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Effect of Abrasion Resistance on the Woven Fabric and its Weaves

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Abstract

From yarns to fibers to fabric, a finished garment goes through various challenges to meet our requirements. One of the major factors that affect a woven fabric is 'Abrasion Resistance'. Abrasion is basically the mechanical deterioration of fabric components by rubbing them against another surface. It ultimately results in the loss of the fabrics' performance and its appearance. This paper shall deal with the various aspects of a woven fabric with respect to abrasion resistance, its tests and various experiments and the effect it has on the weave of the fabric.

Keywords: Abrasion Resistance; Weave; Abrasion; Fabric; Textile; Testing Methods; Factors affecting Abrasion Resistance; ASTM; Martindale Abrasion Tester.

1. Introduction

To understand the topic we have in hand, we first need to start with the basics. Abrasion can be an undesirable effect of exposure to normal use or exposure to the elements. And Resistance can be stated as is the force resisting the relative motion of solid surfaces, fluid layers, and material elements sliding against each other. Now, to combine them, *'Abrasion Resistance'* could be defined process of scuffing, scratching, wearing down, marring, or rubbing away. It can be intentionally imposed in a controlled process using an abrasive. Abrasion ultimately results in the loss of performance characteristics, such as strength, but it also affects the appearance of a fabric. Many parts of apparel, such as collar, cuffs and pockets, are subjected to serious wear in use, which limits their serviceability.

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The abrasion resistance of textile materials is effected by many factors (e.g. fiber fineness, yarn count, yarn type, weave etc.) in a very complex, and as yet little understood manner [1]. To further understand the concept, we need to take a deeper look upon how the resistance of the materials, structures and fabrics can be measured. There are multiple tests that can be performed to know about the resistance of the materials. These often use a specified abrasive or other controlled means of abrasion. Under the conditions of the test, the results can be reported or can be compared items subjected to similar tests. Such standardized measurements can produce two quantities: *abrasion rate* and *normalized abrasion rate* (also called *abrasion resistance index*). The former is the amount of mass lost per 1000 cycles of abrasion. The latter is the ratio of former with the known abrasion rate for some specific reference material. One type of instrument used to get the abrasion rate and normalized abrasion rate is the abrasion scrub tester, which is made up of a mechanical arm, liquid pump, and programmable electronics. The machine draws the mechanical arm with attached brush (or sandpaper, sponge, etc.) over the surface of the material that is being tested. The operator sets a pre-programmed number of passes for a repeatable and controlled result. The liquid pump can provide detergent or other liquids to the mechanical arm during testing to simulate washing and other normal uses. The use of proper lubricants can help control abrasion in some instances. Some items can be covered with an abrasion-resistant material. Controlling the cause of abrasion is sometimes an option. To talk about the subpart of the main topic, we should now try to get a clearer picture of Woven Fabrics and its weaves.

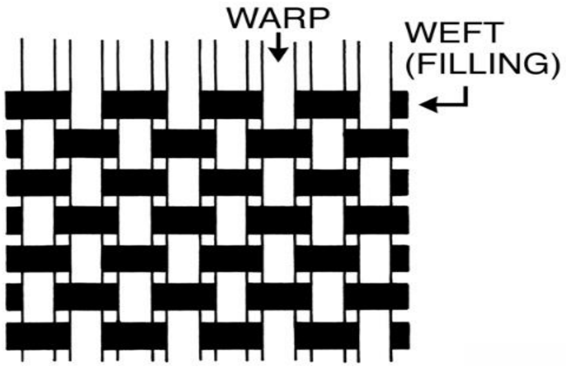


Figure 1: Warp & Weft Depiction in a Woven Fabric

Woven Fabrics is a basic textile that is formed by weaving. These are often created by a loom and made various threads woven along the warp and weft. Technically, any woven fabric is made by interlacement of warp and weft which are kept at right angle to each other. *Fabric Weave* is the pattern for manufacturing a fabric. The yarns are used in different ways to produce various effects or weaves. These weaves can be plain and simple as well as artistic and decorative. 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 fibers from yarns. Therefore, the factors that affect the cohesion of yarns will influence their abrasion resistance. 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. 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. However, there is a lack of information in the literature about the effect of weave type on the abrasion resistance property [1].

