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Investigation of Fabric Properties Woven with Different Fibres

Raziskava lastnosti tkanin iz različnih vlaken

Original Scientific Paper/*Izvirni znanstveni članek*
Received/*Prispelo* 03-2013 • Accepted/*Sprejeto* 04-2013

Abstract

In this study, comfort and handle properties of fabrics woven with various fibre types, e.g. Seacell®, silver, cotton, bamboo viscose fibres and soybean, were investigated and analysed. It was observed that fibre types influence the comfort and handle properties of fabrics. According to the test results, cotton yarn had the best thermal properties compared with other fibres, whereas bamboo and soybean demonstrated better handle properties than other fibres.
Keywords: silver, Seacell®, bamboo viscose fibres, soybean, comfort, handle

Izvleček

Raziskava, predstavljena v članku, ki analizira udobnost in otip tkanin iz različnih vrst vlaken, npr. Seacell®, srebro, bombaž, bambusova in sojina vlakna, je vodila do ugotovitve, da vrsta vlaken vpliva na udobnost in otip tkanin. Rezultati raziskav so pokazali, da ima v primerjavi z ostalimi vlakni bombažna preja najboljše toplotne lastnosti, medtem ko imata bambusova in sojina preja boljši otip kot ostala vlakna.
Ključne besede: srebro, Seacell®, bambusova viskozna vlakna, sojina vlakna, udobnost, otip

1 Introduction

Textile industry continuously searches for new technologies in order to accomplish the consumers' demands. The acceptability of a textile fabric largely depends on the comfort aspects which involve thermal properties, air permeability and water vapour permeability. Although a plethora of researches have been conducted on the mechanical properties of textile fabrics, they have hardly played any role during the actual use of the fabrics. In contrast, comfort properties determine the way in which the heat, air and water vapour are transmitted across the fabric [1].

Thermal comfort properties of textile fabrics are actually influenced by the gamut of fibre, yarn and fabric properties. The type of fibre, spinning technology, yarn count, yarn twist, yarn hairiness, fabric thickness, fabric cover factor, fabric porosity and finish are some of the factors, which play decisive role in determining the comfort properties of fabrics [2, 3]. Finer fibres converted into yarns of finer count with optimum twist and then into fabrics, would improve the smoothness, softness and totally handle properties of fabrics [4].

The fabric hand (touch feeling of a fabric), related to the concept of comfort, style, and appearance, and is also a very important property of the textile end products. Fabric hand can be approached through subjective evaluation and objective measurements [5].

In this study, fibres such as Seacell®, silver, bamboo and soybean were investigated. Woven fabrics were produced from these fibres and comfort and handle properties of fabrics made of these fibres were comparatively investigated.

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2 Material and methods

In this study, 100% bamboo, 100% soybean and 100% cotton yarns, cotton yarns with silver (10%) and Seacell® (10%) fibres were used as weft yarns in the production of plain woven fabrics. Ne 30, 100 % cotton yarns having α_e = 4,5 twist coefficient were used as warp yarn. The details regarding to fibre properties used in the weft yarns were given in Table 1.

Yarn count, diameter and hairiness values were measured with Uster Tester 5. Twist coefficients were determined with Zweigle D315 twist tester. Both tests were carried with 10 repeats for each yarn type. Measured yarn properties were given in Table 2. Woven fabrics were produced with CCI Tech Automatic Dobby Sampling Loom.

2.1 Fabric Properties

All fabrics were conditioned for 24 h under the standard laboratory conditions before testing the comfort and handle properties of fabrics. The physical properties of the fabrics were given in Table 3.

3 Results and disscussion

3.1 Comfort Properties

In this study, thermal conductivity, thermal resistance and thermal absorptivity properties of fabrics were measured with Alambeta; relative water vapor permeability was measured on Permetest instrument working on similar skin model principle derived by Hes [6]. All measurements were repeated three times. The test results and statistical analysis were given in Table 4 and Table 5, respectively.

According to statistical test results, the difference between fabric types was found statistically significant for thermal resistance, thermal absorptivity and relative water vapour permeability properties.

