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"Study of Abrasion Resistance of Denim Fabric by Changing Shedding Mechanism, Fabric Construction & Finishing Process (Singeing, De-Sizing)"

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Abstract

"Study of Abrasion Resistance Properties of Denim Woven Fabric by Changing of Shedding Mechanism, Fabric Construction & Finishing Process (Singeing, De-Sizing)" In this experimental work, the experiment was carried out considering three following cases:

Case 1: Abrasion resistance properties of denim fabrics using cam shedding and dobby shedding, keeping fabric construction, yarn count ($12^s + 12^s + 10^s$) & 10^S70^D (cotton + spandex) same, here same sizing recipe was used in both the cases (Table 1).

Case 2: Abrasion resistance properties of denim fabrics fabric using different fabric construction 3/1 Twill, 2/2 Twill, cam shedding mechanism, same yarn count ($12^s + 12^s + 10^s$) & 10^S70^D (cotton + spandex) and same sizing recipe were used (Table 2).

Case 3: Abrasion resistance properties of denim fabrics where denim fabric of same parameters but one is grey & another is finished where (Table 3).

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 at 4 different cycles (5,000, 7,500, 10,000 and 15,000). According to data obtained from the test results of those three cases, we observed that change of shedding mechanism, the fabric construction and finishing process has a significant effect on the abrasion resistance property of woven denim fabrics.

Keywords: Woven denim fabric; Sizing; Shedding mechanism; Abrasion resistance; Denim fabric mass loss; Rubbing

Table 1: Parameters for Case 1.

S. No	Sample's code Parameters	Sample -A	Sample-B
1	No of tested sample	3(A_1,A_2,A_3)	3(B_1, B_2,B_3)
2	Denim woven fabric	Z-Twill(grey)	Z-Twill(grey)
3	Fabric construction	03-Jan	03-Jan
4	Used fiber	Cotton, Lycra	Cotton, Lycra
5	Warp yarn	100% cotton	100% cotton
6	Warp yarn count	$12^s+12^s+10^s$	$12^s+12^s+10^s$
7	Warping process	Direct warping	Direct warping
8	Weft yarn	Cotton, Lycra blend	Cotton, Lycra blend
9	Weft yarn count	10^S70^D (cotton + spandex)	10^S70^D (cotton + spandex)

10	Sizing Recipe	Emize E-20(Emsland Group)	70.00%	Emize E-20(Emsland Group)	70.00%
		Refnol SP((Refnol Resin)	15.00%	Refnol SP((Refnol Resin)	15.00%
		Emsize CMS 60(Emsland Group)	5.00%	Emsize CMS 60(Emsland Group)	5.00%
		Refnol PA 500	9.00%	Refnol PA 500	9.00%
		Glissofil Extra Soft	1.00%	Glissofil Extra Soft	1.00%
		Temp: 90 °C,Time- 50 min		Temp: 90 °C,Time- 50 min	
11	Shedding Mechanism	Cam		Dobby	

Table 2: Parameters for Case 2.

S. No	Sample's Code Parameters	Sample-C		Sample-D	
1	No of tested sample	3(C_1,C_2,C_3)		3(D_1,D_2,D_3)	
2	Denim woven fabric	Z-Twill (grey)		Z-Twill (grey)	
3	Fabric construction	Cam		Cam	
4	Used fiber	Cotton, Lycra		Cotton, Lycra	
5	Warp yarn	100% cotton		100% cotton	
6	Warp yarn count	$12^s+12^s+10^s$		$12^s+12^s+10^s$	
7	Warping process	Direct		Direct	
8	Weft yarn	Cotton, Lycra blend		Cotton, Lycra blend	
9	Weft yarn count	10^S70^D (cotton + spandex)		10^S70^D (cotton + spandex)	
10	Sizing Recipe	Emize E-20 (Emsland Group)	70.00%	Emize E-20 (Emsland Group)	70.00%
		Refnol SP (Refnol Resin)	15.00%	Refnol SP (Refnol Resin)	15.00%
		Emsize CMS 60 (Emsland Group)	5.00%	Emsize CMS 60 (Emsland Group)	5.00%
		Refnol PA 500	9.00%	Refnol PA 500	9.00%
		Glissofil Extra Soft	1.00%	Glissofil Extra Soft	1.00%
		Temp: 90 °C, Time- 50min		Temp: 90 °C, Time- 50min	
11	Fabric Construction	3/1	2/2		

Table 3 : Parameters for Case 3.

