fabrics of the suiting group. Using the selected parameters, the comparative analysis of fabrics samples was conducted and dependencies between them were determined. Analysis of experimental data showed that the raw components of fabrics do not affect significantly on their properties (drapeability, rigidity). Fabrics with the different raw components can have the same or close values of these parameters. More significant is the weave of fabric, which has an effect on the rigidity characteristics of fabric in the longitudinal and transverse directions. Conducted experimental researches are the basis for development of the suiting group fabrics classification in terms of flexural rigidity for the purpose of developing the recommendations for designing the clothes of different three-dimensional forms.*

Key words: *thickness, drapeability coefficient, surface density, warp and weft rigidity, correlations.*

1 INTRODUCTION

In the design of the clothes in the garment industry a wide range of fabrics is used. The development of the textile industry and the emergence of fabrics with new structural characteristics at the market force the workers of the garment industry to find new solutions for arising problems, which are connected with the provision of the necessary constructive form to the products, retention of the shape during the use of the products.

As a result of analysis of fabric classifications, provided by different sources [1-4], it was determined that the main fabric classification for the purpose of clothes designing was expedient to consider the assortment of clothes and division of fabrics on linen, clothes, suits etc. Exactly the characteristics of fabrics by the assortment and not, for example, by the surface density or thickness makes it possible to provide recommendations on the selection of methods of forming and on techniques of constructive modeling in the design of the clothes.

The aim of the research is determination of parameters of physical and mechanical properties of fabrics of the suiting group, estimation of linkages between them for scientifically grounded selection of fabrics with the purpose of creation the specified three-dimensional form of sewn product.

2 EXPERIMENTAL

It is known that the main elements which characterize the form of the clothes are design, material, size, weight, structure and so on. Materials, in turn, have an effect on the form of the clothes with their aesthetic parameters (appearance of the fabric, surface characteristics, color, decoration etc.) and with their physical and mechanical characteristics. The following characteristics have the biggest impact on the form of clothes: raw components, weave, thickness, surface density, rigidity, drapeability, crease coefficient [5, 12]. Depending on the values of these parameters product designation, its model and design features, technology of its production can be determined.

The rigidity of the fabrics depends on the raw components, fiber structure, structure and degree of twist of the yarn (fiber), on the type of weave, density and decoration of the fabrics. The rigidity of the fabrics increases with increasing of twist of the yarns, their thickness and density. The weave of the yarn in the fabrics structure also significantly affects the rigidity of the fabrics. With increasing length of overlaps and a decrease in the number of connections between yarn systems the rigidity of the fabrics decreases. Increase of the number of filling of the weaves in the material structure leads to the increase of the fabrics rigidity. Configuration of the sectional view of the fabrics also has a significant effect on the rigidity of the fabrics. Sectional view of the round shape has a greater resistance to the flexural efforts, rigidity increases with the thickness of the fabrics. Drapeability of the textile materials closely connected with the same structural parameters, which determine the flexural rigidity.

To achieve the goal, about thirty samples of the suiting fabrics with the different raw components were analyzed, which differ in appearance and physical and mechanical parameters. Were determined such parameters of fabrics as thickness, surface density, flexural rigidity, drapeability coefficient. All tests were conducted under the current regulations [6, 7], in compliance with requirements to the objects of experimental research. The processing of the results of experiments was made by using the mathematical tool for statistical data analysis.

Material thickness was determined by using the manual thickness tool of indicative type TP 10-1 [6], was calculated the surface density of the suiting fabrics *Ms* [g/m^2]. During the analysis of fabric rigidity by console contactless method [10], was used the device, type ПТ-2 (Figure 1).

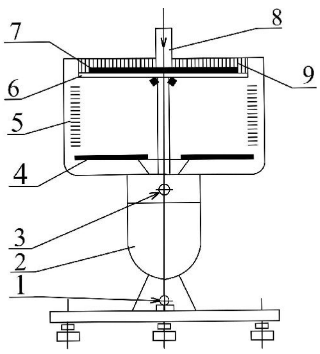

Figure 1 Scheme of device, type ПТ-2 for determination of fabric rigidity by console method:
1 - tumbler; 2 - moving mechanism; 3 - screw; 4 - cripping marker; 5 - scale of absolute cripping; 6 - horizontal plane; 7 - sample; 8 - weight; 9 - scale of symmetry checking

The methodology of experiments is as following. Five elementary samples in longitudinal and transverse directions, size 160×30 mm, are cut out. The prepared tested strips should be kept in climatic conditions not less than 23 hours before testing [11]. Test should be conducted at the same conditions.

Elementary samples of each direction (5 samples of each direction) weigh on the scales with the error no higher than 0.01 g and determine the total weight *m* [g] of the samples of longitudinal and transverse directions separately.

Elementary sample is placed on the supporting horizontal plane 6 face up and symmetrically to the midline, combine the outer edge of the sample and the plane. At the middle of the sample the weight is set with a width of 20±1 mm, weighing 500±5 g and using a tumbler 1 switch on the mechanism of lowering the lateral sides of the supporting plane. After one minute from the moment of separation of elementary sample from the surface of the plane 6 the ends cripping *f* of the sample are measured using the cripping markers 4. As the final cripping taken the arithmetic average of 10 measurement results of each direction with the error no higher than 0.01 mm.

Conventional value of rigidity *EI* [μN·cm^2] has been calculated separately for longitudinal and transverse directions by the formula:

$$EI = 42046.m/A \quad (1)$$

where *m* – total weight of all five elementary samples of fabric [g], size of every sample is 160×30 mm; *A* – function of relative cripping f_0, which is determined from the table in the regulatory documents [10] according to the value f_0:

$$f_0 = f/l = f/7 \quad (2)$$

where *f* – value of the arithmetic average of cripping of the samples [cm]; *l* – length of the sample that is weighted [cm], equal to *l* = (L – 2)/2 = 7 cm, where *L* – the length of elementary sample [cm].

Rigidity coefficient of material was calculated as the ratio of rigidity values in longitudinal and transverse directions:

$$C_{EI} = EI_{longitudinal} / EI_{transverse} \quad [\%] \quad (3)$$

Recommended values of surface density and conventional rigidity of fabrics of the suiting group presented in Table 1 [2, 8-10].

Table 1 Oriented values of surface density and flexural rigidity of fabrics of the suiting group

Group of fabrics	Surface density [g/m^2]	Flexural rigidity [μN·cm^2]
cotton	180–300	4000–9000
linen	200–400	
woolen	220–360	
silk	150–230	

The research of drapeability of the samples of the suiting fabrics was performed on the device for determination of drape by the disk method [8], because it was necessary to evaluate the drapeability of fabrics in longitudinal and transverse directions at the same time. This method is not standardized, but it is used very often in the garment industry because of its simplicity. The scheme of the device is given on Figure 2.

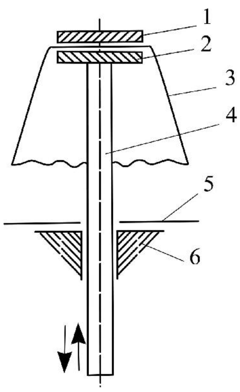

Figure 2 Scheme of device for determination the drapeability of fabric by disc method: 1 – pressed disc; 2 – table; 3 – sample of fabric; 4 – rod; 5 – paper circle; 6 – horizontal plane

Fabric sample 3 that was cut as a circle with a diameter 200±1 mm is put on the Table 2 with the diameter 50±1 mm, which has a needle for fixing the sample. On the top of the sample the pressed disc 1 is placed, the size and shape of which match the size and shape of the Table 2. The table is lifted; the edges of the sample are hanging down. In order to provide the sample with constant natural form, disc with the sample is lifted up and moved down 5 times and after 3 min outline the projection of sample 3 on a paper circle with a diameter 200±1 mm, which can be obtaining by lighting from the top by parallel rays of the light perpendicular to the plate of the sample. Then determine the projection area of the material.

During the research of fabrics of the samples the drapeability coefficient (C_d) was calculated using the results of weighing of the paper (with an error no more than 0.001 g) that was cut in accordance with the projections of undraped sample (mass m) and draped (mass m_d) by the formula:

$$C_d = 100.(m - m_d)/m \quad (4)$$

where m – projection area of original undraped sample [g]; m_d – projection area of draped sample [g].

Drapeability value is essential for overcoating, suiting and clothing fabrics; it is taking into account during the confectioning of materials for the product. Recommended values of drapeability coefficient C_d for the main functional groups of fabrics presented in Table 2 [1, 2, 8, 9].

Table 2 Estimation of drapeability degree of fabrics of different types

Type of fabric	Drapeability coefficient C_d [%]		
	Good, more than	Satisfactory	Bad, less than
Woolen:			
clothing	80	68-80	68
suiting	65	50-65	50
overcoating	65	42-65	42

Drapeability of textile materials depends primarily on their rigidity and it is closely related to the structural parameters and operations of decoration. Good drapeability can have fabrics with different fibers without sizing, with low surface density [8].

3 RESULTS AND DISCUSSION

Physical and mechanical parameters and characteristics of fabrics of the suiting group that were obtained as a result of experimental research summarized in Table 3.

For comparison of the obtained data concerning the thickness and surface density of the researched suiting fabrics it was defined their interdependence and presented in diagrammatic form (Figure 3).

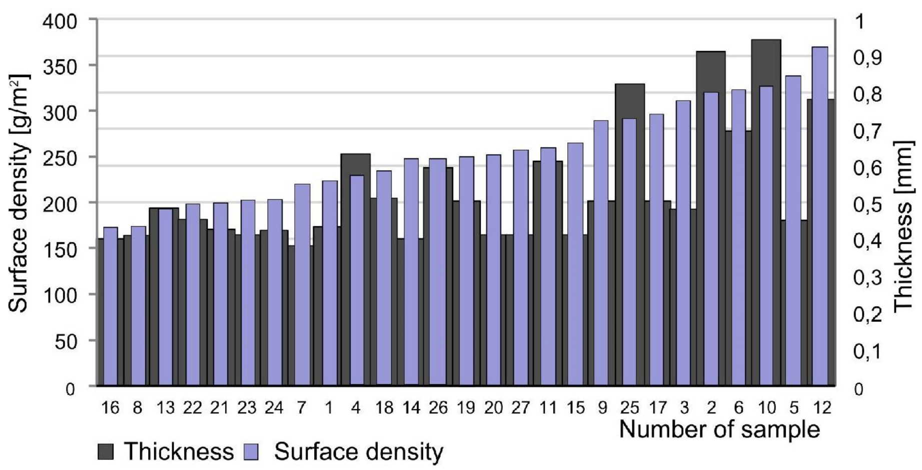

Figure 3 Interdependence of the surface density and thickness of the suiting fabrics

Table 3 Summarized characteristics of suiting fabrics

Number of sample	Raw components	Type of weave	Surface density [g/m^2]	Thickness [mm]	Flexural rigidity [μN·cm^2]		Rigidity coefficient	Drapeability coefficient [%]
					in warp	in weft		
1	2	3	4	5	6	7	8	9
Sample 1	35% wool, 25% PES, 40% PA	satin weave	220	0.43	2923	2407	1.21	38
Sample 2	70% wool, 25% cotton, 5% PES	plain weave	316	0.91	7870	5346	1.47	42
Sample 3	40% wool, 28% PES, 32% PA	compound twill weave	308	0.48	1882	2036	0.92	63
Sample 4	40% cotton, 50% PES, 10% ME	plain weave	226	0.63	2661	2313	1.15	42
Sample 5	65% wool, 35% PA	compound twill weave	332	0.45	1055	1283	0.82	50
Sample 6	70% wool, 30% PA	plain weave	320	0.69	1470	1974	0.74	54
Sample 7	55% cotton, 45% PA	sateen weave	216	0.38	2509	2449	1.02	38
Sample 8	25% wool, 45% cotton, 30% PA	plain weave	172	0.41	1657	1991	0.83	40
Sample 9	50% wool, 20% cotton, 30% PAN	satin weave	286	0.50	7137	7973	0.9	35
Sample 10	75% wool, 25% PA	figured weave	322	0.94	6486	6746	0.96	36
Sample 11	40% wool, 30% PES, 30% cotton	compound figured weave	256	0.61	2045	2162	0.94	48
Sample 12	10% wool, 90% PES	compound twill weave	366	0.8	7718	6395	1.18	46
Sample 13	35% wool, 25% PES, 40% PA	compound twill weave	189	0.5	4698	4117	1.14	38
Sample 14	10% cotton, 90% PES	sateen weave	244	0.4	2024	2467	0.82	42
Sample 15	5% wool, 95% PES	plain weave	261	0.4	4230	2420	1.74	50
Sample 16	20% cotton, 50% PES, 25% PA	satin weave	169	0.4	2201	1727	1.27	51
Sample 17	100% PA	figured weave	293	0.50	9553	6047	1.57	38
Sample 18	40% wool, 60% PES	compound plain weave	232	0.51	2402	2338	1.03	42
Sample 19	65% wool, 35% PA	compound twill weave	246	0.50	4729	4594	1.03	36
Sample 20	70% wool, 30% PA	satin weave	247	0.41	2032	2090	0.97	35
Sample 21	55% cotton, 45% PA	plain weave	196	0.42	2439	2408	1.01	36
Sample 22	50% wool, 20% cotton, 30% PAN	plain weave	194	0.45	2554	2491	1.02	46
Sample 23	75% wool, 25% PA	sateen weave	199	0.41	2004	2002	1.0	53
Sample 24	40% wool, 30% PES, 30% cotton	plain weave	199	0.42	1638	2078	1.74	39
Sample 25	50% wool, 20% cotton, 30% PES	satin weave	288	0.82	3066	3208	0.78	35
Sample 26	75% wool, 25% PA	figured weave	245	0.59	2692	2694	1.57	43
Sample 27	40% wool, 30% PES, 30% cotton	compound figured weave	252	0.41	1401	1649	0.99	57

The average surface density of the tested fabrics varies from 170 to 250 g/m^2, which corresponds to the recommended values for suiting fabrics (Table 1). As it shown in the diagram (Figure 3), surface density of fabric is directly proportional to its thickness, so with an increase of thickness of fabric increases the parameter of its surface density. Samples 2, 10, 11, 12 and 25 have the biggest thickness, so their surface density is the biggest respectively. Despite this, some samples, for example, samples number 5, 20, 27, 7, 14 have average thickness but considerable surface density due to the fact that these samples have compound figured weave or satin weave.

For estimation of the obtained parameters of drapeability coefficient of the tested suiting fabrics the following diagram was presented (Figure 4).

Comparing the drapeability coefficients of the tested fabrics, we can see that fabric samples number 9, 20 and 25 have the lowest ability for draping, samples 3, 6, 23 and 27 – the biggest. Drapeability coefficient of the other samples varies on average within 35-50%, indicating the bad drapeability according to the Table 2. Just one third of the tested samples have the average drapeability.

For the analysis of obtained data and comparison flexural rigidity in the longitudinal and transverse directions of the tested suiting fabrics the following diagram was presented (Figure 5).

Rigidity of the tested samples of fabrics ranging from 2000 to 3000 μN.cm^2, it is less than the standard parameters for suiting fabrics. It can be due to the fact that modern fabrics have more dispersed structure, lower density, as the weave of fabric significantly affects the parameters of rigidity in warp and weft. Long overlaps of twists provide fabrics with greater thickness rather than short ones, that is why when other things being equal, fabric with the plain weave thinner than fabrics with satin or complex patterned weave. It is also well known that with the increase of the fabric density the yarn flattens or shifts and thickness of fabric increases. The highest flexural rigidity in both directions have samples 9, 10, 12 and 17, which thus have bigger thickness of about 1 mm and surface density as compared to other samples. Clearly traceable the regularity that with increase of fabric rigidity in warp its rigidity in weft increases as well.

Were determined the correlation connections between the physical and mechanical parameters of the tested samples of suiting fabrics (Table 4).

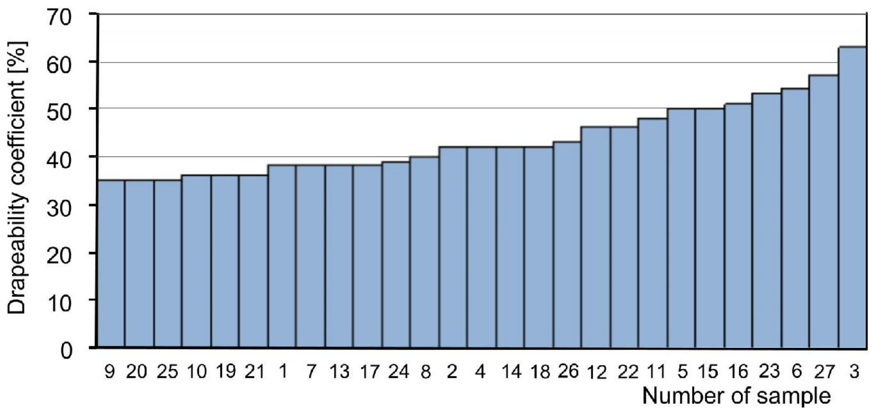

Figure 4 Drapeability coefficients of the suiting fabrics

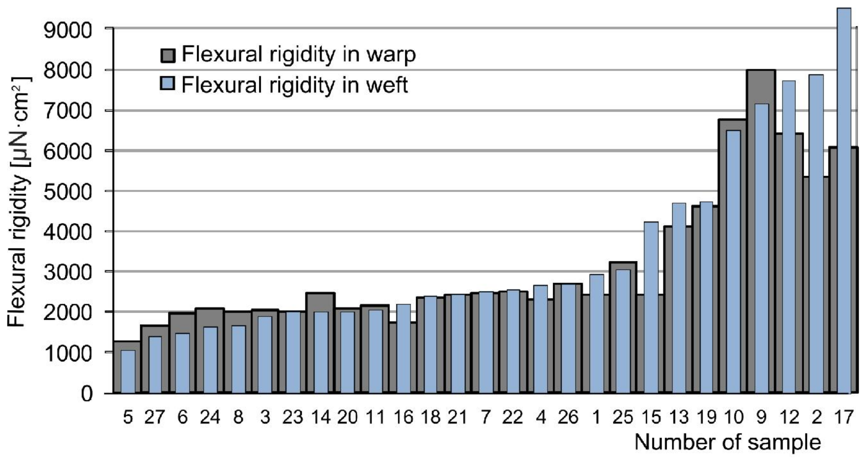

Figure 5 Flexural rigidity of the suiting fabrics in warp and weft

Table 4 Correlation connections between the values of physical and mechanical parameters of suiting fabrics

	Surface density [g/m²]	Thickness [mm]	Flexural rigidity in warp [μN·cm²]	Flexural rigidity in weft [μN·cm²]	Rigidity coefficient [%]
Thickness [mm]	0.65	–			
Flexural rigidity in warp [μN·cm²]	0.47	0.50	–		
Flexural rigidity in weft [μN·cm²]	0.48	0.53	0.76	–	
Rigidity coefficient [%]	-0.11	-0.04	0.35	0.12	–
Drapeability coefficient [%]	0.17	-0.14	-0.37	-0.45	-0.08

The relevance of the correlation coefficients was determined from the table of the standard correlation coefficients. When the number of degrees of freedom is (n - 2) = 27 - 2 = 25, our calculated correlation coefficient p_{xy} should be higher than the table value 0.381, that corresponds to the probability of faultless prognosis of more than 95%. This allows us to suggest the resulting rank correlation coefficient as reliable. We identified the statistically significant coefficients in the Table 4.

The table shows that correlation connections have small or average degree. As a result of analysis, the directly proportional dependence of the surface density from the thickness of suiting fabrics was identified. Also was determined the directly proportional dependence of flexural rigidity in the longitudinal and transverse directions from the thickness of suiting fabrics.

4 CONCLUSIONS

Based on the comparative analysis, were indicated the key parameters of fabrics, which affect the creation of certain form of sewing products and can be taken into account during the design stage, such as thickness, surface density, drapeability coefficient and flexural rigidity in the longitudinal and transverse directions. Experimentally, according to the standardized methods, were identified the main physical and mechanical characteristics of fabrics of the suiting group. Analysis of experimental data showed that the raw components of fabrics do not affect significantly on their properties (drapeability, flexural rigidity). Fabrics with the different raw components can have the same or close values of these parameters. More significant is the weave of fabric, which has an effect on the rigidity characteristics of fabric in the longitudinal and transverse directions. Were identified the correlation connections between the physical and mechanical parameters of fabrics of suiting group and determined that there was the directly proportional dependence between the thickness and the surface density of fabrics and between the flexural rigidity in the longitudinal and transverse directions and the surface density. Conducted experimental researches are the basis for development of the suiting group fabrics classification in terms of flexural rigidity for the purpose of developing the recommendations for designing the clothes of different three-dimensional forms.

5 REFERENCES

[1] Savostitsky N.A., Amirova E.K.: Material authority of garment production, the Academy: Skill: High School, Moscow, 2001, 240 p

[2] Orlenko L.V., Gavrilova N.I.: Confectioning materials for clothing, FORUM: INFRA-M, Moscow, 2006, 288 p

[3] Bazhenov V.I.: The materials for garments, Light and food industry, Moscow, 1982, 312 p

[4] Kalmykova E.A., Lobatskaya O.V.: Material authority of sewing production, High School, Minsk, 2001, 412 p

[5] Pashkevich K.L., Kozitska O.Y.: Improving the design process of female shoulder clothes shape, considering properties of fabric, Journal KNUTD, №5 (43), Kyiv, 2008, 122-126 p

[6] GOST (State Standard) 12023-2003: Textile materials and products from them. Method for determination of thickness, Standartinform, Moscow, 2003, 11 p

[7] GOST (State Standard) 3811-72: Textiles. Fabrics, non-woven fabrics and piece wares. Methods for determination of linear dimensions, linear and surface densities, Publishing House of Standards, Moscow, 1973, 14 p.

[8] Buzov B.A., Alymenkova N.D., Petropavlovskiy D.G.: Workshop on Material authority in garment production, Publishing center "Academy", Moscow, 2004, 416 p

[9] Suprun N.P., Orlenko L.V., Dregulyas E.P., Volynets T.O.: Confectioning materials for clothing, Knowledge, Kyiv, 2005, 159 p

[10] GOST (State Standard) 10550-93: Textiles. Cloth. Methods for determination of flexural rigidity. Interstate Council for Standardization, Metrology and Certification, Moscow, 1993, 10 p

[11] GOST (State Standard) 10681-75: Textiles. Climatic conditions for the conditioning and testing of samples and methods of their determination, Publishing House of Standards, Moscow, 1975, 27 p

[12] Pashkevich K.L.: Design tectonic shape of clothing considering the properties of fabrics, Profi, Kyiv, 2015, 364 p

EXAMINATION OF SLEEP DISTURBANCES USING THE ALICE6 SYSTEM

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Abstract: *The article focuses on monitoring of the quality of sleep in pyjamas with different fibre composition. Diagnostics is carried out repeatedly on one proband in the sleep laboratory under professional guidance of the Head of Otorhinolaryngology Department in Krajská nemocnice Liberec at TUL in Liberec using the ALICE6 polysomnography system and Sleepware G3 system. Using various probes manifestations of sleep disturbances, brain activities – EEG are recorded, facial muscles activity, moves of eyes, limb movements in sleep, volume of oxygen in blood, etc. are measured. The results of the diagnostic test have showed that structure of sleep is basically maintained during all measurements in pyjamas I. and pyjamas II. No waking up occurred. Proband's regime relating to the time of falling asleep and the activities before sleep is important.*

Key words*: ALICE6 polysomnography system, sleep laboratory, hypnograms of sleep in pyjama, apnoea/hypopnoea in sleep in pyjama, saturation, bradycardia and tachycardia in sleep in pyjama.*

1 INTRODUCTION

Sleep influences the whole of our organism and the quality of our sleep has subsequent impact on our success during the day, week, month, etc.

