



UNIVERSITY OF NOVI SAD
TECHNICAL FACULTY „MIHAJLO PUPIN“
ZRENJANIN, REPUBLIC OF SERBIA



4th international scientific – professional conference
TEXTILE SCIENCE AND ECONOMY
Proceedings



Zrenjanin, 06-07th November 2012



Organiser of the Conference:

University of Novi Sad, Technical Faculty „Mihajlo Pupin“, Zrenjanin, Republic of Serbia.

Publisher:

University of Novi Sad, Technical Faculty „Mihajlo Pupin“, Zrenjanin, Djure Djakovica bb, 23000 Zrenjanin, Republic of Serbia.

For publisher:

Milan Pavlović, Ph. D, Proffessor, Dean of the Technical faculty „Mihajlo Pupin“

Technical treatment and design:

Vasilije Petrović, Ph. D, Proffessor

Marija Stanković, Assistant

Aleksandra Zdravković

Design:

Marija Stanković, Assistant

ISBN: 978-86-7672-187-0

CIP – Каталогизacija u publikaciji
Библиотека Матице српске, Нови Сад

677(082)

SCIENTIFIC – Professional Conference Textile Science and Economy
(4; 2012; Zrenjanin)

Proceedings / 4th International Scientific-Professional Conference
Textile Science and Economy, Zrenjanin, 06-07th November 2012 ;
[organiser] Technical Faculty „Mihajlo Pupin“, Zrenjanin. – Zrenjanin :
Technical Faculty „Mihajlo Pupin“, 2012 (Zrenjanin : Diginet). – 1
elektronski optički disk (CD-ROM) : tekst, slika, zvuk; 12 cm

Note:

All the papers presented in this publication have been reviewed. However the editor's and organizer are not responsible for the contents presented within paper

THE SCIENTIFIC COMMITTEE:

President of Committee: Ph. D Jovan Stepanović, Faculty of Technology in Leskovac, *Serbia*,
Ph.D Darko Ujević, Faculty of Textile Technology, Zagreb, *Croatia*
Dr Tsan-Ming Choi (BEng, MPhil, PhD), Faculty of Applied Science and Textile. The Hong Kong Polytechnic University, Hung Hom, KLN, *Hong Kong*,
Ph.D Roshan Paul, LEITAT Technological Center, Terrassa, *Spain*
Ph.D Budimir Mijović, Faculty of Textile Technology, Zagreb, *Croatia*
Ph.D Zenun Skenderi, Faculty of Textile Technology, Zagreb, *Croatia*
Ph.D Marius Sangeorzan, Universitatea de Vest din Timisoara–Facultatea de Arte, *Romania*,
Ph.D Florea Hariton, Universitatea de Vest din Timisoara – Facultatea de Arte, *Romania*,
Ph.D Danilo Jakšić, Naravoslovnotehniška fakulteta, Ljubljana, *Slovenia*
Ph.D Jelka Geršak, Fakulteta za Strojništvo, Maribor, *Slovenia*
Ph.D NADIJA BUKHONKA, Kiev National University of Technologies and Design, Department of Knitting Technology, Kiev, *Ukraine*
Ph.D Dušan Ristić, Faculty of Technology, Banja Luka, *The Republic of Serbian*
Ph.D Dragana Grujić, Faculty of Technology, Banja Luka, *The Republic of Serbian*
Ph.D Goran Demboski, Faculty of Technology and Metallurgy, Skopje, *Macedonia*
Ph.D Milan Pavlović, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
Ph.D Vasilije Petrović, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
Ph.D Momčilo Bjelica, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
Ph.D Miodrag Stamenković, Faculty of Technology, Leskovac, *Serbia*
Ph.D Milan Gašović, Faculty of Economics, Subotica, *Serbia*
Ph.D Dušan Trajković, Faculty of Technology, Leskovac, *Serbia*
M.Sc Srdan Cakić, Faculty of Technology, Leskovac, *Serbia*.

ORGANIZING COMMITTEE:

Ph. D Vasilije Petrović, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*, President of Committee,
Ph. D Milan Pavlović, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
Ph. D Milan Gašović, Faculty of Economics, Subotica, *Serbia*
Ph. D Želimir Branović, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
M.Sc Milan Radovanović, President of Regional Chamber of Commerce, Zrenjanin, *Serbia*
M.Sc Vojin Kerleta, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
Sladana Milojević, FACTS – Fashion and Clothing Industry Cluster of Serbia, Belgrade, *Serbia*
M.Sc Mirjana Reljić, Director of CIS Institut, Belgrade, *Serbia*
Milan Radovanović, Miteks, Arilje, *Serbia*
Zoran Arsenijević, Seventy Five, Kragujevac, *Serbia*
Slavoljub Miljković, BRAMY, Aleksandrovac, *Serbia*
Ph.D Momčilo Bjelica, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
M.Sc Vasilije Kovačev, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
Marija Savić, Assistant, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
Biljana Goševski, Assistant, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
Jelena Danikov, Assistant, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
Marija Stanković, Assistant, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
Aleksandra Zdravković, Research Assistant, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
Sanja Stefanović, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
Dragana Bugarčić Rošu, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*
Aćin Slavica, Technical Faculty „Mihajlo Pupin“, Zrenjanin, *Serbia*.

| | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Miguel Angelo Carvalho, Goran Demboski, Maja Nofitoska INVESTIGATION OF SEAM PUCKER ON SEAMS FOR TALIORED GARMENTS | 116 |
| Dragan DJORDJIC, Mirjana RELJIC, Vasilije PETROVIC USABILITY CHARACTERISTICS ANALYSIS OF MEN'S SOCKS MADE OF COTTON/POLYAMIDE MIXTURE | 122 |
| Tatjana Kozar, Andreja Rudolf, Simona Jevšnik, Zoran Stjepanović DEVELOPING THE ACCURATE SITTING POSITION 3D BODY MODEL FOR GARMENT PROTOTYPING | 133 |
| Dragana Grujić DEPENDENCY OF A TEMPERATURE AND A SKIN MOISTURE FROM THE THERMAL FEATURES OF A SPORTS CLOTHING MATERIALS | 139 |
| V. Petrović, M. Stanković, A.Zdravković, I. Stamatović, J. Danikov OPTIMIZATION OF CUTTING PATTERNS USING CAD SYSTEM ON THE EXAMPLE OF CHILDREN'S CLOTHES | 146 |
| Snezana Milosevic FROM IDEA TO ACTUAL PRODUCT | 152 |
| Burcu Adsay, Gülay Özcan, Seher İşbrakmaz, Deniz Anıl Türkdoğan and Derya Akçay EFFECTS OF FABRIC STRUCTURE ON THERMAL CONDUCTIVITY OF COTTON WOVEN FABRIC | 157 |
| Sonja JORDEVA, Sonja KJORTOSEVA, Nikola KALOJANOV RESEARCH OF THERMO-PHYSIOLOGICAL COMFORT OF SINGLE JERSEYKNITTED STRUCTURES WITH METHOD OF THERMO-VISION ANALYSIS | 161 |
| Mirjana RISTIĆ Vasilije PETROVIC, Jovan STEPANOVIC, Aleksandra ZDRAVKOVIC, Vojin KERLETA ANALYSIS OF TEXTILE AND OTHER MATERIALS INFLUENCE ON THE SLEEPING COMFORT | 170 |
| Marija Savic, Dusan Trajkovic, Tatjana Sarac, Stanislava Sindjelic ANALYSIS OF WATER VAPOUR AND AIR PERMEABILITY AS "COMFORT-FACTORS" THAT AFFECT ON COMFORT OF CLOTHING MADE FROM DOUBLE-LAYERED KNITTED FABRICS | 176 |
| Vojislav Gligorijević, Jovan Stepanović, Nenad Ćirković, Vojin Kerleta THE FUTURE OF THE TEXTILE PROCESSING GEOTEXTILE STRUCTURES AND ROBOTICS SIDED STITCHING | 183 |
| Vojislav Gligorijević, Jovan Stepanović, Nenad Ćirković, Jelena Danikov APPLICATION OF GEOSYNTHETIC CLAY IN THE GEOTEXTILE, GEOMEMBRANE AND GEOGRID | 190 |
| S. Đurđević, V. Petrović, M. Stanković, I. Skoko, A. Zdravković, S. Stefanović, D. Gosevski OPTIMIZATION OF CLOTHES CONSTRUCTIONAL PREPARATION USING CAD SYSTEM | 197 |
| Petrović Marija, Petrović Predrag, Ružičić Lazar CONFORMITY ASSESSMENT MULTIAXIAL FABRIC, LIKE A NEW PRODUCT ON THE EXAMPLE OF APPLYING SECONDARY RAW MATERIALS AT THE LANDFILL | 202 |
| I. Skoko, V. Kovačev, M. Gašović, V. Petrović, J. Danikov, V. Kerleta ANALYSIS OF RESPONDENTS ATTITUDES ABOUT CLOTHING SUPPLY AND PURCHASING CAPACITY | 214 |

RESEARCH OF THERMO-PHYSIOLOGICAL COMFORT OF SINGLE JERSEY KNITTED STRUCTURES WITH METHOD OF THERMO-VISION ANALYSIS

Sonja JORDEVA, Sonja KJORTOSEVA, Nikola KALOJANOV

Abstract: *The term comfort is defined as “the absence of displeasure or discomfort” or “a neutral state compared to the more active state of pleasure”. Clothing comfort includes three main considerations: psychological, sensorial and thermo-physiological comfort. The thermo-physiological comfort, entails both thermoregulation and moisture management. It is known that fiber type, yarn properties, fabric structure, finishing treatments and clothing conditions are the main factors affecting thermo-physiological comfort. In this paper, the influence of structural properties and characteristics of the fiber on the air and water vapor permeability, thermal properties (thermo-physiological comfort), of single jersey knitted fabrics was investigated. Thermal conductivity of knitted fabrics was determined according to new method of thermo-vision analysis developed by researchers. The main advantage of the method is the possibility of non contact determination of the temperature change rate coefficient of the knitted fabric. The results indicate more significant influence of structural characteristics on thermo-physiological comfort, compared with the characteristics of the fibers. Knitted fabric of 50/50% PAN/cotton with the highest density and mass per unit area has lower air and water vapor permeability, thermal conductivity and higher thermal resistance compared with knitted fabrics of 100% wool and 100% PAN.*

Key words: single jersey, thermo-physiological comfort, air permeability, water vapor permeability, thermo-vision analysis

1. INTRODUCTION

The term comfort is defined as “the absence of displeasure or discomfort” or “a neutral state compared to the more active state of pleasure”. Clothing comfort includes three main considerations: psychological, sensorial and thermo-physiological comfort. The thermo-physiological comfort, the subject of this research, entails both thermoregulation and moisture management. It is known that fiber type, yarn properties, fabric structure, finishing treatments and clothing conditions are the main factors affecting thermo-physiological comfort (N. Oglakcioglu, A. Marmarali, 2007), [1].

