

An experimental study on the improvement of functionality of knitted composite for mattress

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Abstract. The comfort and performance of textile products used as mattress covers is analyzed in terms of physical characteristics, so air permeability and whiteness are investigated for different knitted assemblies with different compositions. The knitted system analyzed consists of two knitted surfaces assembled by a filling thread, finally obtaining a consistent composite material. Several samples of different fibrous composition were tested, analyzing their behavior during future use. A connection has been experienced between permeability, thickness, and whiteness of composites knitted of cotton, bamboo, wool, viscose and polyester. Samples tested for air permeability were tested face up and face down, using Static Air Permeability Tester. The whiteness of the knitted samples was checked using the Reflection Spectrophotometer trough the method that defines white and yellow indices. Samples containing bamboo and wool blended polyester have higher yellow markings. Thus, it may be recommended that future composite mattress knitted fabrics be treated with anti-aging to extend the product life cycle, as well as other friction wear-related experiments.

1 Introduction

Nowadays, consumers of mattresses cover product, demand high level of comfort, not only for protecting but to have an exquisite mattress fabric. Depending on customer's needs and the properties of the textile supports, they choose a suitable composite system. Its comfort parameters are also included as elasticity, softness, air permeability, aesthetic appearance like whiteness, thermal insulation and water vapor permeability. Knitting composites used for mattresses covers are widely used for their excellent properties in contact with human body during the rest period. Some studies consider the importance of bedding materials and investigate the comfort conditions of the sleeping environment. Comfort is mainly affected by type of fiber, yarns properties and structure of fabric. Fabric parameters such as fabric density, fabric thickness and fabric weight have been correlated to air and water vapor permeability, and to moisture management properties which includes accumulative one-way transport index and overall moisture management capacity. This is important to determine the overall thermo physiological comfort performance of knitted fabrics [1-3].

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From previous studies carried out on knitted and woven supports, the variation in air permeability depending on the raw material, fabric mass and geometry, linear density, loop length and thickness of yarns [4-6].

Composite knits, with multifunctional properties, is an alternative that is suitable to the purpose being researched due to its thickness and surface characteristics. In addition, thermal, sensorial, esthetic, comfort properties such as air permeability, vapor permeability, thermal insulation, elasticity, softness, and whiteness are appropriate for mattresses coverings. The analysis of knitted fabrics used as mattresses covers is poorly signaled in the literature.

The use of different types of fibrous compositions (performing fibers or a suitable combination of natural and synthetic or artificial fibers) to improve the functional and comfort properties of mattress covers have been considered in our study. The materials used in this investigation correspond to their destination, their functionality being improved by using the finest fibrous composition and the length of the yarns, as well as the stabilization of the whiteness variation during the use of these added value products.

Many studies have considered the fabric density, thickness and weight of the fabric, for which correlations have been made with air permeability, whiteness and the ability to manage the transport index to determine the performance of the knitted products [5-8].

Double layer composite knits have been investigated to find a statistical model for prediction purposes [9-13].

From the point of view of the fibrous composition of the knitted fabrics used, in this research, took knitted fabrics from wool, cotton, bamboo and synthetic (polyester), artificial (viscose) were measured and comparatively analyzed. Knitted composites from polyester fibers yarns in inner layer are combined with cotton or bamboo threads in outer layer, to show comfort benefits due to higher thickness [4,10-12].

For the three-layer composite of bamboo/micro-polyester/lyocell charcoal has a higher air permeability, demonstrating the important effect of fiber on this composite [13].

It was determined, that the presence of polyester spun yams with four channels and polyester textured filament yams with hollow fibers have very big influence on air permeability and drying degree of tested fabric. The presence of polyester textured filament yams with hollow fibers decreases values of these parameters quite distinctly [14,15].

For composite knits, there is an influence on air permeability as well as the construction of the product, as well as the techniques of ennoblement. What we want to highlight in our experiment is the possible correlation between the whiteness values of the cover materials for bedding applications, type of raw material, fabric mass and the air permeability as performance of knitted fabrics.

2 Experimental

All the composite samples are single jersey structures, double layers with polyester filler thread between knit layers. All the samples were knitted on OVJA 1.6 E circular knitting machine, 20-gauge, diameter 38-inch, number of needles 2400. Samples code, fibrous composition and mass per unit area of composite knitted fabrics, are presented on Table 1.