The quality of sleep is first of all influenced by the person's state of mind and physical condition. Sleep is significantly influenced by stress, bad moods, certainly also by depression, disorder of internal, neurological and psychiatric nature.

Certain hygiene habits (going to bed at the same time, lighter dinner, elimination of caffeine and alcohol in the evenings, *suitable environment, suitable temperature,* etc.) are important. Evening visit to a fit centre, longer sleep during the day and many other factors are not suitable.

According to current international classification, sleep disturbances are officially divided into six basic areas:

1. Insomnia – sleeplessness,
2. Breathing disorders at sleep,
3. Central hypersomnia – i.e. increased need of sleep during the day,
4. Parasomnia – i.e. partial wake-up reactions during sleep connected with abnormal behaviour and usually with vegetative manifestations (somnambulism, nightmares, chaotic behaviour, sleep paralysis, behavioural disturbance connected with REM /Rapid eye movement/ sleep, etc.),
5. Circadian rhythm disruptions (e.g. the syndrome of delayed getting to sleep),
6. Abnormal moves at sleep – most frequently the restless legs syndrome, gritted teeth in children or adults, or rhythmic moves while sleeping mainly in children.

One third of our population is suffering one of these disturbances. The quantity of sleep disturbances increases at old age.

Many sleep disturbances are genetic.

Genetic cause is assumed in one of the most frequent disorders – in the *sleep apnoea syndrome* (intermittent breathing), where external factors are contributing – in adults they are most frequently overweight and obesity, smoking, alcohol, laying on back not on the side while sleeping but also congenital changes of facial skeleton (e.g. mandibles).

Genetic influences play an important role in some other disturbances – e.g. the *restless legs syndrome* or *disorders of daily rhythm.*

The most frequent disturbance, *insomnia,* is usually caused by psychical influences.

If any of the problems persists for several weeks, or months, the person should definitely see their general practitioner or physician who shall consider how serious the problem is, and possibly can recommend consultation at a specialist centre or a centre dealing with sleep disturbances.

Insomnia can have many causes, and its treatment depends on them too. Optimum treatment for "real" *insomnia* is combination of special hypnotics and psychotherapy [1].

One of the causes for insomnia is the environment, in which the person falls asleep. Among external influences, there is also the kind and type of clothing, its fibre composition, kind of mat, mattress, etc.

Nowadays polysomnography devices, e.g. Alice 6 by Philips, can be used to examine sleep disturbances.

2 ALICE6 POLYSOMNOGRAPHY SYSTEM

Alice6 is a polysomnography system for fast and reliable examination of sleep intended for examination in an ambulance or a "sleep laboratory" [2].

The sleep laboratory is a specialized health care facility that is equipped with devices for diagnosing of sleep disturbances. From the patient's view, it usually takes the form of the bedroom where the examined person sleeps in the night (or during the day too). The devices record manifestations of sleep disturbances (for example interrupted breathing during sleep) using various probes, and so the physicians get the basis for determination of diagnosis [3].

It is appropriate to be used for adult as well as children patients. Examination is usually done during the night. The diagnosis of sleep *apnoea* and *hypopnoea* syndrome can be acquired using the probes located on proband; they identify decrease of *saturation*, changes in breathing and artefacts. Data is continually recorded for at least 10 hours.

Sound and video recordings that record for example patient's moves are usually parts of polysomnography examination. A standard equipped sleep laboratory has a camera system for night vision so that the patient can sleep in dark and quiet [4].

Data from the Alice6 sensors are forwarded to a computer for program processing using the Sleepware G3 software. Such program equipment is intended for monitoring, displaying, processing and transferring data of polysomnography. The patient unit, into which all probes and electrodes are connected, includes neurology and polysomnography inputs – in total, up to 31 channels can be available.

Polysomnography recording for review of the results can be displayed graphically on the computer monitor as well as in hard copy [2].

3 EXPERIMENT

This sleep monitoring system **Alice6** was used to research the quality of sleep of a young man in the sleep laboratory of Technical University of Liberec deals with Clothing Comfort for a long time [5]. The research tested sleep:

- *in pyjamas of variant I.* with new fibre composition 60%TencelC/40%Tencel+PADh [6]
- *in pyjamas of variant II.* made of 100% cotton that is nowadays available for sale.

A healthy proband not suffering any health complications that would distort the results of sleep examination was chosen for reasons of objective assessment of sleep in tested pyjamas.

The research was executed under professional guidance of Dr. Minařík, the Head of Otorhinolaryngology Department at Krajská nemocnice Liberec, in the "sleep laboratory" at Technical University in Liberec.

In each pyjama, the test of the quality of sleep was carried out three-times on two defined days during three weeks in May 2014. Proband (a man) always spent one night in the sleep laboratory from 10 p.m. to 6 a.m. In total, 6 measurements were carried out, three-times in the pyjama with new fibre composition and three-times in pyjama commonly available for sale. After each test the pyjamas were washed in an automatic washer with adherence to the requirements recommended for washing, i.e. according to the symbols stated on the products; then they were tested again.

3.1 Examining the sleep disturbances using polysomnography

The time spent in bed, time of falling asleep, quality of sleep, snoring, breathing, limb movements, heart rate and pulse were monitored during the test and subsequently assessed. Testing of sleep in the pyjama of variant I. is shown by *hypnograms* in Figure 1, and in pyjama of variant II. in Figure 2, where:

W – Wake,
R – REM – we dream in this phase,
N1 – falling asleep,
N2 – light sleep,
N3 – deep sleep [7-9].

The results of the quality of sleep were acquired based on the video-polysomnography tests, Figure 3, in pyjamas of variant I. and II.

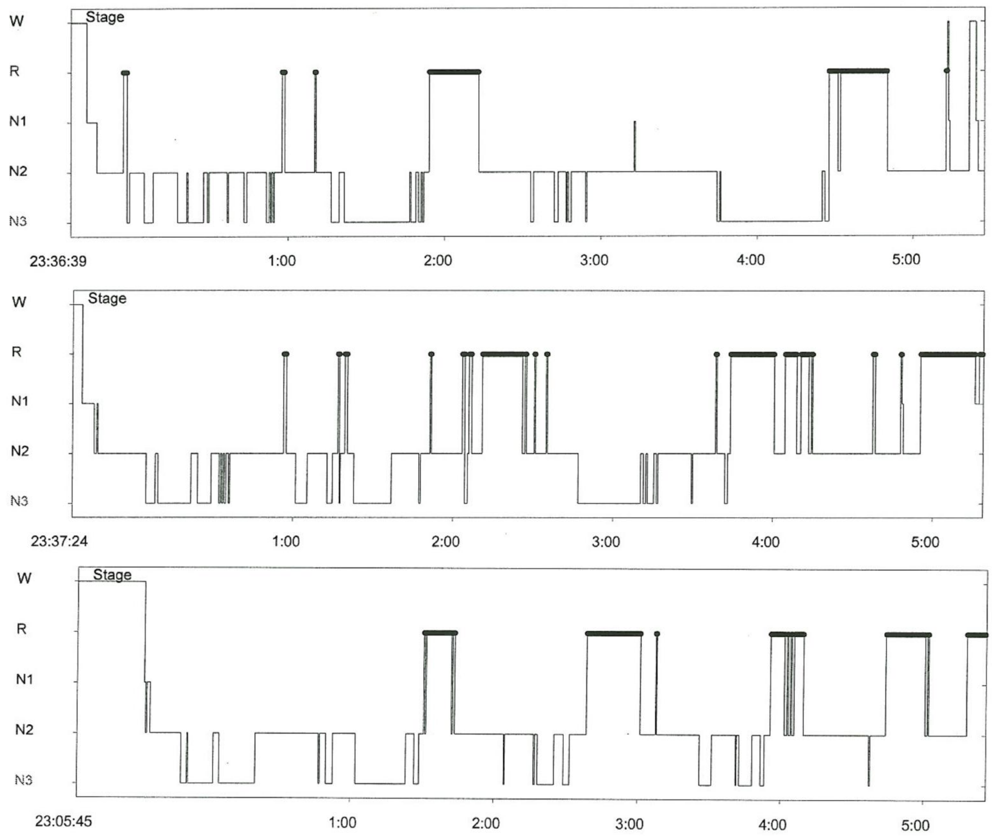

Figure 1 Hypnograms - the tests of sleep in pyjama of variant I.

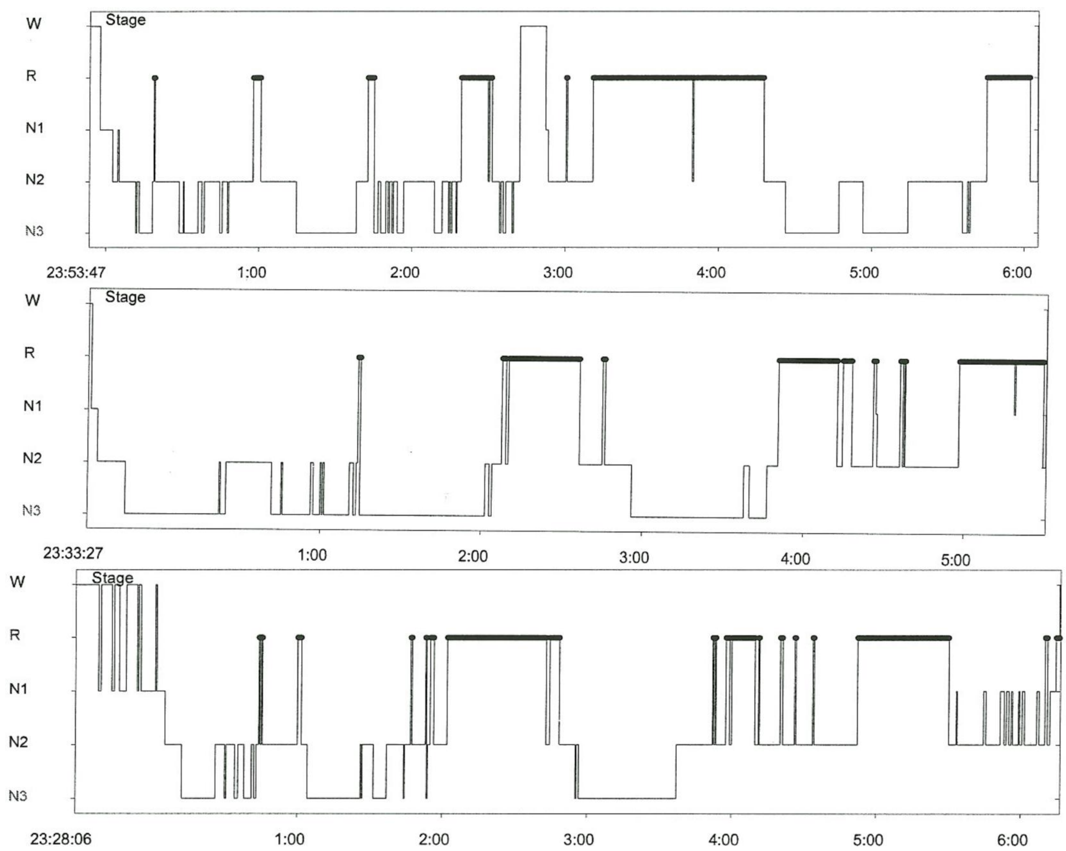

Figure 2 Hypnograms - the tests of sleep in pyjama of variant II.

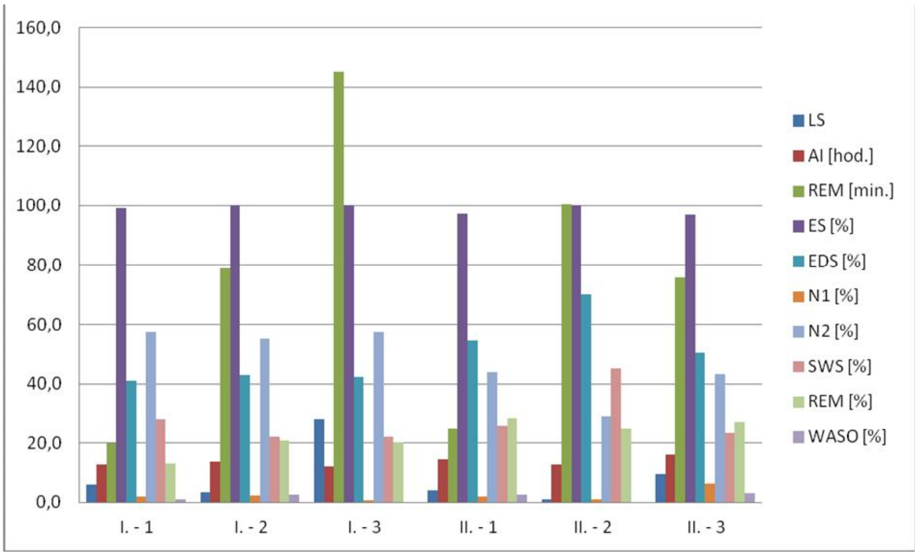

Figure 3 Results of the quality of sleep in pyjamas of variant I. and II.
LS - Latency Sleep; *AI* - Index Wake-up Reactions; *REM* - Rapid Eye Movement latency (the phase of sleep characterised by fast eye movements, low level of muscle activity and low current EEG); *ES* - Efficiency Sleep; *EDS* - Effectiveness of Deep Sleep; *N1* - Stage 1 sleep; *N2* - Stage 2 sleep; *SWS* - Slow Wave Sleep; *WASO* - Wake After Sleep Onset [7-9]

3.2 Examination of respiratory events

Night polysomnography is required for diagnosis of obstructive sleep apnoea (OSA). Apnoea index (AI) and apnoea/hypopnoea index (AHI), i.e. the number of apnoeas (or apnoeas and hypopnoeas per hour) are used for assessment. AI>1 is considered statistically important and AHI>5 is OSA (degree I.) AHI≥30 is heavy - serious (degree III.) and must always be treated. OSA with AI 1-4 is considered light and its treatment depends on symptoms. Each OSA with AI>5 is considered serious and has to be treated. In case of proven OSA, an examination by otorhinolaryngologist to assess adenoid vegetation, tonsils or other possible changes of upper respiratory tract is necessary [7-10].

The following were monitored within respiratory events during sleep in pyjamas I. and II.: Central Sleep Apnoea (CA) during Cheyne-Stokes respiration (periodic breathing, Cheyne-Stokes respiration), Micro Arousals (MA) – macrostructure of sleep, Obstructive Sleep Apnoea (OSA), Apnoea (A), Hypopnoea (H) and their indices, Figure 4.

Apnoea/hypopnoea index expresses the average number of respiratory events of apnoea or hypopnoea per an hour of sleep (AHI in REM) and (AHI in NREM). NREM is the opposite of REM; they regularly change during sleep. The NREM phase is characterised by depression of brain activity as well as bodily relaxation and release, Figure 5.

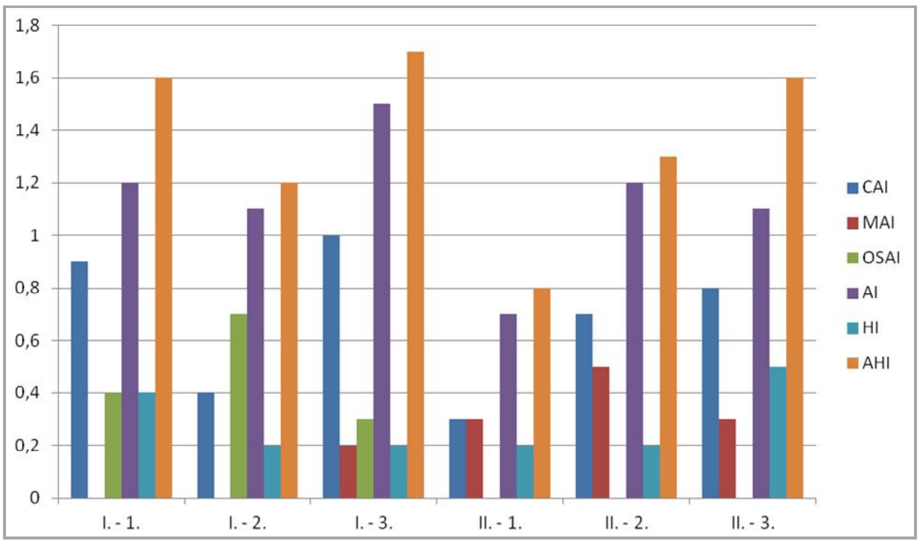

Figure 4 Respiratory events during sleep in pyjamas I. and II. expressed by indices

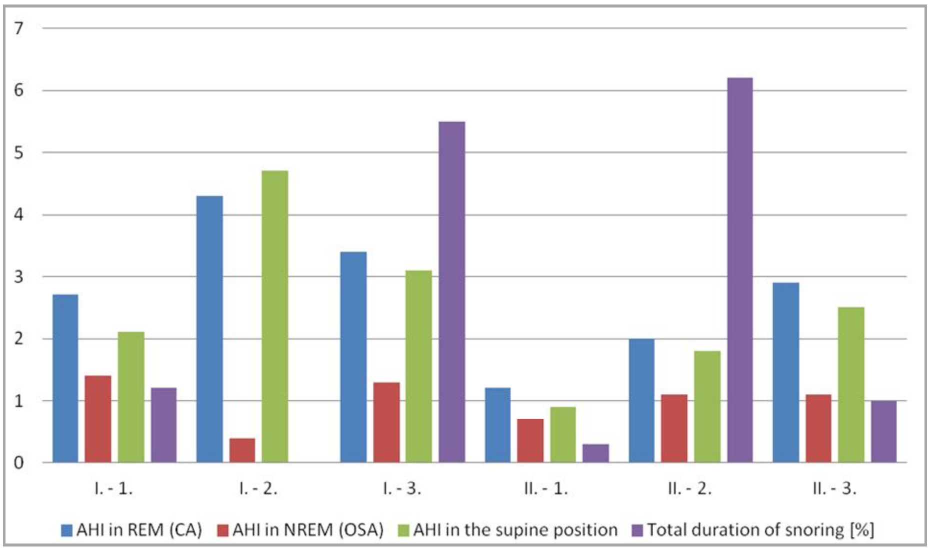

Figure 5 Respiratory indices of apnoea and hypopnoea and overall time of snoring

The overall time of snoring stated in minutes is related to the overall time of sleep and expressed in percentage.

3.3 Measurement of oximetry - saturation

It is measurement of the volume of oxygen in blood, so called saturation. Inhaled air contains 21% of oxygen. Oxygen is transferred to blood in lungs and there it forms its level (saturation). Such level is indicated in pressure units or as an absolute number. It indicates what percentage of overall maximum possible saturation of oxygen in blood is utilized [11].

The research results are shown in Figure 6 - NREM, REM and TIB (Time in Bed) – time from turning the light in the room off to waking up).

Minimum saturation – Oxygen De-saturation Index (ODI) is the de-saturation index of oxygen. It expresses the number of decreases of saturation for three or more percent connected with a respiratory event per an hour of sleep, Figure 7. *Total Sleep Time* (TST) is the time from falling asleep to the last waking up - NREM + REM sleep. Minimum saturation in percentage is stated for each measurement of pyjamas I. and II. in Figure 7.

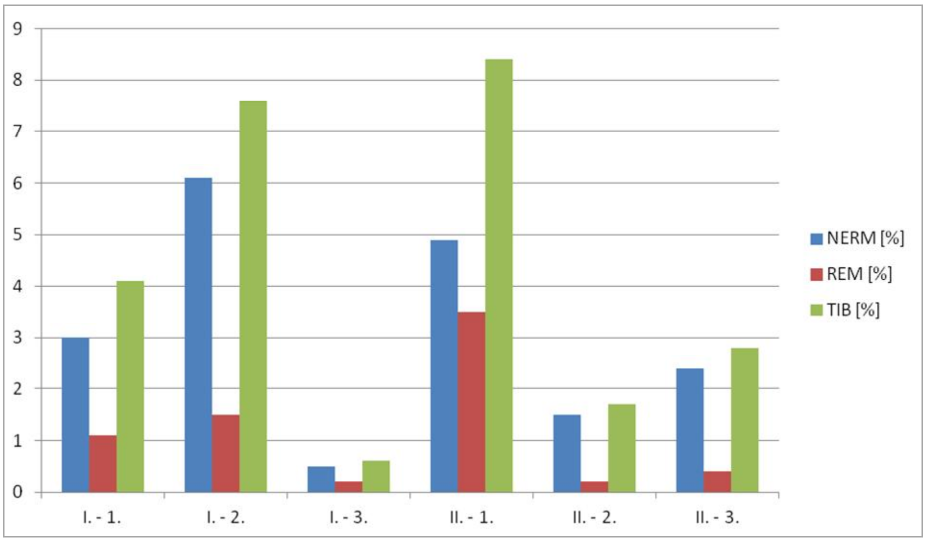

Figure 6 Oximetry <95% – NREM, REM and TIB

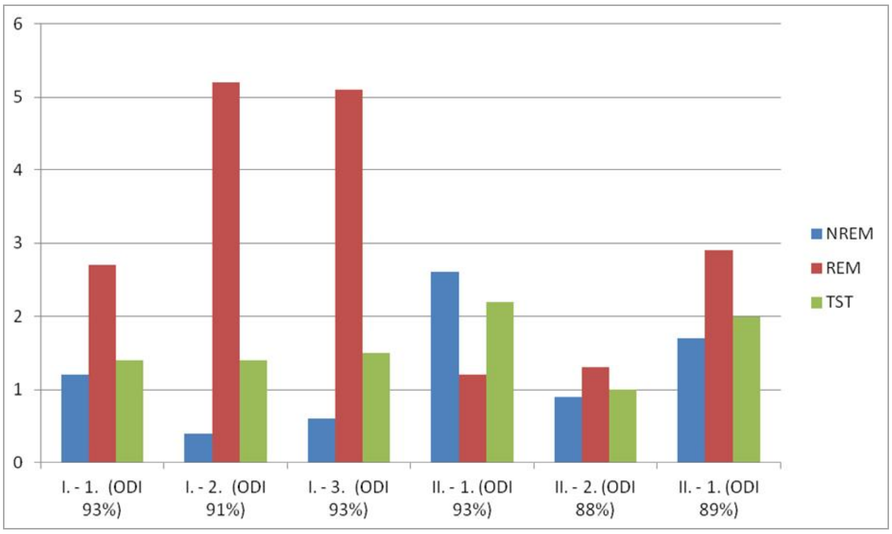

Figure 7 Minimum saturation ODI – NREM, REM and TST [7-9]

3.4 Periodic limb movement during sleep

Restless Legs Syndrome (RLS) and Periodic Limb Movements in Sleep (PLMS) are frequent neurological diseases that, in their developed forms, lead to a sleep disturbance. The disease occurs in the primary and secondary forms - secondary forms are accompanied by other states such as terminal stadium of renal failure, iron deficiency and pregnancy. PLMS that are characterized by stereotyped and regular limb movements in sleep occur in 80% of the patients with RLS [7-9]. The disease diagnosis is set based on polysomnography examination or actigraphy. Dopaminergic therapy is the most efficient treatment for these diseases [12]. Periodic limb movements during the experiment in pyjamas I. and II. are shown in Figure 8.

3.5 Bradycardia and tachycardia

Slow or irregular heart rhythm usually with the frequency less than 60 heart contractions per one minute is understood as *bradycardia*. At this frequency, heart is not able to distribute sufficient volume of oxygen-rich blood into the body. [13]. The results of bradycardia during sleep in pyjamas I. and II. are shown in Figure 9. Overall duration of bradycardia at sleep in the first to third test of pyjama I. was as follows: 1139 s, 41 s and 986 s. Overall duration of bradycardia at sleep in the first to third test of pyjama II. was as follows: 2979 s, 936 s and 796 s.