Over the last few years many studies have been conducted for thermal comfort properties of textile fabrics. Anand (Anand S. 2003), reported that the open construction has better water vapor permeability than micromesh, pique, and rib structures, [2].

Milenkovic (Milenkovic L. et al, 1999), proved that fabric thickness, enclosed still air and external air movement are the major factors that affect the heat transfer through fabric. Greyson and Havenith, mentioned that heat and water vapor resistance increases with the increment of material thickness and air entrapped, [1].

Hes, et.al developed a new functional knitted fabric possessing double layers by using different yarn components (like polypropylene and cotton) in order to maximize the transport moisture, [3]. Thermal properties of 1×1, 2×2 и 3×3 rib knit fabrics were compared by Ucar and Yilmaz (Ucar N., Yilmaz T., 2007). They noted that a decrease in rib number leads to a decrease in heat loss; the use of 1×1 rib and tight structure would provide better thermal insulation, [4]. The mathematical models developed by several researchers (Maxwell 1904; Vary 1952; Kunii and Smith 1960; Woodside and Messmer 1961; Zenner and Schlüder 1970; Bauer et al. 1991; Bogaty and Collar 1987; Fricke 1993) show that the relation between the thermal conductivity of porous surrounding and its thermo-physical properties are non-linear, [5].

Investigation of thermal comfort properties of double layered knitted fabrics with different yarn components show that thermal resistance depends more on synthetic thread type than on natural fiber yarns, [6]. It was found that the structure of the knitting fabric (the knitting pattern structure) highly influences the heat transfer process as distinct from the raw material content of knitted fabric. Investigations were carried out on double-layered knitted fabrics made from cotton or man-made bamboo yarns in the outer (located outer from the skin) layer and PP, PA, PES yarns in the inner (located next to the skin layer), [7].

Thermal conductivity is an intensive property of material that indicates its ability to conduct heat, [8]. **Thermal resistance** is a measure of the thermal insulation of the material. It is defined as the quantity of heat transmitted through a unit thickness in a direction normal to a surface of unit area, due to a unit temperature gradient under steady state conditions, and when the heat transfer is dependent only on temperature. As we can see from the definition, it is necessary to know the rate of heat transfer through the material in order to be measured its thermal resistance, [9].

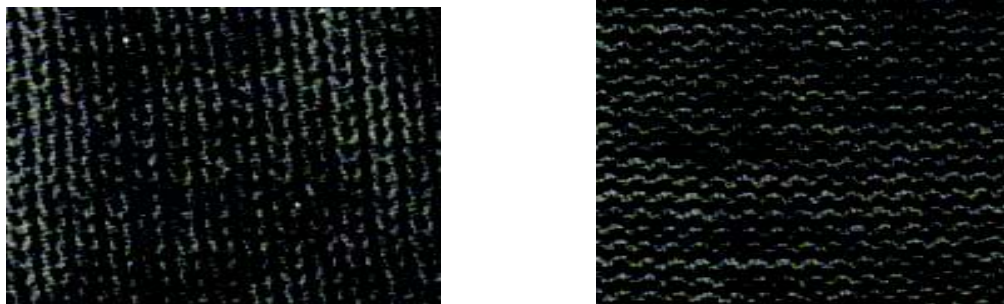
In this paper, the influence of structural characteristics and raw material content of single jersey knitted fabrics on the air and water vapor permeability, thermal properties (thermo-physiological comfort), was investigated.

Thermal conductivity of knitted fabrics was determined according to new method of thermo-vision analysis developed by researchers.

2. EXPERIMENTAL

2.1. Materials

Single jersey structures were knitted using 100 % PAN (acrylic), 50/50% PAN/cotton and 100 % wool. Knitting process of the single jersey knitted fabrics was performed on an flat knitting machine STOLL CMS 12. All knitted fabrics are made of yarn count $T_1=33 \times 2 \times 2$ tex.



a) b)
Figure 1-Single jersey structure a)face)bback

2.2. Methods and instruments

2.2.1. Structural properties of knitted fabrics

Structural properties of knitted fabric (course density, D_n, cm^{-1} and wale density, D_v, cm^{-1}), fabric thickness, $h(mm)$ mass per unit area $m (g/m^2)$, loop length, l are determined according to standard methods. Tigness factor TF and porosity P are calculated according to the equations (1,2):

$$TF = \frac{\sqrt{T_1}}{l} \quad (\text{tex}^{1/2} \text{cm}^{-1}) \quad (1) \quad P = \left(1 - \frac{m}{\rho \cdot h} \right) 100(\%) \quad (2)$$

where:

T – yarn count (tex), l – loop length (mm), ρ – mass density (kg/m³), h – fabric thickness (mm)

2.2.2. Air permeability

Investigation of the air permeability was performed according to the standard EN ISO 9237:1999. An FF-12 Metrimpex instrument was used with difference in contact pressure of 20 Pa and area of the sample 10 cm², [10].