S. No	Sample's Code Parameters	Sample-E		Sample-F	
1	No of tested sample	3(E_1,E_2,E_3)		3(F_1,F_2,F_3)	
2	Denim woven fabric	Z-Twill		Z-Twill	
3	Fabric construction	Cam		Cam	
4	Used fiber	Cotton, Lycra		Cotton, Lycra	
5	Warp yarn	100% cotton		100% cotton	
6	Warp yarn count	$12^s+12^s+10^s$		$12^s+12^s+10^s$	
7	Warping process	Direct		Direct	
8	Weft yarn	Cotton, Lycra blend		Cotton, Lycra blend	
9	Weft yarn count	10^S70^D (cotton + spandex)		10^S70^D (cotton + spandex)	
10	Sizing Recipe	Emize E-20 (Emsland Group)	70.00%	Emize E-20 (Emsland Group)	70.00%
		Refnol SP (Refnol Resin)	15.00%	Refnol SP (Refnol Resin)	15.00%
		Emsize CMS 60 (Emsland Group)	5.00%	Emsize CMS 60 (Emsland Group)	5.00%
		Refnol PA 500	9.00%	Refnol PA 500	9.00%
		Glissofil Extra Soft	1.00%	Glissofil Extra Soft	1.00%
		Temp: 90 °C, Time- 50 min		Temp: 90 °C, Time- 50 min	

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11	De-sizing Recipe	Wetting agent-1gm/L salt → 4 gm/Litre MgCl2 → 1 gm/L CH3 COOH → 0.5 gm/L Enzyme → 6 gm/Litre PH-7 Temp-70-90 °C Time-10min	Wetting agent-1gm/L salt → 4 gm/Litre MgCl2 → 1 gm/L CH3 COOH → 0.5 gm/L Enzyme → 6 gm/Litre PH-7 Temp-70-90 °C Time-10min
12	Fabric Construction	03-Jan	03-Jan

Introduction

Abrasion resistance is a major factor in determining the life span of many textile products. It is influenced by all parts of a fabric's hierarchy by the fiber, by the yarn structure, and by the webbing construction type.

Abrasion is a wear process. Wear is erosion or movement that occurs on a solid surface when it comes into contact with another surface and includes adhesive wear, abrasion, surface fatigue, erosion and fretting wear. Tribology is the umbrella term that describes wear, friction and the interaction of surface

Abrasion occurs during all aspects of a textile's life-cycle during manufacture, use, and during cleaning. It affects the appearance of a textile, but may also influence its strength and functionality. Abrasion testing must replicate the real-life conditions that a textile will encounter during its lifespan. There are many different options for abrasion testing, though they are all based on similar principles. Abrasion resistance is not described by the Textile Institute, but is defined by ASTM as the resistance to abrasion, usually stated in terms of a

number of abrasion cycles. Academics at Leeds University have described abrasion as "the physical destruction of fibers, yarns, and fabrics, resulting from the rubbing of a textile surface over another surface" [1].

This test usually used to simulate the wear performance of textile yarns, fabric or Denim fabric in use [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 straight line in the opposite direction and traces the same figure again under known conditions of pressure and abrasive action [3].

Literature Review

Influence of fabric pattern on the abrasion resistance property of woven fabrics

In this experimental work they studied, 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 ($P<0.01$). Turkey test results showed that weave types with a high number of floats and low number of interlacing decrease the abrasion resistance property ($P<0.05$) [4].

Tensile and tearing properties of newly developed structural denim fabrics after abrasion

In this experimental work they studied to assess the tensile and tearing properties of newly developed structural denim fabrics after an abrasion load and to compare them with those of traditional denim fabric. The fabrics developed were designed as large and small structural pattern and traditional denim fabric. All the denim fabrics were first abraded, and later tensile and tearing tests were performed on them separately. The tensile properties of the abraded large structural pattern denim fabrics were generally inferior to those of the small structural pattern and traditional denim fabric. When the abrasion cycles were increased, the tensile properties of all the denim fabrics generally decreased. The weft directional tearing strength of the small structural pattern denim fabric was significantly higher than that of the traditional and large structural pattern denim fabrics. When the abrasion cycles were increased, the tearing properties in the weft and warp of all the denim fabrics generally decreased [5].

Methodology

Abrasion Resistance by the Martindale Method ASTM D4966-98 Standard Test Method for Abrasion Resistance of Textile Fabrics (Martindale Abrasion Tester Method) [6].

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Methods & Materials

ASTM D 4966-98 Standard Test Method for Abrasion Resistance of Textile Fabrics. (ASTM= American Society for Testing and Materials).

