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Comparable Analysis of the End-Use Properties of Woven Fabrics with Fancy Yarns. Part I: Abrasion Resistance and Air Permeability

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Abstract
The aim of this research was to analyse the influence of fancy yarn structure on the abrasion resistance and air permeability of woven fabrics with these yarns. The dependencies of end-use properties and such fancy yarn structures as slub, loop or spiral were analysed. The influence of the fancy yarn structure, raw material and fabric weave on the above-mentioned properties of fabrics with fancy yarns was established during the investigation. Abrasion resistance is the fabric's ability to not change its strength and appearance during friction. The air permeability of outerwear is very important in wear comfort and durability. It was estimated that the parameters of yarns and fabric mentioned above influence the end-use properties of fabrics with fancy yarns.

Key words: *woven fabric, fancy yarn structure, abrasion resistance, air permeability.*

Introduction

Comfortability as well as physiological, mechanical and end-use properties are very important for many flat textile products, such as weaving or knitting fabrics, outerwear etc. [1, 2]. Fabrics with fancy yarns can also be included in this group. Fancy yarns present deliberate, decorative, continuous by repeatably, also programmed effects of colour and/or form, and they are used to create certain variations in their aesthetic appearance. The assortment of fancy yarns is very wide, and in recent years their structure is becoming more and more complex: they differ in their structural features, fiber components, way of manufacture etc. [3, 4].

The end-use properties of textile materials, such as air permeability, abrasion resistance, mass and their loss, and the pilling effect are influenced by many factors such as the raw materials of yarns, fibre fineness, yarn count (linear density), yarn type, the tensile and hairiness of yarn, weave, surface density etc. [5-10]. Fancy yarns give decorativeness and improve the appearance of the garment; however, they can change the end-use properties of fabric [11].

The majority of textile fabrics are used in static as well as dynamic conditions. The behaviour of textile products is determined by the conditions they are used in. Therefore, air permeability should be studied by evaluating these conditions [1]. Abrasion resistance shows the fabric's ability to not change its strength and appearance during friction. Pilling is a fabric defect observed as small balls or groups consisting of intervened fibers. Pills are formed during wear and washing, which means that fabrics are affected by friction forces during use [2, 6].

Most of the literature published regarding this has focused on the study of the end-use properties of knitted, woven and coated fabrics [1, 2, 5 - 8, 10], but there have been few investigations on fabrics with fancy yarns.

The aim of this research was to analyse the influence of fancy yarn structure and fabric weave on the abrasion resistance and air permeability of woven fabrics with these yarns.

Materials

Woven fabrics with different structures, raw materials and fancy yarns in the weft were analysed during the investigation. Fancy yarns were produced by one process method using a fancy-twisting machine - Jantra-PrKV 12 ("Jantra", Bulgaria) with hollow spindles of the FAG type (Germany) using Prenomit technology. A full description of the production of these yarns is in [4]. The components and structure of the fancy yarns used for weaving are presented in ***Table 1***.

Fancy yarns with a slub, loop and spiral structure were used. The fabrics investigated were separated into two groups:

- Fabrics with fancy yarns of synthetic components, i. e. fabric samples 1, 2 and 3 ;
- Fabrics with fancy yarns of woolen components, i. e. fabric samples 4, 5 and 6.

Table 1. *Components and structure of fancy yarns used in the weft.*

Var. Nr.	Core component	Effect component	Binder component	Type of fancy yarns
1	Multifilament textured PES yarns, 16.7 tex	Multifilament textured PES yarns, 16.7 tex	Multifilament PES yarns, 5.6 tex	Yarn with slubs
2				Yarn with loops
3	Blended yarns from PES and viscose fiber, 12 tex × 2	Multifilament textured PES yarns, 16.7 tex	Multifilament PES yarns, 5.6 tex	Spiral structure yarn
4	1) Multifilament textured PES yarns, 16.7 tex; 2) Multifilament viscose yarns, 13.3 tex	Worsted yarns from wool, 32 tex	Multifilament PA yarns, 5.0 tex	Yarn with slubs
5				Yarn with loops
6	Worsted yarns from wool, 50 tex	Worsted yarns from wool, 50 tex	Multifilament PES yarns, 5.6 tex	Spiral structure yarn

Kumpikaitė E., Ragaišienė A., Barburski M.; Comparable Analysis of the End-Use Properties of Woven Fabrics with Fancy Yarns. Part I: Abrasion Resistance and Air Permeability. FIBRES & TEXTILES in Eastern Europe 2010, Vol. 18, No. 3 (80) pp. 56-59.