2.2.3. Water vapor permeability

The investigation of water vapor permeability was performed on a sample with 15x15 cm dimensions. All the measurements were done under standard climatic conditions with apparatus consisting of thermostat and glass with 62 cm² surface (internal diameter 89 mm). Water is put in the glass until the level of water rises up to 35 mm below the upper glass edge. The glass is covered with the sample and is put under the influence of water vapor with temperature of 50 °C for four hours. After 4 hours the loss of water is determined and the mass increment of the sample, P_v , and the procedure is repeated under the same conditions for four more hours. According to the given results the water vapor permeability is calculated with the following relation, [11]: (3)

$$PVP = m_v - \frac{P_v}{A \cdot t} \cdot 100 (\%) (mg/cm^2 h) \quad (3)$$

where: m_v – loss of water in the glass (g); P_v – increment of the mass of the sample (g); A – active surface of the sample (cm²); t – time of procedure (h)

The results are the average value from three measurements in each sample.

2.2.4. Thermal conductivity

In order to measure the thermal conductivity coefficient of the knitted fabrics λ (W/mK) the method of thermo-vision analysis is used. The apparatus (figure 2) consists of:

- infrared camera) FLIR P-45;
- temperature measurement instrument and online software monitoring: TESTO 635-2;
- heating and cooling thermostat.

The measuring was conducted according to the following procedure:

- samples of knitted fabrics with 250x250 mm dimensions are put on the thermostat;
- the infrared camera is set to a 15 min interval and 5 pictures are captured every 3 minutes;
- the online monitoring software generates data that is automatically noted while the shooting takes place. Data is generated for: the exact time of each picture, temperature, air relative humidity rH(%), and the temperature plate of the thermostat T_w ;
- the investigations are conducted with air temperature of 22,0 ± 0,3 °C and the air relative humidity of 63,4 ± 0,5%;
- during the picture capturing the thermograms are generated for each sample;
- the pictures taken are processed with special software – FLIR;
- the temperature in the center of the sample is displayed on the thermogram (T_{sp1}) (°C). Also, the temperature of another dot (T_{sp2}) (°C) located outside the square area is displayed. Finally, the thermogram displays the average temperature T_{arp1} (°C) of the fabric squared area. The temperature change dependence from the time of capture for each sample diagrams are drawn T_{sp1} , T_{arp1} and T_w . The values of the time in hours- t (3/60), are applied on the x-axis, while the values of natural logarithm $\ln(T_{sp1}, T_{arp1}, T_w)$ of the temperature are applied on the y-axis.;
- the temperature change rate coefficient of the knitted fabric m_1 is determined from the linear line equation for average value of the temperature of the knitted fabric T_{arp1} , i.e. $y = ax + b$, where $y = T_{arp1}$ and $a = m_1$.



Figure 2-Thermo-vision device

The determining of the thermal conductivity coefficient λ , according to the thermo-vision analysis is based on the theory of the regular temperature regime, i.e. on Kondratievs' second theorem [12]: (4) and(5)

$$m_1 = K \cdot a \quad (4) \quad a = \frac{m_1}{K} \quad (5) \quad \text{and} \quad a = \frac{\lambda}{c \cdot \rho} \quad (6)$$

where: m_1 – temperature change rate coefficient (heating or cooling of the material(s^{-1}); K – proportionality coefficient; a - thermal diffusion (m^2/s); ρ - fabric density (kg/m^3); c - specific heatcapacity (J/kgK)

m_1 coefficient depends on the physical characteristics, the dimensions and the geometry of the material. K coefficient depends only on the geometry of the material and for flat plate is calculated according to the formula (7)

$$K = \left(\frac{\pi}{2h} \right)^2 \quad (7)$$

where: h - thickness of the material (mm)

The specific heat capacity of more component fabrics is calculated according to the equation (8).

$$c = \sum_{i=1}^{i=n} c_i \cdot p_i \quad (J/kgK) \quad (8)$$

where: c_i - components' specific heat capacity; p_i - mass percentage of the component

The volume mass or the fabric density ρ is calculated according to the equation (9).

$$\rho = \frac{m}{h} \quad \left(\frac{kg}{m^3} \right) \quad (9)$$

where: h - fabric thickness (m); m - mass per unit area of the fabric (kg/m^2).

(ρ for more component fabrics is calculated considering the mass percentage of the components).

The thermal resistance is defined with the equation (10).

$$R_{ct} = \frac{h}{\lambda} \left(\frac{m^2 K}{W} \right) \quad (10)$$

where: R_{ct} –thermal resistance(m^2K/W); h –fabric thickness(m); λ –thermal conductivity(W/mK).

3. RESULTS AND DISCUSSION

3.1. Structural characteristics

In Table 1 the structural characteristic of single-jersey fabrics with different raw material content are given (figure 3).

