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THE INFLUENCE OF STRUCTURAL PROPERTIES AND CHARACTERISTICS OF THE FIBER ON THE PHYSICAL-MECHANICAL PROPERTIES AND THERMO-PHYSIOLOGICAL COMFORT OF SINGLE YERSEY KNITTED FABRICS

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Abstract

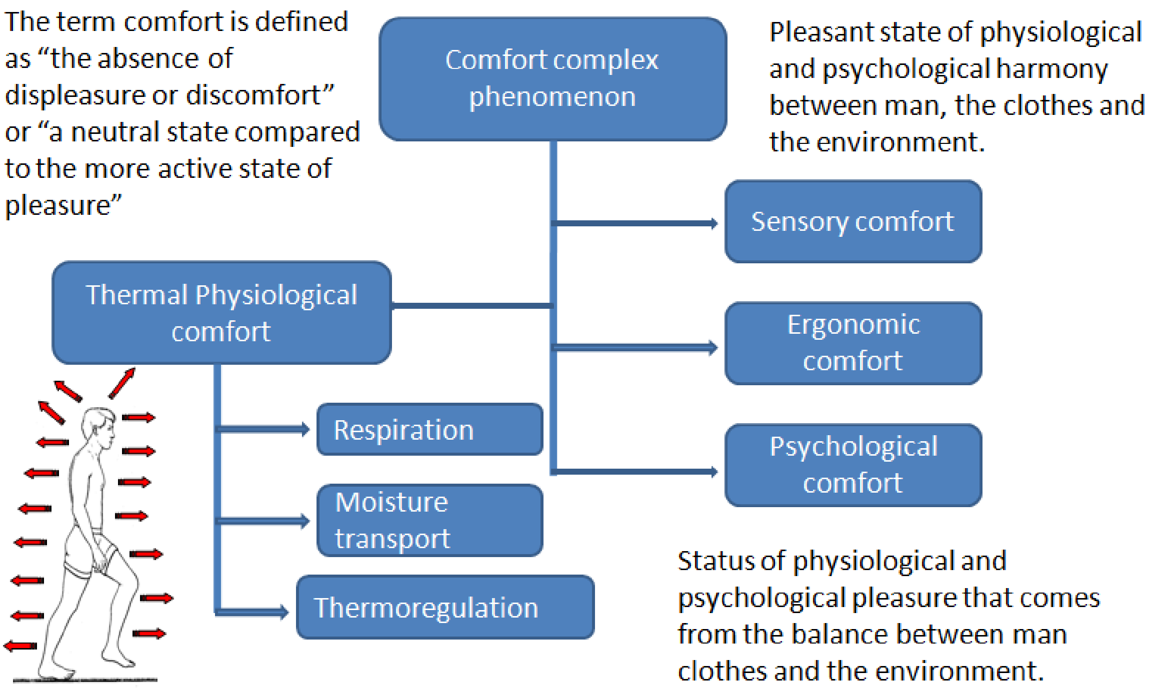
The most important properties of the majority of knitted fabrics are good stretchability and elasticity, and thus the resulting freedom of movement. They are able to adopt themselves to the body shape of the wearer and have good air permeability, offering high standard of wear comfort.
In this paper, the influence of structural properties and characteristics of fiber on the thermal properties, air and water vapor permeability, as well on the physical-mechanical properties of single jersey knitted fabrics were investigated.

Single jersey knitted fabrics are made of 100% wool, 50/50% acryl/cotton, and 100% acryl yarn. The thermal properties of knitted fabrics were measured by method of D-r Boc. Correlation and regression analysis were used for data processing.

The results indicate that characteristics of the fibres have significant influence on the the physical-mechanical and thermal properties, while structural characteristics have significant influence on the air and water vapor permeability. Knitted fabrics made of 100%wool have the highest thermal resistance and warmer feeling and touch due to the lower thermal absortivity value, while knitted fabrics of 50/50% acryl/cotton gave a séance of coolness. On the other hand, density and cover factor have most important influence on air and water vapor permeability

Key words: single jersey, thermo-physiological comfort, air permeability, water vapour permeability

DEFINITION AND ASPECTS OF COMFORT



EKSPERIMENTAL

In this paper, the influence of structural characteristics and raw material content of single jersey knitted fabrics on the thermal properties, air and water vapour permeability (thermo-physiological comfort), as well as on the physical-mechanical characteristic (tear strength, tensile properties, abrasion resistance and dimensional stability) was investigated.

