

Determination of abrasive strength of fabrics through mass loss at various washing intervals

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ABSTRACT

Fabrics undergo many wear and tear conditions through their lifetime. Abrasion occurs with the rubbing of fibers to another surface during their manufacturing process, usage, and laundering procedure. It is necessary to evaluate upholstery fabrics for their abrasive strength before presenting it to the customers for their satisfaction. Abrasion causes mechanical deterioration of fibers and yarns in a fabric. This study was aimed at determining the abrasive strength of collected upholstery fabric from local markets after various number of washing intervals through Martindale abrasion tester. The results depicted that fabric made with polyester and cotton having a blend ration of (87% and 13%) manufactured by following plain interlacing pattern was better able to resist rubbing action as compared to other samples.

1. Introduction

The serviceability of fabric used for upholstery largely depends on its fiber content, yarn type, construction technique, care, and usage. Textile manufacturers must be very vigilant in making selection for upholstery fabric to attract the ultimate consumer [1].

Structural patterns make the appearance of a fabric good or bad, attractive, or dull, smooth, or coarse and tight or loose etc. These factors contribute to the durability of end fabric. Fabrics used for upholstery items such as bed sheets, curtains, sofa covers, cushions and wall panels etc. should have enough abrasive strength to withstand daily encounters of people using them [2-3].

Abrasion is the deterioration of fibers or yarns in a fabric against some other surface. Lack of resistance against abrasion makes fabric less durable as well as affects the overall look of the produced fabric [4].

Moreover, it also changes the internal behavior of fabric [5]. Thus, it is necessary to study the fabric geometry by identifying various parameters such as fiber kind, yarn type, weave structure, twist factor, laminations, or coatings etc. [6]. Lack of abrasive strength produces entangled fibers over the surface of fabric due to rubbing or washing. It also loses the mass of the fabric, changes its appearance and color, breaks the yarn, and finally makes a hole in the fabric structure [7].

Two modes of action are taken in determination of abrasive strength. First mode occurs with displacement of hard particles from the other surface. Second mode comprised of rolling off or sliding down the particles on the surface of fabrics [8].

Laundering is one of the important steps in taking care of apparel and upholstery fabrics. It assists in removal of impurities and dirt. Laundering may affect the mechanical behavior and appearance of fabrics due to friction forces [9]. The fibers and yarns used for manufacturing

upholstery fabric are supposed to maintain their mechanical and structural characteristics after many numbers of washings, as these fabrics need to be laundered frequently. The aim of the study was to determine the effect of various types of polymers on the abrasion resistance of textile materials used for various end uses. Research question was to determine the mass loss of tested fabrics at various rubbing intervals. It was necessary to improve the wear resistance of fabrics.

2. Materials and Methods

Samples of fabrics used for upholstery were randomly collected from local markets of Lahore. These materials were assessed for their fiber kind through qualitative analysis in the form of visual examination, burning test and microscopic tests by following AATCC test method 20-2013 [10].

Table 1

Construction parameters of collected upholstery fabrics

Sample code	Fiber content	Weave type	Fabric mass (GSM)	Warp / Weft per inch	Thread count
AS1	Cotton 100%	Twill	205	108 x 80	188
AS2	Rayon 70%	Twill	135	101 x 72	173
AS3	Polyester 30%				
	Cotton 13%	Plain	215	115 x 95	210
	Polyester 87%				
AS4	Cotton 45%	Plain	157	75 x 67	142
	Polyester 55%				
AS5	Cotton 97%	Satin	195	70 x 65	135
	Polyester 3%				

Samples were laundered in front load washer with the speed of 45 ± 5 rpm and temperature set at 54 ± 2 °C for approximately 12 minutes by following AATCC Monograph M6 [14]. Specimens from each of the five categories were taken and laundered up to 15 washes and assessed for their abrasion resistance after interval of every 5 washes.

Resistance of collected samples against abrasive strength was measured by following specifications given in ASTM D 4966 [15]. Martindale abrasion tester was used for this purpose. Three specimens from each sample were taken and cut with a diameter of 1.5 inches so that it was made sure that this circular specimen should have both warp and weft yarns in it. No specimen was cut near or from edge or selvedge area. Creases and wrinkles were also avoided in the specimen. Preconditioning was done for all specimens under standard atmosphere by following ASTM-D1776 requirements [16].

It was difficult to identify some synthetic fibers through qualitative analysis, so quantitative analysis with chemical test was also employed by following AATCC test method 20A-2014 [11]. Finally, a total of five groups were formed based on their fiber type. These materials were also evaluated for their construction parameters.