2. Weaves of a Woven Fabric

Plain weave is the most simple and common type of construction which is inexpensive to produce, durable, flat having tight surface on which printing and other finishes can be easily applied. The examples of plain weave fabrics are crepe, taffeta, organdy, cotton calicos, cheesecloth, gingham, percale, voile and muslin. *Satin weave*, although more complicated, is a flexible type of weave than the plain weave. It is called 'satin' when filament fibers such as silk or nylon are used and is called 'sateen' when short-staple yarns like cotton is used to make it. The satin weave is lustrous with a smooth surface and it drapes in an excellent manner. The examples of satin weave fabrics are brocade, brocatelle, crepe-satin, Satin, peau de soie, velvet, satin, etc. *Twill weave* is somewhat similar to plain weave. Twill weave is durable, heavier, wrinkle and soil resistant, and is more flexible than plain weave. The examples of twill weave fabrics are covert cloth, drill, jean, jersey, tussah, velvet, worsted cheviot etc.

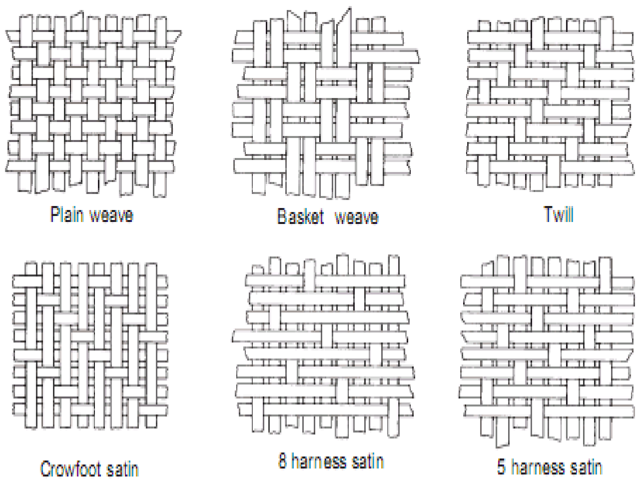
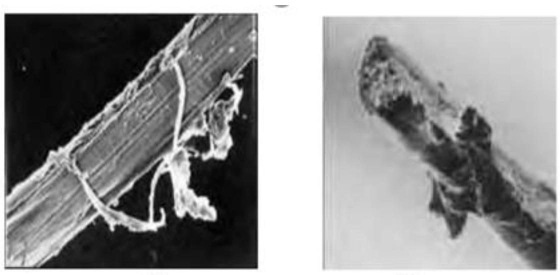


Figure 2: Types of Weaves

Basket weave is a variation of plain weave in which the fabrics have a loose construction and a flat look. It is more flexible and stronger but less stable than a plain weave. This weave is used in composites industry, outerwear, monk's cloth and drapery fabrics etc. *Jacquard weave* is for creating complex patterns on fabrics and is woven on jacquard loom. The fabrics made through this weave have floats, luster, and are more stable and stretchy than the basic weaves. Some of its examples are matelassé, satin falcone etc. It is used for upholstery and drapery. *Rib weave* is a basic weave which produces ribs on the fabric. Resulting fabric is abrasion and tear resistant examples of which are broadcloth, cord fabric, faille, poplin, taffeta etc [2].