Table 1- Structural characteristics of the single jersey knitted fabrics with different raw material content

| No. | Raw material content (%) | | D_h (cm^{-1}) | D_v (cm^{-1}) | D (cm^{-2}) | l (mm) | m (g/m^2) | h (mm) | TF ($tex^{1/2}cm^{-1}$) | P (%) |
|-----|--------------------------|--------------------|---------------------|---------------------|-------------------|----------------|-----------------|-----------------|-----------------------------|---------|
| 1 | 100 PAN | \bar{x} Cv(%) | 5,50 (0,55) | 7,75 (0,45) | 42,6 | 7,30 (3,20) | 412 (3,54) | 1,245 (3,75) | 15,7 | 71,0 |
| 2 | 50/50 PAN/cotton | \bar{x} Cv(%) | 5,75 (0,45) | 9,00 (0,71) | 51,7 | 6,90 (2,40) | 472 (4,23) | 1,280 (1,27) | 16,6 | 71,0 |
| 3 | 100 Wool | \bar{x} Cv(%) | 6,00 (0,45) | 8,00 (0,55) | 48,0 | 6,95 (3,40) | 440 (4,10) | 1,314 (1,25) | 16,5 | 73,9 |

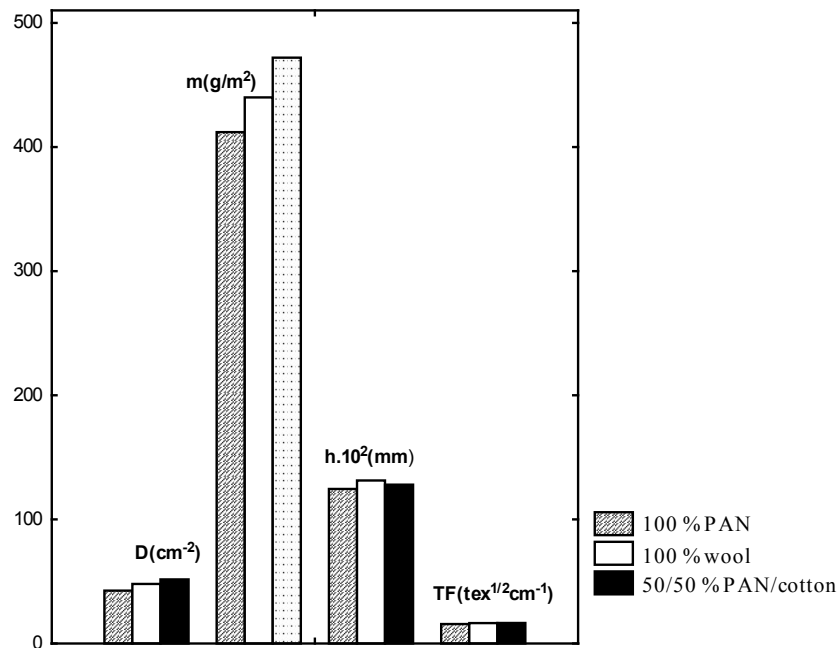


Figure 3 -Density(D),mass per unit area (g/m^2), thicknes(h) and tightness factor(TF) of the single jersey knitted fabrics with different raw material content

As the density (D) increases, the mass per unit area (m) and tightness factor (TF) also increase, but not the thickness as a result of the different raw material content of the fabrics.

3.2. AIR AND WATER VAPOUR PERMEABILITY

In table 2 air and water vapor permeability values are given (figure 4a and 4b.)

Table 2-Air and water vapor permeability of the single jersey knitted fabrics with different raw material content

| No. | Raw material content (%) | Air permeability Q (dm^3/h) | Coefficient of variation $Cv(\%)$ | Coefficient of air permeability $B_{\Delta p}$ (m/s) | Water vapor permeability 4 hours (PVP,4h) | Water vapor permeability 8 hours (PVP,8h) |
|-----|--------------------------|-----------------------------------|-----------------------------------|------------------------------------------------------|-------------------------------------------|-------------------------------------------|
| 1 | 100 PAN | 1640 | 3,1 | 0,455 | 62,90 | 55,03 |
| 2 | 50/50 PAN/cotton | 355 | 5,5 | 0,098 | 52,34 | 46,80 |
| 3 | 100 Wool | 1110 | 4,4 | 0,308 | 62,31 | 53,95 |

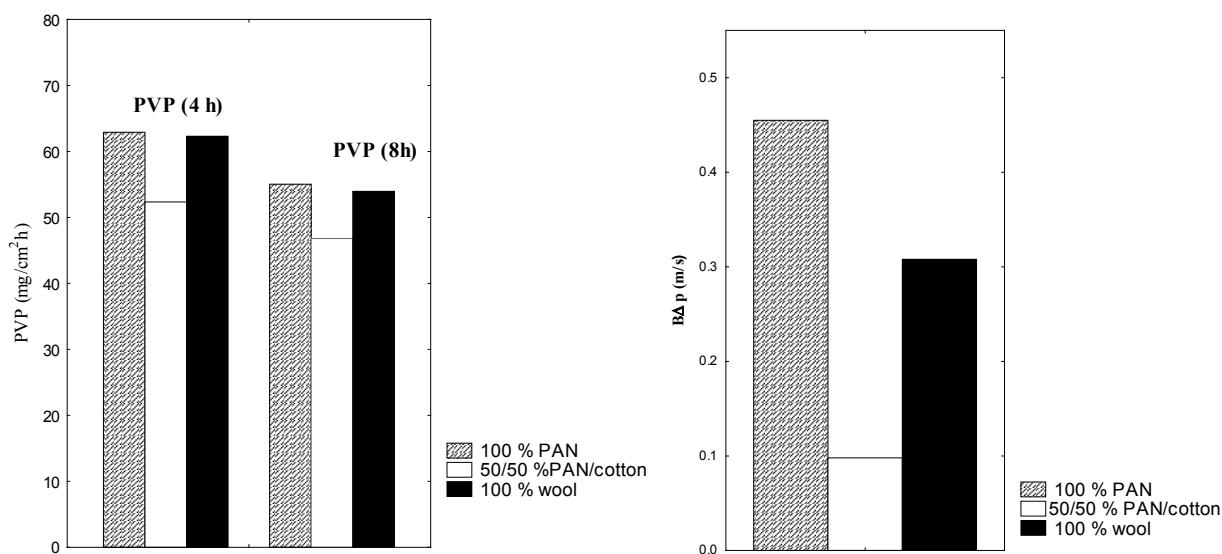


Figure 4: a) water vapor permeability (PVP 4 and 8 hours) and b) coefficient of air permeability ($B_{\Delta p}$)