MATERIAL

Single jersey knitted structures were knitted using yarn of the same count (33x2x2 tex), with different row material content: PAN(acrylic)100%, PAN/cotton 50/50% and wool 100%. Knitted structures are knitted on flat knitting machine STOLL CMS 12 E.

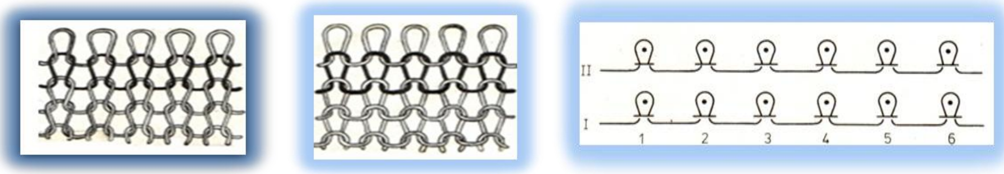


Fig. 1- Single jersey

RESEARCH METHODS AND INSTRUMENTS

1. **STRUCTURAL CHARACTERISTICS:**

- ***fabric thickness-h,***
- ***mass per unit area – m,***
- ***course– D_h and wale- D_v density,***
- ***loop length- l,***

are measured according to standard methods.

- ***cover factor-TF and porosity-P***

are determined according to: $TF = \frac{\sqrt{T_t}}{l}$ (tex$^{1/2}$cm^{-1})

$$P = \left(1 - \frac{m}{\rho h}\right)100(\%)$$

2. **PHYSICAL-MECHANICAL CHARACTERISTICS:**

- ***breaking strength, wale- F_{ak}, breaking strength, course - F_{ar},***
- ***tensile strength, wale- ε_k, tensile strength, course - ε_r,***
- ***bursting strength- F_{pr}, abrasion resistance-Δm***
- ***dimensional stability - S_s and S_d, air permeability- Q or $B_{\Delta p}$,***
- ***water vapour permeability- PVP,***

are measured according to standard methods.

3. **THERMAL CHARACTERISTICS:**

- ***Thermal conductivity - λ,*** $\lambda = \frac{Q}{A\frac{\Delta t}{h}}\left(\frac{W}{mK}\right)$
- ***Thermal resistance- Rct,*** $R_{ct} = \frac{h}{\lambda}\left(\frac{Km^2}{W}\right)$
- ***Thermal diffusion- a,*** $a = \frac{\lambda}{\rho c}\left(\frac{m^2}{s}\right)$
- ***Thermal absorptivity-b*** $b = \sqrt{\lambda \rho c}\left(\frac{Ws^{\frac{1}{2}}}{m^2K}\right)$

$$\lambda = \frac{q \cdot S}{\left(\Delta tm - qW\right)}\left(\frac{W}{mK}\right)$$

Fig. 2- D-r "BOK" instrument used to measure thermal characteristics

RESULTS AND DISCUSSION

1. STRUCTURAL CHARACTERISTICS

Table 1. -Structural characteristics of the single jersey knitted structures with different row material content

Num.	*Row material content (%)*		D_h (cm^{-1})	D_v (cm^{-1})	*c*	*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)	0,709	42,6	7,30 (3,20)	412 (3,54)	1,245 (3,75)	15,7	71,0
2	50/50 Cotton/PAN	$\bar{x}$ Cv(%)	5,75 (0,45)	9,00 (0,71)	0,638	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)	0,812	48,0	6,95 (3,40)	440 (4,10)	1,314 (1,25)	16,5	73,9