Fabrics were woven on a Picanol Gama rapier loom from PES 16.7 tex multifilament textured yarn in the warp, cotton 20 tex × 2 yarn, and fancy yarn in the weft. The fabrics researched were woven in Poland at the Technical University of Lodz, Institute of Textile Architecture. The fancy yarns in the weft of the woven fabrics researched had been used in different repeats, i.e. one fancy yarn, three cotton yarns for fabrics of twill 2/2 and one fancy yarn, four cotton yarns for fabrics of sateen 5/3. The warp and weft settings for both weave fabrics were the same (warp setting: 300 dm^{-1}, weft setting: 120 dm^{-1}).

Test methods

In this study, such end-use properties of woven fabrics with fancy yarns in the weft as air permeability and abrasion resistance were analysed and predicted.

The yarns were tested on standard test equipment using standard test methods. The abrasion resistance of samples of fabric with fancy yarns were performed on a Martindale Abrasion and Pilling Tester MESDAN-LAB, Code 2561E (SDL ATLAS, England) in accordance with the standard [12]. Conventional wool abradant fabric was used. The pressure applied to the fabric during rubbing was 9 kPa, as indicated for clothing. Firstly, a probationary measurement was performed that showed how many cycles the sample could sustain until disintegration. To show the abrasion kinetics at various stages, the number of cycles were varied widely, ranging from rather low to large values. Therefore, after probationary measurements received number of cycles was brought under approximately on the same number of intervals, i. e. for sateen fabrics it was 7000 cycles, for twill 2/2 - 15000 cycles. After each interval, the abrasion machine was stopped and the testing indices measured, i. e. air permeability and mass.

The air permeability was measured using a D-69450 Weinheim air permeability tester (Karl Schroder KG, Germany), as specified in the standard [13], at a pressure drop of 100 Pa. The test area was 5 cm^2 for all samples.

The air permeability (mm/s) was determined as follows:

$$R = \frac{\overline{q}_v}{A} 167, \qquad (1)$$

were:

$\overline{q}_v$ – an arithmetical average of the debit of air flow, dm^3/min (1/min);

A – test area, cm^2;

167 – coefficient of conversation from $dm^3/cm^2 \cdot min$ or $1/cm^2 \cdot min$ to mm/s.

The fabrics were conditioned at a temperature and relative humidity of 20 ± 2 °C and 65 ± 2%, respectively, as specified in the standard [14].

Statistical and regression analysis was done using a Microsoft Excel Analysis Tool Pack.

Results and discussions

The use of fancy yarns in woven fabrics not only changes the fabric appearance but also the end-use properties of the fabric. ***Figure 1*** shows diagrams of abrasion resistance for fabrics with different raw materials and fancy yarn structure, woven in different weaves.

It can be seen from the diagrams in ***Figure 1*** that yarn structure influences the abrasion resistance of fabrics of different raw material in various ways. Similar tendencies were established for fabrics woven from synthetic fabrics with loop yarn and from wool fabrics with spiral yarn, being the most resistant to abrasion. Synthetic fabrics with slub yarn and wool fabrics with loop yarn are the least resistant to abrasion. This can be influenced by the structural parameters of the effects of fancy yarn (height, length of effects, effect spacing), i.e. when the dimensions of effects are higher (slubs), the abrasion resistance of the fabric is lower, whereas yarn with effects of smaller dimension (spiral) are more resistant to abrasion. The abrasion resistance of fabrics with wool yarn is almost always higher than that of fabrics with synthetic yarn. This phenomenon is influenced by the properties of the raw material the fancy yarns are made from i.e. synthetic yarn is of synthetic multifilament thread, which has high strength, and wool yarn is of spun yarn, but it does not have high strength. The tendencies of twill fabric with loop fancy yarn are different – the abrasion resistance of fabric with wool yarn is a