Table 1. Fibre properties

	Cotton	Silver	Seacell®	Bamboo	Soybean
Fibre fineness [dtex]	1.73	2.5	1.7	1.33	1.5
Fibre length [mm]	28.6	38	38	38	38

Table 2. Measured yarn properties

	Weft yarns					Warp yarn
	90% Cotton/ 10% Silver	90% Cotton/ 10% Seacell®	100% Cotton	100% Bamboo	100% Soybean	100% Cotton
Yarn count [Ne]	29.1	29.9	28.5	28.5	31.6	30.3
Yarn twist coefficient [α_e]	3.71	3.70	3.73	3.73	3.71	4.22
Yarn diameter [mm]	0.216	0.230	0.257	0.222	0.216	0.213
Yarn hairiness [Uster]	4.34	6.75	7.59	5.52	4.79	5.50

Table 3. Physical properties of fabrics

Yarn code	Yarn type	Thickness [mm]	Warp density [ends/cm]	Weft density [ends/cm]	Weight [g/m²]	Tenacity [N]	Extension [%]
A	90% Cotton/ 10% Silver	0.427	21	21	94.95	380.21	21.68
B	90% Cotton/ 10% Seacell®	0.425	21	21	93.19	273.78	23.70
C	100% Cotton	0.469	21	21	96.12	269.10	18.28
D	100% Bamboo	0.422	21	21	105.87	239.97	44.59
E	100% Soybean	0.413	21	21	99.39	229.41	41.88

Table 4. Thermal comfort test results of fabrics

Fabric property	95% Cotton/ 5% Silver (A)	95% Cotton/ 5% Seacell® (B)	100% Cotton (C)	50% Cotton/ 50% Bamboo (D)	50% Cotton/ 50% Soybean (E)
Thermal conductivity [W/m K]	0.046	0.044	0.045	0.045	0.045
Thermal resistance [m²K/W]	0.00935	0.00975	0.01039	0.00935	0.00921
Thermal absorptivity [Ws½/m²K]	148.5	147.3	152.6	184.6	167.2
Relative water vapour permeability [%]	61.63	60.60	60.03	51.10	64.63

Table 5. Statistical test results of thermal comfort results of fabrics

	Sum of squares	F	Sig.
Thermal conductivity [W/m K]	0.000	2.324	0.127
Thermal resistance [m²K/W]	0.000	6.120	0.009*
Thermal absorptivity [Ws½ / m²K]	3013.571	13.100	0.001*
Relative water vapour permeability [%]	308.720	5.500	0.013*

* *Statistically significant*

Thermal conductivity is defined as the measure of conducted heat pass though unit thickness under 1°C heat difference. According to test results, fabrics analysed in this study, have similar thermal conductivity values.

The thermal resistance is a heat property and a measure of a temperature difference by which a material resists to a heat flow. The thermal resistance of a fabric represents a quantitative evaluation of how good the fabric is in providing a thermal barrier to the wearer [7]. The results of fabrics thermal resistance were given in Figure 1. Cotton fabric (C) had the highest thermal resistance values. The difference between thermal resistance results was due to the fact that the thickness of cotton fabric is higher than the other fabric types. There is a strong and statistically significant correlation exists between the thickness of fabrics and their thermal resistance, the higher the fabric thickness, the higher the thermal resistance [8]. When cotton/silver (A) and cotton/Seacell® (B) fabrics were compared, thermal resistance of cotton/silver fabrics was calculated lower than cotton/ Seacell® fabric, eventhough the thickness of two fabrics were found similar. It could be explained with the higher value of thermal conductivity property of silver fibres due to metallic structure.

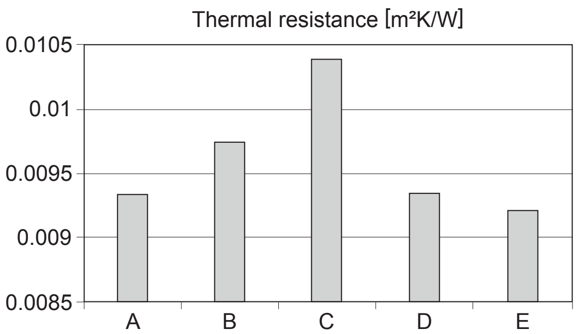

Figure 1. Thermal resistance value of fabrics

Thermal absorbtivity is defined as sudden heat flow occurs when two materials with different temperatures contact to each other. The thermal absorbtivity results of fabrics were given in Figure 2. Cotton/bamboo fabric (D) had the highest thermal absorbtivity value; second highest test result was found for cotton/soybean (E). The rest of the fabrics had statistically the same thermal absorbtivity properties. According to these results, when bamboo or soybean fibres were used in cotton fabrics as a component, the fabric will give us more cooler feeling than 100% cotton fabrics in warmer conditions.