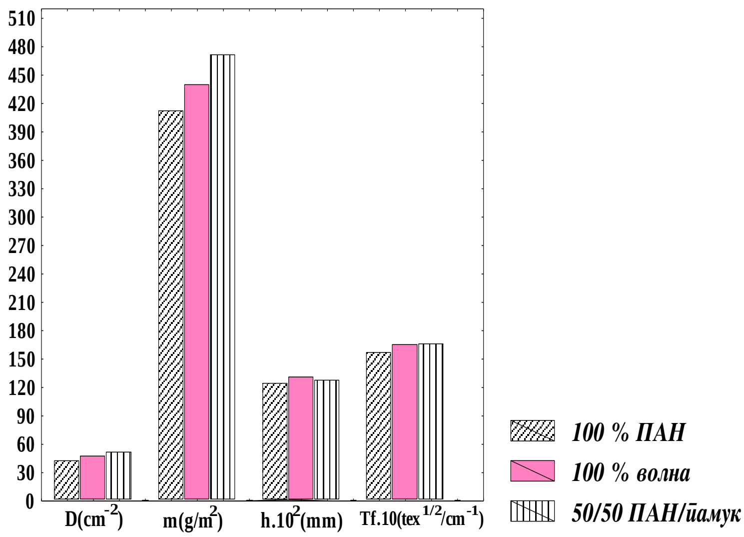


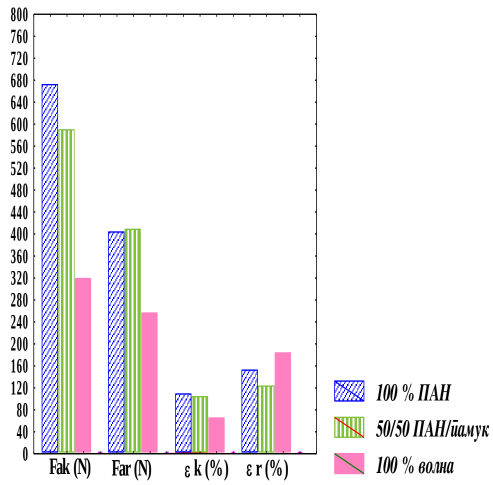
Fig. 3- Density(D), mass per unit area(m), thickness(h) and cover factor(TF) of the single jersey knitted structures with different row material content

Due to increase of density-D, mass per unit area-m and the cover factor-TF increases, but not the fabric thickness-h according to the fabric order, which is result of the different row material content.

2. PHYSICAL-MECHANICAL CHARACTERISTICS

Table 2- Mechanical characteristics of the single jersey knitted structures with different row material content

Num.	***Row material content (%)***		***Breaking strength***			***Tensile strength***		***Bursting strength F_{pr} (daN)***
			Breaking strength, wale F_{ak} (N)	***Breaking strength, course F_{ar} (N)***	***Specific breaking strength, F_{sp} (Nm^2g^{-1})***	***Tensile strength, wale ε_K (%)***	***Tensile strength, course ε_r (%)***	
1	100 PAN	$\bar{x}$ Cv(%)	672,2 (11,0)	403,7 (20,1)	2,60	107,8 (7,5)	152,9 (23,5)	64,00 (5,1)
2	50 /50 Cotton/PAN	$\bar{x}$ Cv(%)	589,5 (9,5)	408,1 (4,81)	2,11	104,4 (6,2)	122,5 (14,1)	63,17 (1,6)
3	100 wool	$\bar{x}$ Cv(%)	318,6 (0,53)	255,9 (11,7)	1,30	64,42 (21,5)	183,9 (16,0)	23,00 (5,7)



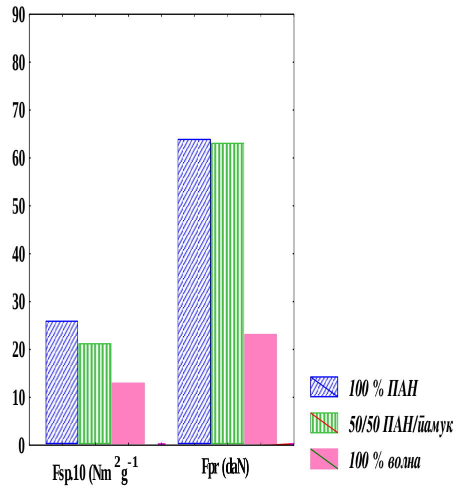


Fig. 4 –a) Breaking strength, wale-F_{ak}(N) and course-F_{ar}(N), tensile strength, wale -ε_k(%), tensile strength, course-ε_r (%), b) Specific breaking strength - F_{sp}(Nm^2/g) and bursting strength F_{pr} (daN)

Knitted structure of PAN 100% has highest value of breaking strength- F_{ak}, specific breaking strength- F_{sp} and bursting strength- F_{pr}, while knitted structure of wool

100% has the lowest value of breaking strength- F_{ak}, specific breaking strength - F_{sp} and bursting strength F_{pr} which is result of fiber characteristics. All three knitted structures have higher tensile strength, course- ε_r related to tensile strength, wale - ε_k.