At first, we cut the fabric into 3 pieces for each cases according to the measurement of the instrument (Abrasion cutter).Weighted these all pieces of fabric samples. Placed 3 samples every times in the instrument under a certain load (9KN). On the machine and observed the counter of abrasion no. 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. This values were expressed by the ratio of masses loss vs samples and again ratio of masses loss vs. number of cycles [7].

Materials

Procedure

Our tested Sample fabrics were woven by a PICANOL OMNI plus loom with an electronic dobby shedding mechanism and a cam shedding mechanism where rapier weft insertion at a loom speed of 500 r.p.m. Warping process is done by direct warping process system and sized with a sample sizing in slasher sizing machine. After sizing, a straight draft was applied to the warp sheet manually. 8 frames were used for all sample fabrics with a straight draft. The only finishing treatment applied to the samples was de-sizing. The sizing and de-sizing recipe are given in Table 4. Structural views of the 6 woven fabrics tested in this experimental study are given in Figure 1.

Table 4: Physical Properties of Fabric.

Sample Code	Construction	Case
A_1 A_2 A_3	3/1 –Z Twill	Cam, Finished
B_1 B_2 B_3	3/1 –Z Twill	Dobby, Finished
C_1C_2 C_3	3/1 –Z Twill	Grey
D_1 D_2 D_3	2/2 –Z Twill	Grey
E_1 E_2 E_3	3/1 –Z Twill	Grey
F_1 F_2 F_3	3/1 –Z Twill	Finished

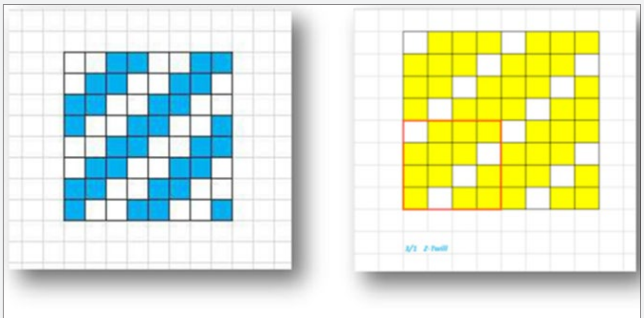

Figure 1A: 2 Z- Twill   Figure1B: 3 Z –Twill

Figure 1: Structural views of weave types.

Results & Discussion

In Case 1

The average mass loss values of Aavrgat different cycles is Aavrg5000=0.577%, Aavrg7500=0.835%, Aavrg10000=1.117%, Aavrg15000=2.237% and the average mass loss values of Bavrgat different cycles is Bavrg5000=0.936%, Bavrg7500=1.476%, Bavrg10000=1.824%, Bavrg15000=3.129%. All of results here show that B>A.

So the fabric produced by Cam shedding mechanism(A), it's abrasion resistance property is better than the fabric produced by Dobby shedding mechanism(B) (Figure 2).

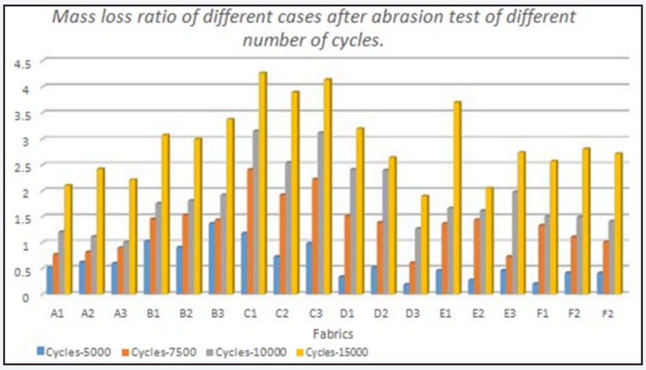

Figure 2 : Mass loss ratio of different cases after abrasion test of different number of cycles.

Cam shedding mechanism is very simplest, it gives the best result within its capacity, less wear and tear, Puts less strain upon the threads, Dwell period may be adjustable, but the adjustment of dwell is complicated for dobby and strain upon threads is more. Yet, our used speed (500rpm) and Heald frames (8) are suitable for Cam shedding mechanism (Table 5).