Water vapor permeability is the ability to transmit vapor from the body. The water vapor permeability values were higher for the fabrics A, B, C and E because of capillarity between the fibres in the yarn. According to the permetest results, cotton/bamboo fabric (D) had the lowest water vapour permeability value. No statistically significant difference was found between the water vapour permeability results of other fabric types. Bamboo yarns had higher fibre content in the same yarn count because of lower fibre fineness of bamboo, thus this structure decreased the water vapour permeability of cotton/bamboo fabric. The relative water vapour permeability results of fabrics are given in Figure 3.

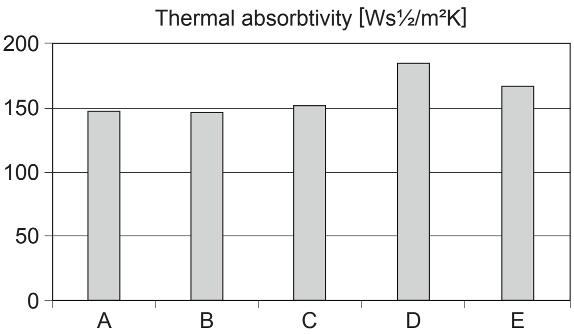

Figure 2. Thermal absorptivity value of fabrics

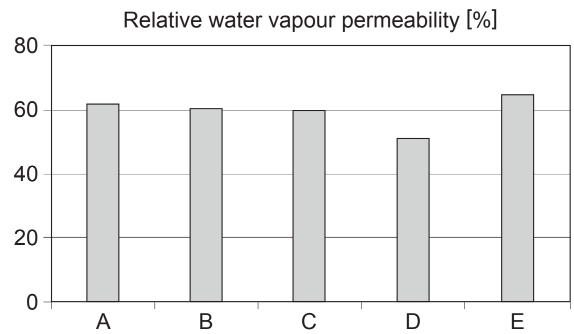

Figure 3. Relative water vapour permeability value of fabrics

3.2 Handle Properties

The comfort sensation of a fabric has multidimensional attributes and is impossible to quantify through a single physical property. In order to find a method for the comfort evaluation of textiles, the concept of "fabric hand" is commonly used to assess fabrics. Term "fabric handle" or simply "handle" or "hand" is also used. Fabric hand refers to the total sensations experienced when a fabric is touched or manipulated in the fingers [9].

In this study, friction coefficient of fabrics, Shirley bending stiffness and subjective handle tests were examined to determine the effect of material types on handle property of fabrics used in the production.

Friction coefficient tests of the fabrics were carried out by using Frictor instrument developed by Minho University-Portugal. Kinematic friction coefficient of the samples ($\mu_{kinetic}$) and the graphic showing the variation of the friction values during 20 sec were supplied from the instrument. For each product, the average of the friction coefficient values was calculated. The lower the kinematic friction coefficient means the smoother and more even product.

Shirley stiffness tester was used for the bending rigidity measurements according to ASTM D 1388. In this measurement, a specimen in the form of 2.5 × 15 cm is slid at a specified rate in a direction parallel to its long dimension, until its leading edge projects from the edge of a horizontal surface. For each fabric group, five trials were done only in weft direction, since the warp yarns were remained same. The relation between the length of overhanging strip, the angle that it bends to and bending rigidity (G) of the fabric is calculated as follows [10]:

$$G = WC^3 \qquad (1),$$

where G is bending rigidity [g.cm], W is fabric weight [g/cm²] and C is bending length [cm].

The subjective fabric handle evaluation tests were performed by ten panelists who were textile engineer in order to compare the results of objective test measurements. The panelists were allowed to see the fabrics without knowing the fabric type. A grading scale from 1 to 5, in which 1 means hardest and 5 meant softest, was used in the subjective evaluation of the fabrics. Results of handle properties and statistical analysis results regarding to these tests were displayed in Table 6 and Table 7, respectively.

According to test results, lower friction coefficient values were determined for cotton/soybean fabrics (E) comparing with the others (Figure 4). No statistically significant difference was found between friction coefficient values of cotton/silver (A), cotton/ Seacell® (B), cotton (C) and bamboo fabrics (D). Thus, it can be concluded that soybean fibres gives smoother filling when used in the production of woven fabrics.