Table 3- Abrasion resistance, Δm (%) and dimensional stability of the single jersey knitted structures with different row material content

N.	***Row material content (%)***	***Abrasion resistance Δm (%)***	***Dimensional stability***	
			Shrinking per course, S_s (%)	***Shrinking per wale, S_d (%)***
1	100 PAN	0,473	0,0	0,8
2	50/50 Cotton/PAN	1,149	0,8	1,6
3	100 wool	4,812	1,0	3,0

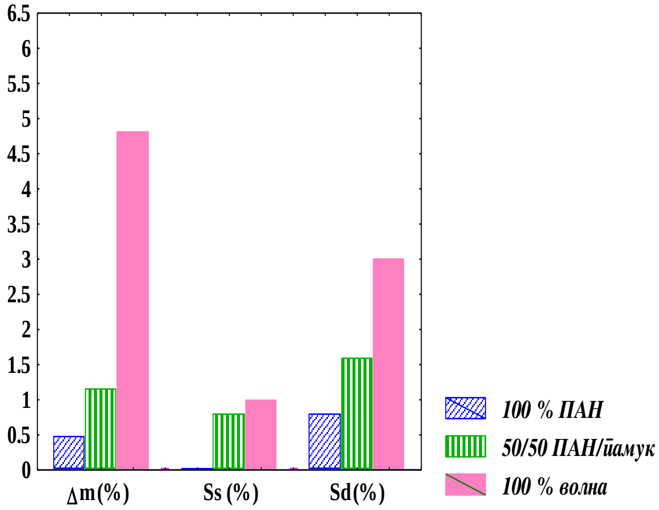


Fig. 5– Abrasion resistance- Δm (%)and dimensional stability (shrinking per course S_s,% shrinking per wale S_d, %)

The presence of PAN increases abrasion resistance-Δm, so the knitted structure of wool 100% has the highest mass loss, while the knitted structure of PAN 100% has the lowest mass loss. All three knitted fabrics are dimensionally stable with a small shrinking per course-S_s and wale-S_d. Lowest shrinking per course-S_s and wale-S_d has the knitted structure of PAN 100% due to fiber characteristics.

Table 4- Air permeability and water vapour permeability of the single jersey knitted structures with different row material content

Num	*Row material content (%)*	*Air permeability Q (dm^3/h)*	*Coefficient of variation for Q Cv (%)*	*Coefficient of air permeability $B_{\Delta p}$ (m/s)*	*Water vapour permeability 4 hours (PVP,4h)*	*Water vapour permeability 8 hours (PVP,8h)*
1	100 PAN	1640	3,1	0,455	62,90	55,03
2	50/50 Cotton/PAN	355	5,5	0,098	52,34	46,80
3	100 wool	1110	4,4	0,308	62,31	53,95

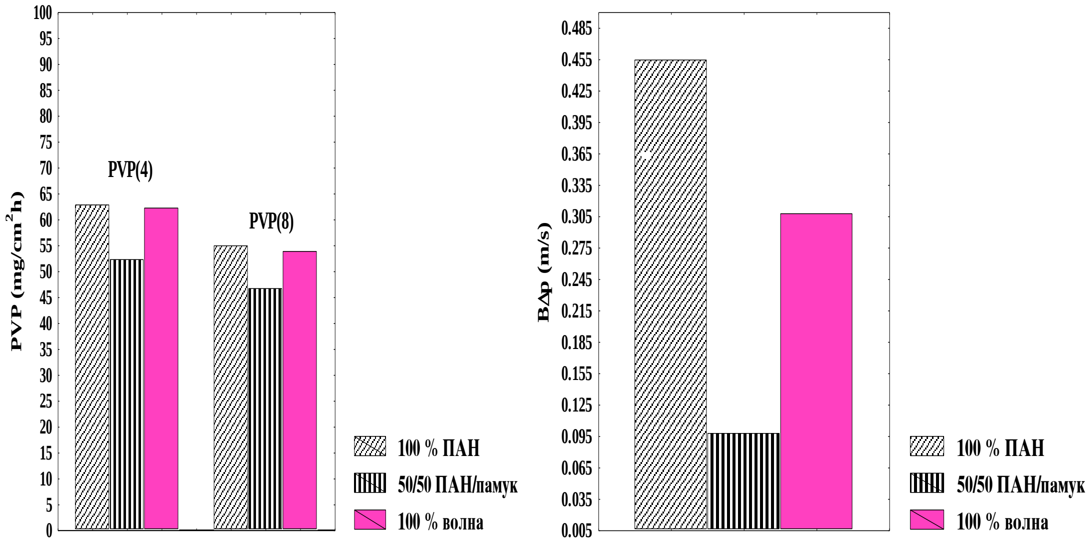


Fig.6- a) Air permeability coefficient ($B_{\Delta p}$) and b) Water vapour permeability(PVP 4 and 8 hours)

Air permeability coefficient- $B_{\Delta p}$ and water vapour permeability- PVP 4 and 8 hours have the same trend of increase and both decrease with increase of mass per unit area-m and cover factor –TF.