Tachycardia is characterized by fast or irregular heart rhythm with the heart rate exceeding 100 per one minute. If the above mentioned increased heart rhythm occurs, heart is not able to supply the body with oxygen-rich blood sufficiently [14].

The results of tachycardia during sleep in pyjamas I. and II. are listed in Figure 10. The record of the third test of pyjama I. is not stated.

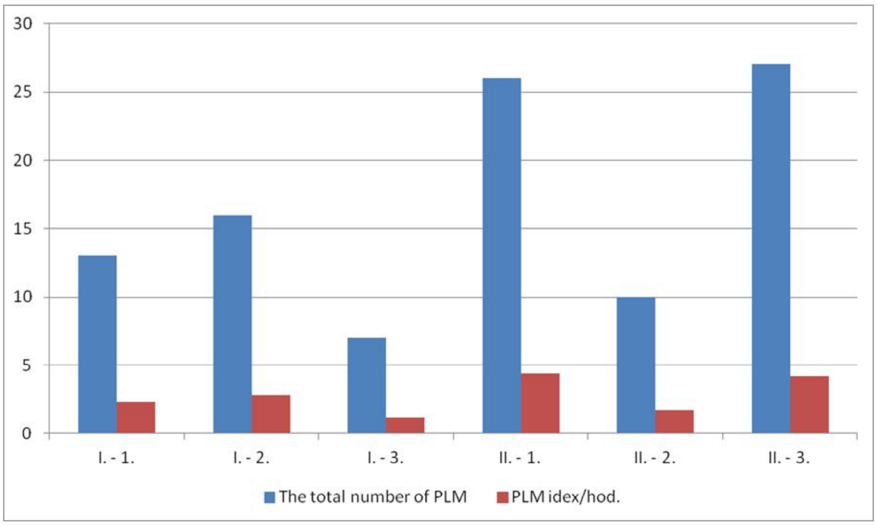

Figure 8 Periodic limb movements in sleep

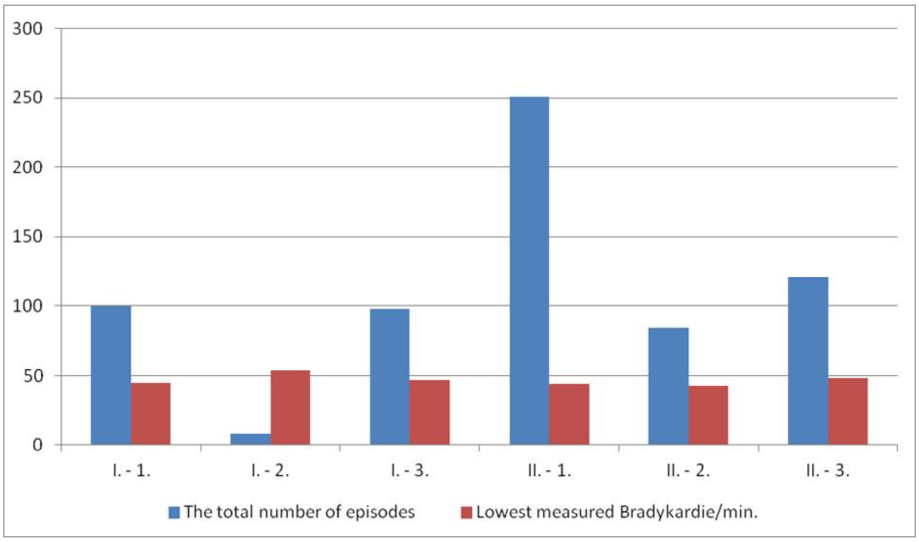

Figure 9 Bradycardia during sleep in pyjamas I. and II.

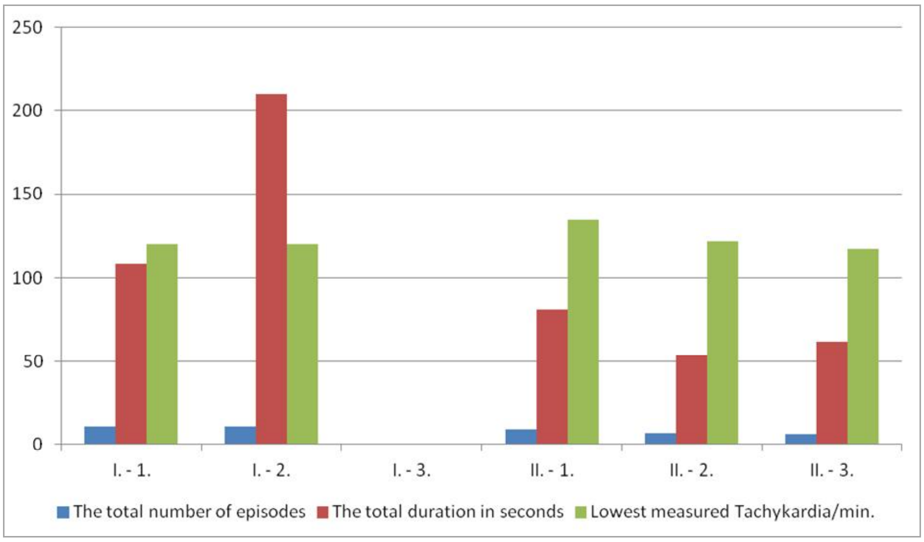

Figure 10 Tachycardia during sleep in pyjamas I. and II.

4 ASSESSMENT DIAGNOSTICS OF SLEEP

Diagnostics of sleep in pyjamas I. and II. are graphically documented in individual sub-chapters in section 3 of this article. The results of *sleep* from the monitoring polysomnography system Alice6 are in Table 1 and the results of *cardio* in Table 2. They provide the information about the number and duration of individual events as well as possible disorders connected with the position of the body.

The quality of sleep and its assessment is influenced by the following changes: environment, in which the proband stayed during the research and probands' daily regime particularly relating to the time of falling asleep, differences in falling asleep – proband's state and activities before sleep. When assessing the pyjamas, proband assessed pyjama I. as nicer and finer, as for the sensation.

The results of the diagnostics test have shown that the structure of sleep during all measurements in pyjama I. and in pyjama II. is basically maintained and no waking occurred. Waking-up occurred in the second week when monitoring was interrupted by waking up due to a siren. No other significant differences concerning the pyjama proband was wearing for sleep, or other influences that would have an impact on breathing, heart and pulse frequency are recorded.

Table 1 Results of ***sleep*** from the monitoring polysomnography system Alice 6

Sleep	Kind of pyjama					
	i.	i.	i.	ii.	ii.	ii.
AHI	1.6	1.2	1.7	0.8	1.3	1.6
OA/hour	0.4	0.7	0.3	0.0	0.0	0.0
HY/hour	0.4	0.2	0.2	0.2	0.2	0.5
MA/hour	0.0	0.0	0.2	0.3	0.5	0.3
CA/hour	0.9	0.4	1.0	0.3	0.7	0.8
de-saturation/hour of sleep	1.4	1.4	1.5	2.2	1.0	2.0
the lowest measured saturation	93%	91%	93%	93%	88%	89%
average saturation during the entire night	96%	95%	96%	96%	96%	96%
patient spends the sleep timesin saturation below 90%	0%	0%	0%	0%	10%	0%
snoring	4 min., it means 1.2% of overall time of sleep	0.2 min., it means 0.0% of overall time of sleep	19.5 min., it means 5.5% of overall time of sleep	1.1 min., it means 0.3% of overall time of sleep	22.1 min., it means 6.2% of overall time of sleep	3.8 min., it means 1.0% of overall time of sleep

Table 2 Results of ***cardio*** from the monitoring polysomnography system Alice 6

Cardio	Kind of pyjama					
	i.	i.	i.	ii.	ii.	ii.
asystole	0	0	0	0	0	0
bradycardia	100 episodes of 1139 sec.	8 episodes of 41 sec.	98 episodes of 986 sec.	251 episodes of 2979 sec.	84 episodes of 936 sec.	121 episodes of 796 sec
the lowest heart rate	45/min.	54/min.	47/min.	44/min.	43/min.	48/min.
tachycardia	11 episodes of 108 sec.	11 episodes of 210 sec.	0 episodes of 0 sec.	9 episodes of 81 sec.	7 episodes of 54 sec.	6 episodes of 62 sec.
the highest heart rate	120/min.	120/min.	0/min.	135/min.	122/min.	117/min.
periodic limb movements in sleep	2.3/hour	2.8/hour	1.2/hour	4.4/hour	1.7/hour	4.2/hour
structure of sleep	maintained	normal	maintained	normal	normal	slight increase of the time of shallow sleep
proportion of rem	low	decrease of rem proportion	decrease of rem proportion	monitoring disturbed	proportion of the deep sleep stages	slight increase of the time of shallow sleep

5 CONCLUSION

Measurement was carried out in a short period of time and in the minimum number. For more objective results of measurements and monitoring of the quality of sleep in new kinds of clothing it would be appropriate to plan another longer-lasting research, i.e. – minimum duration for three months, more measurements on more probands (men and women).

The Alice6 system provides the laboratory with a basic set of channels, which:

- allow the physician to rather attend to the patient than to operate technology
- allow to fulfil the AASM (American Academy of Sleep Medicine) standards created to ensure the highest quality of care for patients with sleep disturbances.

Somnologists can use the Alice6 system as a key item for provision of effective routine polysomnography [4].

The Alice6 system can be used in applied research for testing sleep due to external effects such as the type and kind of clothing, its fibre composition, kind of mat and mattress, on which the proband sleeps.

6 REFERENCES

[1] Poruchy spánku: http://www.tchiboblog.cz/o-poruchach-spanku-s-profesorkou-nevsimalovou/?utm_source=google&utm_medium=search&utm_campaign=PoruchySpanku

[2] Systém Alice 6:
http://www.saegeling-mt.cz/produkty/spankova-medicina/diagnosticke-systemy/polysomnograficke-systemy/product/polysomnograficky-system-alice-6-lde-1/

[3] Spánková laboratoř:
http://www.spatnespim.cz/id84.htm

[4] Polysomnografie: http://www.spatnespim.cz/id74.htm

[5] Nagy, L, Havelka, A, Jandová, S., Kus, Z.: Physiological Comfort in Garments for Sport Activities and its Testing. In: Luo Q. (ed.) Sports

Technology and Engineering: Proceedings of the 2014 Asia-Pacific Congress on Sports Technology and Engineering. London: CRC Press, 2015, 347-351

[6] Pletenina na bázi vlákna Tencel TencelC/Tencel+PADh. VÚB a.s., Clevertex, Ústí nad Orlicí, Česká republika

[7] Novák, V., Plačková, M.: Spánek a hypertenze. Centrum pro poruchy spánku a bdění. FN Ostrava, 2012

[8] Šonka, K., Slonková, J.: Spánková apnoe dospělého věku. LF UK a VFN, Praha, FN, Ostrava, 2008

[9] Šonka, K. a kol.: Apnoe a další poruchy dýchání ve spánku. Copyright© Grada Publisching, a.s., 2004

[10] Respirační události: http://telemedicina.med.muni.cz/pdm/detska-neurologie/index.php?pg=poruchy-spanku--poruchy-dychani

[11] Oxymetrie: http://www.skialpnadhrobem.cz/guide/zdravoveda/co-to-je-oxymetrie/

[12] Restless legs syndrome: http://www.medicinapropraxi.cz/pdfs/med/2012/01/06.pdf

[13] Bradykardie: http://www.medtronic.cz/vase-zdravi/bradykardie/index.htm

[14] Tachykardie: http://www.medtronic.cz/vase-zdravi/tachykardie/

HODNOCENÍ KVALITY SPÁNKU POUŽITÍM SYSTÉMU ALICE6

Translation of the article

Examination of sleep disturbances using the ALICE6 system

Článek je zaměřen na monitorování kvality spánku v pyžamech s rozdílným materiálovým složením. Diagnostika je provedena opakovaně na jednom probandovi ve spánkové laboratoři pod odborným vedením primáře ORL oddělení Krajské nemocnice Liberec, na TUL v Liberci na polysomnografickém systému ALICE6 a software Sleepware G3. Pomocí různých sond se zaznamenávají projevy spánkových poruch, aktivity mozku - EEG, měří se aktivita svalstva na obličeji, pohyby očí, pohyby končetin ve spánku, množství kyslíku v krvi apod. Výsledky diagnostického testu ukázaly, že struktura spánku je v podstatě během všech měření v pyžamu I. a v pyžamu II. zachována. Nedocházelo k buzení. Důležitý je ale režim probanda, týkající se doby usínání a činnosti před spaním. Objektivnější výsledky by se projevily při výzkumu většího počtu probandů.

DESIGN OF NEW ARTICLES OF CLOTHING USING PRINCIPLES OF CONTEMPORARY STYLE DIRECTIONS IN ARCHITECTURE AND ART

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Abstract: *This article considers the results of new articles of clothing design using principles of contemporary style directions in architecture and art. The design of particularly new articles of clothing with help of modular design method - origami method has been defined. Suggestions and recommendations for application of this method have been developed.*

Key words: design of new articles of clothing, design techniques, modular design of clothes, new articles of modern clothes, contemporary style directions.

1 INTRODUCTION

Development of a contemporary dress and related fashion is an important part of material and spiritual life of human society, which serves as a link between past, present and future. Everything is intertwined in contemporary world. Scientific and technical progress intrudes increasingly and yet more into the field of art, architecture and fashion.

Day after day, we have been approaching to the future with fantastic buildings, “smart” technology and clothes, which may be changed in form, colour and temperature. Architecture obviously makes a great impact on fashion.

Nowadays a new term “architectural fit” has been accustomed to the fashion industry, and numerous designers have coordinated with each other in order to search for a new design of articles of clothing and create interesting projects.

2 EXPERIMENTAL

Contemporary architecture and art constitute the styles without stereotypes and set rules, they are abstract, with strong emotional component, designed according to principles of composition or without proportions, symmetry and logics, they are unique and unpredictable. All these features are appropriate for creation of new edgy clothes (Table 1) [1-3].

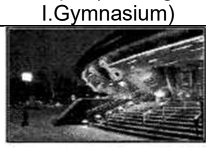
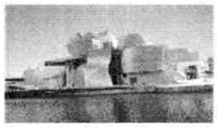
Let us consider the examples substantiating this new direction in order to apply new methods to any kinds of special clothing.

Object of research is the process of design of new articles of clothing using principles of contemporary style directions in architecture and art.

Research methods are based mainly on empirical research and associative methods which are the underlying principles of creative concept. In the course of doing research, the general methodology of systemic approach to clothing design, analysis and synthesis as theoretical methods of scientific research, and contemporary methods of design-projecting, particularly, combinatorial analysis based on search, investigation and appliance of principles of variable change of spatial, constructional, operational and graphical structures, as well as on clothing design with the help of typified elements, were used.

In order to solve the problems, experimental research methods of creating new articles of clothing with the modular design method – the method of "origami" – were used. This method of folding was borrowed from the art of "origami" - the art of paper folding. The purpose of this art is to create works of art using a scheme of geometrical bends and folds. Only few different folds are used in Origami but they can be variously combined and form very complex shapes. This method gives a possibility to create new articles of modern clothes [4].

Table 1 Styles of contemporary architecture

	High-tech	Deconstruction	Techno	Biomorphic	Brutalism
Major features	Application of high technologies and non-conventional construction materials, as well as glass and metal (N. Foster, R. Rogers, N. Greamshow, K. Tange, P. Piano)	Visual complexity, unexpected broken patterns, deliberately aggressive intrusion into local environment (К. Himmelblau, P. Eisenman, F. Gehry, Z. M. Hadid, R. Koolhaas, D. Libeskind)	Various communications located outside the buildings: pipes, reinforcement, channels with decorations; residential buildings resemble plants and shops. (К. Tange, I.Gymnasium)	Active use of latest computer technologies and mimesis in architecture (F. Gehry, F. Hundertwasser)	Striking capacity of constructions and volumes, bold large-scale compositional solutions (Elison and Peter Smithsons, H. Kalmann, M. McKinnel, E. Nowles, Д. Lasdan)
Examples	 Sogetsu Hall. Arch. – Kenzo Tange	 Central Library in Seattle. Arch. – Rem Kiokhais	 Gorkovskaya (suburban station, Sankt-Petersburg)	 Guggenheim Museum, Bilbao. Arch. – Frank Gerry, 1997 p.	 Parliament Building, Bangladesh. Arch. – Luis Kan
	 Residential tower Suite Vollard in Brasilia	 Museum of World War. Arch. – D. Libeskind	 Headquarters of Fuji TV. Arch. – Kenzo Tange	 Guggenheim Museum, Bilbao. Arch. - Frank Gerry, 1997 p.	 Hazel Library of California University

The purpose of this paper is to create modern clothes using the principles of contemporary style directions in architecture and art based on the formation of new challenges in designing clothes and new technological solutions.

- To develop a “suit-human-environment” system to form the object of design as a system of interrelated material, functional and cultural elements, that determines distinct functional links between the environment, its elements and processes that are created in cooperation with the a human;
- To develop a creative concept of style-making of contemporary art and architecture;
- To analyse and systematize principles of the origami folding and their basic modules;
- To develop a constructive module for creating articles of clothing;
- To develop schemes of designing new articles of female shoulder clothes on the basis of the origami folding principles;
- To develop suggestions and recommendations on how to use the origami method to develop new articles of clothing and accessories.

3 RESULTS AND DISCUSSION

The major artistic devices of an architect and fashion designer are geometric measurements which form the basis of any building or piece of clothing. However, unlike the architect who uses these forms freely, the fashion designer is relatively limited in their work since it relates to the human figure. This prerequisite distinguishes the creative work of the artist-fashion designer from an architect-designer. Clothing composition is based on a set of fixed measurements (parts), comprising clothes, the ratio of these measurements, the overall proportions of clothing, silhouette. Thus, the most characteristic lines, shapes, proportionate division of the building, its texture and colour qualities, in short, all that contains creative content of an object shall be selected for the study of the creative source [5, 6].

Fashion designers are turning to a variety of design techniques in order to reflect lines and shapes of contemporary architecture in clothing. One of them is the method of origami that refers to a modular design of clothes. This method involves structural, technological and functional completeness (Figure 1).

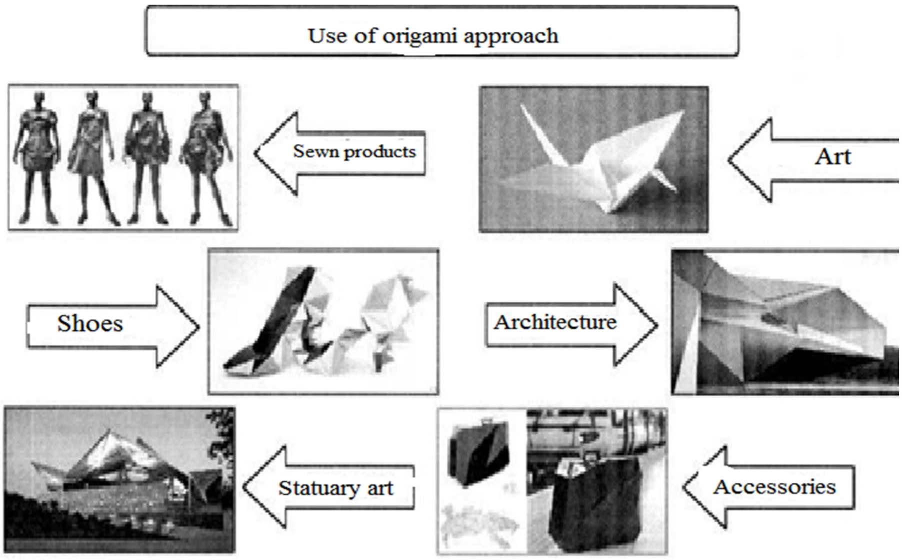


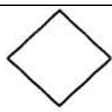
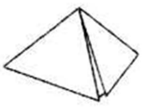
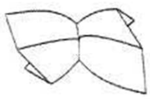
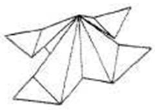
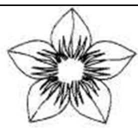
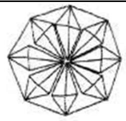
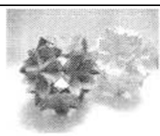
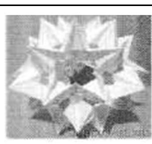
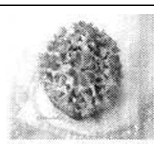
Figure 1 Use of origami approach in various areas of industrial design

Use of modular design is considered the highest form of activity in the branch of standardization. In this respect, standardization detects and fixes the most advanced methods and design tools. This method contributes to unification of the structural elements of the products. The availability of building blocks and standard parts used in various combinations enables to transform the design of some products into other ones [7]. Thus a modular method of modern designing of clothes is often used by fashion designers; in particular, the use of modular method of origami art in designing of new articles of clothing becomes very popular (Table 2).

It is known that a human is a modelling object of a dress - their image, proportions and figure structure features. The very figure with its curves and posture determines the character of a dress shape. The surface of the human figure, mannequin, and clothing constitutes a non-geometric surface, and can be expanded only with some approximation in relation to designing of clothing.

The shape of a clothing detail from a fully flattened material is obtained either through its constructional division into parts applying such elements as seams, gores, tucks, or by means of compulsory change of geometric dimensions of cutting in separate areas using stretching or velouring both on the basis and in weft and in oblique course [8].

Table 2 Use of origami modules in modern clothing

Basic module						
Derivative module						
Origami product						
Clothing model						

Every curved complex shape existing in the nature can be inscribed in a simple geometric figure. So, the volumetric human figure can be inscribed in a cylinder. Since the development of a cylinder is a rectangle, a simplified development of a human figure is also a rectangle. The module is the elementary unit of measurement which is repeated and folds without remainder in a coherent form.

The origami modules are a simple geometric shape - square. But in order to obtain the dimensions of the module, it is necessary to compare it with the development of a human figure. To do this, it is necessary to define the required outline dimensions of the finished product – product width in the chest line, finished product length. Using these dimensions, a square side can be calculated by the theorem of Pythagoras (Figure 2).

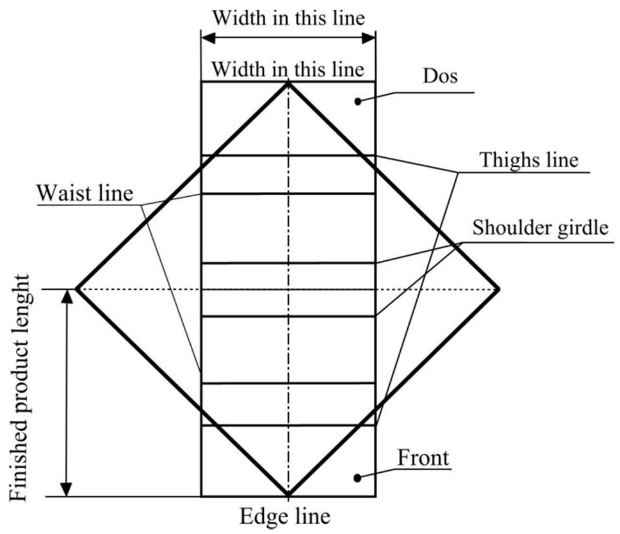


Figure 2 Design principle of the origami module for creating new articles in the modern clothing

Product width in the chest line = chest third +
+ widening for a loose joining in chest third line (1)

Finished product length = distance from the neck shoulder point to the waist +
+ ½ distance from the neck shoulder point to the waist ± widening to the distance from the neck shoulder point to the waist (2)

Square side^2 *= finished product length*^{2} *+*
+ finished product length^2 *= 2.finished product length*^{2} (3)

Thus, after determining the outline dimensions of the module, the operations of folding it around the human figure are done. That is creation of volumetric shape with a flat piece of material. Initial design is transformed into a finished product with the help of folding and some cutting out (Figures 3 and 4).

