Hatice Kübra Kaynak, Mehmet Topalbekiroğlu

Department of Textile Engineering, University of Gaziantep,
27310 Gaziantep, Turkey
E-mail: tuluce@gantep.edu.tr, tbekir@gantep.edu.tr

Influence of Fabric Pattern on the Abrasion Resistance Property of Woven Fabrics

Abstract
In this experimental study, the abrasion resistance properties of woven fabrics were investigated as a function of weave type. Seven woven fabrics with different weave derivatives were woven with 100% cotton and 20 Tex (Ne 30/1) combed ring spun yarn for this investigation. These fabrics were tested with a Martindale Abrasion Tester to determine the abrasion resistance property. The abrasion resistance of the fabrics was evaluated according to their mass loss ratio after 4 different cycles (5,000, 7,500, 10,000, 15,000) of the Martindale Abrasion testing device. According to data obtained from the test results of sample weave patterns, we observed that the weave pattern has a significant effect on the abrasion resistance property of woven fabrics (P < 0.01). Furthermore, it was also noted that the number of rubbing cycles has a significant effect on the abrasion resistance property of woven fabrics (P < 0.01). Tukey test results showed that weave types with a high number of floats and low number of interlacings decrease the abrasion resistance property (P < 0.05).

Key words: *weave.abrasion resistance, woven fabric mass loss, rubbing*

Introduction

Abrasion is the mechanical deterioration of fabric components by rubbing them against another surface. Abrasion ultimately results in the loss of performance characteristics, such as strength, but it also affects the appearance of a fabric [1]. Many parts of apparel, such as collar, cuffs and pockets, are subjected to serious wear in use, which limits their serviceability. The abrasion resistance of textile materials is effected by many factors (e.g. fibre fineness, yarn count, yarn type, weave etc.) in a very complex, and as yet little understood manner [2].

Abrasion first modifies the fabric surface and then affects the internal structure [2]. Abrasion resistance is measured by subjecting the specimen to a rubbing motion in the form of a geometric figure, that is, a straight line, which becomes a gradually widening ellipse, until it forms another straigth line in the opposite direction and traces the same figure again under known conditions of pressure and abrasive action [3].

Different fabric weaves differentiate the structure of fabrics, and these different structural properties of fabrics will cause the fabrics to behave differently from each other. In this way, woven fabric properties will differ by changing the weave pattern. A fabric pattern must be evaluated not only as an appearance property, but also as a very important structure parameter. Fabric properties are influenced with the wide range of this structure parameter.

One of the results of abrasion is the gradual removal of fibres from yarns. Therefore, the factors that affect the cohesion of yarns will influence their abrasion resistance [4]. The float length in woven fabrics can affect their resistance to abrasion. Long floats in a weave are more exposed and will abrade faster, usually breaking the yarns. For example, a satin weave fabric will abrade more easily than a twill weave [1].

The more pronounced the crimp in a woven fabric is, the more exposed the yarns will be to abrasion, and the faster the fabric will abrade. The crimp of the yarns in the fabric affects whether the warp or the weft is graded the most. Fabrics with the crimp evenly distributed between warp and weft give the best wear because the damage is spread evenly between them [1, 4].

Many researchers have investigated the influence of raw material, yarn production technology, yarn twist and chemical treatment on the abrasion resistance property of woven fabric [2, 5 - 7]. However, there is a lack of information in the literature about the effect of weave type on the abrasion resistance property.