Warp and filling count per inch was determined with magnifying counting glass by following ASTM D 3775-12 method [12]. Fabric mass was measured by following ASTM D 3776 test method and it was calculated in grams per square meter [13].

Weave structure of all samples was also identified and noted. The groups were labeled and assessed for their abrasive strength after various number of laundering intervals (Table 1).

A piece of felt with similar dimensions were cut and mounted with the sample being tested. The specimens were placed with their front side in the downward direction in the holder of machine. A standard pressure of 12 kPa was produced onto the tested specimen. Machine was switched on to give abrasive cycles to the surface of specimens. The machine was automatically stopped after the completion of preselected number of rubbing cycles (1500, 3000, 4500, 6000, 7500). Then the specimen from the holder was removed with care so that yarns were not displaced or get damaged. Loss in mass of the tested specimens was calculated and compared with their mass before testing.

3. Results and Discussion

Three specimens from each of five groups were taken and evaluated for their abrasion resistance at 0-wash, 5th wash, 10th wash and 15th wash. The average values and their standard deviation were calculated. Statistical analysis

was made by using SPSS. ANOVA was applied to determine the difference of mass loss among tested specimens after washing intervals at 0, 5, 10 and 15. P-value < 0.05 was taken as significant. It was clearly seen from the results that percentage of mass loss was increased with increasing number of washing cycles. Sample AS4 presented less mass loss as compared to

other specimens (Table 2). One possible reason can be the nature of fibers used in its manufacturing, as it contained 87% of polyester content. Fibers made with polyester have more abrasion resistance than acrylic, cotton, wool, or viscose [17]. Blending ratio also has a strong effect on abrasive strength of fabrics.

Table 2

Mass loss at 1500 rubbing cycles at various washing interval

Sample code	Mass loss at 1500 rubbing cycles (%age)							
	At 0-Wash		At 5-Wash		At 10-Wash		At 15-Wash	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
AS1	0.3	1.52	0.9	2.31	1.2	1.25	2.1	1.33
AS2	0.2	1.87	1.2	0.54	1.7	2.54	2.5	0.25
AS3	0.2	2.58	0.4	1.24	0.6	1.77	0.7	1.12
AS4	0.3	1.69	0.6	1.99	0.8	1.54	2.0	0.47
AS5	1.2	1.56	2.1	1.87	2.7	1.36	3.0	0.32

It was shown that increase in blending ratio of cotton and polyester produce high abrasion resistance (Fig. 1). Fibers belong to polyamide family are better able to resist abrasion. So, the more amount of polyamide presents better results as compared to less quantity in blending ratio [18]. It was seen that coarse yarns are more prone to abrasion rather than fine yarns. Similarly plied yarns also show high mass loss after abraded motions due to their coarse and rough texture [18-19].

Table 3

Statistical Analysis of Within-Subject of Mass loss at 1500 rubbing cycles

Source type	Different Washes	Type III Sum of Squares	df	Mean Square	F	p-value
Different-washes	Linear	85.75	1	85.75	73.26	0.01

The p-value clearly explains that there is a statistically significant difference among mass loss of all the tested fabrics after various washing intervals and at 1500 rubbing cycles (Table 3).

It can be seen that warp and weft density of yarns has also a strong relationship with abrasion resistance of fabrics. It was observed that weight loss was decreased with increase in number of weft yarns (Table 4). It was due to the tight and compact fabric structure that makes it more resistant.