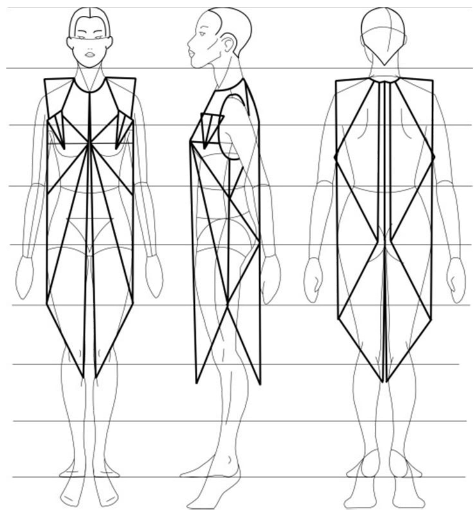


Figure 3 Sketch of folding a women's vest

There are two main stages of folding. The first stage involves folding with further development. A so-called "net" is formed.

The underlying net structure can be based on the shape of an equilateral triangle or a square. The existence of only two net bases is possible due to the fact that an equilateral shape must form the basis: a triangle or a square. There are possibilities of using other equilateral shapes, such as hexagon, rhombus, but all of them consist of equilateral triangles.

The second stage involves deflection along the lines of the first pattern and forms shapes very different from the first sample. The second sample is flat or textured designs. This is what is considered to be the final sample of the finished product. The Figure 3 shows a diagram of folding women's vest.

Thus, the result of the work is the creation of new articles of clothing with the help of the modular design method – the origami method.

The Figure 5 shows a collection of women's vests using the principles of contemporary style directions in architecture and art.

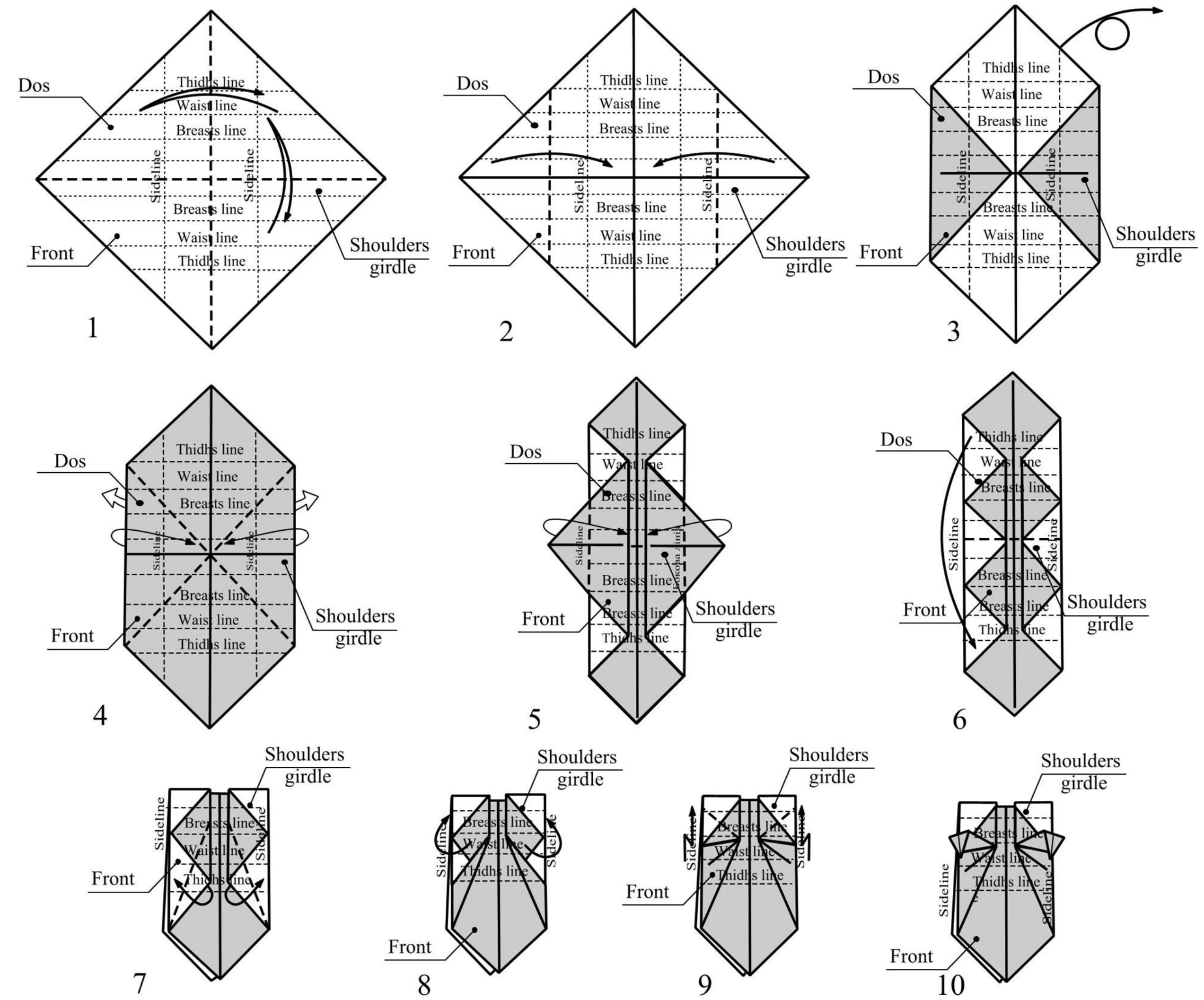


Figure 4 Diagram of folding a women's vest

Figure 5 Collection of women's vests using the principles of contemporary style directions in architecture and art

4 CONCLUSIONS

Thus, due to the definition of the ways to improve the modern process of clothing design, the creative concept of clothes collection on the basis of the examples of contemporary architecture and art has been developed. Using the modular design method a fundamentally new method of creating modern shapes of a dress – the origami method – has been mastered.

Based on the research results, the designer's offers as to creating new articles of clothing using contemporary style directions in architecture and art by the origami method have been developed. It has been examined that this method is appropriate when creating all other design objects that surround a person.

5 REFERENCES

[1] Malinska A.M., Pashkevich K.L., Smirnova M.R., Kolosnichenko O.V.: Design clothing collections, PP "NVC"Profi", Kiyiv, 2014, 140 p.

[2] Kolosnichenko O.V.: The development approaches to the new forms of clothes creation with signs and symbols of Tripill culture by designing methods, Vlákna a textile Vol. 2, 2013, pp. 41-45

[3] Chouprina N.V.: Characteristics of «fast fashion» concept in fashion industry, Vlákna a textile Vol. 1, 2014, pp. 31-36

[4] Em A.: Origami. We figure out step by step, Harwest, Minsk, 2010, 319 p

[5] Efimov A.V., Minervin G.B., Shimko B.T.: Design of architectural environment, Architecture-C, Moscow, 2005, 504 p

[6] Ermilova V.V., Ermilova D.U.: Modeling and decoration of clothes, Skill; Academy; High School, Moscow, 2001, 180 p

[7] Kolosnichenko M.V., Zubkova L.I., Pashkevich K.L., Polka T.O., Ostapenko N.V., Vasileva I.V., Kolosnichenko O.V.: Ergonomics and design. Designing of modern types of clothing, PP "NVC"Profi", Kiyiv, 2014, 386 p

[8] Docenko A.,: Characterization methods of clothing design, Fashion technology №2, 2002, pp. 10-14

OBJEKTIVNÍ HODNOCENÍ OMAKU FUNKČNÍCH PLETENIN

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Abstrakt: *V tomto článku je objektivně hodnocen omak (senzorický komfort) funkčních pletenin. Objektivní měření omaku je provedeno pomocí systému japonských přístrojů dle Kawabaty pro měření vlastností významných pro objektivní hodnocení omaku textilních struktur. Každé stanovení probíhá při standardním zatížení, které odpovídá malé deformaci, podobně jako při ohmatání textilie rukou. V experimentální části jsou porovnány naměřené hodnoty omaku funkčních pletenin bez použití aviváže a s použitím aviváže, která se běžně aplikuje na textilní výrobky v poslední fázi pracího cyklu, kdy se přidává do poslední máchací lázně.*

Klíčová slova: *objektivní hodnocení omaku, měřící systém KES, aviváž, primární omak.*

1 ÚVOD

Při výrobě textilních struktur je kromě jiného kladen důraz na komfortní vlastnosti daného materiálu. Zejména pak na vjemy získávané mechanickým a tepelným kontaktem pokožky s textilií. Komfort přímo souvisí s fyziologickými procesy v našem těle. Pokud je povrch textilie příliš hladký (plochý), ve styku se zpocenou pokožkou přilne. Pokud má příliš mnoho tuhých konců vláken, textilie na kůži škrábe [1].

Senzorický komfort textilií (omak) je soubor parametrů, které souvisí s vlastnostmi materiálu, jako je ohebnost, stlačitelnost, pružnost, pevnost, hustota, dále povrchové charakteristiky (drsnost, hladkost). Omak lze objektivně měřit pomocí systému přístrojů KES (Kawabata Evalution Systém), který je k dispozici na katedře oděvnictví FT [2] a který umožňuje měření takových výše uvedených vlastností materiálu.

Aviváže obsahují kationtové povrchově aktivní látky, které jsou fixovány na povrch textilie a vytvoří lubrikační vrstvu. Tato vrstva plní několik funkcí:

- snižuje tvorbu elektrostatického náboje u syntetických textilií a všechny jeho projevy (lepení, jiskření, praskání),
- snižuje špinivost textilie v důsledku eliminace vysokého povrchového elektrického odporu vláken a jejich nabíjení elektrostatickým nábojem,
- zlepšuje omak zvýšením hebkosti a hladkosti povrchu vláken a jejich vzájemnou schopností smyku ve struktuře textilie,
- zvyšuje pružnost vláken, která ovlivňuje schopnost stálosti tvaru v procesu užívání,
- snižuje oděr vláken a tím prodlužuje původní vzhled textilie
- snižuje tvorbu žmolků stabilizací polohy vláken v textilii, zabráněním vyčnívání volných konců vláken na povrch textilie,
- zvyšuje rychlost sušení, neboť lubrikační vrstva brání průniku vody do vláken, a snižuje obsah zbytkové vody po odstředění. Toto zkrácení doby sušení představuje 3-6 min. při použití sušičky,
- zvyšuje dojem čistoty a svěžesti prostřednictvím působení vonných látek.

Popsané účinky lze vyvolat použitím aviváže, jejíž množství je nutno dodržet.

Doporučuje se dávkovat

- 36 ml aviváže na 4,5 kg bavlněného prádla,
- 24 ml aviváže na 2 kg vlny,
- 18 ml aviváže na 2 kg syntetických textilií.

Aviváž se nesmí aplikovat na výrobky s funkcí ochrany proti povětrnostním vlivům, tedy na materiály vnější vrstvy oblečení.

Jedná se o funkční a membránové outdoorové oděvy, neboť poškozuje funkci nepronikavosti vody, odolnosti vůči vodním parám a větruodolnosti. U výrobků s membránou může aviváž snížit, případně zničit její funkčnost. Údržba takovýchto výrobků se musí striktně podřídit doporučení výrobce. Některé speciální funkční a ochranné vlastnosti plošných textilií mohou být rovněž použitím aviváže dotčeny. Aviváž se nesmí používat na výrobky s ochrannou funkcí proti ohni, neboť zlepšuje podmínky hoření. Ošetření aviváží snižuje kapilární výkon některých profilovaných syntetických materiálů a tím zhoršuje jejich celkový transport vlhkosti [3].

2 PRINCIP MĚŘÍCÍHO SYSTÉMU KES

Vlastní měřící systém je složen ze 4 přístrojů:

KES 1 – měření tahu a smyku

KES 2 – měření ohybu

KES 3 – měření tlaku

KES 4 – měření povrchových vlastností.

2.1 Měřící software a standardní podmínky měření

Velikost deformačních sil za standardních měřících podmínek je daná měřícím software a je definovaná takto:

- Při měření tahových vlastností je za standardních podmínek vzorek namáhán do meze 490 N/m (500 gf/cm) ve směru osnovy a útku.
- Při stanovení smykových charakteristik je vzorek vystaven deformaci smykem v obou směrech ke zvolenému úhlu smyku, standardně ±8 stupňů.
- Při zjišťování ohybových vlastností je vzorek textilie rovnoměrně ohýbán do mezí křivosti ±2,5 cm^{-1}, opět v obou směrech.
- Měření kompresních vlastností probíhá za působení tlaku na materiál až do meze 4900 N/m² (50 gf/cm^2).
- Povrchové vlastnosti jsou dány hodnotou koeficientu tření a geometrické drsnosti, které jsou snímány pomocí dvou čidel ve směru osnovy a útku po dráze 30 mm a zpět. Hodnoty jsou vyhodnocovány na střední dráze 20 mm. Vzorek je v čelistech upnut pod předpětím 19,6 N/m (20 gf/cm).

Výše uvedené schéma deformačních sil je vhodné pro tkané oděvní materiály [2].

2.2 Kalkulační software KES

Celková hodnota úrovně omaku je hodnocena dvoustupňově, kde v první fázi je hodnocen omak primární (HV) a na jeho základě je vyčíslen omak celkový (THV).

Primární omak HV - je vyjádřen užitnými vlastnostmi KOSHI - tuhost, NUMERI - hladkost, FUKURAMI - plnost a měkkost, které jsou považovány za základní pro zvolený účel použití. Podle intenzity jejich projevu jsou hodnoceny ve škále 1-10, kde 10 představuje silný projev vlastnosti v hodnocení omaku.

Konečné celkové hodnocení omaku textilie se označuje jako totální omak THV - TOTAL HAND VALUE. Nabývá hodnot ve škále 1-5 [2], jak ukazuje Tabulka 1.

Tabulka 1 Klasifikace celkového hodnocení omaku

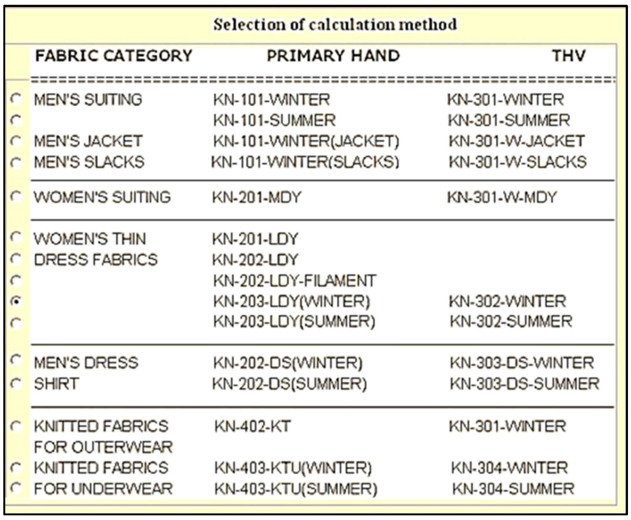
Klasifikace THV	
1	velmi špatný, nevyhovující
2	podprůměrný
3	průměrný
4	nadprůměrný, velmi dobrý
5	výborný

2.3 Úprava podmínek měření a vzorků pletenin

Doporučené standardní podmínky měření nelze uplatnit při měření a vyhodnocení objektivního omaku vysoce tažných pletenin. Největší problémy vznikají při měření tahových charakteristik na přístroji KES FB1-Auto, neboť v důsledku vysoké tažnosti nevyhovuje stávající upínací mechanizmus. Podobný problém vzniká při stanovení povrchových charakteristik na přístroji KES FB4-Auto. Toto měření probíhá při předpětí vzorku, kde pro vysokou tažnost není možné zajistit korektní funkci upnutí vzorku v čelistech stroje a jeho pohyb pod kontaktními senzory.

Z těchto důvodů byly podmínky měření tahových vlastností pletenin na stroji KES FB1-Auto upraveny snížením deformační tahové síly, kde limitním faktorem byla hodnota tažnosti 30%. Experimentálně byla úspěšně ověřena deformační tahová síla 24,5 N/m.

Pro měření na přístroji KES FB4 byla provedena úprava vzorku spočívající ve snížení tažnosti pleteniny, aby při upnutí vzorku pod předpětím nedocházelo k vysunutí čelistí mimo standardní pracovní prostor. Vzorky pletenin byly opatřeny nažehlovací vložkou typu vliselin, která fixovala strukturu pleteniny z rubní strany, snížila její tažnost a deformaci struktury po roztažení a neovlivnila povrch vzorku. Ve vyhodnocení měření v KES CALK byla použita kategorie užívání KN-203-LDY; KN-302 WINTER (Obrázek 1).



Obrázek 1 Hodnocené kategorie účelu použití v programu KES CALK

3 EXPERIMENT

3.1 Testované materiály a postup práce

Pro testování omaku byla vybrána sada termoregulačních a termoizolačních pletenin vyvzorovaných společností VÚB a.s. Ústí nad Orlicí. Materiálové složení, druh pleteniny a plošnou hmotnost textilie ukazuje Tabulka 2.

Soubor experimentálních vzorků byl hodnocen po procesu praní a sušení. Pro praní byl použit běžný prací prostředek Formil, teplota lázně 40°C.

Pro stanovení vlivu aviváže na hodnotu omaku byla použita komparativní metoda, kdy experimentální vzorky byly hodnoceny bez aviváže a po ošetření aviváží Lenor v množství 20 ml na 2 kg funkčních pletenin.

3.2 Zkušební podmínky

Podmínky měření byly vztaženy na velikost vzorků 200x200 mm. Každý vzorek byl měřen ve směru sloupku a řádku. Pro výpočet omaku byl použit průměr hodnot z obou směrů měření.

KES FB1-Auto-TAH
Podmínky měření:
senzitivita standard
rychlost 0,1 [mm/s]
vzdálenost čelistí 5 [cm]
maximální tahová deformační síla 25 [gf/cm]

Hodnocené charakteristiky vlastností:

LT	linearita (křivky zatížení-protažení)	[-]
WT	tahová energie na jednotku plochy	[gf.cm/cm^2]
RT	elastické zotavení	[%]
EMT	tažnost při max. tahové síle	[%]

KES FB1-Auto-SMYK
Podmínky měření:
senzitivita standard
konstantní předpětí vzorku 10 [gf/cm]
vzdálenost čelistí 5 [cm]
maximální smykový úhel ±8 [°]

Hodnocené charakteristiky vlastností:

G	tuhost ve smyku na jednotku délky v mezích od 1,0° do 3,0°(±)	[gf/cm.degree]
2HG	hystereze smykové síly při smyk. úhlu ±1,0°	[gf/cm]
2HG5	hystereze smykové síly při smyk. úhlu ±5,0°	[gf/cm]

KES FB2-Auto-OHYB
Podmínky měření:
senzitivita 20 standard
rychlost 0,5 [cm/s]
vzdálenost čelistí 1 [cm]
maximální křivost K ±2,5 [cm^{-1}]

Hodnocené charakteristiky vlastností:

B	ohybová tuhost vztažená na jednotku délky v mezích křivosti 0,5 - 1,5 cm^{-1} (±)	[gf.cm^2/cm]
2HB	hystereze ohybového momentu na jednotku délky při křivosti ±1,0 cm^{-1}	[gf.cm/cm]

KES FB3-Auto-KOMPRESE
Podmínky měření:
kompresní rychlost 50 [s.mm^{-1}]
plocha čelisti 2 [cm^2]
maximální zatížení 50 [gf/cm^2]

Hodnocené charakteristiky vlastností:

LC	linearita (křivky tlak-tloušťka)	[-]
WC	energie stlačení	[gf.cm/cm^2]
RC	elastické zotavení	[%]
T_0	tloušťka textilie (při tlaku 0,5 gf/cm^2)	[mm]
T_M	tloušťka textilie (při tlaku 50 gf/cm^2)	[mm]

KES FB4-Auto-POVRCHOVÉ VLASTNOSTI
Podmínky měření:
senzitivita standard
rychlost posunu vzorku 1 [mm/s]
napětí vzorku 20 [gf/cm]
kontaktní síla 10 [gf]

Hodnocené charakteristiky vlastností:

MIU	střední hodnota koeficientu tření	[-]
MMD	střední odchylka koeficientu tření	[-]
SMD	střední odchylka geometrické drsnosti	[μm]

Poznámka: 1 gf/cm odpovídá cca 0,98 N/m.

Tabulka 2 Parametry vybraných testovaných materiálů

Vzorek	Materiálové složení [%]	Druh pleteniny	Plošná hmotnost [g/m²]
1	50Viloft/50PP	ZJ plyš s kanálky barvený	253,2
2	100 Porexil Warm&light	ZO hladká barvená	182,7
3	50PorexilThermocool/50Tencel C	ZJ vzorová chytová	119,7
4	50 Smartcel^{TM}Clima/50CO+EL	ZO 1:1 hladká barvená	253,5
5	39Viloft/37PESstandard/21PES dutá vlákna/4EL	Jednoduchý výplněk	372,0

3.3 *Výsledky měření*

Na základě proměření souboru vzorků a stanovení jejich 15-ti charakteristik (viz Hodnocené charakteristiky vlastnosti, kap. 3.2 Zkušební podmínky) a po vložení plošné hmotnosti pletenin do sofistikovaného výpočetního software KES CALK, který je součástí testovacího souboru přístrojů KES, bylo provedeno hodnocení primárního (HV) a celkového omaku (THV) vzorků ve vybrané kategorii užívání. Výsledky měření ukazují obrázky 2-12 pro každou testovanou pleteninu.