Table 1. *Sizing, desizing and washing recipies.*

Sizing recipe	Desizing recipe	Washing recipe
150 l liquor	2.5 g/l Torozym NT	2 g/l Sevalin D
20 kg EMSIZE CMS 60	2 g/l Schnellnetzer KE	1 g/l Schnellnetzer KE
10 kg BP20 (PVA)	1 g/l R. Entlüfter BK	0.6 g/l Optiderm BS-L
500 g Glissofil Extra (Oil)	1g/l Emulgator BE-O	

Table 2. *Properties of the yarn used in the experimental study.*

Parameter, unit	value
Yarn twist, turns/m	919
Yarn strength, cN/tex	22.2
Hairness	5.67
CVm, %	12.26
Thick +50% per 1,000 m	20
Neps +200% per 1,000 m	71.7
Staple fiber length, mm	29.4
Fiber fineness, micronaire	4.25

Materials and procedure

Sample fabrics were woven by a Dornier loom with an electronic dobby shedding mechanism and rapier weft insertion at a loom speed of 450 r.p.m. A warp sheet was prepared by a sample warping machine and sized with a sample sizing machine. After sizing, a straight draft was applied to the warp sheet using the sample drawing machine. 12 frames were used for all sample fabrics with a straight draft. The only finishing treatment applied to the samples was desizing. The fabrics were treated by enzymatic desizing for 6 hours. Then they were washed at a 60 m/min washing speed in a washing machine, which had 5 vats with liquor temperatures of 95 °C, 95 °C, 85 °C, 65 °C, and 30°C, respectively. The drying operation of the 140 cm wide fabrics was done at 120 °C and at a 30 m/min drying speed. The sizing, desizing and washing recipes are given in Table 1.

These samples were produced as men's shirts. The weft sett was 28 wefts/cm and the warp sett was 46 warps/cm for all samples. The component yarn used for both warp and weft was 20 tex, 100% cotton combed ring yarn. Detailed information about the yarn used to produce the fabric samples, with relevant structures, is given in Table 2.

Structural views of the seven woven fabrics tested in this experimental study are given in Figure 1 and the fabric weight in g/m^2, yarn crimp in % and fabric thickness in mm properties of the samples are shown in Table 3.

In this study, we report an experimental investigation of the abrasion resistance properties of different weave types of woven fabrics. The abrasion resistances of the fabrics were tested according to ASTM D 4966-98 Standard Test Method for Abrasion Resistance of Textile Fabrics - Martindale Abrasion Tester Method. We measured the abrasion resistance of the fabrics with the help of a Martindale Abrasion Tester device. The abrasion resistance was determined by the mass loss as the difference between the masses before and after abrasion cycles of 5,000, 7,500, 10,000 and 15,000. These values were then expressed as a percentage of the inital mass.

In order to understand the statistical importance of weave pattern on the abrasion resistance property of woven fabrics, an ANOVA was performed. To determine the groups of weave pattern types and the effects of these groups on the abrasion resistance property, the Tukey multiple comparison test was used. In addition, Pearson correlation analysis was done to show the relationship between mass loss and the abrasion tester cycle using a statistical approach. For this aim the statistical software package SPSS 8.0 was used to interpret the experimental data. All test results were assessed at significance levels of $\alpha \leq 0.05$ and $\alpha \leq 0.01$.

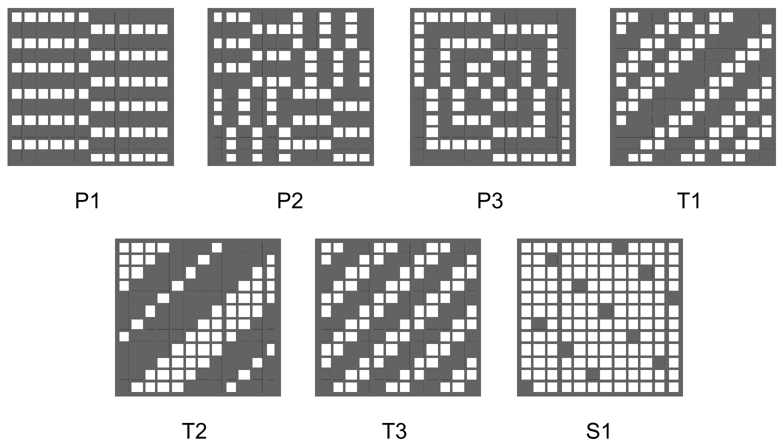

Figure 1. *Structural views of weave types (P1)Regular weft rib, (P2) Combined Rib, (P3) Basket weave, (T1) Unbalanced Twill, (T2) Warp faced twill, (T3) Twill, (S1) Sateen.*