Table 5:

Weave Type	Sample Code	Fabric Weight, g/m² (Avrg)	Yarn crimp, %	
			Warp	Weft
TWILL	A	312.7	8	15
TWILL	B	307.2	8	15
TWILL	C	252.8	8	15
TWILL	D	310.2	6	10
TWILL	E	266.2	8	15
TWILL	F	314.6	8	15

In Case 2

The average mass loss values of Cavrgat different cycles is Cavrg5000=0.963%, Cavrg7500=2.148%, Cavrg10000=2.947% Cavrg15000=4.107% and the average mass loss values of Davrgat different cycles is Davrg5000=0.256%, Davrg7500=1.183%, Davrg10000=2.024%, Bavrg15000=2.570%. All of results here show that C>D. 3/1 Z Twill fabric's abrasion resistance property is less than 2/2 Z twill fabric. 2/2 Z twill fabric has more contact

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points that makes the fabric dimensionally very strong than 3/1 Z Twill fabric (Table 6).

Table 6: Mass values of samples at different rubbing cycles.

Sample Code	Mass of Samples before Testing, (gms)	Mass of Samples after Different Cycles, (gms)			
		5,000	7,500	10,000	15,000
A1	4.71	4.686	4.674	4.654	4.613
A2	4.698	4.669	4.66	4.646	4.587
A3	4.714	4.686	4.672	4.667	4.612
A(Avrg)	4.707	4.68	4.668	4.655	4.604
B1	4.733	4.685	4.665	4.651	4.592
B2	4.78	4.737	4.708	4.695	4.641
B3	4.724	4.681	4.657	4.635	4.57
B(Avrg)	4.745	4.701	4.676	4.66	4.601
C1	3.864	3.819	3.773	3.746	3.706
C2	3.87	3.842	3.797	3.774	3.725
C3	3.901	3.863	3.816	3.783	3.746
C(Avrg)	3.878	3.841	3.795	3.767	3.725
D1	4.753	4.737	4.682	4.641	4.607
D2	4.825	4.8	4.759	4.712	4.701
D3	4.789	4.78	4.76	4.729	4.7
D(Avrg)	4.789	4.772	4.733	4.694	4.669
E1	4.151	4.132	4.095	4.083	4.003
E2	4.083	4.072	4.025	4.018	4.001
E3	4.13	4.111	4.1	4.05	4.02

In Case 3

The average mass loss values of Eavrgat different cycles is Eavrg5000=0.390%, Eavrg7500=1.178%, Eavrg10000=1.753% Eavrg15000=2.819% and the average mass loss values of Favrgat different cycles is Favrg5000=0.333%, Favrg7500=1.144%, Favrg10000=1.461%, Favrg15000=2.682%. All of results here show that E>F (Table 7).

Table 7: Mass losses Percentage Calculation.

Sample Code		Mass Loss Percentage (%)		
	Cicles-5000	Cicles-7500	Cicles-10000	Cicles-15000
A1	0.5122	0.7702	1.203	2.103
A2	0.621	0.815	1.119	2.42
A3	0.598	0.898	1.007	2.212

Mass loss percentage=weight of sample before abrasion−weight of sample after abrasion × 100 weight of sample after abrasion.

So, Grey fabric's abrasion resistance property is lower than finished fabric During the finished operation, fibres on the fabric surface will cling to it, hence the fabric will achieve a closer state, and the movement of fibres within the yarn will be limited (Figure 3).

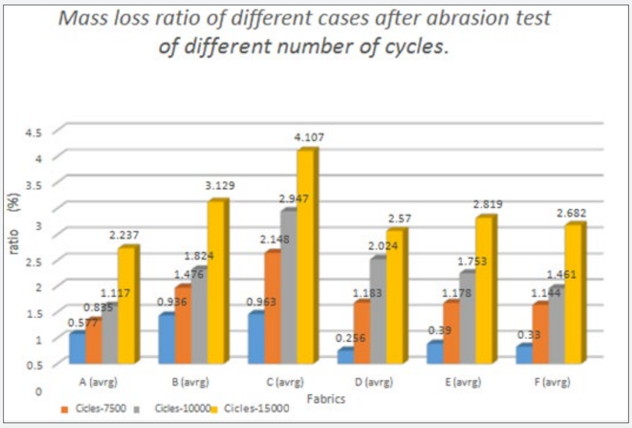

Figure 3 : Mass loss ratio of different cases after abrasion test of different number of cycles.

Conclusion

Abrasion resistance properties of fabric is very important in respect of end users. There is a huge demand of denim fabrics in the world. The production and demand of denim are increasing day by day. Different types of effect on the surface of denim is done by abrasion. The denim fabric damaged by abrasion through its used. So abrasion resistance properties of denim fabric with different parameters should be known. In our study, we observed that the result of abrasion resistance changes with the change of parameters of denim fabric like fiber, yarn, sizing, desiring, shedding mechanism, finishing process etc.

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