Air permeability ($B_{\Delta p}$) and water vapor permeability (PVP for 4 and 8 hours) have the same trend of increase, i.e. their value decreases as the mass per unit area and tightness factor TF of the fabric increase. More dominant influence of the structural characteristics on the air and water vapor permeability compared to raw material content is noticeable.

3.3. Thermal characteristics

On figure 5 a thermogram for one sample of the examined fabrics is given. The values obtained from the thermograms of all samples and their natural logarithms are given in Table 3.

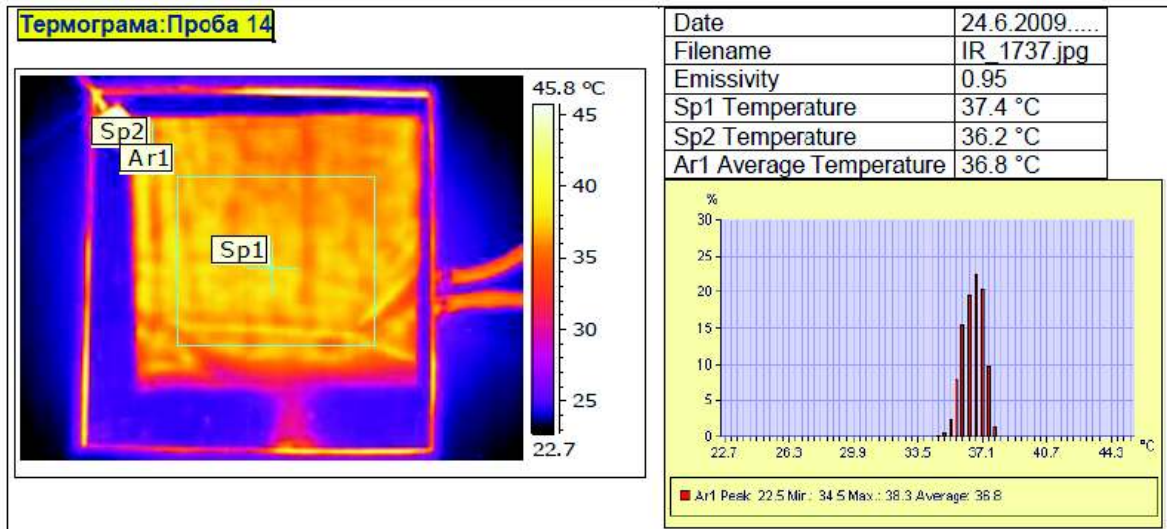


Figure 5- Thermogram for single jersey of 100% PAN

*Table 3-*Data obtained from thermograms (T_{sp1} , T_{arp1} , T_w) for single jersey knitted fabrics with different raw material content and the temperature of the plate (T_w)

| Raw material content (%) | Picture number | T_w (°C) | T_{sp1} (°C) | T_{sp2} (°C) | T_{arp1} (°C) | $\ln T_w$ | $\ln T_{sp1}$ | $\ln T_{arp1}$ |
|--------------------------|----------------|------------|----------------|----------------|-----------------|-----------|---------------|----------------|
| PAN 100 | 1 | 47.38 | 37.4 | 36.2 | 36.8 | 3.8582 | 3.6217 | 3.6055 |
| | 2 | 46.01 | 37.0 | 35.8 | 36.6 | 3.8289 | 3.6109 | 3.6000 |
| | 3 | 44.44 | 36.1 | 35.0 | 36.0 | 3.7941 | 3.5863 | 3.5835 |
| | 4 | 42.91 | 35.9 | 34.3 | 35.4 | 3.7591 | 3.5807 | 3.5667 |
| | 5 | 41.46 | 35.0 | 34.0 | 34.7 | 3.7247 | 3.5553 | 3.5467 |
| PAN/cotton 50/50 | 1 | 34.19 | 30.2 | 30.5 | 30.1 | 3.5319 | 3.4078 | 3.4045 |
| | 2 | 33.57 | 30.5 | 30.6 | 30.5 | 3.5136 | 3.4177 | 3.4177 |
| | 3 | 33.07 | 30.0 | 30.4 | 30.2 | 3.4986 | 3.4012 | 3.4078 |
| | 4 | 32.57 | 29.7 | 30.1 | 29.8 | 3.4834 | 3.3911 | 3.3945 |
| | 5 | 32.05 | 29.4 | 29.5 | 29.5 | 3.4673 | 3.3810 | 3.3844 |
| Wool 100 | 1 | 51.75 | 35.5 | 38.4 | 35.8 | 3.9464 | 3.5695 | 3.5779 |
| | 2 | 51.03 | 37.3 | 39.9 | 37.1 | 3.9324 | 3.6190 | 3.6136 |
| | 3 | 49.80 | 37.4 | 40.2 | 37.7 | 3.9080 | 3.6217 | 3.6296 |
| | 4 | 48.22 | 37.3 | 40.0 | 37.4 | 3.8758 | 3.6199 | 3.6217 |
| | 5 | 46.79 | 36.9 | 39.4 | 37.3 | 3.8450 | 3.6082 | 3.6189 |

In figures 6, 7 and 8 the linear line equation of the examined fabrics are given, based on which the coefficient for temperature change rate m_1 is determined.