ITEM			WARP	WEFT	MEAN	$(x-\bar{x})/\delta$
TENS.	EM	[%]	14.50	27.10	20.80	
	LT	[-]	0.828	0.797	0.812	0.7689
	WT	[g.cm/cm^2]	1.50	2.70	2.10	1.7137
	RT	[%]	43.33	53.70	48.52	-1.1902
BEND.	B	[g·cm^2/cm]	0.063	0.029	0.046	0.8193
	2HB	[g·cm/cm]	0.0854	0.0509	0.0682	1.4194
SHEAR	G	[g/cm·deg]	0.29	0.24	0.26	-0.6754
	2HG	[g/cm]	1.06	0.98	1.02	0.5028
	2HG5	[g/cm]	1.01	0.98	0.99	-0.0728
SURFACE	MIU	[-]	0.246	0.333	0.290	1.4158
	MMD	[-]	0.0118	0.0335	0.0227	0.1752
	SMD	[μm]	2.31	14.08	8.19	1.0609
COMP.	LC	[-]	1.019		1.019	4.6431
	WC	[g·cm/cm^2]	0.936		0.936	4.8906
	RC	[%]	38.32		38.32	-1.2451
T&W	T	[mm]	1.100		1.100	2.2065
	W	[mg/cm^2]	25.3000		25.3000	2.4933

H.V. :	KN-203-LDY
[H.V. 10 ; Strong.	H.V. 1 ; Weak .]
KOSHI	5.31
NUMERI	5.75
FUKURAMI	7.87
T.H.V. :	KN-302-WINTER
[T.H.V. 5 ; Excellent.	T.H.V. 1 ; Poor.]
T.H.V.	3.79

Obrázek 2 Experimentální data vzorku pleteniny 1 bez použití aviváže Lenor a výsledek hodnocení primárního (HV) a celkového omaku (THV)

ITEM			WARP	WEFT	MEAN	$(x-\bar{x})/\delta$
TENS.	EM	[%]	4.36	19.50	11.93	
	LT	[-]	0.917	0.759	0.838	1.0808
	WT	[g.cm/cm^2]	0.50	1.85	1.17	0.9987
	RT	[%]	60.00	59.46	59.73	-0.2371
BEND.	B	[g·cm^2/cm]	0.029	0.006	0.017	-0.3720
	2HB	[g·cm/cm]	0.0268	0.0088	0.0178	0.2810
SHEAR	G	[g/cm·deg]	0.29	0.36	0.33	-0.3707
	2HG	[g/cm]	0.53	1.16	0.84	0.3553
	2HG5	[g/cm]	0.63	1.33	0.98	-0.0851
SURFACE	MIU	[-]	0.194	0.275	0.235	0.1951
	MMD	[-]	0.0122	0.1009	0.0565	1.9872
	SMD	[μm]	2.60	8.76	5.68	0.6633
COMP.	LC	[-]	0.705		0.705	0.0038
	WC	[g·cm/cm^2]	0.425		0.425	3.8935
	RC	[%]	40.09		40.09	-1.0211
T&W	T	[mm]	0.637		0.637	1.0536
	W	[mg/cm^2]	18.2000		18.2000	1.6842

H.V. :	KN-203-LDY
[H.V. 10 ; Strong.	H.V. 1 ; Weak .]
KOSHI	4.97
NUMERI	4.67
FUKURAMI	6.77
T.H.V. :	KN-302-WINTER
[T.H.V. 5 ; Excellent.	T.H.V. 1 ; Poor.]
T.H.V.	3.17

Obrázek 3 Experimentální data vzorku pleteniny 2 bez použití aviváže Lenor a výsledek hodnocení primárního (HV) a celkového omaku (THV)

ITEM			WARP	WEFT	MEAN	$(\chi - \bar{x})/\delta$
TENS.	EM	[%]	9.56	28.10	18.83	
	LT	[-]	0.669	0.698	0.683	-0.7833
	WT	[g.cm/cm²]	0.80	2.45	1.63	1.3979
	RT	[%]	56.25	55.10	55.68	-0.5817
BEND.	B	[g·cm²/cm]	0.006	0.004	0.005	-1.8866
	2HB	[g·cm/cm]	0.0101	0.0061	0.0081	-0.3829
SHEAR	G	[g/cm·deg]	0.20	0.23	0.21	-0.9769
	2HG	[g/cm]	0.55	0.65	0.60	0.0960
	2HG5	[g/cm]	0.53	0.63	0.58	-0.5940
SURFACE	MIU	[-]	0.199	0.244	0.222	-0.0912
	MMD	[-]	0.0141	0.0271	0.0206	-0.0129
	SMD	[µm]	6.46	9.80	8.13	1.0528
COMP.	LC	[-]	0.833		0.833	1.8885
	WC	[g·cm/cm²]	0.359		0.359	3.6804
	RC	[%]	47.81		47.81	-0.0428
T&W	T	[mm]	0.449		0.449	0.3156
	W	[mg/cm²]	11.9000		11.9000	0.6405

H.V. : KN-203-LDY
[H.V. 10 ; Strong. H.V. 1 ; Weak .]

KOSHI	3.40
NUMERI	6.80
FUKURAMI	8.04

T.H.V. : KN-302-WINTER
[T.H.V. 5 ; Excellent. T.H.V. 1 ; Poor.]

T.H.V.	2.92

Obrázek 4 Experimentální data vzorku pleteniny 3 bez použití aviváže Lenor a výsledek hodnocení primárního (HV) a celkového omaku (THV)

ITEM			WARP	WEFT	MEAN	$(\chi - \bar{x})/\delta$
TENS.	EM	[%]	4.27	42.20	23.24	
	LT	[-]	1.311	1.090	1.201	5.4489
	WT	[g.cm/cm²]	0.70	5.75	3.22	2.2419
	RT	[%]	42.86	36.52	39.69	-1.9408
BEND.	B	[g·cm²/cm]	0.201	0.029	0.115	1.9317
	2HB	[g·cm/cm]	0.2759	0.0404	0.1581	2.1326
SHEAR	G	[g/cm·deg]	0.59	0.65	0.62	0.5479
	2HG	[g/cm]	2.54	1.98	2.26	1.1236
	2HG5	[g/cm]	1.96	1.46	1.71	0.4508
SURFACE	MIU	[-]	0.198	0.274	0.236	0.2221
	MMD	[-]	0.0122	0.0305	0.0213	0.0564
	SMD	[µm]	3.18	10.60	6.89	0.8727
COMP.	LC	[-]	0.445		0.445	-3.8396
	WC	[g·cm/cm²]	0.275		0.275	3.3438
	RC	[%]	40.73		40.73	-0.9407
T&W	T	[mm]	1.180		1.180	2.3546
	W	[mg/cm²]	25.3000		25.3000	2.4933

H.V. : KN-203-LDY
[H.V. 10 ; Strong. H.V. 1 ; Weak .]

KOSHI	6.38
NUMERI	6.29
FUKURAMI	8.00

T.H.V. : KN-302-WINTER
[T.H.V. 5 ; Excellent. T.H.V. 1 ; Poor.]

T.H.V.	3.96

Obrázek 5 Experimentální data vzorku pleteniny 4 bez použití aviváže Lenor a výsledek hodnocení primárního (HV) a celkového omaku (THV)

ITEM			WARP	WEFT	MEAN	$(\chi - \bar{x})/\delta$
TENS.	EM	[%]	8.51	4.49	6.50	
	LT	[-]	1.081	0.980	1.031	3.3978
	WT	[g.cm/cm²]	1.15	0.55	0.85	0.6000
	RT	[%]	60.87	54.55	57.71	-0.4090
BEND.	B	[g·cm²/cm]	0.358	0.240	0.299	3.0886
	2HB	[g·cm/cm]	0.3688	0.2875	0.3282	2.7510
SHEAR	G	[g/cm·deg]	1.06	1.16	1.11	1.3688
	2HG	[g/cm]	2.81	2.71	2.76	1.2796
	2HG5	[g/cm]	2.36	2.54	2.45	0.7981
SURFACE	MIU	[-]	0.284	0.292	0.288	1.3780
	MMD	[-]	0.0111	0.0158	0.0134	-0.8617
	SMD	[µm]	2.05	3.11	2.58	-0.1948
COMP.	LC	[-]	1.094		1.094	5.7492
	WC	[g·cm/cm²]	1.570		1.570	5.5438
	RC	[%]	43.31		43.31	-0.6131
T&W	T	[mm]	1.570		1.570	2.9572
	W	[mg/cm²]	37.2000		37.2000	3.4403

H.V. : KN-203-LDY
[H.V. 10 ; Strong. H.V. 1 ; Weak .]

KOSHI	7.95
NUMERI	6.26
FUKURAMI	8.47

T.H.V. : KN-302-WINTER
[T.H.V. 5 ; Excellent. T.H.V. 1 ; Poor.]

T.H.V.	2.94

Obrázek 6 Experimentální data vzorku pleteniny 5 bez použití aviváže Lenor a výsledek hodnocení primárního (HV) a celkového omaku (THV)

ITEM			WARP	WEFT	MEAN	$(\chi-\overline{\chi})/\delta$
TENS.	EM	[%]	12.20	25.40	18.80	
	LT	[-]	0.852	0.787	0.820	0.8606
	WT	[g.cm/cm²]	1.30	2.50	1.90	1.5905
	RT	[%]	50.00	52.00	51.00	-0.9793
BEND.	B	[g·cm²/cm]	0.071	0.025	0.048	0.8698
	2HB	[g·cm/cm]	0.0918	0.0452	0.0685	1.4235
SHEAR	G	[g/cm·deg]	0.29	0.29	0.29	-0.5457
	2HG	[g/cm]	1.11	0.90	1.01	0.4931
	2HG5	[g/cm]	0.90	0.93	0.92	-0.1489
SURFACE	MIU	[-]	0.219	0.275	0.247	0.4706
	MMD	[-]	0.0108	0.0301	0.0205	-0.0270
	SMD	[μm]	2.86	15.99	9.43	1.2132
COMP.	LC	[-]	0.460		0.460	-3.6157
	WC	[g·cm/cm²]	0.967		0.967	4.9317
	RC	[%]	38.47		38.47	-1.2267
T&W	T	[mm]	2.230		2.230	3.6978
	W	[mg/cm²]	25.3200		25.3200	2.4953

H.V. : KN-203-LDY
[H.V. 10 ; Strong. H.V. 1 ; Weak .]
KOSHI 5.13
NUMERI 7.23
FUKURAMI 9.82
T.H.V. : KN-302-WINTER
[T.H.V. 5 ; Excellent. T.H.V. 1 ; Poor.]
T.H.V. 4.84

Obrázek 7 Experimentální data vzorku pleteniny 1 s použitím aviváže Lenor a výsledek hodnocení primárního (HV) a celkového omaku (THV)

ITEM			WARP	WEFT	MEAN	$(\chi-\overline{\chi})/\delta$
TENS.	EM	[%]	6.20	23.70	14.95	
	LT	[-]	0.903	0.743	0.823	0.8966
	WT	[g.cm/cm²]	0.70	2.20	1.45	1.2576
	RT	[%]	57.14	59.09	58.12	-0.3742
BEND.	B	[g·cm²/cm]	0.023	0.006	0.015	-0.5685
	2HB	[g·cm/cm]	0.0301	0.0094	0.0198	0.3702
SHEAR	G	[g/cm·deg]	0.28	0.33	0.30	-0.4849
	2HG	[g/cm]	0.63	1.08	0.85	0.3668
	2HG5	[g/cm]	0.53	1.08	0.80	-0.2757
SURFACE	MIU	[-]	0.199	0.287	0.243	0.3788
	MMD	[-]	0.0122	0.0510	0.0316	0.8327
	SMD	[μm]	2.78	15.87	9.33	1.2016
COMP.	LC	[-]	0.397		0.397	-4.5489
	WC	[g·cm/cm²]	0.457		0.457	3.9852
	RC	[%]	39.61		39.61	-1.0827
T&W	T	[mm]	1.280		1.280	2.5263
	W	[mg/cm²]	18.2700		18.2700	1.6937

H.V. : KN-203-LDY
[H.V. 10 ; Strong. H.V. 1 ; Weak .]
KOSHI 4.35
NUMERI 6.33
FUKURAMI 8.59
T.H.V. : KN-302-WINTER
[T.H.V. 5 ; Excellent. T.H.V. 1 ; Poor.]
T.H.V. 3.73

Obrázek 8 Experimentální data vzorku pleteniny 2 s použitím aviváže Lenor a výsledek hodnocení primárního (HV) a celkového omaku (THV)

ITEM			WARP	WEFT	MEAN	$(\chi-\overline{\chi})/\delta$
TENS.	EM	[%]	8.66	28.60	18.63	
	LT	[-]	0.785	0.727	0.756	0.0933
	WT	[g.cm/cm²]	0.85	2.60	1.72	1.4715
	RT	[%]	58.82	53.85	56.33	-0.5257
BEND.	B	[g·cm²/cm]	0.007	0.005	0.006	-1.6917
	2HB	[g·cm/cm]	0.0119	0.0081	0.0100	-0.2077
SHEAR	G	[g/cm·deg]	0.20	0.19	0.19	-1.1087
	2HG	[g/cm]	0.55	0.68	0.62	0.1120
	2HG5	[g/cm]	0.48	0.58	0.53	-0.6817
SURFACE	MIU	[-]	0.237	0.221	0.229	0.0655
	MMD	[-]	0.0305	0.0219	0.0262	0.4630
	SMD	[μm]	6.58	7.97	7.28	0.9319
COMP.	LC	[-]	0.398		0.398	-4.5423
	WC	[g·cm/cm²]	0.369		0.369	3.7151
	RC	[%]	44.99		44.99	-0.4011
T&W	T	[mm]	0.933		0.933	1.8590
	W	[mg/cm²]	11.9700		11.9700	0.6549

H.V. : KN-203-LDY
[H.V. 10 ; Strong. H.V. 1 ; Weak .]
KOSHI 3.13
NUMERI 7.20
FUKURAMI 9.05
T.H.V. : KN-302-WINTER
[T.H.V. 5 ; Excellent. T.H.V. 1 ; Poor.]
T.H.V. 3.01

Obrázek 9 Experimentální data vzorku pleteniny 3 s použitím aviváže Lenor a výsledek hodnocení primárního (HV) a celkového omaku (THV)

ITEM			WARP	WEFT	MEAN	$(x-\bar{x})/\delta$
TENS.	EM	[%]	7.43	37.60	22.51	
	LT	[-]	1.238	0.979	1.108	4.3370
	WT	[g.cm/cm²]	1.15	4.60	2.88	2.1005
	RT	[%]	47.83	41.30	44.57	-1.5263
BEND.	B	[g·cm²/cm]	0.109	0.028	0.069	1.3085
	2HB	[g·cm/cm]	0.1400	0.0331	0.0866	1.6223
SHEAR	G	[g/cm·deg]	0.54	0.49	0.52	0.2791
	2HG	[g/cm]	1.81	1.51	1.66	0.8825
	2HG5	[g/cm]	1.56	1.26	1.41	0.2636
SURFACE	MIU	[-]	0.192	0.253	0.223	-0.0696
	MMD	[-]	0.0181	0.0190	0.0186	-0.2207
	SMD	[μm]	4.93	7.15	6.04	0.7293
COMP.	LC	[-]	0.474		0.474	-3.4123
	WC	[g·cm/cm²]	0.345		0.345	3.6302
	RC	[%]	42.32		42.32	-0.7390
T&W	T	[mm]	1.160		1.160	2.3186
	W	[mg/cm²]	25.3000		25.3000	2.4933

H.V. : KN-203-LDY
[H.V. 10 ; Strong. H.V. 1 ; Weak .]
KOSHI 5.92
NUMERI 6.84
FUKURAMI 8.49
T.H.V. : KN-302-WINTER
[T.H.V. 5 ; Excellent. T.H.V. 1 ; Poor.]
T.H.V. 4.40

Obrázek 10 Experimentální data vzorku pleteniny 4 s použitím aviváže Lenor a výsledek hodnocení primárního (HV) a celkového omaku (THV)

ITEM			WARP	WEFT	MEAN	$(x-\bar{x})/\delta$
TENS.	EM	[%]	12.10	5.37	8.74	
	LT	[-]	0.959	1.043	1.001	3.0392
	WT	[g.cm/cm²]	1.45	0.70	1.08	0.8892
	RT	[%]	58.62	57.14	57.88	-0.3942
BEND.	B	[g·cm²/cm]	0.223	0.212	0.217	2.7040
	2HB	[g·cm/cm]	0.2393	0.1772	0.2083	2.3658
SHEAR	G	[g/cm·deg]	0.83	0.93	0.88	1.0423
	2HG	[g/cm]	2.14	2.26	2.20	1.1017
	2HG5	[g/cm]	1.93	1.98	1.96	0.5830
SURFACE	MIU	[-]	0.286	0.303	0.294	1.5130
	MMD	[-]	0.0129	0.0133	0.0131	-0.9054
	SMD	[μm]	2.12	3.31	2.71	-0.1387
COMP.	LC	[-]	1.118		1.118	6.1074
	WC	[g·cm/cm²]	1.550		1.550	5.5276
	RC	[%]	46.39		46.39	-0.2229
T&W	T	[mm]	1.530		1.530	2.9028
	W	[mg/cm²]	37.2000		37.2000	3.4403

H.V. : KN-203-LDY
[H.V. 10 ; Strong. H.V. 1 ; Weak .]
KOSHI 7.55
NUMERI 6.38
FUKURAMI 8.55
T.H.V. : KN-302-WINTER
[T.H.V. 5 ; Excellent. T.H.V. 1 ; Poor.]
T.H.V. 3.41

Obrázek 11 Experimentální data vzorku pleteniny 5 s použitím aviváže Lenor a výsledek hodnocení primárního (HV) a celkového omaku (THV)

4 ZÁVĚR

V systému objektivního hodnocení omaku, výše uvedenou komparativní metodou, dosáhly testované pleteniny mimořádně dobrých výsledků. Z hlediska primárních vlastností (HV) disponují všechny pleteniny nízkou až průměrnou tuhostí, vysokou hladkostí a nadprůměrnou měkkostí a plností omaku. Z toho vyplývá vysoký stupeň celkového omaku (THV) dle klasifikace celkového hodnocení omaku (Tabulka 1).

Tabulka 3 zobrazuje přehledně hodnoty celkového omaku testovaných pletenin. Při použití aviváže u funkčních pletenin došlo ke zvýšení pásma omaku u dvou vzorků 1 a 2, kde byl z nadprůměrného dosažen výborný omak (č. 1) a z průměrného dosažen nadprůměrný omak u vzorku č. 2.

Tabulka 3 Hodnoty omaku testovaných pletenin

Vzorek	Praní bez aviváže		Praní s aviváží	
	THV (stupně)	*Pásmo omaku*	*THV (stupně)*	*Pásmo omaku*
1	3,79	Nadprůměrný	4,84	Výborný
2	3,17	Průměrný	3,73	Nadprůměrný
3	2,92	Průměrný	3,01	Průměrný
4	3,96	Nadprůměrný	4,40	Nadprůměrný
5	2,94	Průměrný	3,41	Průměrný

U vzorků 3-5 nemělo použití aviváže vliv na zvýšení pásma omaku. Hodnota omaku pletenin s použitím aviváže byla podobná hodnotě omaku pletenin bez použití aviváže. Došlo pouze k mírnému zvýšení omaku v rámci pásma omaku.

Na základě tohoto hodnocení lze předpokládat dobrý, velmi dobrý a výborný senzorický komfort uživatele při užívání výrobků z těchto pletenin po praní a s ošetřením aviváže Lenor. Závěrem je možno konstatovat, že z hlediska omaku je použití aviváže v procesu praní významné u dvou vzorků, a to 1 a 2, a je přínosné u zbylých tří vzorků.

PODĚKOVÁNÍ: *Tato práce byla podpořena Technologickou agenturou České republiky v projektu TERMOTEX TA02010703 - Nová generace vysoce funkčních bariérových termoregulačních a termoizolačních smart textilií pro použití v náročných a specifických klimatických podmínkách a zlepšení ochrany člověka.*

5 LITERATÚRA

[1] Hes, L., Sluka, P.: Úvod do komfortu textilií, Skripta, Technická univerzita v Liberci, 2005, ISBN 80-7083-926-0

[2] Kawabata, S.: The Standardization and Analysis of Hand Evaluation, The user´s quide, Osaka,1980, Japan

[3] Kryštůfek, J., Machaňová, D., Odvárka, J., Prášil, M., Wiener, J.: Zušlechťování textilií, Skriptum, Technická univerzita v Liberci, 2002, ISBN 80-7083-560-5

OBJECTIVE EVALUATION OF TOTAL HAND VALUE OF FUNCTIONAL KNITTED FABRIC

Translation of the article

Objektivní hodnocení omaku funkčních pletenin

This article is objectively evaluated total hand value (sensory comfort) of functional knitted fabrics. Objective measurements of total hand value by using the Japanese devices by Kawabata for measuring the characteristics important for an objective evaluation of total hand value of textile structures. Each determination is carried out at a standard load which corresponds to a small deformation similarly to the fabric fingered hands. In the experimental part the measured values of total hand value of functional knitted fabrics are compared without using fabric softener and with using fabric softener which is commonly applied to the textile articles in the last process of the washing cycle in the rinsing bath.

MULTIFUNKČNÉ TEXTÍLIE Z MODIFIKOVANÝCH PP VLÁKIEN

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Abstrakt: *Cieľom práce je výskumná príprava multifunkčných koncentrátov v kombinácii úpravy nasledovných vlastností polypropylénových vlákien: zníženie horľavosti (FR) + zvýšenie odolnosti voči UV žiareniu (UV) + antimikrobiálna úprava (AMB). V príspevku je uvedená základná charakteristika pripravených multifunkčných koncentrátov a pripravených typov polypropylénových vlákien. Ďalej sú v príspevku uvedené charakteristiky pletenín a tkanín (keprová a plátnová väzba) pripravených z PP vlákien modifikovaných multifunkčnými aditívami FR+UV+AMB. Experimentálne výsledky sú doplnené hodnotením vlastností multifunkčnej osnovnej pleteniny typu „Doppel Jersey“ pripravenej z aditivovaných PP vlákien priamo v prevádzkových podmienkach. Následne sú stručne popísané zvolené metodiky použité na hodnotenie horľavosti pletenín a tkanín, posúdenie zmeny fyzikálno-mechanických vlastností vplyvom UV žiarenia a dosiahnutej antibakteriálnej úpravy textílií hodnotenej metódou AATCC 100-2012 s použitím mikroorganizmov Staphylococcus aureus a Klebsiella pneumoniae. v diskusii sú porovnávané dosiahnuté výsledky zmeny vybraných úžitkových vlastností textílií vo vzťahu k ich konštrukcii a možnostiam použitia v praxi.*

Kľúčové slová: *multifunkčné koncentráty, multifunkčné PP vlákna, znížená horľavosť, odolnosť voči UV žiareniu, antimikrobiálna úprava.*

1 ÚVOD

Rozvoj výroby PP vlákien v súčasnosti, okrem iného, sa orientuje najmä na prípravu technických a špeciálnych typov s vysokými funkčnými a úžitkovými vlastnosťami, pričom rozšírenie sortimentu pre textilné a technické aplikácie sa uskutočňuje predovšetkým cestou fyzikálnej a chemickej modifikácie [1-4]. Medzi najviac požadované modifikácie PP vlákien, zo strany textilného priemyslu, patria: znížená horľavosť, vysoká UV stabilita, antimikrobiálna úprava, antistatická úprava a zlepšené transportné vlastnosti vo vzťahu k potu. v poslednom období sa čoraz viac objavujú požiadavky na textilné vlákna a textílie s multifunkčnými úžitkovými vlastnosťami, ktoré nie sú k dispozícii na súčasnom svetovom trhu. Jedná sa najmä o kombináciu zníženej horľavosti (FR), vysokej UV stability (UV) a antimikrobiálnej modifikácie (AMB) v jednom produkte pre oblasť textilu pre automobilový a nábytkársky priemysel. Ďalšou požiadavkou na multifunkčnosť modifikovaných vlákien a textílií je kombinácia modifikácie pre zlepšenie transportu potu (TV) a súčasne antimikrobiálnej (AMB) a antistatickej (ANT) modifikácie najmä pre športové a pracovné odevy. Najvýznamnejší svetoví producenti koncentrátov modifikačných aditív majú vo svojej ponuke len „monofunkčné“ koncentráty na PP polymérnom nosiči [2-9]. Firma Schulman ponúka pre PP fólie a pásky monokoncentráty pre AMB modifikáciu (Polybatch Abact a Polybatch Amic), pre UV modifikáciu (Polybatch FFP UVRI a Polybatch UV 38I) a FR modifikáciu (rad Polyflam). Firma Clariant ponúka pre PP fólie, pásky a vlákna monokoncentráty pre AMB modifikáciu (CESA Antimikro, Mevopur a Sanitized) a FR modifikáciu (CESA Flam). Firma Ciba (BASF) ponúka pre PP fólie, pásky a vlákna monokoncentráty pre AMB modifikáciu (Irgaguard), pre UV modifikáciu (Irgastab) a ANT modifikáciu (Irgasurf a Irgastat). Firma Gabriel Chemie ponúka pre PP fólie a pásky monokoncentráty pre UV modifikáciu (HP 794160UV, HP 793680UV a HP 793680UVAO), FR modifikáciu (HP 72521FR, HP 791460UVFR) a ANT modifikáciu (PP 791310AS a PP 78680AS20). Ani jeden zo svetových výrobcov však neponúka multifunkčné koncentráty modifikačných aditív s PP polymérnym nosičom.