Table 3. *Fabric properties of samples.*

Weave type	Sample code	Fabric weight, g/m^2	Yarn crimp, %		Fabric thickness, mm
			warp	weft	
	P1	150	1.6	16.7	0.48
Plain	P2	150	5.0	15.1	0.44
	P3	146	4.7	13.5	0.42
	T1	148	4.9	14.8	0.29
Twill	T2	149	4.9	14.0	0.33
	T3	149	6.0	14.1	0.30
Sateen	S1	141	2.9	11.5	0.41

Table 4. *Mass values of samples after different rubbing cycles.*

Sample Code	Mass of samples before testing, g	Mass of samples after different cycles, g			
		5,000	7,500	10,000	15,000
P 1	0,1796	0,1756	0,1720	0,1690	0,1637
P 2	0,1778	0,1709	0,1684	0,1665	0,1637
P 3	0,1768	0,1699	0,1664	0,1640	0,1599
T 1	0,1675	0,1636	0,1614	0,1598	0,1568
T 2	0,1655	0,1597	0,1579	0,1562	0,1533
T 3	0,1689	0,1638	0,1621	0,1601	0,1572
S 1	0,1746	0,1702	0,1664	0,1632	0,1579

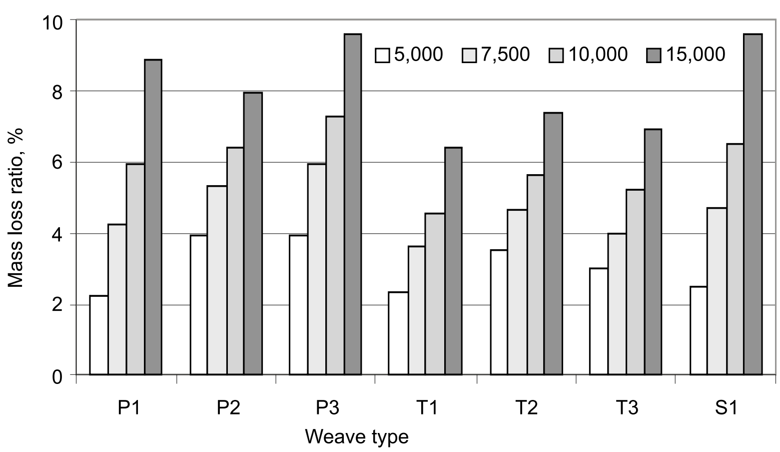

Figure 2. *Mass loss ratio of different weave types after abrasion test of different number of cycles.*