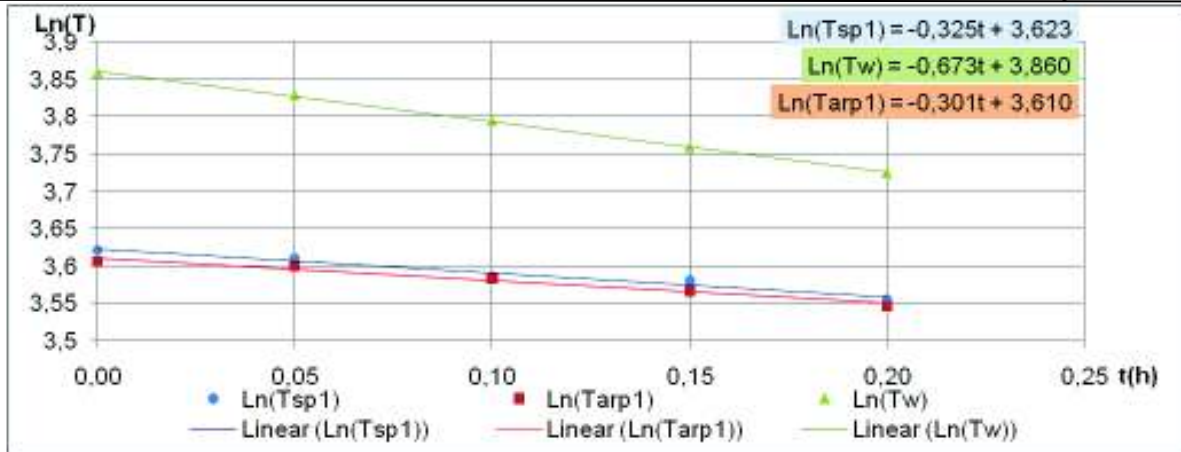


Figure6 – The temperature change dependence from the time of capture T_{sp1} , T_{arp1} and T_w for single jersey of 100% PAN

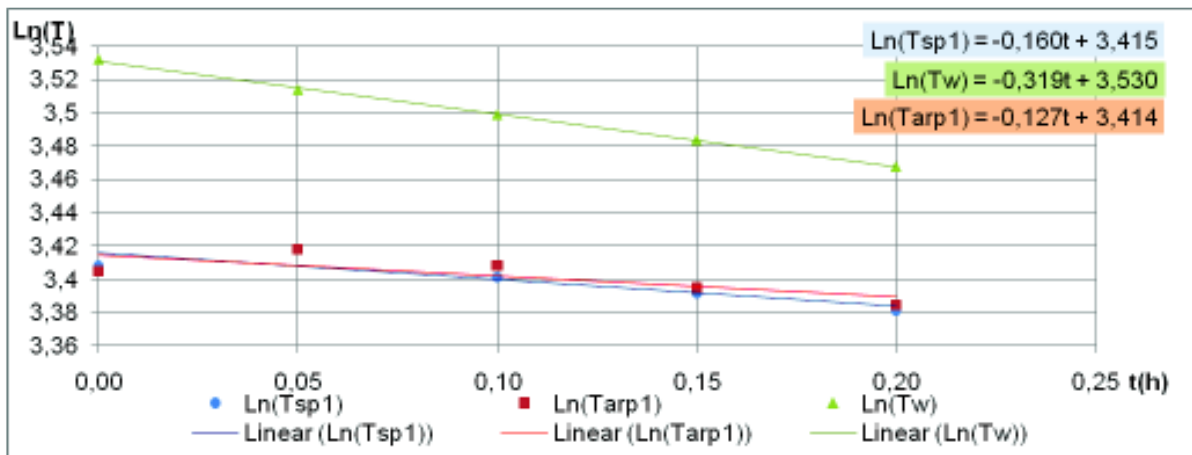


Figure7– The temperature change dependence from the time of capture T_{sp1} , T_{arp1} and T_w for single jersey of 50/50% PAN/cotton