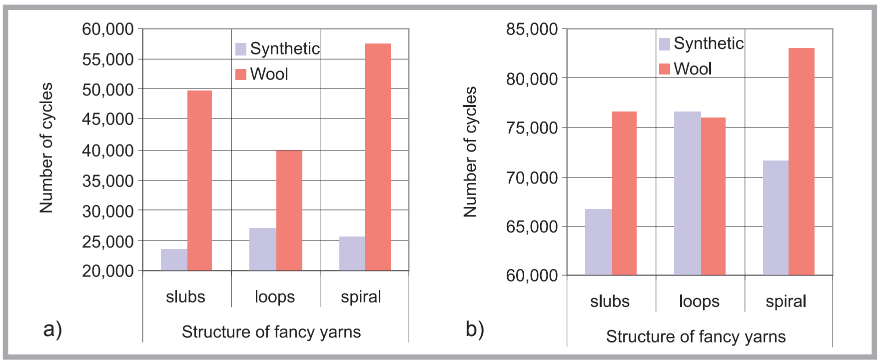

Figure 1. *Influence of the fancy yarn structure and raw material on the abrasion resistance of fabrics with these yarns: a – for fabrics woven in sateen; b – for fabrics woven in twill 2/2.*

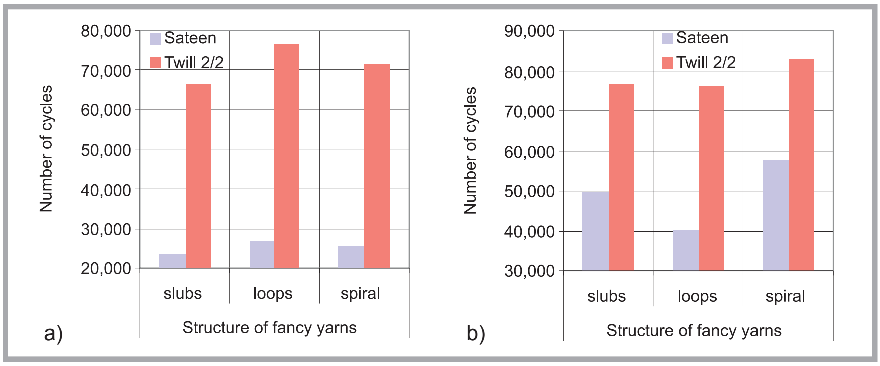

Figure 2. *Influence of the fancy yarn structure and fabric weave on the abrasion resistance of fabrics with these yarns: a – for fabrics with synthetic yarns; b – for fabrics with wool yarns*

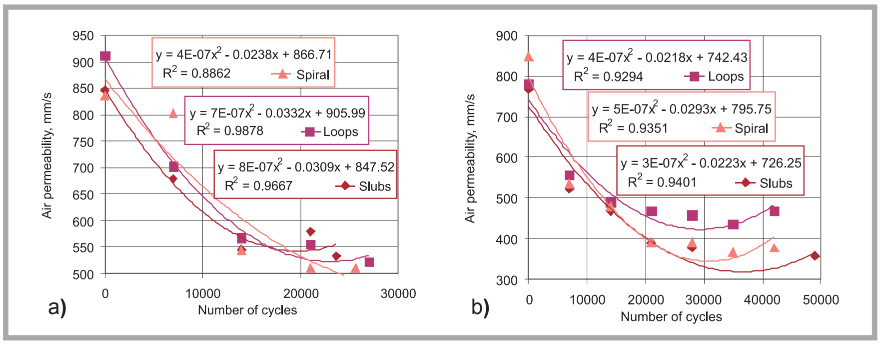

***Figure 3.** Dependencies of fabric air permeability on the number of abrasion cycles for sateen fabrics with fancy yarns of different structure: a – for fabrics with synthetic yarns; b – for fabrics with wool yarns.*