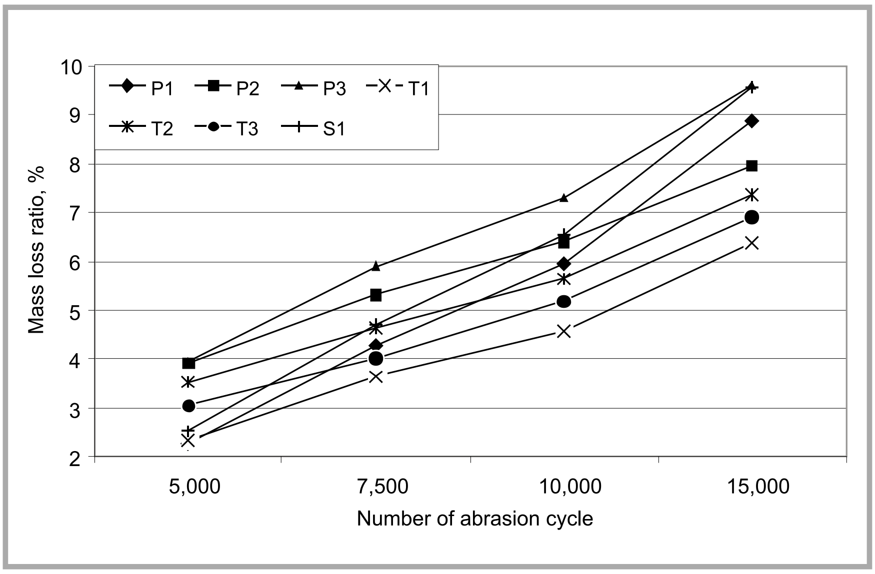

Figure 3. *Relationship between number of abrasion cycles and mass loss.*

Results and discussion

The mass values of sample weave types for rubbing cycles of 5,000, 7,500, 10,000 and 15,000 are given in Table 4.

Figure 2 shows the mean mass loss ratio in % values of different weave types for 4 different rubbing cycles of the abrasion test device.

According to the results of the abrasion test at 5,000 ($F_{(6-21)} = 26.91$, $P < 0.01$), 7,500 ($F_{(6-21)} = 21.43$, $P < 0.01$), 10,000 ($F_{(6-21)} = 32.21$, $P < 0.01$) and 15,000 ($F_{(6-21)} = 37.88$, $P < 0.01$) cycles, weave type has a significant effect on mass loss. When the weave types used in this study are observed very different structures are seen. Samples P1, P3 and S1 comprise a group of weaves that has high number of floats and low number of interlacings, while samples T1 and T3 are in the group that have a low number of floats and a high number of interlacings. Besides these, samples P2 and T2 constitute a group between these. The Tukey test created groups of samples according to the effect of weave type on mass loss values.

These results showed that at the end of the abrasion test, samples T1 ($\bar{X}$ = 6.37) and T3 ($\bar{X}$ = 6.90) comprised the group that has the lowest effect ($P < 0.05$) on mass loss, while sample P3 ($\bar{X}$ = 9.59), S1 ($\bar{X}$ = 9.57) P1 ($\bar{X}$ = 8.87) comprised the group that causes the highest increase in the mass loss value. When the constructions of samples P3, S1and P1 are observed, long yarn floats and a low number of interlacings are evident. So in this type of weave, these two characteristics cause the continuous contact area of one yarn strand to expand and this facilitates the yarn to lose its form more easily by providing easier movement as a result of the rubbing motion. In this way, holding the fibres in the yarn structure becomes harder and the removal of fibre as a result of the rubbing motion becomes easier, and then mass loss increases. In samples T1 and T3, the number of floats is low, and the number of interlacings is high. This causes lower mass loss values, contrary to samples P1 and P3. Besides these samples, samples P2 and T2 have mass loss values between the mass loss values of these two groups. This can be explained by their weave structure having of a normal number of interlacings and floats.

If the effect of the number of abrasion cycles on mass loss values are observed, it is seen that for whole samples the effect of the number of abrasion cycles on mass loss values is significant ($P < 0.01$). According to the Tukey test results for each of the sample weaves tested, the group of sample tested at 15,000 cycles that in which the highest mass loss value is observed, while the group is that tested at 5,000 cycle, which has the lowest mass loss values. By increasing the abrasion cycle of the abrasion test device, higher mass loss values are expected.

The Pearson correlation analysis showed that there is an important, positive and significant relationship between mass loss and abrasion cycle values ($r = 0.898$, $P < 0.01$). The calculated r^2 value is 0.8064. This means that increasing the number of abrasion cycles causes higher mass loss. Figure 3 exhibits a diagram that shows the relationship between the number of abrasion cycles and mass loss.

Conclusions

Our experimental study on the abrasion resistance property of different weave types showed that weave type has a significant effect on mass loss values. The test results indicated that long yarn floats and a low number of interlacings decrease the abrasion resistance of woven fabrics by increasing the mass loss. According to ANOVA results the effect of weave type on abrasion resistance is found to be significant ($P < 0.01$). The TUKEY test also confirmed our results.

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