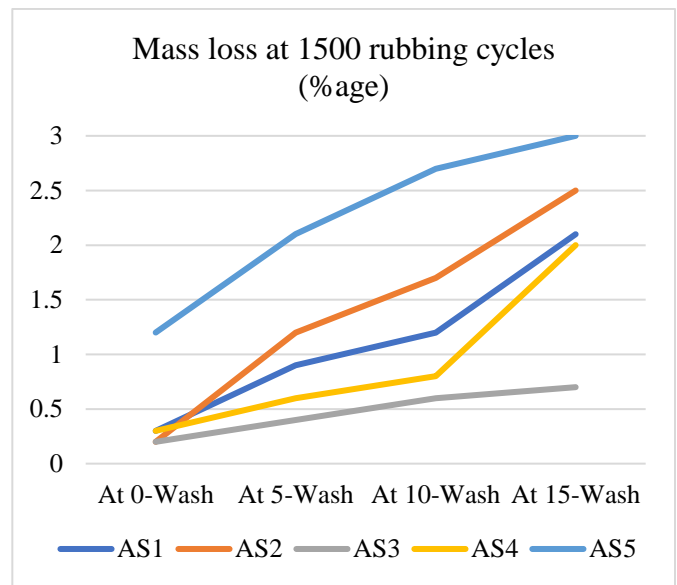


Fig. 1. Mass loss at 1500 rubbing cycles at various washing intervals

Table 5

Statistical Analysis of Within-Subject of Mass loss at 3000 rubbing cycles

Source type	Different Washes	Type III Sum of Squares	df	Mean Square	F	p-value
Different-washes	Linear	111.12	1	111.12	88.97	0.02

Excellent results in abrasion were observed with polyester fabric made with plain interlacing pattern followed by twill and satin weaves (Fig. 2). The statistical

difference clearly dictates that type of fiber is one of the main causes of varied mass loss percentages (Table 5). Sample AS5 showed maximum weight loss. It can be due

to the long interlacings with satin weave. Whereas samples with plain and twill were better in their resistance as compared to it (Table 6).

Table 4

Mass loss at 3000 rubbing cycles at various washing intervals

Sample code	Mass loss at 3000 rubbing cycles (%age)							
	At 0-Wash		At 5-Wash		At 10-Wash		At 15-Wash	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
AS1	2.2	0.12	2.9	1.87	3.2	0.26	3.6	1.89
AS2	2.6	1.54	3.1	0.25	3.6	2.14	3.9	1.85
AS3	0.8	1.26	1.0	2.54	1.2	1.65	1.4	0.21
AS4	2.1	1.58	2.8	1.48	3.0	1.26	3.2	1.65
AS5	3.1	1.98	3.9	1.23	4.3	0.89	4.7	1.28

Table 6

Mass loss at 4500 rubbing cycles at various washing intervals

Sample code	Mass loss at 4500 rubbing cycles (%age)							
	At 0-Wash		At 5-Wash		At 10-Wash		At 15-Wash	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
AS1	3.7	0.52	4.0	1.57	4.2	1.87	4.7	0.58
AS2	4.0	2.15	4.3	0.25	4.5	1.59	4.7	1.78
AS3	1.5	1.25	1.8	0.32	2.0	0.84	2.1	1.26
AS4	3.3	1.65	3.7	2.58	3.9	1.45	4.1	1.65
AS5	4.8	1.89	5.1	1.54	5.8	1.89	6.2	0.25

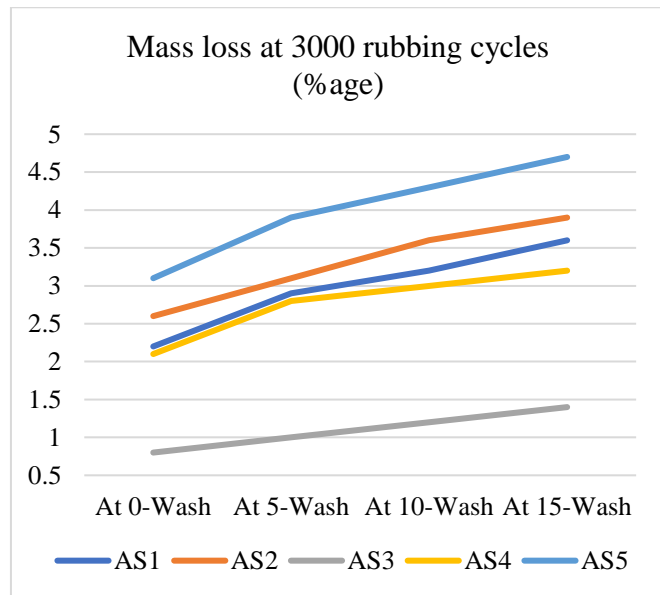


Fig. 2. Mass loss at 3000 rubbing cycles at various washing intervals

Plain weave presents higher abrasive strength due to higher number of frictional forces between the two directions such as warp and weft in their cross-sectional area [20]. This phenomenon is also supported by another

study that few number of floats and high number of interlacings produces less mass loss in fabrics [6]. P-value 0.01 also states the same phenomenon (Table 7).