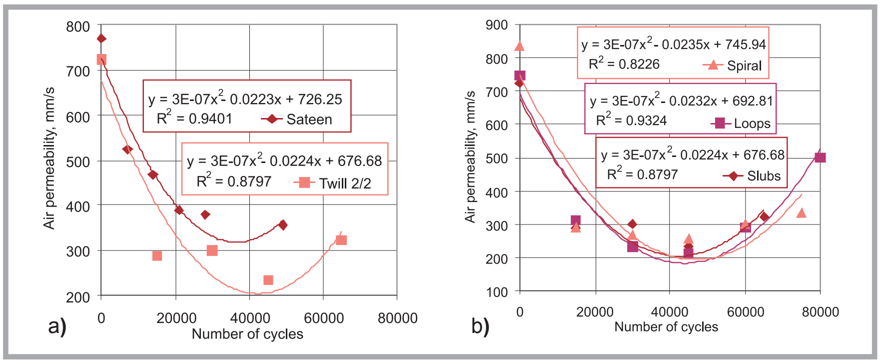

***Figure 4.** Dependencies of fabric air permeability on the number of abrasion cycles for twill fabrics with fancy yarns of different structure: a – for fabrics with synthetic yarns; b – for fabrics with wool yarns.*

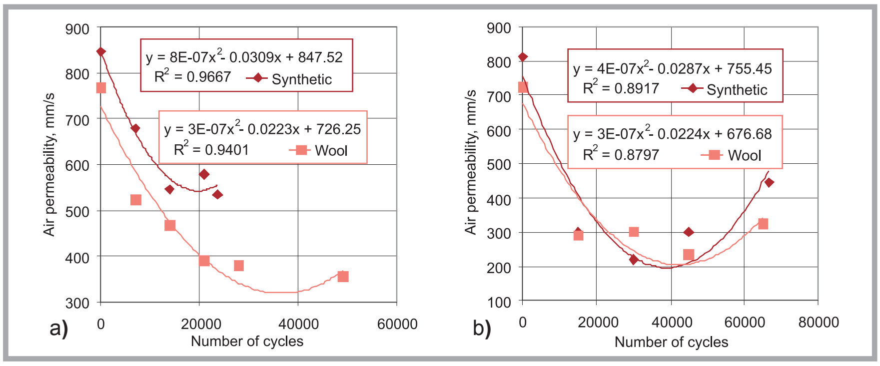

***Figure 5.** Dependencies of air permeability on the number of abrasion cycles for slub yarn of different raw materials: a – for sateen fabrics; b – for twill fabrics.*

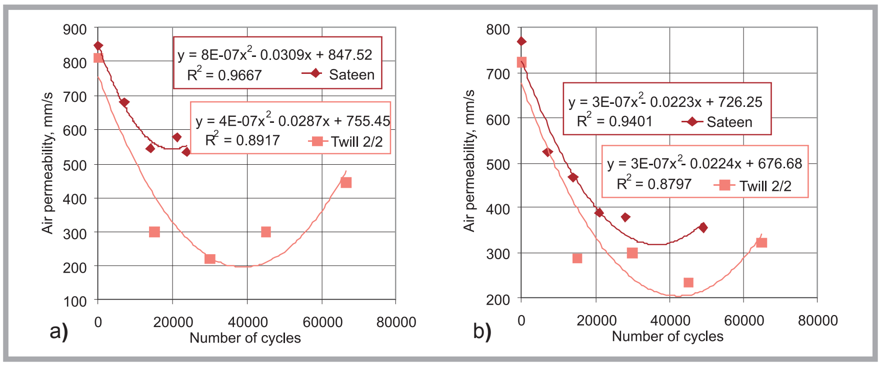

***Figure 6.** Dependencies of fabric air permeability on the number of abrasion cycles for fabrics of different weave with slub yarn: a – for fabrics with synthetic yarns; b – for fabrics with wool yarns.*

little bit lower than that of fabrics with synthetic yarn, but this result is probably accidental.