3. Abrasion Mechanism of Textiles

Abrasive wear in textiles is caused by different conditions mainly given below: - Friction between textile materials, such as rubbing of a jacket or coat lining on a shirt, pants pockets against pants fabric etc. - Friction between the textile materials to the external object, such as rubbing of trousers to the seat, friction of the yarn to the needle etc. - Friction between the fibers and dust, or grit, in a fabric that results in cutting of the fibers. This is an extremely slow process, it may be observed on flags hanging out or swimwear because of the unremoved sand. - Friction between the fabric components. Flexing, stretching, and bending of the fibers during the usage causes fiber slippage, friction to each other and breakage [3]. The study of the gradual processes of wear is part of the discipline of tribology and the mechanism of wear is very complex. Under normal mechanical and practical procedures, the wear-rate normally changes through three main stages: the first stage which is called as the '*primary stage or early run-in period'*, in this stage the surfaces adapt to each other and the wear-rate might vary between high and low; The next or the second stage is known as the '*secondary stage or mid-age process'*, where a steady rate of wearing is in motion. Most of the components operational life is comprised in this stage. The final stage is called the '*Tertiary stage or old-age period*', in this stage the components are subjected to rapid failure due to extreme rate of wearing. Some commonly referred to wear mechanisms include: *Adhesive wear, abrasive wear, surface fatigue, fretting wear, erosive wear.* Adhesive, abrasive wear and surface fatigue mechanism play an extremely important role in the abrasion mechanism of the yarns and fabrics. To talk about the 'Adhesive wear', it mainly occurs between surfaces during frictional contact and generally refers to unwanted displacement and attachment of wear debris and material compounds from one surface to another. The adhesive wear and material transfer due to direct contact and plastic deformation are the main issues in adhesive wear. The asperities or microscopic high points or surface roughness found on each surface, define the severity on how fragments of oxides are pulled off and adds to the other surface. This is partly due to strong adhesive forces between atoms, but also due to accumulation of energy in the plastic zone between the asperities during relative motion. Abrasive wear, occurs when a hard rough surface slides across a softer surface. ASTM (American Society for Testing and Materials) defines it as the loss of material due to hard particles or hard protuberances that are forced against and move along a solid surface. Abrasive wear is commonly classified according to the type of contact and the contact environment. The type of contact determines the mode of abrasive wear. The two modes of abrasive wear are known as two-body and three-body abrasive wear. Two-body wear occurs when the grits or hard particles remove material from the opposite surface. The common analogy is that of material being removed or displaced by a cutting operation. Three-body wear occurs when the particles are not constrained, and are free to roll and slide down a surface. Fatigue wear of a material is caused by a cycling loading during friction. Fatigue occurs if the applied load is higher than the fatigue strength of the material. Fatigue cracks start at the material surface and spread to the subsurface regions. The cracks may connect to each other resulting in separation and delamination of the material pieces. One of the types of fatigue wear is fretting wear caused by cycling sliding of two surfaces across each other with small amplitude (oscillating). The friction force produces alternating compression-tension stresses, which result in surface fatigue [4]. In terms of wear mechanism in textiles, abrasion first modifies the fabric surface and then affects the internal structure of the fabric, damaging it [5]. Good abrasion resistance depends more on a high energy of rupture than on high tenacity at break. Abrasion is not influenced so much by the energy absorbed in the first deforming process (total energy of rupture), as by the work absorbed during repeated deformation. This work is manifested in the elastic energy or the recoverable portion of the total energy. Thus, to prevent abrasion damage, the material must be capable of absorbing energy and releasing that energy upon the removal of load. Energies in tension, shear, compression, and bending are all important for the evaluation of surface abrasion; however, these energies are unknown, and therefore elastic energies in tension permit at least a quantitative interpretation of abrasive damage in fibers and fabrics [6]. Fibers in use are subject to a variety of different forces, which are repeated many times [7]. The gradual breakdown of the internal cohesion of the individual fibers or by a gradual breakdown of the forces of structural cohesion between the fibers results fabric failure. The relative occurrence of these two phenomena depends to a great extent upon the fabric geometry, but there are limitless factors involved (e.g., construction of yarns and weaves) depending on the individual behavior of different fibers [6].



(a) (b)

Figure 3: Abrasion of Fibers over rotating pin (a) Nylon, (b) Wool

Figure 4: Fiber rupture occurred as abraded against standard worsted fabric

During the course of abrasion in textiles, fiber to fiber cohesion plays an important role, usually influenced by yarn twist or close fiber packing. Abrasion behavior indicates that fiber cohesion is strong in the fabric system, and it causes the shear of the fibers themselves. Frictional forces developed in the yarn due to the motion of the abrasion test are dissipated largely in the fibers by the development of tensile and shear stresses; repetition of such stresses results in fiber fatigue, which causes the loss of fiber mechanical properties, leading to rupture. Fibers in the crowns are broken down in succession, and this causes a reduction in fiber cohesion and yarn strength. In lateral abrasion cycles, frictional forces are able to displace fiber from their normal position, and these fibers ruptures through bending and flexing (Figure 3). In addition, it is also possible that some cracking is initiated by abrasion and then propagated by bending action [6]. Although the mechanism of abrasion is similar, because of the differences in the measurement methods, abrasion resistance of textile materials can be studied in two parts such as fabric abrasion and yarn abrasion.