Pripraviť multifunkčné vlákna z dostupných monofunkčných koncentrátov je problematické. Pridávaním viacerých „monofunkčných“ koncentrátov aditív do polymérneho systému PP vlákna sa zvyšuje podiel počtu polymérnych nosičov a cudzorodých nepolymérnych súčastí vo vlákne, mení sa reológia taveniny, čím sa polymérna zmes stáva nezvlákniteľnou. Originálny detailný výskum, orientovaný na skúmanie synergických efektov používaných a dostupných aditív a na poznanie uvedených zákonitostí v procese prípravy vlákna, umožní pripraviť PP vlákno s požadovanými viacfunkčnými vlastnosťami. Celosvetová originalita predmetného výskumu, v časti prípravy viacfunkčných vlákien, spočíva v detailnom preskúmaní znášanlivosti viaczložkového koncentrátu s PP polymérnym systémom v procese zvlákňovania spojenom so štúdiom vplyvu na morfológiu a štruktúru mikrovlákna až po vyhodnotenie funkčných vlastností.

V súčasnosti nie sú dostupné na svetovom trhu PP vlákna s viac ako dvoma permanentnými modifikáciami. Trojfunkčná modifikácia polypropylénového, v hmote farbeného, mikrovlákna je absolútnou svetovou novinkou a postup jeho prípravy s použitím jedného multifunkčného koncentrátu modifikačných aditív je vysoko inovatívny.

Funkčné textílie sú novou paradigmou pre textilný priemysel a reprezentujú silný základný sektor pre uvedené priemyselné odvetvie. Funkčné textílie sú textílie s vyššou pridanou hodnotou, ktorá zvyšuje možnosti ich využitia, tak v rámci odevných výrobkov (najmä pre šport, voľný čas, zvýšený komfort a hygienu nosenia), ale aj v sortimente technických textílií (automobilový priemysel, stavebníctvo, nábytkársky priemysel, zdravotníctvo a pod.). Súčasné trendy vo svete sú orientované na zvýšenie funkčnosti prostredníctvom:

- povrchových chemických úprav pri zošľachťovaní textílií v rámci ktorých je možné „pridanú hodnotu“ zabezpečiť ovplyvnením jednej, maximálne dvoch funkčných vlastností,
- využitia špeciálnych, aditivovaných typov vlákien prostredníctvom, ktorých je možné zvýšiť „pridanú hodnotu“ textílií zabezpečením ich multifunkčnosti, t.j. udelením synergického efektu prostredníctvom ovplyvnenia min. 2-3 funkčných vlastností textílií,
- využitím zmesných priadzí, ktoré obsahujú jednotlivé komponenty špeciálnych vlákien a ich prostredníctvom sa zabezpečí multifunkčnosť textílie.

Súčasné trendy vo svete sa orientujú aj na nasledovné spôsoby a postupy pre ovplyvnenie funkčnosti textílií [13]:

a. nanotechnológie – aplikáciou nanočastíc na chemickej báze sa zlepšujú funkčné vlastnosti napr. antimikrobiálne vlastnosti, UV odolnosť, antistatické vlastnosti, odolnosť voči zašpineniu, zlepšenie nekrčivosti,
b. antimikrobiálna úprava - zabezpečuje sa v prevažnej miere aditiváciou v hmote vlákna na potlačenie rastu mikroorganizmov (resp. ich zničenie), potláčanie nepríjemného zápachu textílií (odevné textílie pre šport a voľný čas), resp. zvýšení hygieny napr. v obuvi, bytovom textile, interiérových textíliách pre automobily, resp. v zdravotníctve. V prevažnej miere sú na aditiváciu využívané nosiče obsahujúce nanočastice. Zo známych textilných výrobkov uvádzame: Odor-Easter (obuv), Sole Fresh TM a Foot Smart (ponožky), Aegis Microbe Shield (odevy).
c. transport vlhkosti – transport vlhkosti je jedným z kľúčových kritérií funkčnosti najmä pre odevné textílie. Schopnosť odevu transportovať vlhkosť výrazne ovplyvňuje komfort nosenia. Uvedená schopnosť sa dosiahne použitím mikrovlákien alebo aplikáciou silikónov na molekulárnej úrovni v hmote vlákna s cieľom zvýšiť hydrofilné vlastnosti textílie. Zo známych príkladov zvýšeného transportu vlhkosti uvádzame textílie Coolmax (športové odevy), Coolplus (ponožky, spodná bielizeň).
d. zníženie horľavosti textílie – v súčasnosti sa všeobecne využívajú dva spôsoby pre zníženie horľavosti: aditivácia vlákna koncentrátom obsahujúcim retardér horenia a povrchová úprava prostredníctvom impregnácie textílie. Obidva spôsoby sú z hľadiska environmentálneho prísne sledované lebo využívajú prostriedky na báze zlúčenín fosforu alebo halogénových organických zlúčenín. Najdrahším spôsobom zníženia horľavosti textílií je využitie napr. aramidových vlákien s permanentnou nehorľavosťou (napr. vlákno Kermel alebo Nomex).

Aj ďalšie literárne odkazy [14-15] potvrdzujú vysoké požiadavky na viacfunkčnosť textílií, ktoré sa väčšinou riešia kombináciou modifikovaných vlákien do textílií s využitím aj povrchových úprav textílií [16].

2 EXPERIMENTÁLNA ČASŤ

2.1 Charakteristika pripravených multifunkčných koncentrátov

V rámci výskumných prác boli postupne zabezpečené a vyhodnotené vybraté PP polyméry s vyhovujúcimi spracovateľskými vlastnosťami pre výskum PP koncentrátov (Moplen HF501N, Tatren HG1007) a zvlákňovacie testy multifunkčných PP vlákien (Tatren HT2511).

Na základe študijnej časti nášho výskumu boli vybrané a zabezpečené bezhalogénové FR modifikátory na báze derivátov triazínu (označenie FR) a N-alkoxy tieneným amínom (FRUV), antioxidanty Irgafos 168, synergická zmes dvoch typov oligomérnych UV stabilizátorov (UV) ako aj AMB aditíva na báze anorganických nosičov SiO_2 (AMB1); $BaSO_4$ (AMB2) aditivované iónmi striebra pre výskum multifunkčných PP koncentrátov. Termickými analýzami bola potvrdená ich vhodnosť pre prípravu multifunkčných koncentrátov.

Materiálovým výstupom výskumu multifunkčného PP koncentrátu boli 3 typy PP koncentrátov v kombinácii FR, UV a AMB s označením 28/1673, 28/1674 a 28/1676. Technologická spoľahlivosť procesu pri optimalizovaných parametroch ich prípravy bola vyhovujúca, porovnateľná so spoľahlivosťou procesu prípravy štandardných monofunkčných koncentrátov. Spracovateľské a reologické vlastnosti pripravených modelových vzoriek multifunkčných koncentrátov boli na požadovanej úrovni pre aditiváciu PP vlákien (tabuľka 1 a 2) [17].

Tabuľka 1 Zloženie pripravených multifunkčných PP koncentrátov (FR+AMB+UV)

Koncentrát	PP [%]	FR [%]	FR+UV [%]	AMB2 [%]	Dispergátor [%]	UV stabilizátory [%]
28/1673	49,4	25,0	-	10,0	5,6	10,0
28/1674	41,4	33,0	-	10,0	5,6	10,0
28/1676	49,7	25,0	3,0	10,0	4,8	7,5

Pozn. Technologická stabilita prípravy koncentrátov bola bezproblémová vo všetkých technologických uzloch.

Tabuľka 2 Reologické konštanty PP polyméru a modelových vzoriek multifunkčných PP koncentrátov

Vzorka	K [Pa.s]	n	B
PP Tatren HT2511	2104,8	0,5364	0,9985
28/1673	2280,8	0,5051	0,9992
28/1674	2786,0	0,4851	0,9990
28/1676	2503,6	0,4910	0,9995

Pozn.: Hodnotenie podľa mocninového modelu $\tau = K.\gamma^n$.
K - koeficient konzistencie; n – pseudoplastická odchýlka; B – koeficient určitosti

V projekte pre riešenie aditivácie bol použitý dispergačný prípravok s vyváženým charakterom chemických vplyvov, fyzikálnych a chemických konštánt, ktorý je dostupný pod obchodným názvom Slovacid S44P.

Pre meranie reologických závislostí bol použitý kapilárny extrúderový rheoviskozimeter Göttfert s tryskou dĺžky 28,0 mm a priemerom 2,5 mm, pri teplote taveniny 230°C.

Pre hodnotenie indexu toku sa používal kapilárny rheoviskozimeter Kayenness s tryskou dĺžky 8,0 mm a priemerom 2,096 mm, pri teplote taveniny 230°C a dobe temperácie 600 s.

Meranie bolo vykonané v automatickom režime metódou B s využitím enkódera.

Uvedenými skúškami boli potvrdené pozitívne výsledky dosiahnuté v etape laboratórneho výskumu PP koncentrátov s FR+AMB+UV modifikačným účinkom. Následne boli uskutočnené skúšky zvlákniteľnosti pripravených multifunkčných koncentrátov (laboratórna zvlákňovacia linka TŠ-32 s odťahom do 2500 m/min) s pozitívnym výsledkom, čím bola potvrdená ich vhodnosť pre prípravu PP multifunkčných FR+AMB+UV vlákien.

2.2 Charakteristika pripravených PP multifunkčných vlákien

Laboratórne bolo testovaných 11 rôznych typov mono a viacfunkčných koncentrátov a aditív. Pripravené boli modifikované PP vlákna s vyššou jednotkovou jemnosťou 5 dtex v prevedení hladkom a frikčne tvarovanom v režnom stave s rôznou koncentráciou aditíva. Na prípravu a laboratórne skúšky bola použitá modelová zvlákňovacia dĺžiaca linka, ktorá umožňuje pracovať pri znížených teplotách zvlákňovania. Len na niektorých výrobných zariadeniach je možné pracovať s teplotami zvlákňovania pod 250°C.

Hladké typy PP vlákien boli pripravené priamo na zvlákňovacej dĺžiacej linke pri nasledovných technologických podmienkach:

- teplotný profil 5 zónového extrúdera: 215, 225, 235, 240, 245°C,
- teplota rozvodnej vetvy a hubicového bloku: 245°C,
- hubica: 16 kruhových otvorov priemer 0,5 mm, L/D 2,24,
- preparácia: Stantex S 6051 fy Pulcra, 14%-ný vodný roztok,
- obsah preparácie: 1,5% hm.

Frikčne tvarované PP vlákna boli tvarované na stroji AFK od firmy Barmag a združované typy PP vlákien na stroji TG 20. Hodnotené multifunkčné koncentráty boli bežne spracovateľné, ale pri dlhodobom tepelnom namáhaní dochádzalo u niektorých aditív k ich degradácii, čo spôsobilo žltnutie vlákna. Vplyv aditíva na farebnú odchýlku je vyhodnotený v tabuľke 3. Fyzikálno-mechanické vlastnosti finálneho vlákna sú uvedené v tabuľke 4. Pripravené vzorky multifunkčných vlákien spĺňajú normou predpísané hodnoty fyzikálno-mechanických vlastností. Na hodnotenie zníženia horľavosti boli použité stanovenie LOI, výsledky sú uvedené v tabuľke 4. Už pri obsahu 2%-ného koncentrátu aditív typu 28/1674 bolo dosiahnuté významné zvýšenie LOI o 6% O_2 oproti nemodifikovanej vzorke, čo je výrazný efekt FR úpravy. Najlepšie výsledky laboratórneho výskumu v skupine PP vlákien s úpravou FR+UV+AMB boli dosiahnuté s multifunkčným koncentrátom typu 28/1674, ktorý bol použitý aj v rámci poloprevádzkového výskumu [17].

Tabuľka 3 Hodnotenie koloristických vlastností modifikovaných PP vlákien s úpravou FR+UV+AMB, s obsahom multifunkčného koncentrátu 3%hm. (typ svetla D 65)

Vzorka	dL	da	db	dC	dH	dE
36/2014/4 (štandard)	0,44	0,03	-0,05	0,05	0,03	0,44
36/2014/7	1,59	-0,21	0,75	-0,72	-0,29	1,77
36/2014/10	1,9	-0,11	0,42	-0,42	-0,12	1,19
36/2014/13	-2,21	-2,33	17,28	14,6	-9,53	17,57

Poznámka: dL, da, db, dC, dH, dE – označenie koloristickej odchýlky od štandardu.

Tabuľka 4 Fyzikálno-mechanické vlastnosti a LOI multifunkčného tvarovaného PP vlákna 84/16 x 4 FT, odtieň P-001 s obsahom multifunkčného koncentrátu 3%hm.

Vzorka PP vlákna	Typ koncentrátu aditív	Podiel v polyméri [%hm.]	Jemnosť PP vlákna [dtex]	Pevnosť vlákna [cN/dtex]	Ťažnosť [%]	LOI [%obj.O_2]
36/2014/4 (štandard)	-	-	368,9±0,1	3,51±0,1	96±12	26 ± 0,5
36/2014/7	28/1673	3	372,7±0,4	2,29±0,1	111,5±5,8	32 ± 0,5
36/2014/10	28/1674	3	372,6±0,7	2,33±0,1	113,5±7,9	31 ± 0,5
36/2014/13	28/1676	3	373,9±0,3	2,3±0,1	112±16	31,5 ± 0,5

Vzorka PP vlákna 36/2014/13 bola experimentálne pripravená pri overovaných technologických podmienkach priamo na výrobnej linke. Pri použití koncentrátu 28/1676 bola dosiahnutá koloristická odchýlka (dE=17,57), ktorá je podstatne vyššia ako pri použití koncentrátu 28/1673 aplikovanom na prípravu PP vlákna 36/2014/7. Z uvedeného vyplýva, že zistená koloristická odchýlka bola spôsobená rozdielnym podielom použitých aditív v koncentráte 28/1676.

3 VÝSLEDKY a DISKUSIA

3.1 Hodnotenie vplyvu multifunkčných PP vlákien na úžitkové vlastnosti vybraných typov textílií

Za účelom overenia textilnej spracovateľnosti v rôznych konštrukciách textílií bola pripravená základná skupina modifikovaného PP vlákna Prolen VEL FTS 167/36x2 dtex P-001 aditivovaného koncentrátom FR+UV+AMB, v podiele 3%hm.

Bola overovaná spracovateľnosť a následné vlastnosti pripravených textílií zo vzoriek PP vlákien s označením:
vz. č. 36/2014/4 (štandard),
vz. č. 36/2014/7 (koncentrát aditív č. 28/1673),
vz. č. 36/2014/10 (koncentrát aditív č. 28/1674),
vz. č. 36/2014/13 (koncentrát aditív č. 28/1676).
Modifikované PP vlákno bolo spracované na plochých pletacích strojoch typu CMS 330 Tc, s delením 12 E, do jednolícnych pletenín (pleteniny pre odevné účely) a súčasne na ihlovom tkacom stave typ CCI Evergreen 2014 do tkanín s použitím plátnovej a keprovej (typ 3/1) väzby. Následne boli vyhodnotené fyzikálno-mechanické, funkčné a úžitkové vlastnosti pripravených textílií [17]. Popis a identifikácia pripravených vzoriek textílií z vlákna Prolen VEL FTS 167/36x2 dtex P-001 aditivovaného multifunkčným koncentrátom FR+UV+AMB (podiel 3%hm.):

A) PLETENINA	štandard:	vz.č.36/14/4	(bez aditíva)
	vzorka č.1:	vz.č.36/14/7	(koncentrát č. 28/1673)
	vzorka č.2:	vz.č.36/14/10	(koncentrát č. 28/1674)
	vzorka č.3:	vz.č.36/14/13	(koncentrát č. 28/1676)
B) TKANINA, plátnová väzba	štandard:	vz.č.36/14/4	(bez aditíva)
	vzorka č.1:	vz.č.36/14/7	(koncentrát č. 28/1673)
	vzorka č.2:	vz.č.36/14/10	(koncentrát č. 28/1674)
	vzorka č.3:	vz.č.36/14/13	(koncentrát č. 28/1676)
C) TKANINA, keprová väzba	štandard:	vz.č.36/14/4	(bez aditíva)
	vzorka č.1:	vz.č.36/14/7	(koncentrát č. 28/1673)
	vzorka č.2:	vz.č.36/14/10	(koncentrát č. 28/1674)
	vzorka č.3:	vz.č.36/14/13	(koncentrát č. 28/1676)

Výsledky hodnotenia horľavosti sú doplnené o hodnotenie osnovnej pleteniny „Doppel Jersey“ zo 100% modifikovaného polypropylénového textilného hodvábu (PPtxh) pripravenej v prevádzkových podmienkach vo výrobnom podniku.

Na hodnotenie horľavosti boli použité 2 osnovné pleteniny:

vzorka č.1: osnovná pletenina (ďalej označovaná ako „štandard“) pripravená zo 100% PES na okrúhlom pletacom stroji typ VBD 38“ S fy Mayer v spoločnosti Bodet & Horst Mattress Ticking k.s., Vrbové,

vzorka č.2: osnovná pletenina pripravená zo 100% modifikovaného PPtxh pripravená na okrúhlom pletacom stroji typ VBD 38“ S fy Mayer v spoločnosti Bodet & Horst Mattress Ticking k.s., Vrbové, SR.

3.2 Hodnotenie vplyvu zníženia horľavosti textílií

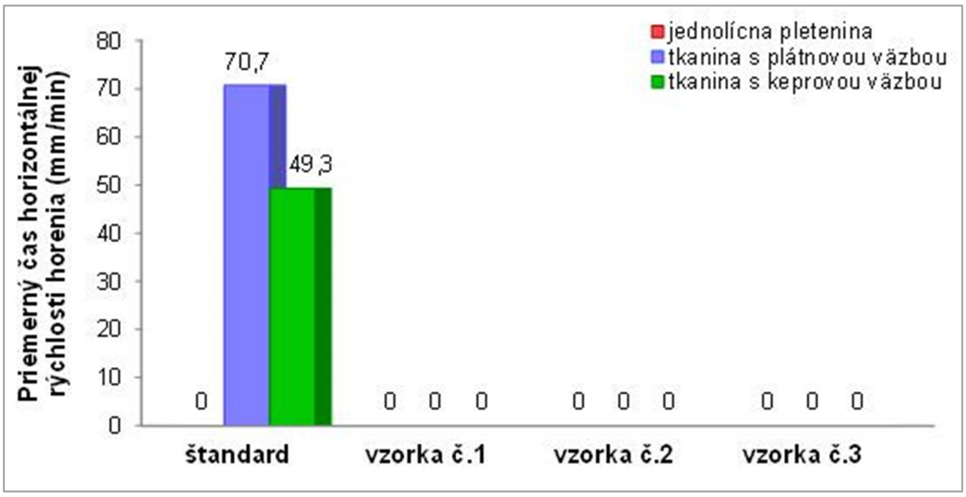
V grafoch 1 a 2 sú uvedené výsledky hodnotenia horľavosti pletenín a tkanín (plátno a keper) v horizontálnom a vertikálnom smere stanovené podľa príslušných skúšobných noriem.

Z výsledkov uvedených v grafe 1 vyplýva, že všetky skúšané textílie z multifunkčných FR+AMB+UV PP vlákien majú horizontálnu rýchlosť horenia na úrovni 0 sekúnd, bez rozdielu použitého multifunkčného koncentrátu v PP vlákne, konštrukcie textílie (pletenina, tkanina) a väzby tkaniny (plátno, keper), čo je významne pozitívny výsledok retardácie horenia.

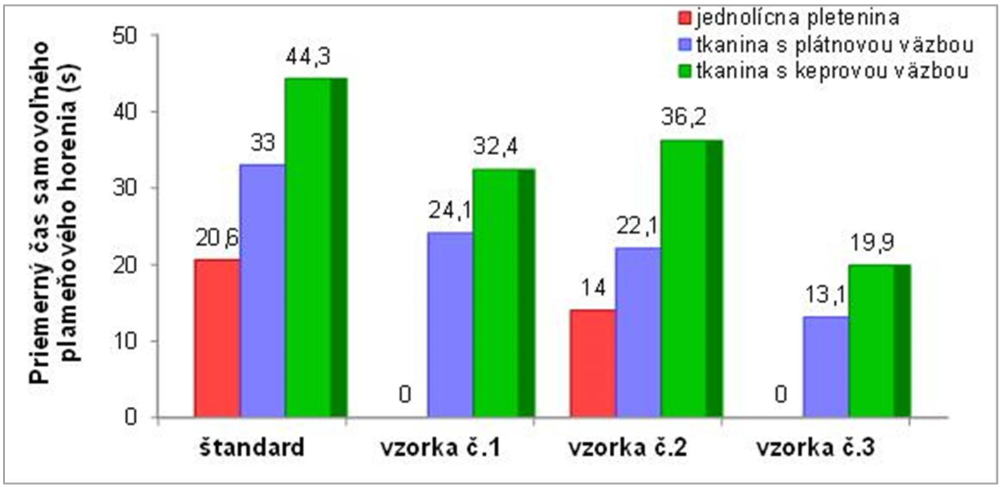
Podľa výsledkov uvedených v grafe 2 (samovoľné plameňové horenie vo vertikálnom smere) najlepšie výsledky boli dosiahnuté u textílií pripravených z modifikovaného PP vlákna obsahujúceho multifunkčný koncentrát vz. č. 28/1676 (vzorka č. 3), u ktorých sa priemerný čas samovoľného plameňového horenia pohyboval na úrovni max. 0-19,9 sekúnd v závislosti od konštrukcie textílie, u ostatných multifunkčných textílií sa tento čas pohyboval v rozsahu od 14 do 44 sekúnd.

Na základe dosiahnutých výsledkov je možné konštatovať, že bez rozdielu konštrukcie textílie (pletenina, tkanina, väzba) z hľadiska horľavosti dosiahli najlepšie výsledky PP vlákna modifikované multifunkčným koncentrátom č. 28/1676.

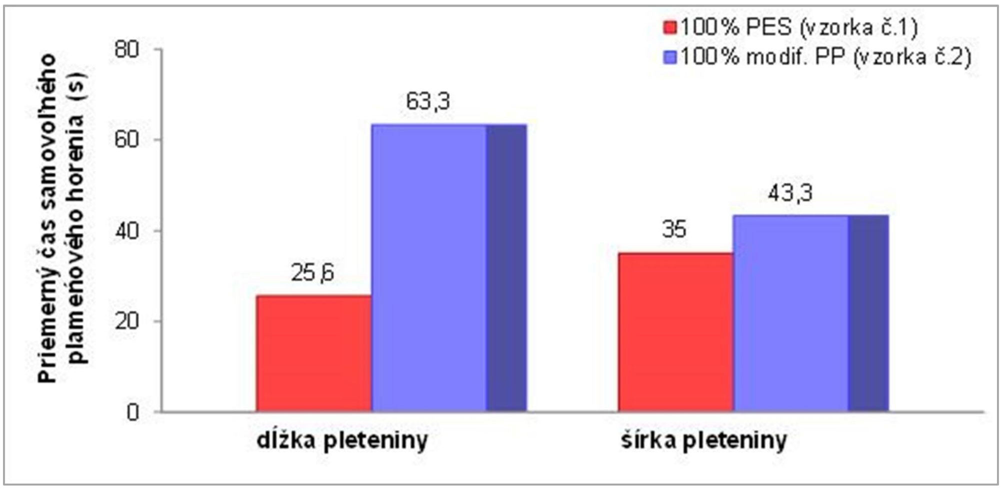
V grafe 3 sú uvedené výsledky hodnotenia horenia štandardnej pleteniny „Doppel Jersey“ pripravenej zo 100% PES vlákien a osnovnej pleteniny „Doppel Jersey“ (t.j. rovnaká konštrukcia) pripravenej zo 100% multifunkčných PP vlákien aditivovaných koncentrátom č. 28/1676. Osnovné pleteniny boli pripravené v bežných prevádzkových podmienkach v sortimente povlakov na posteľné matrace. Dosiahnuté výsledky podľa grafu 3 a obrázku 1 preukazujú významné rozdiely v hodnotách času samovoľného horenia v prospech osnovnej pleteniny z multifunkčných PP vlákien.