Cotton/silver fabrics (A) had the highest bending stiffness values (Figure 5). On the other hand, the lowest stiffness results were achieved for cotton/bamboo (D) and cotton/soybean (E) fabrics. The addition of Seacell® fibres to cotton didn't affect the bending stiffness property of fabrics, thus cotton/

Table 6. Results of handle properties of fabrics

Fabric property	95% Cotton/ 5% Silver (A)	95% Cotton/ 5% Seacell® (B)	100% Cotton (C)	50% Cotton/ 50% Bamboo (D)	50% Cotton/ 50% Soybean (E)
Friction coefficient [$\mu_{kinetic}$]	0.2983	0.2944	0.2971	0.2906	0.2857
Shirley bending stiffness [g.cm]	108.61	67.93	57.31	26.36	17.69
Subjective handle test	2.3	3.9	3.7	4.0	3.2

Table 7. Statistical test results of handle properties

Fabric property	Sum of squares	F	Sig.
Friction coefficient [$\mu_{kinetic}$]	0.001	3.299	0.031*
Shirley bending stiffness	62.444	29.954	0.000*
Subjective handle test	15.92	7.57	0.000*

* *Statistically significant*

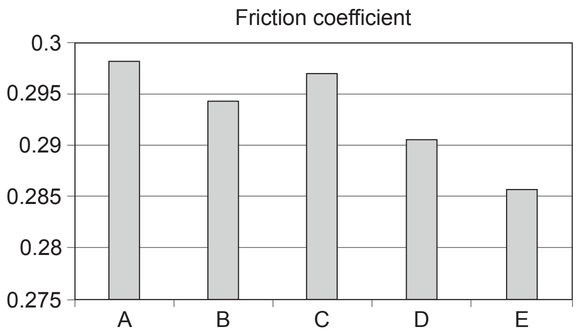

Figure 4. Friction coefficient value of fabrics

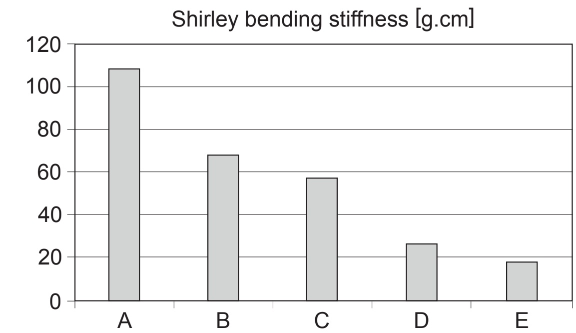

Figure 5. Shirley bending value of fabrics

Seacell® (B) and cotton (C) had similar bending stiffness values. While silver fibres increase the bending stiffness property of cotton fabrics, bamboo and soybean decrease it.

Cotton/silver (A) fabrics are the stiffest fabrics according to subjective handle test and the rest have

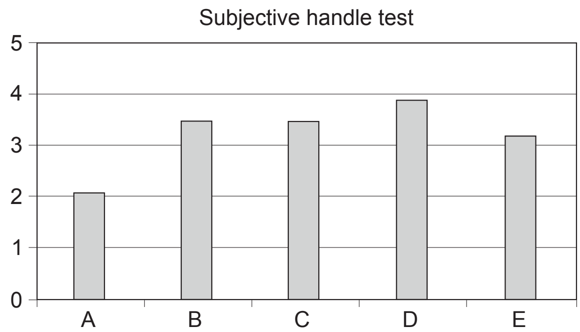

Figure 6. Subjective handle test values of fabrics

similar handle property (Figure 6). Adding of Seacell®, bamboo and soybean fibers increase the softness of the fabrics however the difference is not statistically significant.

4 Conclusions

The fabrics from cotton and various fibres such as silver, Seacell®, bamboo and soybean, were woven for the investigation of comfort and handle properties discussed in the paper. It was concluded from the study that the raw material type used in the woven fabrics affects the fabric comfort and handle properties significantly.

Adding of bamboo, soybean and Seacell® to cotton fibers didn't affect the thermal conductivity; however the usage of 5 percentage silver fiber in cotton fabrics increased the conductivity properties of fabrics. Cotton fabric (C) had the highest thermal resistance value which indicates that cotton fabrics will protect the body from temperature difference more than other fabrics According to thermal absorbtivity results, when bamboo or soybean fibres were used in cotton fabrics as a component (50%) the fabric will give cooler feeling than 100% cotton fabrics in warmer conditions. Cotton/soybean fabrics (E) had the most vapour permeability ability which proves that this fabric is the most breathable fabric compared to others. In addition to this cotton/soybean fabrics had the smoothest surface and the lowest bending stiffness according to the test results. While the roughest feeling was obtained with cotton/silver (A) fabrics, the softest feeling was obtained with cotton/bamboo (D) fabrics.

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