THERMAL CHARACTERISTICS

Table 5 - Thermal characteristics of the single jersey knitted structures with different row material content

Num.	*Row material content (%)*	*S (mm)*	*λ (W/mK)*	*R_{ct} (m^2K/W)*	*$a \cdot 10^{-6}$ (m^2/s)*	*b ($Ws^{1/2}/m^2K$)*	*ρ_{pl} (g/cm^3)*
1	100 PAN	2,90	0,1158	0,0251	0,6793	140,44	0,142
2	50/50 Cotton/PAN	2,00	0,1155	0,0173	0,3853	186,04	0,236
3	100 wool	3,25	0,1265	0,0257	0,7208	139,00	0,135

S (mm)-thickness measured on D-r Bok instrument, ρ_{pl} (g/cm^3)-fabric density

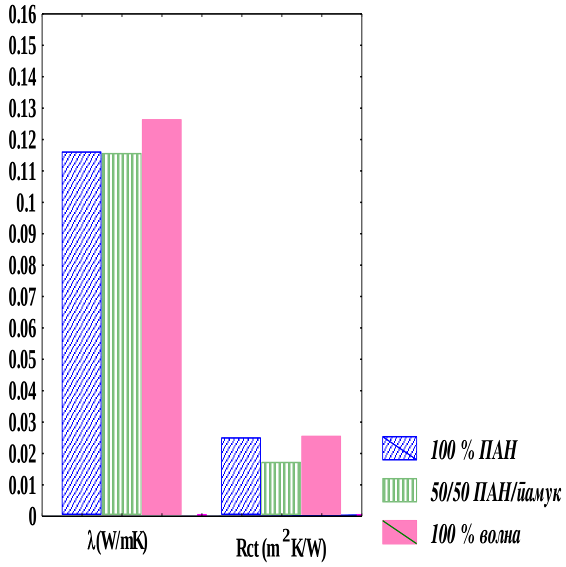


Fig.7-Thermal conductivity(λ) and thermal resistance(R_{ct})

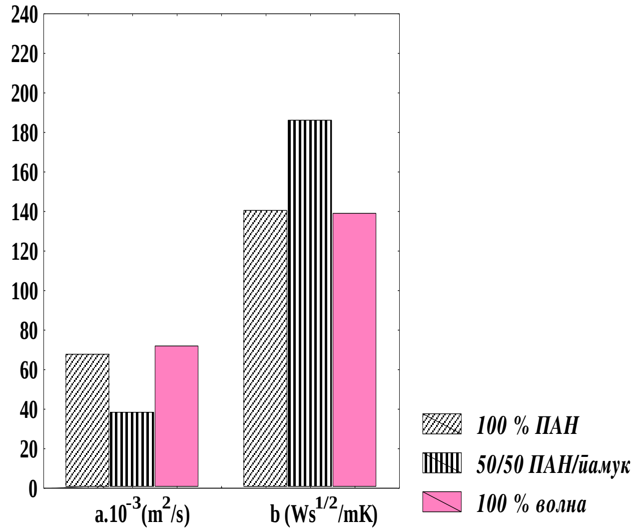


Fig.8- Thermal diffusion (a) and thermal absortivity(b)

- Thermal conductivity -λ and thermal resistance-R_{ct} have the same trend of increase and both increase with increase of fabric thickness- h.
- Thermal absortivity-b increases while thermal diffusion–a decreases due to increase of mass per unit area- m.
- According to value of thermal absortivity- b the warmest touch has knitted fabric of wool 100% and the coldest, knitted fabric of PAN/cotton 50/50%.

CONCLUSION

The results indicate that raw content of knitted structure has significant influence on the physical-mechanical and thermal characteristics, while its influence on the air and water vapour permeability was lower concerning the structural characteristics.

Knitted structure of 100% wool has a highest thermal resistance and also gives a warmest feeling at touch due to the lowest thermal absorptivity value, while knitted structure of 50/50 acrylic/cotton gives a sense of coolness.

On the other hand, density and cover factor have most important influence of air permeability and water vapour permeability.

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