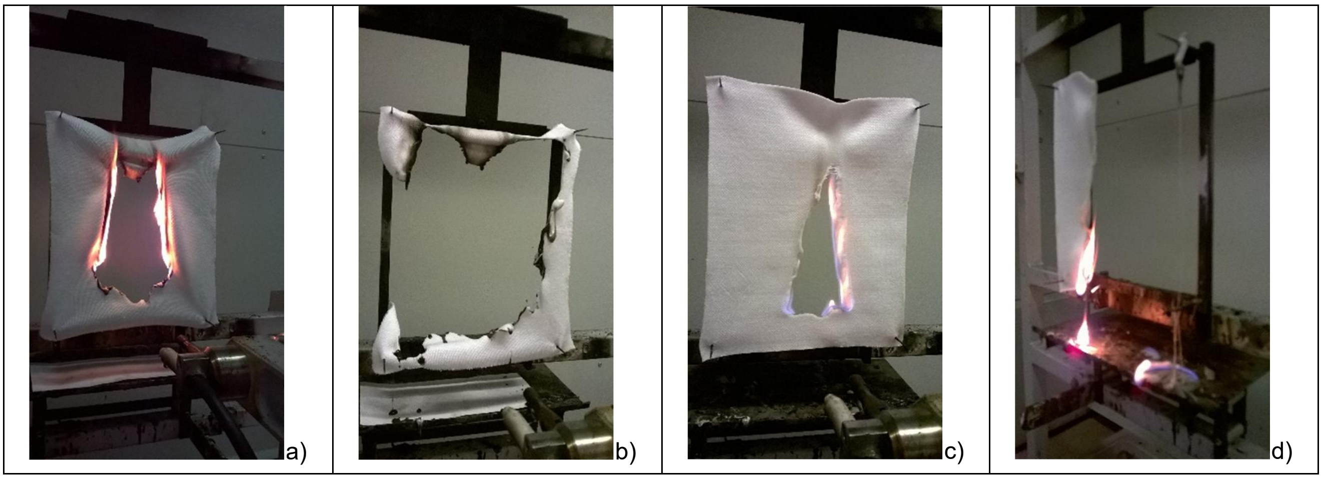
Graf 1 Priemerný čas horizontálnej rýchlosti horenia textílií (pletenín a tkanín) stanovený podľa ISO 3795:1995



Graf 2 Priemerný čas samovoľného plameňového horenia (pletenín a tkanín) vo vertikálnom smere stanovený podľa EN ISO 15025: 2003



Graf 3 Priemerný čas samovoľného plameňového horenia textílií vo vertikálnom smere stanovený podľa STN EN ISO 15025: 2003 (priemyselne pripravená pletenina)



Obrázok 1 Priebeh horenia a zvyšok po skúške stanovenia ohraničeného šírenia plameňa osnovnej pleteniny pripravenej zo 100% PES vlákna (a) a (b); 100% modifikovaného PP vlákna (c) a (d)

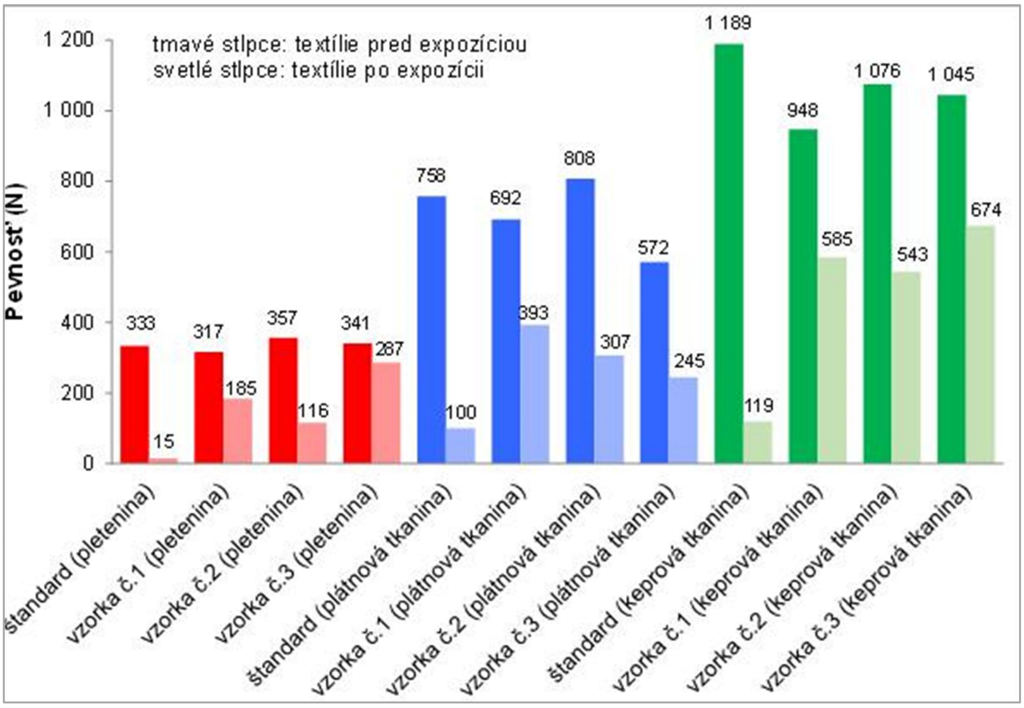
3.3 Hodnotenie vplyvu zvýšenia odolnosti multifunkčných PP vlákien voči UV žiareniu

V grafe 4 sú uvedené výsledky hodnotenia vplyvu UV žiarenia na fyzikálno-mechanické parametre štandardnej a multifunkčnej pleteniny a tkaniny (plátnová a keprová väzba), ktoré boli pripravené z vyššie uvedených PP vlákien modifikovaných koncentrátom s aditívami FR +UV+AMB2.

Bola zvolená metóda porovnávania fyzikálno-mechanických vlastností (pevnosť, ťažnosť) hadicových pletenín a tkanín pred a po expozícii UV lampou. Čas ožarovania bol vypočítaný, pri intenzite ožarovania 60±2 (W.m^{-2}), vlnová dĺžka 300 až 400 nm, na dobu 741 hodín (1 ročný ekvivalent UV žiarenia pre mierne pásmo), stanovené podľa normy STN EN 12 608:2005 a použitého prístroja Xenotest Alpha. Pokiaľ na pletenine zo štandardného PP vlákna bol zaznamenaný pokles pevnosti po 741 hod až o takmer 95%, na pletenine z PP vlákien upravených aditívom typu 28/1676 bol tento pokles len o 15%. Podľa dosiahnutých výsledkov je možné konštatovať významne pozitívny výsledok použitia UV aditíva, najmä v type multifunkčného koncentrátu č. 28/1676, aj na tkaninách. Pri keprovej tkanine zabezpečil zníženie pevnosti po 741 hodinách expozície len o cca 35%, zatiaľ čo pri tkanine zo štandardných (nemodifikovaných) PP vlákien bol pokles až o 90%. Uvedené rozdiely pevnosti neboli také významné pri tkanine s plátnovou väzbou. V súvislosti s hodnotením zmeny farebného odtieňa po expozícií UV žiarením bol zistený najvyšší stupeň 4 vždy u vz. č. 3 (multifunkčný koncentrát č. 28/1676), na ostatných vzorkách bol registrovaný nižší stupeň 3-4 resp. u vz. č. 1 (plátno) s koncentrátom č. 28/1673 len na úrovni stupňa 2-3.

3.4 Hodnotenie vplyvu antimikrobiálnej účinnosti pripravených textílií

V tabuľkách 5 až 7 sú uvedené výsledky hodnotenia antimikrobiálnej aktivity (AMA) na pleteninách a tkaninách pripravených z multifunkčne modifikovaných typov PP vlákien.



Graf 4 Porovnanie hodnôt pevnosti na pleteninách a tkaninách (plátno, keper) z modifikovaných PP vlákien pred a po expozícii UV žiarením po dobu 741 hodín

Tabuľka 5 Výsledky hodnotenia antimikrobiálnej účinnosti na PP pleteninách s baktériami *Staphylococcus aureus* a *Klebsiella pneumoniae* metódou AATCC 100:2012

Baktéria	***Staphylococcus aureus* (CFU/vzorka)**				***Klebsiella pneumoniae* (CFU/vzorka)**			
Kontaktná doba	**štandard**	**vzorka č.1**	**vzorka č.2**	**vzorka č.3**	**štandard**	**vzorka č.1**	**vzorka č.2**	**vzorka č.3**
0 h	$174x10^3$	$51x10^3$	$92x10^3$	$101x10^3$	$132,6x10^3$	$109x10^3$	$125x10^3$	$136x10^3$
24 h	$101x10^4$	<100	<100	$253x10^1$	$116,3x10^5$	$121x10^4$	$282,3x10^3$	$58x10^2$
Redukcia [%]	žiadna	>99,80	>99,89	>97,50	žiadna	žiadna	žiadna	99,2

Tabuľka 6 Výsledky hodnotenia antimikrobiálnej účinnosti na PP tkaninách s plátnovou väzbou s baktériami *Staphylococcus aureus* a *Klebsiella pneumoniae* metódou AATCC 100:2012

Baktéria	***Staphylococcus aureus*** **(CFU/vzorka)**				***Klebsiella pneumoniae*** **(CFU/vzorka)**			
Kontaktná doba	**štandard**	**vzorka č.1**	**vzorka č.2**	**vzorka č.3**	**štandard**	**vzorka č.1**	**vzorka č.2**	**vzorka č.3**
0 h	$42x10^{4}$	$100x10^{3}$	$52x10^{2}$	$136x10^{1}$	$150x10^{3}$	$179x10^{3}$	$110,3x10^{3}$	$114,6x10^{3}$
24 h	$93x10^{5}$	< 100	$246x10^{0}$	< 100	$82x10^{5}$	$264,3x10^{4*}$	$79,6x10^{3}$	$105x10^{1}$
Redukcia [%]	žiadna	≥98,82	99,17	≥ 99,51	žiadna	žiadna	27,83	99,08

Tabuľka 7 Výsledky hodnotenia antimikrobiálnej účinnosti na PP tkaninách s keprovou väzbou s baktériami *Staphylococcus aureus* a *Klebsiella pneumoniae* metódou AATCC 100:2012

Baktéria	***Staphylococcus aureus*** **(CFU/vzorka)**				***Klebsiella pneumoniae*** **(CFU/vzorka)**			
Kontaktná doba	**štandard**	**vzorka č.1**	**vzorka č.2**	**vzorka č.3**	**štandard**	**vzorka č.1**	**vzorka č.2**	**vzorka č.3**
0 h	$129x10^{3}$	$43x10^{2}$	$53x10^{2}$	$73x10^{2}$	$150,6x10^{3}$	$88x10^{3}$	$111,6x10^{3}$	$51,3x10^{3}$
24 h	$69x10^{4}$	$51x10^{1}$	75	43	$111,3x10^{5}$	$111x10^{2}$	$32x10^{1}$	164
Redukcia [%]	žiadna	88,14	98,58	99,4	žiadna	87,39	99,71	99,68

Tabuľka 8 Výsledky hodnotenia antimikrobiálnej účinnosti na osnovnej pletenine „Doppel Jersey“ s baktériami *Staphylococcus aureus* a *Klebsiella pneumoniae* metódou AATCC 100:2012

Baktéria	***Staphylococcus aureus*** **(CFU/vzorka)**		***Klebsiella pneumoniae*** **(CFU/vzorka)**	
Kont. doba	**vzorka č. 1**	**vzorka č. 2**	**vzorka č. 1**	**vzorka č. 2**
0 h	$1,25 \times 10^{5}$	$1,96 \times 10^{4}$	$1,15 \times 10^{5}$	$7,50 \times 10^{4}$
24 h	$1,54 \times 10^{5}$	< 100	$1,83 \times 10^{5}$	$1,99 \times 10^{2}$
Redukcia [%]	žiadna	> 99,49	žiadna	99,74

Vzorka. č.1: Osnovná pletenina „Doppel Jersey“ – 100% PES
Vzorka. č.2: Osnovná pletenina „Doppel Jersey“ – 100% PP

Vysoká antibakteriálna aktivita (redukcia nad 99%) pri hodnotení na baktériu *Staphylococcus aureus*, bola potvrdená u všetkých vzoriek pletenín pripravených z modifikovaných PP vlákien. Pri hodnotení s baktériou *Klebsiella pneumoniae* dosiahla vysokú redukciu len pletenina s koncentrátom č. 28/1676 (vzorka č. 3), u ostatných PP vlákien nebola zistená žiadna redukcia.

Vysoká antibakteriálna aktivita, pri hodnotení na baktériu *Staphylococcus aureus*, (redukcia nad 88%) bola potvrdená aj u všetkých vzoriek tkanín s plátnovou aj s keprovou väzbou (3/1) pripravených z multifunkčne modifikovaných PP vlákien. Pri použití baktérie *Klebsiella pneumoniae* (ktorá je podstatne rezistentnejšia) bola vysoká redukcia (nad 99%) zistená na tkanine s plátnovou väzbou pripravenej z PP vlákna s obsahom koncentrátu č. 28/1676 (vzorka č. 3), u vzorky č. 2 (koncentrát č. 28/1674) bola redukcia 27,8% a u vzorky č. 1 nebola zistená žiadna redukcia. Naopak, pri tkanine s keprovou väzbou bola zistená vysoká redukcia (nad 87%) u všetkých vzoriek tkanín s modifikovaným PP vláknom. Rozdielne výsledky dosiahnuté s uvedenou baktériou zrejme súvisia s povrchovou štruktúrou tkaniny vo vzťahu k zmáčaniu povrchu inokulom.

Podľa celkového hodnotenia antimikrobiálnej aktivity vyplýva, že aplikácia použitých AMB aditív v kombinácii s aditívami FR a UV, neznižuje ich účinnosť, resp. nevyvoláva negatívne sprievodné javy. Podľa dosiahnutých výsledkov za najvhodnejší multifunkčný FR+AMB+UV koncentrát je možné považovať koncentrát č. 28/1676.

Hodnotenie antimikrobiálnej aktivity bolo následne vykonané, podľa príslušnej metódy, aj na prevádzkovo vyrobenej osnovnej pletenine s označením "Doppel Jersey". Výsledky sú uvedené v tabuľke 8.

Opakovane bol potvrdený vysoký stupeň antimikrobiálnej aktivity na úrovni „bakteriocídny“ pri použití obidvoch typov baktérií.

4 ZÁVER

Cieľom výskumnej práce bola príprava multifunkčného koncentrátu (FR+UV+AMB), s nosičom na polypropylénovom polyméri, určeným pre modifikáciu PP vlákien. Následným hodnotením vybraných úžitkových vlastností textílií (pletenín a tkanín) pripravených z modifikovaných vlákien bola potvrdená vysoká multifunkčná účinnosť koncentrátu (označenie č. 28/1676) so zložením: 25% hm. bezhalogénový FR modifikátor na báze derivátov triazínu + 3% hm. N-alkoxy tieneným amínom - modifikátor FR UV + 10% hm. antimikrobiálne aditívum na anorganickom nosiči $BaSO_4$ - AMB 2 + 4,8% hm. dispergátor kondenzačný produkt kyseliny stearovej a propylénoxydu a 7,5% hm. synergickej zmesi oligomérnych HALSov v kombinácií s antioxidačným aditívom. Overená technologická spracovateľnosť multifunkčného koncentrátu potvrdila vyhovujúcu spracovateľnosť pri aditivácii PP vlákien bez negatívnych vedľajších reologických resp. koloristických vplyvov. Následne, po aplikácii 3%hm. podielu uvedeného typu koncentrátu do modifikovaných PP vlákien, boli v textíliách (pleteniny a tkaniny) zistené, v porovnaní s textíliami zo štandardných PP vlákien nasledovné pozitívne zmeny úžitkových vlastností:

- zníženie priemerného času samovoľného plameňového horenia na zvisle umiestnených pleteninách o 20 sekúnd (zníženie o 100% oproti štandardu) a vo zvisle umiestnených tkaninách tiež o 20 sekúnd (zníženie o 80% voči štandardu);
- po expozícii UV lampou, s podmienkami stanovenými pre mierne pásmo, na pleteninách došlo k zníženiu jej pevnosti len o 5% oproti zníženiu pevnosti o 95% po expozícii na štandardnej pletenine. Na tkaninách (keprová väzba) bol zistený pokles pevnosti len o 35%, zatiaľ čo pri štandardnej textílií bol zistený pokles pevnosti až o 90%;
- skúšky hodnotenia antibakteriálnej aktivity, pre baktérie *Staphylococcus aureus* a *Klebsiella pneumoniae*, potvrdili vysoký stupeň redukcie (> 90%) na pleteninách z modifikovaného PP vlákna. Pri uvedenom type multifunkčného koncentrátu (28/11676) bola vysoká AMB aktivita (redukcia > 80%) stanovená pre obidva typy baktérií aj v tkaninách s plátnovou a keprovou väzbou.

Dosiahnuté výsledky zmeny vybraných úžitkových vlastností pletenín a tkanín boli potvrdené na prevádzkovo pripravenej osnovnej pletenine „Doppel Jersey“. V porovnaní so štandardnou pleteninou vyrobenou zo 100% PES vlákien boli preukázané aj reálne možnosti využitia multifunkčného koncentrátu typu 28/1676 pre účinnú modifikáciu PP vlákna, ktoré je možné s výhodou použiť napr. v sortimente bytových textílií (matracoviny) alebo technické textílie (napr. autopoťahy).

PODAKOVANIE: *Táto práca bola podporovaná Agentúrou na podporu výskumu a vývoja na základe zmluvy č. APVV-0056-12.*

5 LITERATÚRA

[1] Budzák D., Jambrich M., Kochan J., Štupák A., Revus M.: Development of special types of PP fibers in Slovakia, Chemical Fibers International 3, 2006, 161-163

[2] www.plasticportal.cz

[3] www.aschulman.com

[4] www.gabriel.chemie.com

[5] www.medical.clariant.com

[6] www.wellsplastics.com

[7] www.bm-chemie.sk

[8] www.basf.com

[9] www.cibaspeciality.com

[10] Elizabeth P. Easter: Performance Textiles, University of Kentucky, Apríl 2008

[11] US patent č.20030056297, 2003

[12] US patent č. 20070148449, 2007

[13] US patent č. 20080005852, 2008

[14] WIPO patent WO/2008/098420

[15] Zhiguang W. et al.: Technical Textiles, 2007 (04)

[16] Šesták J., Krivoš Š., Michlík P., Zimány V., Balogová Ľ.: Nové viacfunkčné PP disperzie, vlákna a textílie, Projekt APVV Bratislava, 2013

[17] Šesták J. a kol.: Ročná správa k projektu APVV-0056-12, Január 2015

MULTIFUNCTIONAL TEXTILES FROM MODIFIED PP FIBRES

Translation of the article

Multifunkčné textílie z modifikovaných PP vlákien

Goal of the work is research preparation of multifunctional concentrates in combination of finish of following properties of polypropylene fibres: flammability reduction (FR) + enhancement of UV resistance (UV) + antimicrobial finish (AMB). Basic characteristics of the prepared multifunctional concentrates and prepared types of polypropylene fibres are given in the contribution. Besides, characterization of knitted and woven fabrics (twill and plain weave) of the prepared PP fibres modified with multifunctional additives FR + UV + AMB are described in the contribution. Experimental results are complemented by evaluation of properties of the multifunctional warp knitted fabric „Doppel Jersey“ type prepared from additived PP fibres directly in operational conditions. Selected procedures used to evaluate flammability of the knitted and woven fabrics, assess change of physico-mechanical properties caused by UV radiation and achieved antibacterial finish of the textiles evaluated with AATCC 100-2012 method using micro-organisms Staphylococcus aureus and Klebsiella pneumoniae are described shortly in further part of the contribution. Obtained results of change of selected performance characteristics of the textiles in relation to their construction and possibilities of practical application are compared in discussion.

REVIEW: INSTRUMENTS USED FOR TESTING MOISTURE PERMEABILITY

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Abstract: *This article presents several methods of evaluating moisture transportation through textile materials. Some of the measurements are carried out at steady state however in actual time the clothing experiences unsteady state and there is simultaneous presence of moisture and temperature difference. Due to the consideration of initial specimen absorption as moisture permeability, permeability of moisture should be evaluated for longer period of time. There is need of some newly designed instrument which can evaluate moisture permeability under static and transient conditions.*

Keywords*: thermal comfort, moisture vapor permeability, steady state, transient state.*

1 INTRODUCTION

Clothing comfort has become one of the most important aspects of clothing. Despite of many efforts to define comfort, still an agreeable definition has yet to be made [1]. Clothing comfort is defined by several scientists in different ways i.e. [2]

- Temperature regulation of a body
- Physiological reaction of wearer
- Absence of discomfort or unpleasant feeling
- Condition of pleasant physical, physiological, psychological and harmony between a human being and surrounding environment

Clothing comfort can be categorized into four different elements, which are:

1. Thermo-physiological or thermal
2. Sensorial or tactile
3. Physiological
4. Fitting

Thermo-physiological comfort is related to thermal equilibrium of human body, which is influenced by physical activities, metabolic rate of human body, ambient temperature along with thermal and moisture transmission behavior of worn clothing [3]. The sensorial or tactile comfort is associated to contact of skin with clothing i.e. feeling of person when garment is worn next to the skin. These are warm cool feeling, creation of static charge, feeling of fullness or softness, pricking and itching. The physiological comfort is reliant on aesthetic properties of fabric, i.e. color, pilling, drape and luster. The comfort related to size and fitting is called fitting comfort [4]. In case of thermal comfort, transmission of heat and moisture in the fabric play a pivotal role in managing thermal comfort [5-6].Transmission of moisture through textile material takes place in the form of vapors and liquids. Without sweating, human body cannot maintain its temperature in an environment and sweat collected in clothes evaporates slowly till heat lost from the human body can be more than required and human body started to feel cool and uncomfortable [7]. Water vapor resistance is one of the measurements utilized to evaluate values linked with water vapor transmission properties. It is the differentiation of water vapor pressure difference across the two sides of the fabric divided by the heat flux per unit area, measured in square meters pascal per watt. In colder climate, layered fabrics instead of single fabrics are utilized in most of conditions. Under these circumstances, two most important parameters of fabrics are heat and water vapor transmission [8-10]. Wicking properties in these circumstances evaluated how swiftly and widely liquid water spreads laterally on the surface of fabric and measure water vapor transportation through layer of fabric. It was noted that heat and water vapor transport properties are dependent on factors like density, porosity, thickness and water vapor absorbability of fibers etc. [11-13]. Breathable fabrics submissively permit water vapor to diffuse through them but still avert penetration of liquid water. In order to regulate temperature of the body it is necessary for skin to generate water vapor. Depending on the conditions, the normal body temperature is 37°C and skin temperature is between 33-35°C. Death can result if the temperature goes beyond critical range of 24°C and 45°C. Adversarial effects such as disorientation and convulsions can occur in limits of 34°C and 42°C [14].