4. Factors Affecting Abrasion Resistance of Fabrics

Abrasion resistance of the textile materials is very complex phenomenon and affected by many factors, mainly classified as follows: Fiber, yarn, fabric properties and finishing processes. Some of these parameters affect fabric surface whereas some of them has an influence on internal structure of the fabrics. For example fiber characteristics like wool ratio and fineness play a significant role in surface abrasion, while yarn and fabric characteristics like yarn linear density and interlacing coefficient are significantly related with structural abrasion [5].

4.1 Fiber properties

The mechanical properties and dimensions of the fibers are important for abrasion. Fiber type, fiber fineness and fiber length are the main parameters that affect abrasion. Fibers with high elongation, elastic recovery and work of rupture have a good ability to withstand repeated distortion; hence a good degree of abrasion resistance is achieved. Nylon is generally considered to have the best abrasion resistance, followed by polyester, polypropylene [8] Blending either nylon or polyester with wool and cotton is found to increase abrasion resistance at the expense of other properties [9]. Higher wool rate increase the mass loss [5]. Acrylic and modacrylic have a lower resistance than these fibers while wool, cotton and high modulus viscose have a moderate abrasion resistance. Viscose and acetates are found to have the lowest degree of resistance to abrasion. However, synthetic fibers are produced in many different versions so that the abrasion resistance of particular variant may not conform to the general ranking of fibers [9]. The removal of the fibers from yarn structure is one of the reasons of the abrasion. Therefore factors that affect the cohesion of yarns will influence the abrasion resistance of fabrics as well. Longer fibers incorporated into a fabric confer better abrasion resistance than short fibers because it is harder to liberate them from the fabric structure. For the same reason filament yarns are more abrasion resistant than staple yarns made from the same fiber [8,9]. The using of finer fibers in the production of yarns causes increment in the number of the fiber in cross section with higher cohesion which results better abrasion resistance. So abrasion retention is better for fabrics with finer fibers [10].

5. Methods for Testing Abrasion Resistance of Fabrics

Most abrasion tests depend on applying energy to the fabrics and measuring their response to it. The manner of transferring the energy from machine to the fabric is different for different machines, but the basic principles are the same [6]. There are three types of abrasion in terms of occurrence; flat, edge and flex abrasion. Therefore different abrasion test methods have been described by the abrasion type, the test head movement or testing device setup. The differences among the procedures include the type of equipment, abradant (the material that rubs against the specimen), material used (including woven, nonwoven, and knit apparel fabrics, household fabrics, industrial fabrics, and floor coverings) and assessment method. In all of the test methods, the tested specimen is rubbed in a particular manner against an abradant which may be a fabric, or a emery sheet for either a certain amount of time for a certain number of strokes or cycles [11]. ASTM and ISO define several methods to quantify abrasion resistance of textile materials and introduce methods for the evaluation of abraded fabrics. However, there is not a linear relationship between successive measurements using any of these methods and progressive amounts of abrasion [9]. In Table 1, these test methods and relevant test equipment are given.