Similar tendencies can be seen in the diagrams in ***Figure 2***. The abrasion resistance of sateen fabrics woven from both synthetic and wool yarns is lower than that of twill fabrics. The reason for this is that twill fabric is more rigid and stronger than sateen fabric; neighboring threads are more strongly bonded to each other. Because of this, the abrasion resistance of fabric is higher than that of sateen fabric. Fabrics with synthetic loop yarn have the highest abrasion resistance, whereas fabrics with slub yarn have the lowest. In the case of wool yarn, fabrics with spiral yarn have the highest abrasion resistance, whereas fabrics with loop yarn have the lowest. Hence, the tendencies of the abrasion resistance of both synthetic and wool yarns for fancy yarns of different structure are completely different, what is difficult to explain.

The dependencies of air permeability on the number of abrasion cycles for fabrics with fancy yarns of different structure were drawn. The tendencies of yarns of different raw materials for sateen fabrics are shown in ***Figure 3***. When the number of abrasion cycles is increased, the air permeability decreases in the initial part of the curve, and at a particular point the air permeability increases, the reason being that at the beginning of fabric abrasion, pilling and pile cover the surface of the fabric and because of this the air permeability increases in the initial part of abrasion. During further abrasion, the pilling and pile are eliminated from the surface of the fabric, the fabric begins to thin, holes appear, and the air permeability of the fabric increases. This phenomenon is clearer in fabrics with wool yarns because the elementary fibres of wool spun yarn separate from the fabric surface. Fabrics with loop yarn have the highest air permeability, whereas fabrics with slub yarn have the lowest. The reason for this can be the dimensions of fancy yarn effects and the regularity of their distribution.

Similar dependencies for twill fabrics, where the tendency of curve curvature is clearer, are shown in ***Figure 4***. Probably, the surface of these fabrics cover pilling faster, and pile is eliminated from the fabric surface faster. Fabrics with spiral yarn have the highest air permeability because the dimensions of their effects are the smallest; their distribution is the most regular. Fabrics with slub yarn have the lowest air permeability because the dimensions of their effects are the biggest.

It can be seen from ***Figure 5*** that the air permeability of fabrics with synthetic yarns in both weave cases is higher; however, it can be seen that sateen fabric with synthetic yarns is less resistant to abrasion. The curvature of curves of twill fabrics is more expressed.

Figure 6 (see page 59) shows that the air permeability of sateen fabrics with yarns of both raw materials is higher because the weave is less rigid than twill weave; threads slip in the fabric. For the same reason sateen fabrics sustain less abrasion cycles. The difference between the air permeability curves is higher for fabrics with synthetic yarns.

Similar tendencies were established for fabrics with loop and spiral yarns. Thus, it can be said that the use of fancy yarns in clothing fabrics signally affects their end-use properties.

Conclusions

- It was estimated that the structure of fancy yarns influences the abrasion resistance of fabrics with these yarns, i.e. when the dimensions of effects are higher (slubs), the abrasion resistance of the fabric is lower, whereas yarns with effects of smaller dimension (spiral) are more resistant to abrasion.
- The raw material of fancy yarns and fabric weave also influence the abrasion resistance of fabrics with fancy yarns. The abrasion resistance of fabrics with wool yarns is almost always higher than that of fabrics with synthetic yarns. The abrasion resistance of sateen fabrics is lower than that of twill fabrics.
- It was established that air permeability during the abrasion process changes in a different way, i.e. when the number of abrasion cycles increases, the air permeability decreases in the initial part of the curve, and at a particular point the air permeability increases. Air permeability depends on the kind of effects of the fancy yarn and the regularity of their distribution.
- The raw material and fabric weave influenced the air permeability of the fabrics as well. The air permeability of fabrics with synthetic yarns is higher in both weave cases; the curvature of the curves of twill fabrics is more expressed.

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Received 22.09.2008 Reviewed 06.10.2009