Table 7

Statistical Analysis of Mass loss at 4500 rubbing cycles

Source type	Different Washes	Type III Sum of Squares	df	Mean Square	F	p-value
Different -washes	Linear	231.12	1	231.12	89.54	0.01

It was studied in another research conducted by Choudhary and Bansal, [21] that fabrics manufactured with plain weave show high tensile and abrasive strength due to high number of binding points between them. Plain weave has small floats to go through the structure. It will give cohesion and strength to the fibers to withstand any external force [22] (Fig. 3).

Fabric produced by following long floats and few number of interlacings are more prone to yarn slippage as the yarn expands easily and shifts its place from one position to another due to rubbing action (Table 8). (Fig 4). It makes difficult for the yarns to hold each other at

one place thus reduces their mass [6]. P-value 0.03 states that there is a statistical difference among tested fabrics at 600 rubbing cycles against various washing intervals (Table 9).

Table 8

Mass loss at 6000 rubbing cycles at washing intervals

Sample code	Mass loss at 6000 rubbing cycles (%age)							
	At 0-Wash		At 5-Wash		At 10-Wash		At 15-Wash	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
AS1	4.8	0.29	5.1	1.65	5.6	1.65	5.8	1.26
AS2	4.8	1.98	5.0	1.89	5.3	2.89	5.7	0.85
AS3	2.2	1.54	2.5	0.78	2.6	1.48	2.8	1.95
AS4	4.2	1.28	4.5	1.59	4.9	0.89	5.2	1.48
AS5	6.3	1.59	6.5	1.98	6.9	0.87	7.3	1.52

Table 9

Statistical Analysis of Mass loss at 6000 rubbing cycles

Source type	Different Washes	Type III Sum of Squares	df	Mean Square	F	p-value
Different -washes	Linear	145.56	1	145.56	93.45	0.03

High fabric mass also contributes to providing high tensile and abrasive strength (Table 10). Fabric with high thread count and weight gives more strength to the fiber and prevents yarn breakage during processing. An increase in warp and weft per inch increases the mass of the prepared.