Test Standard		Testing Device / Method
ASTM D 4966	Standard Test Method for Abrasion Resistance of Textile Fabrics	Martindale Abrasion Tester
ASTM D 3884	Test Method for Abrasion Resistance of Textile Fabrics	Rotary Platform Double-Head (RPDH)
ASTM D 3885	Test Method for Abrasion Resistance of Textile Fabrics	Flexing and Abrasion Method
ASTM D 3886	Test Method for Abrasion Resistance of Textile Fabrics	Inflated Diaphragm
ASTM D 4157	Test Method for Abrasion Resistance of Textile Fabrics	Oscillatory Cylinder Method
ASTM D 4158	Test Method for Abrasion Resistance of Textile Fabrics	Uniform Abrasion Method
AATCC-93 Test Method	Abrasion Resistance of Fabrics: Accelerator Method	Accelerator Method
ISO 12947-1	Determination of the abrasion resistance of fabrics by the Martindale method Part 1: Martindale abrasion testing apparatus	Martindale Abrasion Tester
ISO 12947-2	Determination of the abrasion resistance of fabrics by the Martindale method Part 2: Determination of specimen breakdown	Martindale Abrasion Tester
ISO 12947-3	Determination of the abrasion resistance of fabrics by the Martindale method Part 3: Determination of mass loss	Martindale Abrasion Tester
ISO 12947-4	Determination of the abrasion resistance of fabrics by the Martindale method Part 4: Assessment of appearance change	Martindale Abrasion Tester

Figure 5: Test Methods of Abrasion Resistance of Fabrics

6. Factors Affecting Abrasion Test Results

During testing, the resistance to abrasion is also greatly affected by the conditions of the tests, such as the nature of the abradant, variable motion of the abradant over the area of specimen, the tension of the specimen, the pressure between the specimen and the abradant, and the condition of the specimen (wet or dry). The type of abrasion like flat, flex or edge abrasion or a combination of more than one affect the test results as expected. In many fabrics the abrasion resistance in the warp direction differs from that of the weft direction. Ideally the rubbing motion used by an abrasion machine should be such as to eliminate directional effects. In jacquard and textured fabrics, the test sample should include both the textured and different parts, sensitive to abrasion. Abradants can consist of anything that will cause wear. A number of different abradants have been used in abrasion tests including standard fabrics, abrasive paper (glass paper, sand paper etc.) or stones (aluminum oxide or silicon carbide), steel plates and metal ‘knives’. The nature of abradants and the type of action control the severity of the test. For the test to correspond with actual wear in use it is desirable that the abrasive should be similar to that encountered in service. The abradant itself wear during the test so they should be replaced after a certain usage time (Hu, 2008 ; Saville, 1999). Abrasion tests are all subject to variation due to changes in the abradant during specific tests. The abradant must accordingly be discarded at frequent intervals or checked periodically against a standard. With disposable abradants, the abradant is used only once or discarded after limited use. With permanent abradants that use hardened metal or equivalent surfaces, it is assumed that the abradant will not change appreciably in a specific series of tests. Similar abradants used in different laboratories will not change at the same rate, due to differences in usage. Permanent abradants may also change due to pick up of finishing or other material from test fabrics and must accordingly be cleaned at frequent intervals. The measurement of the relative amount of abrasion may also be affected by the method of evaluation and may be influenced by the judgment of the operator (ASTM D 3884). The pressure between the abradant and the sample and the test speed affects the severity and rate at which abrasion occurs. It has been shown that using different pressures can seriously alter the ranking of a set of fabrics when using a particular abradant. Excessive pressure and testing speed can result in shorter testing time but however, the results cannot simulate the normal usage conditions. The tension of the mounted specimen is also important, and it should be same for all samples. Tension during the test is provided by backing foam or inflated diaphragm.

7. Experiment to study the affect of Abrasion Resistance on the Weave of the Fabric

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 Figure 6. Structural views of the seven woven fabrics tested in this experimental study are given in Figure 1 and the fabric weight in g/m2, yarn crimp in % and fabric thickness in mm properties of the samples are shown in the next figure.

Weave type	Sample code	Fabric weight, g/m²	Yarn crimp, %		Fabric thickness, mm
			warp	weft	
Plain	P1	150	1.6	16.7	0.48
	P2	150	5.0	15.1	0.44
	P3	146	4.7	13.5	0.42
Twill	T1	148	4.9	14.8	0.29
	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

Figure 6: Fabric Properties of Samples

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 7: Mass values of samples after different rubbing cycles.

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 initial 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 $\alpha \leq 0.01$.

8. 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 Figure 7.