Table 1. Description of composite knitted fabrics

Samples code		Fibrous composition and yarn linear density	Mass per unit area [g/m²]
S1		PES 167Dtex PES 150Den Filler yarn PES1200 Den	230
S2		PES 20/1 Ne PES 150Den Filler yarn 3000Den	268
S3		PES 150 Den Filler yarn 1200 Den	243
S4		Cotton 24/1 Ne+ PES 150 Den Filler Yarn 1200 Den	270
S5		PES 20/1Ne + PES 150 Den Filler yarn 300 Den	216
S6		PES 150 Den Filler yarn 1200 Den	265
S7		Bamboo 20/1Ne + Viscose 20/1Ne Filler yarn 1200Den	285
S8		Wool 20/1 Ne + PES 20/1 Ne Filler Yarn 1200 Den	270
S9		PES 167 Dtex + Viscose 20/1Ne Filler yarn 1200Den	225
S10		PES 150 Den + Viscose 29.5tex Filler yarn 1200Den	235
S11		Cotton 24/1 Ne + PES 150 den Filler yarn 1200 Den	252

Same comfort properties of knitting fabrics composite for mattresses, was qualitatively investigated by alternative measuring the whiteness (CIE, Berger, WI), yellowness indices (YI) and the air permeability resistance, after conditioning for 24 hours at 20° C and 65% relative air humidity. The device Static Air permeability TexTester FX 3300-III and method of DIN EN ISO 9237 [16] have been used together with the measurement details, test area 20 cm², test pressure 100 Pa and unit l/dm²/min, in accordance with the sample.

To determine the whiteness was used Datacolor 110 LAV reflection spectrophotometer according to ASTM method E313 [17], that defines the whiteness and yellowness indices. The samples were evaluated by light reflectance measurements with CIE standard illuminant and observer in D65/10° and C2 in Berger's system.

3 Results and discussion

Samples were investigated for air permeability and whiteness, and the results obtained from the experiments are shown in Table 2.

Table 2. Whiteness and air permeability values of tested fabrics

Fabric sample		Air permeability [l/dm ² /min]	CIE Whiteness	Berger Whiteness	Yellowness Index
S1	Face up	682	80.62	82.15	-1.17
	Face down	664	90.15	92.27	-7.32
S2	Face up	747	64.04	64.79	2.02
	Face down	740	47.74	50.48	5.49
S3	Face up	999	81.65	81.92	2.14
	Face down	997	83.75	84.17	1.33
S4	Face up	627	61.88	60.55	7.57
	Face down	628	-6.38	5.58	30.61
S5	Face up	959	1.76	63.85	64.42
	Face down	940	3.92	52.01	53.56
S6	Face up	615	38.09	38.44	17.80
	Face down	589	65.88	63.70	8.30
S7	Face up	588	53.59	55.74	9.74
	Face down	582	52.87	54.51	6.55
S8	Face up	733	127.48	132.41	-15.73
	Face down	719	92.70	93.51	-2.24
S9	Face up	654	63.62	59.56	3.29
	Face down	653	-1.99	-4.77	46.06
S10	Face up	530	69.89	69.19	1.73
	Face down	533	62.41	49.54	-11.91
S11	Face up	639	106.97	115.74	-14.91
	Face down	637	63.76	63.22	1.42

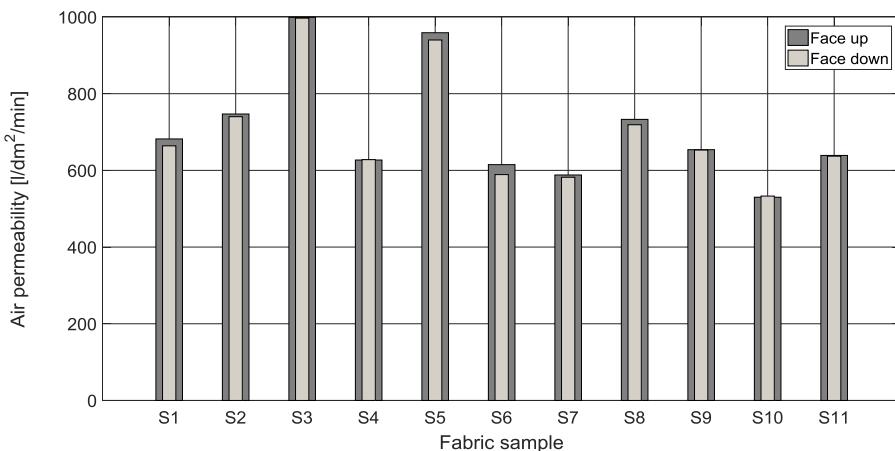


Fig. 1. The influence of type of raw material on static air permeability

The graphical presentation of the influence of raw material on air permeability is presented in Figure 1. The air permeability of the samples was analyzed in relation to the type of yarn components and the material weight.