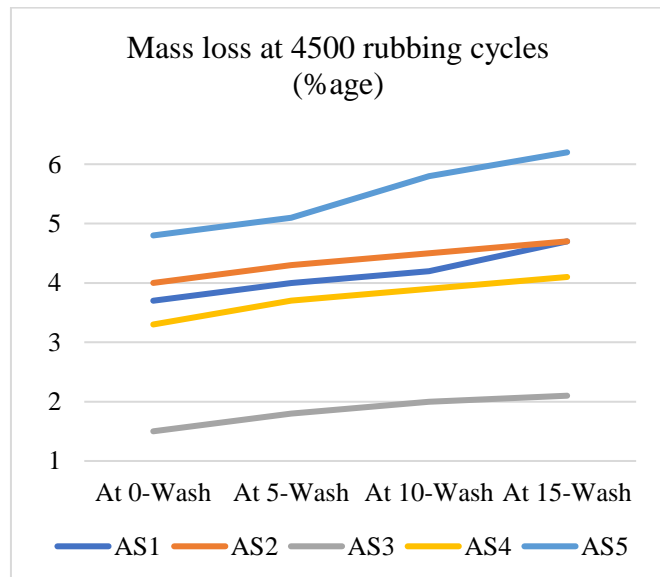


Fig. 3. Mass loss at 4500 rubbing cycles at various washing intervals

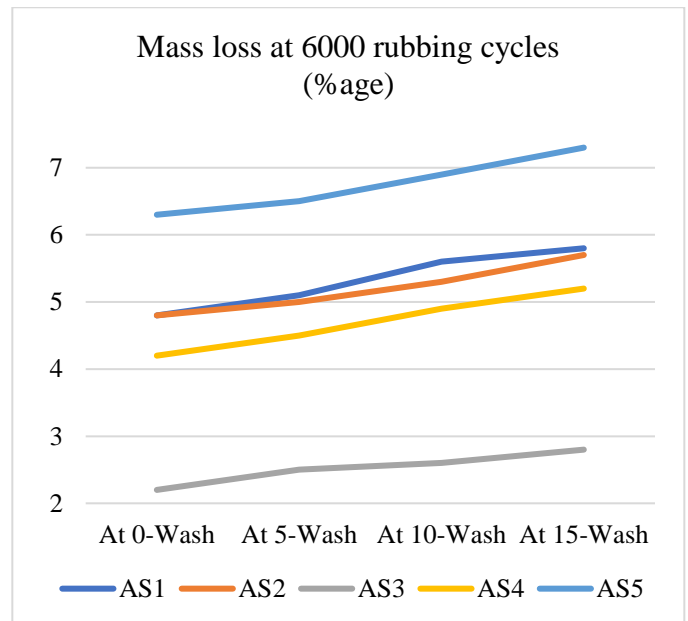


Fig. 4. Mass loss at 6000 rubbing cycles at various washing intervals

It was observed that woven velour fabric reduced its mass more as compared to the other fabric due to the absence of any lamination and coating over its surface [23]. Whereas, on the other hand it was concluded that laminated fabrics presented better fabric, which resultantly produces high resistance against any rubbing action [21] (Fig 5). P-value 0.01 explains that there is a significant difference among fabrics when evaluated for mass loss at 7500 rubbing cycles after number of washing intervals abrasive strength than non-laminated fabrics [24]. Coating and finishing treatments help to create an extra shield on the surface of the fabric that protects the material underneath and presents better abrasive strength.

In one study, it was observed that up to 10,000 rubbing cycles, no observation was made in loss of abrasive strength of tested fabrics. Whereas, in another research,

it was found that after 20,000 rubbing cycles, only a variation in the color of the fabric was observed with minimum of fiber breakage [25].

Table 10

Mass loss at 7500 rubbing cycles at various washing intervals

Sample code	Mass loss at 7500 rubbing cycles (% age)							
	At 0-Wash		At 5-Wash		At 10-Wash		At 15-Wash	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
AS1	5.9	2.56	6.1	1.87	6.4	1.15	6.6	1.28
AS2	5.8	0.98	6.0	1.54	6.3	1.54	6.5	1.35
AS3	2.9	1.45	3.1	0.48	3.3	1.95	3.6	1.65
AS4	5.3	1.95	5.8	1.45	6.3	2.25	7.0	1.52
AS5	7.4	1.32	7.7	1.25	7.9	1.65	8.2	0.98

Table 11

Statistical Analysis of Within-Subject of Mass loss at 7500 rubbing cycles

Source type	Different Washes	Type III Sum of Squares	df	Mean Square	F	p-value
Different-washes	Linear	132.22	1	132.22	74.37	0.01

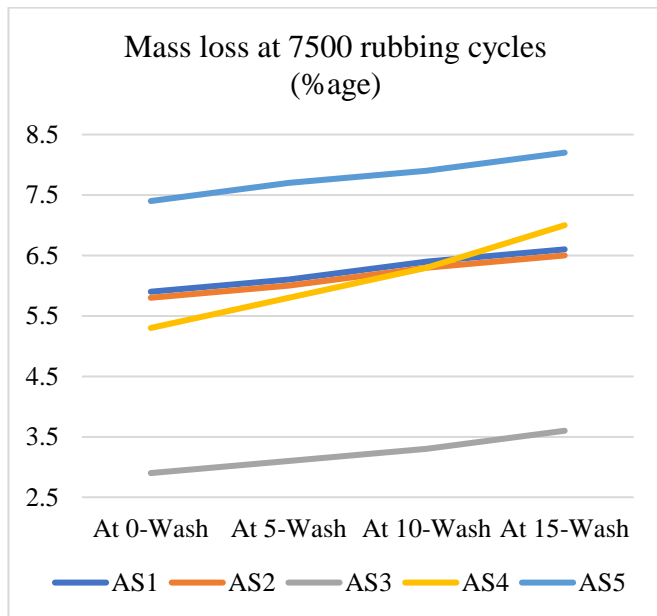


Fig. 5. Mass loss at 7500 rubbing cycles at various washing intervals

Laundering greatly affects the performance of tested fabrics. It was investigated that increase in laundering cycles increases the mass loss of fabrics due to the poor quality of fibers used in their production process [26]. Increased number of washing cycles reduces the mass of fabric, as the lint from the surface of fabric was removed and making it thinner in appearance, and weight [27].

Abrasive strength of textile materials depends on their structure. It has been investigated and concluded that uneven surface of the fabrics produces thick and thin areas. Thick areas become thinner due to the constant abrasion and thinner areas are unable to withstand the applied force in the form of rubbing while sitting, moving, or washing and damage the surface completely [25, 28].

4. Conclusion

This study determined the abrasive strength of fabrics used in making upholstery items. It concludes that nature of fiber, weave type, fabric mass and laundering have a strong effect on the resistance against rubbing action. Findings of this study can assist in developing a framework for the textile manufacturers in selecting right type of fabric with right construction specifications suitable for upholstery fabric. They can alter their construction parameters in the light of results of this study to provide appropriate type of fabric to their consumer of various end products.

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