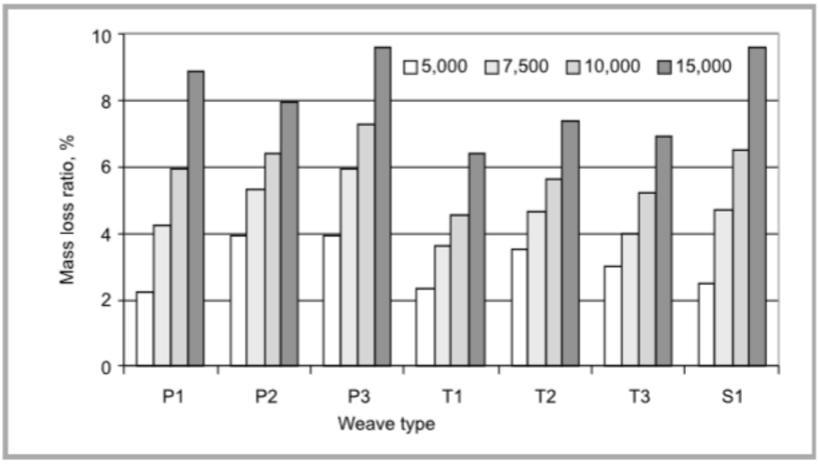


Figure 8: Mass loss ratio of different weave types after abrasion test of different number of cycles

Figure 8 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 interlacing, while samples T1 and T3 are in the group that have a low number of floats and a high number of interlacing. 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 (= 6.37) and T3 (= 6.90) comprised the group that has the lowest effect (P < 0.05) on mass loss, while sample P3 (= 9.59), S1 (= 9.57) P1 (= 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 interlacing 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 fibers in the yarn structure becomes harder and the removal of fiber 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 interlacing 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 interlacing 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.

9. Conclusion

To conclude this paper, we can say that abrasion truly affects serviceability of textile materials was explained in detail. The abrasion mechanism of textiles is a complex phenomenon and associated with the properties of fibers, yarns, fabric structure and applied treatments. Abrasion in textiles such as fabrics, yarns, socks and technical textiles can be measured by different methods. Due to the technological improvements and growing demands on the properties of textile materials, it seems the development of new test techniques and equipment will continue on this issue. 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 interlacing 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.

References

[1] H. Kaynak and M. Topalbekiroğlu, “Influence of Fabric Pattern on the Abrasion Resistance Property of Woven Fabrics,” Department of Textile Engineering, University of Gaziantep, Gaziantep.

[2] T. School, “Fabric weave and its basics”.

[3] P. Mehta, “An Introduction to Quality Control for the Apparel Industry,” ASQC Quality Press, (1992).

[4] N. Özdil, G. Kayseri and G. S. Mengüç, “Analysis of Abrasion Characteristics in Textiles,” Ege University, Textile Engineering Department, Izmir, Izmir, Turkey.

[5] A. C. M. S. R. M. R. B. A. Manich, “Abrasion Kinetics of Wool and Blended Fabric,” Textile Research

Journal, Vol.71, (2001).

[6] I. B. R. R. S. T. J. Abdullah, “Abrasion Phenomena in Twill Tencel Fabric,” Journal of Applied Polymer Science Vol. 102, p. 1391–1398, 2006.

[7] J. M. W. Hearle, Physical Properties of Textile Fibres (Fourth edition), Woodhead Publishing Series in Textiles No. 68, ISBN-13: 978 1 84569 220 9, 2008.

[8] J. Hu, “ Fabric testing,” Woodhead Publishing Series in Textiles, 2008, p. 76.

[9] B. (. ,. ,. Saville, “Physical Testing of Textiles, CRC,” Cambridge, England, Woodhead Publishing Limited.

[10] F. Ö. E. Ö. B. Kaloğlu, “Influence Of Varying Structural Parameters On Abrasion Characteristics of 50/50 Wool/Polyester Blended Fabrics,,” Textile Research Journal, Vol. 73, No. 11,, pp. pp. 980-984., (2003). .

[11] S. Kadolph, “Quality Assurance for Textiles and Apparel,,” ISBN:156367-144-1, Fairchild Publication, 2007.