Composite knit weight has an inverse influence proportional to air permeability, especially face up, as seen in the bamboo with cotton sample and PES with viscose with high mass but lower permeability, especially face down. In other samples, the mass is lower, so sample S3 and S5 in PES, air permeability and face up and face down are elevated in line with literature studies and describe inversely proportional correlations [1]. In relation to the mass of the knitted support and the fibrous composition of the material, we can appreciate that:

- for PES fibrous knits (samples S1, S2, S3, S5, S6) and mass fabric between 216-268 g/m², the decrease in air permeability face down to face up is between 0.94-4.23%;
- for cotton with PES knitted fabrics (S4, S11 samples) and mass fabric of 252-270 g/m², air permeability face down to face up remains relatively constant;
- for bamboo with cotton knitted fabric (sample S7) and mass 285 g/m², the decrease of air permeability is small up to 1.03%;
- for the knitted fabric of wool with PES (sample S8) and mass fabric of 270 g/m², the decrease in air permeability face down to face up is 1.91%;
- for PES with viscose fibrous knits (S9, S10 samples) and mass 225-235 g /m², the decrease in air permeability face down to face up is minimal and insignificantly increased by 0.47%.

The variation of fibrous composition over whiteness values of knitted fabrics is presented in Figure 2 and Figure 3. Whiteness is higher in wool with PES (S8), cotton with PES (S11), PES (S1, S3) and lower PES samples (S5, S6) and bamboo with cotton (S7) as it is signaled in previous research [8].

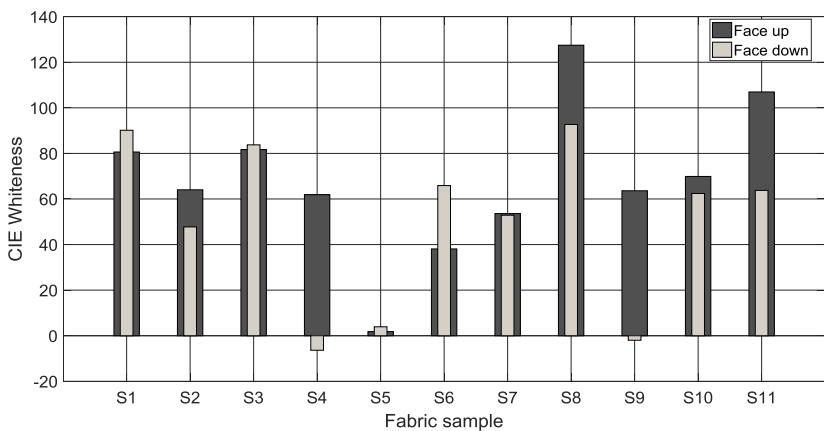


Fig. 2. The influence of fibrous composition on the degree of white (CIE Whiteness)

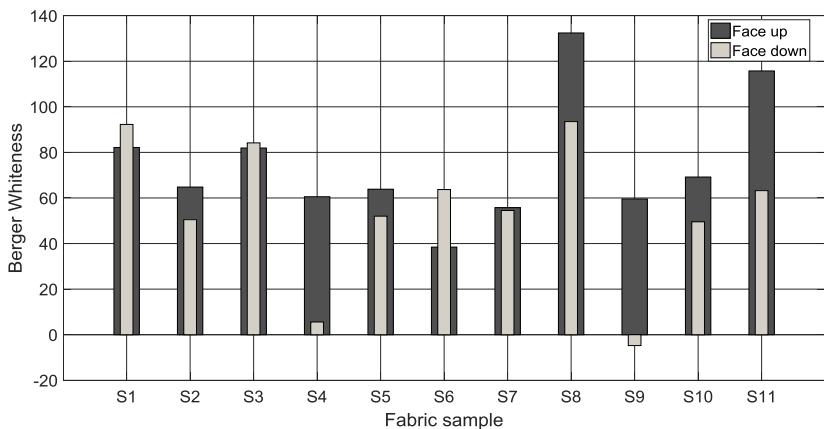


Fig. 3. The influence of fibrous composition on the degree of white (Berger Whiteness)

Thus, bamboo content influences the mass (the largest of all samples) but also the whiteness of the knitting material. Regarding the CIE whiteness, the following can be observed:

- for PES-fiber knits (samples S1, S2, S3, S5, S6) the increase in the degree of white face down to face up is in the range of 11.82-72.95%;
- for cotton with PES knitted fabrics (samples S4, S11), the degree of white to face down to face up decreases with values of 89.69-40.4%;
- for bamboo with cotton fabric composition (sample S7), the drop in white to face up is up to 1.35%;
- for wool with PES knitted fabric (sample S8), the drop in white to face up is 27.29%;
- for the knitted fabrics of PES with viscose (samples S9, S10), the decrease in the degree of white down to face up is appreciable, ranging from 10.71 to 96.88%.