2 FUNDAMENTALS OF MOISTURE VAPOR TRANSMISSION

- Moisture vapor transmit through fibrous materials by the following mechanisms:
- Diffusion of the water vapor through the air gaps between the fibers
- Absorption, transmission and desorption of the water vapor by the fibers
- Adsorption and migration of the water vapor along the surface of fiber
- Water vapor transportation by forced convection [4]

Investigation of scientific literature revealed keen interest of researchers to solve the issue of reliable determination of vapor permeability properties of textile materials [15-24]. It is pertinent to design fabric with required moisture transmission properties. The selection of experimental procedure is the most important concern being monitored during evaluation of moisture transmission properties of fabric or clothing system.

Heat and moisture transfer through fabric is evaluated in two conditions:

1. Steady state
2. Transient state

The steady state experiments deliver reliable heat and mass transfer data for the non-active case, but they are unable to demonstrate the heat and moisture transfer mechanisms in actual wearing situation [5]. A number of test conditions, design of devices and approaches facilitate fundamental understanding and comprehensive learning of vapor permeability process [25].

The evaluation of moisture vapor transmission through fabric is slow and sensitive but very effective process. Different standard methods utilized for evaluating moisture vapor transmission properties of textile substrates are:

- Evaporative dish method or control dish method (BS 7209)
- Upright cup method or Gore cup method (ASTM E 96-66)
- Inverted cup method and the desiccant inverted cup method (ASTM F 2298)
- The dynamic moisture permeable cell (ASTM F 2298)
- The sweating guarded hot plate method, skin model (ISO 11092)
- Sweating manikins [26-28].

2.1 Evaporative dish method

Gravimetric method is used to evaluate water vapor transmission rate through fabric. The sample to be tested is shielded over the open mouth of a dish containing water and positioned in the standard atmosphere for testing. After certain amount of time, total system maintains equilibrium state followed by sequential weighing of the dish and calculation of the rate of water vapor transfer through the sample. The steady state water vapor permeability is also evaluated in this method. The relative permeability of the specimen is measured by comparing experimental test results with a reference fabric.

$$(WVP) = 24M / A.t \qquad (1)$$

$$\text{Relative water vapor permeability index [\%]} = (WVP)f \times 100/(WVP)r \qquad (2)$$

where *(WVP) is* water vapor permeability [gm^2/day], *M* is the loss in mass [g] of water vapor through the fabric specimen, *t* is the time between weighing [h], *A* is the internal area of the dish [m^2], *(WVP)f* and *(WVP)r* are the water vapor permeability of the test fabric and reference fabric, respectively.

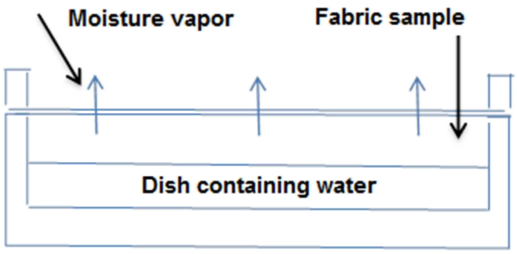

Figure 1 Moisture vapor permeability tester [6]

2.2 Upright cup method

In this method, fabric sample is positioned and sealed above a cup, 2/3rd of cup is filled with water and then it is placed in a wind tunnel at a standard atmosphere on a weighing balance and the variation in mass of the fabric at a time interval is calculated [29].

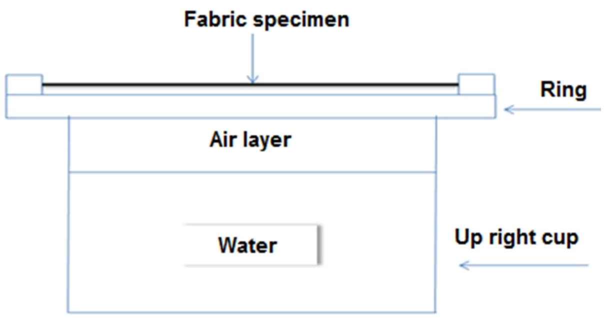

Figure 2 Upright cup method [6]

2.3 Inverted cup method

For the inverted cup method, the cup along with the fabric is arranged in such a way that the fabric will be in the lower side of the water. The inverted cup method is developed for utilizing waterproof samples, as the fabrics which let the passage of liquid water, may not be inverted because of leakage. The calculations used for this method are same as that of upright cup method [29].

2.4 Desiccant inverted cup method

In this methodology, water vapor transmission rates of fabric are evaluated in similar manner as that of inverted cup method. Desiccant inverted cup method works as per ISO 15496 2004. The difference between inverted cup method and desiccant method is that in later case, the cup is partially filled with desiccant such as potassium acetate, Calcium chloride and anhydrous $MgClO_4$ or anhydrous $CaSO_4$. The path of water vapor is minimized due to direct contact of drying agent with fabric. Inverted cup along the fabric sample is dipped into water bath filled with distilled water along with the aid of sample holder. The measuring cup is first weighed by the balance. Later on, measuring cup is inverted and inserted into sample holder. After a certain amount of time (*t*), the measuring cup is detached and then weighed again.

Calculation of water vapor permeability of fabric sample is done by using following equation:

$$WVT = t \times (W_2 - W_1)/a \quad (3)$$

where WVT is water vapor transmission rate, W_2 is weight of cup assembly after test and W_1 is weight of cup assembly before test, a is the test area [4].

2.5 Sweating guarded hot plate

This method is also called skin model and is utilized for evaluating thermo-physiological comfort of clothing and work as per ISO 11092 standard [30, 31]. This method simulates transportation of moisture through textiles and clothing assemblies when they are worn next to human body. Evaluation of the water vapor resistance of the fabric is done by the evaporative heat loss in the steady state condition in this method. The temperature of the guarded hot plate is maintained at 35°C and the standard atmospheric condition for testing (65% R.H. and 20°C) is utilized. The water vapor resistance (R_{et}) of fabric is calculated as follows:

$$R_{et} = \frac{A(P_m - P_a)}{H - \Delta H_c} - R_{et0} \quad [\mathrm{m^2Pa/W}] \quad (4)$$

where, A is the test area; P_m is the saturation water vapor partial pressure at the surface of the measuring unit; P_a is the water vapor partial pressure of the air in the test chamber; H is the amount of heat supplied to the measuring unit; ΔH_c is a correction factor and R_{et0} is the apparatus constant [4].

2.6 The PERMETEST apparatus

This instrument was designed by Hes [32] for evaluation of water vapor permeability of textile fabrics, soft polymer foils, non-woven webs and garments. The working principle of this instrument is sensing of heat flux by evaluating evaporative heat resistance. For isothermal conditions, the temperature of measuring head is kept at room temperature. Heat provided to keep constant temperature with and without fabric mounted on plate is evaluated.

$$\text{Relative water vapor permeability [\%]} = \frac{\text{Heat lost when fabric is placed on measuring head}}{\text{Heat lost from bare measuring head}} \times 100 \quad (5)$$

This method can be utilized according to both BS 7209 and ISO 9920 standards. When ring above measuring head is utilized, evaluating condition according to BS 7209 is used, forming a separate air layer between measuring head and fabric layer. On the other hand, when ring above the measuring head is not used; there will be direct contact of fabric with measuring head in accordance with condition ISO 9920 standard [4].

2.7 Dynamic moisture permeable cell

This method has the capability of measuring moisture transmission characteristics of textiles under several conditions like convection, pure convection, pure diffusion and combined diffusion [33]. The convective heat flow is calculated by evaluating relative pressure drop at bottom outlet. Due to ability of fiber to take up water vapor and undergo fiber swelling, the convective flow through hygroscopic material is complex process. The variation in fabric connective flow properties is assumed to be a function of relative humidity. This method is used to attain both steady state and dynamic state data [4].

2.8 Moisture vapor transmission cell

The working principle of this method is that, the cells evaluate the humidity created under controlled conditions as a function of time. It is a faster and simplified method. In this method, two cells i.e. upper and lower cells are utilized. These cells are parted by test sample. The upper cell is nearly dry and lower cell is partly filled with water at the start of test. There is an increment in relative humidity of upper cell with time as moisture is transferred through fabric specimen [4]. The relationship is given by:

$$T = (269 \times 10^{-7}).(\Delta\%RH \times \frac{1440}{\text{Time interval}}) \quad (6)$$

where T is the moisture vapor transmission rate [g/in^2/day].

2.9 Holographic bench technique

Sari and Berger [34] developed this technique. This method utilizes micro weighing technique to measure mass flow. The resistance to water vapor transportation is dependent on resistance of outer clothing and air layer. The resistance of the fabric in case of vapor transportation from skin to atmosphere is lower than resistance offered by external boundary layer and also much lower than that of inner narrowed layer between fabric and skin. A separate measurement of water vapor flow resistance due to different air layers is offered by this technique and consequentially it measures accurate vapor resistance value of textile layer.

Most of the current methods for measurement of moisture vapor permeability consume lot of time and needed large quantity of materials. Huang and Qian [35] established new test equipment for illustrating water vapor permeability of fabrics. In this apparatus, an aluminum cylinder shielded with water proof and vapor permeable PTFE laminate is utilized for creating water vapor source on one side of the fabric specimen. For transporting water vapor away, a dry nitrogen gas stream is utilized. The evaluation of rate of water vapor transmission across the fabric specimen is built on measurement of relative humidity of leaving nitrogen stream. The test time for this new equipment is short and requires small size fabric specimen. The test results obtained from this apparatus correlated well with those acquired from ISO 11092 and ASTM E96 standard.

Zhang et al [36] devised a simplified and new test apparatus for evaluating heat and water vapor transport properties of textile fabrics. A microclimate was designed between the artificial skin and the fabric sample to represent the actual condition of heat and water vapor transfer from the skin through the fabric to the environment. Dry bulb coefficient and wet bulb coefficient are the two measuring parameters suggested to investigate heat and water vapor transfer properties of fabric specimen. The results of tests revealed that these two parameters are able to distinguish heat and water transport characteristics of fabric specimen at steady-state [36].

Wilson et al [37] utilized improved form of the sweating guarded hot plate for investigation of water vapor resistance of four infant bedding fabric layers and pointed that with increase in number of layers, water vapor resistance of bedding assemblies' increases. Currently, a lot of research has been conducted on investigation of steady-state water vapor transfer through multilayer fabrics. A sweating arm apparatus was designed by Rossi et al [38], to calculate water vapor resistance of 12 polyester fabric layers at four different level of fairly cold temperature and concluded that fabric combinations with outer layer of hydrophilic membranes managed lower water vapor resistance and lower condensation than assemblies with microporous membranes.

2.10 Thermal sweating manikins

The first thermal manikin was developed by the US army during World War II since then it is estimated that more than 100 thermal manikins have been developed in the world [39, 40]. Over the last 20 years, Empa has designed heated sweating body parts and a whole body sweating thermal manikin (Sweating Agile thermal Manikin, SAM). These manikins are utilized in clothing research to evaluate water vapor resistance and insulation under steady state conditions as well as investigating effects of clothing, posture, wind and climate on local heat flux from different parts of the body [40].

Several advanced thermal manikins are distributed into many segments and temperature of each section is controlled independently in order to acquire distribution as that human skin. Simulation of sweating is done by delivering water through tiny tubes to the holes dispersed at the surface of manikins. Such types of thermal manikins are very expensive because of complex control system for supplying heat and water. Simulation of sweating in these types of manikins is restricted by effective number of water supplying tubes and holes lesser than sweating glands of human which are approximately six million in numbers. Moreover, these manikins are not so much accurate as it is very difficult to maintain consistent sweating and accurate determination of humidity at the surface of skin [41]. The first thermal manikin made of water and high strength breathable fabric is "walter" which was encouraged by thermal regulation system of human body. Walter is not so much costly and attains high accuracy.

The key sub systems of "Walter" are:

- System for simulation of "Walking" motion
- Water circulation system
- Control and measurement system
- Online water supply system

Some of the unique features of "Walter" are:

- Simulation of sweating is done with the help of waterproof, but moisture permeable, fabric 'skin' holding water, but permit moisture transmission from the manikin's innards through the millions of miniature pores in the skin.
- Walter's core body temperature is maintained at 37°C as Walter simulates human thermal physiology. Whereas body temperature is maintained by adjusting rate of pumps which deliver warm water from central region to extreme regions.
- Accurate measurement of simultaneous evaporative water transfer loss and heat loss can be done from Walter. As a result, two significant parameters i.e. water vapor

resistance and thermal insulation are evaluated in one step only.

- In order to simulate walking motion, arms and legs of manikin can be motorized.
- The rate of sweating can be monitored by varying temperature skin and having fabric skin with different moisture permeability.
- This manikin has similar weight and heat capacity, comparable to human body because it is mainly composed of water, as human body is also composed mainly of water [42].

The sweating heated TORSO [43] comprises of cylinder with exterior diameter of 30 cm, distributed into two guard sectors at the end and evaluation sector in the center. Each segment is regulated with either constant power or temperature. Water utilized for stimulated heat is being provided at controlled rate through 54 sweat outlets spread over the surface of evaluation section. When functioned under constant power mode, the surface temperature of guards pursues surface temperature of evaluation cylinder to reduce lateral heat exchange between guards and evaluation cylinder.

In a research conducted by Richards et al [40] two sweating manikins are designed so that thermo-physiological behavior of human being can be simulated. This is made possible by coupling the control software of each sweating manikin to multimode thermo-physiological model. The first manikin to be coupled is heating sweating cylinder developed to simulate the torso of an adult arm. The initial results obtained from coupled torso are in good agreement with human thermal response.

Fan and Chen [41] reported a new perspiring fabric thermal manikin simulating gaseous perspiration by moisture transportation through "skin" made of a breathable fabric. The manikin has been utilized to evaluate moisture vapor resistances and thermal insulation of clothing assemblies and confirmed high reproducibility and accuracy. Some general features of perspiring fabric manikin are:

- The shape of the body is comparable to a man. The body of manikin is flexible and "skin" has soft feeling.
- The core temperature of the manikin is 37°C.
- The height of manikin is 1.65 m and surface area of manikin is 1.66 m^2.
- The manikin can generate gaseous perspiration. The insensible perspiration of human body is approximately 30 g h^{-1} and in case of sweating, perspiration can increase up to 1000 g h^{-1}. The perspiration of manikin varies with the type of clothing of worn nonetheless within the range of human perspiration.
- There is a zip at the back of manikin's skin. Thus after a prolonged usage of manikin, skin can be replaced with new one or substituted with another one made of different fabric.
- The temperature distribution of the skin can be altered by adjusting pumps output and opening valves.
- The dressing and undressing of manikins are convenient as it can be hanged [41].

3 CONCLUSION

The moisture permeability is the one of the most important factor to determine the comfort of clothing. Multiple methods of measuring the moisture transport through textile are discussed in this report. Most of these measurements can be only performed at the steady state but in real time the clothing undergoes unsteady state and moisture and temperature gradient exist simultaneously. The temperature gradient influences the moisture transport significantly and can cause the condensation inside the textile material. These moisture permeability should be measured for longer time (nearly 3-4 hours) as the initial sample absorption can be considered as the moisture permeability, as most of these instrument determine the energy or moisture loss through the textile layer. The clothing undergoes constant load, that means the thickness and pore size changes as load is applied on it, which can cause a significant change in the permeability of the material and decrease in thickness of layer; there should be some new designed instrument which can measure the moisture permeability under static or dynamic load.

4 REFERENCES

[1] Slater K.: Comfort properties of textiles, Text. Prog. 9, 1977, pp. 1-42

[2] Slater K.: The assessment of comfort, J. Text. Inst. 77, 1986, pp. 157-171

[3] Olschewski H., Bruck K.: Cardiovascular and muscular factors related to exercise after pre-cooling, J. Appl. Physiol. 64, 1988,pp. 803-811

[4] Das A., Alagirusamy R.: Moisture transmission, chapter in Science in clothing comfort, Woodhead Publishing, 2010, pp. 124-130

[5] Li Y.: The science of clothing comfort, Textile progress 31, 2001, pp. 1-135

[6] Zhang P., Watanabe Y., Kim S.H., Tokura H., Gong R.H.: Thermoregulatory responses to different moisture-transfer rates of clothing materials during exercise, J. Text. Inst. 92, 2001, pp. 372-378

[7] Hollies N.R.S.: Mt. Washington Feasibility Test, Report #20 Contract DA-19-129-qm 331, Natick R&D Center, 1956

[8] Whitaker S.: In advances in Heat Transfer, Academic Press New York 31, 1998, p. 1

[9] Mazari A., Havelka A.: Prediction of needle heating in an industrial sewing machine, Textile Res. J 86(3), 2016, pp. 302-310

[10] Mazari A., Zhu G., Havelka A.: Sewing needle temperature of an industrial lockstitch machine, Industria Textila 65(6), 2014, pp. 335-339

[11] Monego C.J., Golub S.J.: Insulating values of fabrics, Foams and Laminates, Am. Dyest. Rep 52, 1963, pp. 21-32

[12] Morris M. A.: Thermal Insulation of single and multiple layers of fabrics, Textile Res. J 25, 1955, pp. 766-773

[13] Peirce F.T., Rees W.H.: The transmission of heat through textile fabric, Part II, J. Textile Inst 37, 1946, pp. 181-204

[14] Haghi A.K.: Heat and Mass transfer in textiles, WSEAS press, Montreal, 2011, pp. 96-97

[15] Watkins D.A., Slater K.: Moisture-vapor permeability of Textile fabrics, Journal of the Textile Institute 72, 1981, pp. 11-18

[16] Gibson P.W.: Effect of temperature on water vapor transport through polymer laminates, Journal of Polymer testing 19, 2000, pp. 673-691

[17] Qu J., Ruckman J.: A new calculation method of water vapour permeability at unsteady states Journal of the Textile Institute 97, 2006, pp. 449-453

[18] Das A., Kothari V., Fanguiero R., Araujo M.: Moisture transmission through textiles, Part 1: Process involved in moisture transmission and the factors at play, AUTEX Research Journal 7, 2007, pp. 100-109

[19] Das A., Kothari V., Fanguiero R., Araujo M.: Moisture transmission through textiles, Part II: Evaluation methods and mathematical modeling, AUTEX Research Journal 7, 2007, pp. 194-216

[20] Skenderi Z., Cubric I., Srdjak M.: Water vapour resistance of knitted fabrics under different environmental conditions, Fibers & Textiles in Eastern Europe 17, 2009, pp. 72-75

[21] Ramkumar S., Purushothaman A., Hake K., McAlister D.: Relationship between cotton varieties and moisture vapor transport of knitted fabrics, Journal of Engineered Fibers and Fabrics 2, 2007, pp. 10-18

[22] Huang J.: Sweating guarded hot plate test method, Journal of Polymer testing 25, 2006, pp. 709-716

[23] Hes L.: A new indirect method for fast evaluation of the surface moisture absorptivity of engineered Garment, Conference on Engineered Textiles, UMIST, Manchester, *UK*, 1998, pp. 32-36

[24] Hes L.: Effect of planar conduction of moisture on measured water vapor permeability of thin woven Fabrics, The Fiber Society Fall Technical Meeting, Natick, Massachusetts, 2002, pp. 7-9

[25] Arabuli S., Vlasenko V., Havelka A., Kus Z.: Analysis of modern methods for measuring vapor permeability properties of textiles, 7th International Conference TEXSCI, 2010

[26] Gali K., Jones B., Tracy J.: Experimental techniques for measuring parameters describing wetting and wicking in fabrics, Text Res 64, 1994, pp. 106-111

[27] Lomax G.R.: The design of waterproof, water vapor-permeable fabrics, J. Coated Fabrics 15, 1985, pp. 40-49

[28] Ren Y.J., Ruckman J.E.: Condensation in three-layer waterproof breathable fabrics for clothing, Int J Clothing Sci and Tech 16, 2004, pp. 335-347

[29] McCullogh E.A., Kwon M., Shim H.A.: Comparison of standard methods for measuring water vapor permeability of fabrics, Meas. Sci. Technol 14, 2003, pp. 1402-1408

[30] Havenith G., Holmer I., Hartog E. A.D., Pasrons K.C.: Clothing evaporative heat resistance – proposal for improved representation in standards and models, Ann Occup Hyg 43, 1999, pp. 339-346

[31] Congalton D.: Heat and moisture transport through textiles and clothing ensembles utilizing the "Hohenstein" skin model, J Coated Fabrics 28, 1999, pp. 183-196

[32] Gibson P.W.: Water vapor transport and gas flow properties of textiles, polymer membranes and fabric laminates, J Coated Fabrics 28, 1999, pp. 300-327

[33] Gibson P., Kendrick C., Rivin D., Sicuranza L.: An automated water vapor diffusion test method for fabrics laminates and films, J Coated Fabrics 24, 1995, pp. 322-345

[34] Berger X., Sari H.: A new dynamic clothing model. Part 1: Heat and mass transfers, Int J Therm Sci 39, 2000,pp. 673-683

[35] Huang J., Qian X.: A new test method for measuring the water vapor permeability of fabrics, Measurement Science and Technology 18, 2007, pp. 3043-3047

[36] Zhang C., Wang X., Lv Y., Ma J., Huang J.: A new method for evaluating heat and water vapor transfer properties of porous polymeric materials, Polymer testing 29, 2010, pp. 553-557

[37] Wilson C.A., Laing R.M., Niven B.E.: Multi-layer bedding materials and the effect of air spaces on 'wet' thermal resistance of dry materials, J Hum Environ Syst 4, 2000, pp. 23-32

[38] Rossi R.M., Gross R., May H.: Water vapor transfer and condensation effects in multilayer textile combinations, Text Res J 74, 2004, pp. 1-6

[39] Holmer I.: Thermal manikin history and application, European Journal of Applied Physiology 92, 2004, pp. 614-618

[40] Richards M.G.M., Psikuta A., Fiala D.: Current Development of Thermal Sweating Manikins at Empa, Sixth International Thermal Manikin and Modeling Meeting (6i3m), Hong Kong Polytechnic University, 2006, pp. 173-179

[41] Fan J., Chen Y.S.: Measurement of Clothing Thermal Insulation and Moisture Vapor Permeability Using a Novel Perspiring Fabric Thermal Manikin, Measurement Science and Technology 13, 2002, pp. 1115-1123

[42] Fan J.: Recent Developments and Applications of Sweating Fabric Manikin-"Walter"**,** 6th Int. Thermal Manikin and Modelling Meeting (6i3m), Hong Kong Polytechnic University, 2006, pp. 202-209

[43] Zimmerli T., Weder M.S.: Protection and comfort - A sweating Torso for the simultaneous measurement of protective and comfort properties of PPE, 6th International Symposium on Performance of Protective Clothing: Emerging Protection Technologies, Orlando FL, 1996

NÁSTROJE POUŽÍVANÉ NA HODNOTENIE PRIEPUSTNOSTI VLHKOSTI

Prehľadný článok

Translation of the article

Review: Instruments used for testing moisture permeability

Tento príspevok predstavuje niekoľko metód pre hodnotenie transportu vlhkosti cez textilné materiály. Niektoré z týchto meraní sa uskutočňujú v rovnovážnom/stabilnom stave, avšak odev predstavuje nestabilný stav, v ktorom je súčasne prítomná zmena vlhkosti a teploty s časom. Vzhľadom nato, by posúdenie počiatočnej absorpcie vzorky, ako navlhavosť, priepustnosť vodných par, mali byť hodnotené po dlhší čas. Preto vystáva potreba navrhnutia nového prístroja, ktorým by bolo možné vyhodnocovať priepustnosť vodných par ako za statických, tak aj prechodných podmienok.

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