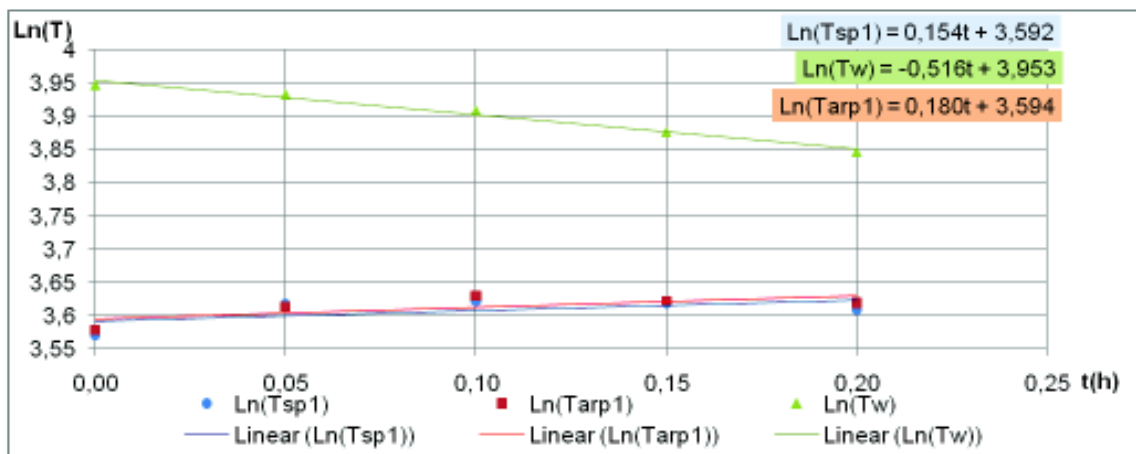


Figure8 – The temperature change dependence from the time of capture T_{sp1} , T_{arp1} and T_w for single jersey of 100% wool

Based on the thermograms and the linear line equations the coefficient of the temperature change dependence from the time of capture m_1 is determined. After that the coefficient K is calculated. This data is needed to determine the thermal conductivity λ and thermal resistance R_{ct} (table 4).

Table 4–Thermal characteristics of single jersey knitted fabrics with different yarn components

| No. | Yarn component (%) | $K=(\pi/2h)^2$ | m_1 | c (J/kgK) | ρ (kg/m ³) | λ (W/mK) | R_{ct} (m ² K/W) |
|-----|--------------------|----------------|--------|-------------|-----------------------------|------------------|-------------------------------|
| 1 | 100 PAN | 1591823 | 0,3017 | 1200 | 331 | 0,0753 | 0,0165 |
| 2 | 50/50 PAN/cotton | 1505960 | 0,1270 | 1270 | 369 | 0,0395 | 0,0324 |
| 3 | 100 Wool | 1429035 | 0,1803 | 1300 | 335 | 0,0549 | 0,0239 |

It can be noticed that the thermal conductivity decreases as the density and mass per unit area of the fabric increase, while the thermal resistance rises respectively. The fabric made of 100% PAN, which has the highest air and water vapor permeability, also has the highest thermal conductivity, i.e. the lowest thermal resistance.

4. CONCLUSION

The results indicate that the structural characteristics of the knitted fabric have dominant influence on thermo-physiological comfort, as opposed from the rawmaterial content. The density, mass per unit area and tightness factor of the knitted fabrics determine the air and water vapor permeability and thermal characteristics. The final assessment of the thermo-physiological comfort depends on the wearing conditions. According to this, a single jersey made of 50/50%PAN-cotton will provide the best comfort when being worn on lower temperatures, while a single jersey of 100%PAN on higher temperatures. The single jersey made of 100%wool did not show the highest thermal resistance as expected because of its raw material content, which is a result of the structural characteristics i.e. lower density of the fabric.

One of the aims of the investigation was to check the possibility for using the method of thermo-vision analysis when investigating the thermal properties of knitted fabrics as important element of thermo-physiological comfort. The results from this research provide a huge area for further investigation.

LITERATURE

- [1]OglakciogluN., MarmaraliA.,(2007), *Thermal comfort properties of some knitted structures*, Fibres&Textiles in Eastern Europe, Vol.15, 64-65
- [2]Anand S.,(2003), *Sportswear Fabrics*, Knitting International, pp 23-25
- [3] Hes L, Gerald M J & Araújo M, (2002), *How to Improve the Thermal Comfort with High Performance PP Fibres*, 2nd Autex Conference Proceeding, p. 428-430, Bruges, Belgium
- [4]UcarN., YilmazT.,(2007), *Thermal properties of 1x1, 2x2 and 3x3 rib knit fabrics*, Fibres &Textiles in Eastern Europe, Vol.12, No 3
- [5]FayalaF., AlibiH., BenltoufaS., JemniA.,(2008), *Neural Network for Predicting Thermal Conductivity of Knit Materials*,Journal of Engineered Fibers and Fabrics ,Vol. 3
- [6]BivainyteA., MinucianieneD., KerpauskasP.,(2012), *Investigation on thermal properties of Double-Layered Weft Knitted fabrics*,Fibres&Textiles in Eastern Europe,Vol.18, No.2
- [7]BivainyteA.,MinucianieneD., MilasieneD.,(2012), *Influence of the Knitting Structure of Double-Layered fabrics on the heat transfer process*,Fibres&Textiles in Eastern Europe, Vol.20, No.2
- [8]MatusiakM.,(2006), *Investigation of the thermal insulation properties of Multilayer Textiles*, Fibres&Textiles in Eastern Europe, Vol.14, No. 5
- [9]SavilleB.P.,(1999), *Physical testing of textiles*, Woodhead Publishing, Cambridge England 209-234
- [10]Стоянова Германова-КрстеваД., (2007), *Раководство за лабораторни упражнения по текстилни испитвания и анализ*,Технически университет- София,2-75
- [11]CunkoR., (1988), *Ispitivanje tekstila*,Sveučilišna naklada,Zagreb, 221
- [12]СендовС.,(2000), *Топломасопреносение*,Технически университет, София