In Berger system, white changes are relatively acceptable, increase on face down comparative with face up to 12,19% on sample S1 (PES), 65,71% on S6 (PES), and

decrease on face down, the highest values, 90,71 and 45,38 for samples S4, S1 (cotton+PES), 29,38% for sample S8 (wool with PES) due to the type of fiber used in the composite.

The correlation between the mass and the whiteness of the material can be interpreted by the fact that the increase in mass, leads to a white increase for most samples, such as S2, S4, S6, S8, S11 with mass values between 250-285 g/m² and a white degree in the range 81-127 WI. The smallest white matter values can be seen in sample S5 with the smallest mass of 216 g/m².

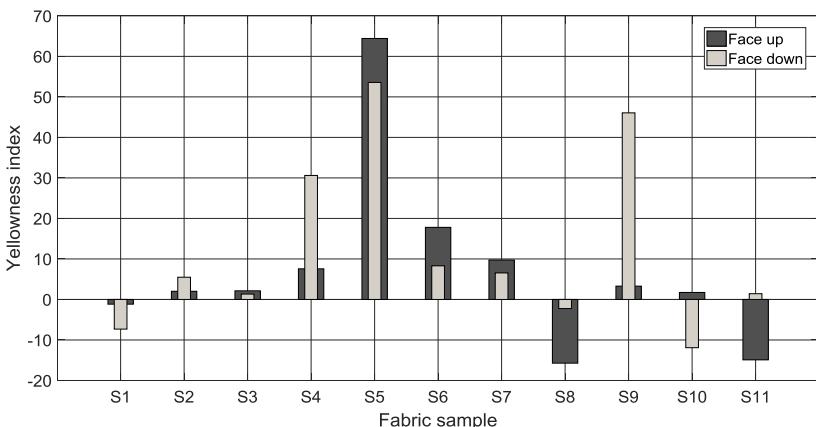


Fig. 4. The influence of fibrous composition on the yellowness index

The yellowness degree observed in the analyzed samples has higher values for the corresponding S5, S6, S9 samples of the PES knit, and PES with viscose, probably due to the viscose content of the material. It is seen that a correlation between permeability and whiteness for composite knitted fabrics, both up and down makes it easy to set is probably due to fibrous structure. Thus, a high permeability and a high CIE white are at samples S3, S8, S11, but there is also a high permeability to S5 and a very low white grade. Samples with low permeability, for example S10 and S6, are medium white, due to the composition of PES with viscose and PES. There are S1, S7 samples that have a medium air permeability and where the degree of white varies between 50-80.

The negative white value of the S4 and S9 samples makes it down, corresponds to a medium permeability of the fabrics. The highest sample permeability S6 corresponds to a low white scale for face down measurements.

4 Conclusions

In this research it was concluded that the modification of the raw material composition of the knitted fabric and the mass, significantly affects air permeability and white index values with good functional characteristics to increase the added value of the knitted composites used to mattresses covers.

Tests on white quality - an important factor in the aesthetic appearance and refinement of the products, showed the influence of yarn composition and medium change during use. Composite knit pads under polyester record increases in whiteness, while in all other composites white decreases occur between the front and back of the material.

Spectrophotometric analysis showed that the degree of white increases or decreases relative to the face up of knitted materials in range of values between 10.71 to 96.88%.

Fabric knit underlays for polyester with reduced mass generally record decreases with variations in air permeability up to face up, quite high up to 4.23%, while at all other samples there are small decreases between face up and behind the composite structures (in the range 0.47-1.91%). Further work can be carried out on utilizing diversified knitted composites for development of generic model fabrics with features that complement the performance and functionality of the products. To extend the product life for bed fabrics, a wide variety of special properties for the benefit of the customers, hygienic and allergen reducing, antifriction and long-lasting anti-aging effect can be induced.

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