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Effect of Potassium Permanganate Finish on the Properties of Denim Fabric

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ABSTRACT

Denim is a most popular dress material that has acclaimed most popularity in the past three decades from special wear to regular wear; denim has barged into acceptance of kid, women and men and has become a most preferred dress irrespective of age in India and world. The present day trend indicates that consumer is interested to wear denim and feels more comfortable. An insight into the literature reveals that work on improving the comfort using KMnO4 is sparse and this paper examines the role of Potassium permanganate finish to improve comfort properties. Denim fabric was treated with different levels of potassium permanganate finish using pad -dry -cure method. Finished product was characterized for comfort, aesthetic properties and tear strength. Results were significant at 95 % of confidence level and showed that fabrics treated with 12 gpl offered highest flexural rigidity, crease recovery angle and abrasion resistance but offering lower tear strength values on comparison with other fabric samples.

Key words: Denim fabric, comfort, washing, potassium permanganate

INTRODUCTION

Denim has been used as clothing material since from three decades due to its excellent durability. A number of studies have shown the importance of clothing comfort in deciding customer satisfaction [1-2] It is learnt that desired comfort properties can be imparted thro' industrial washing as a finishing methods for fabric or garment [3]. Needless to mention that washing factors viz., type of washing solution, abrasion, creasing, heat, various chemicals during washing cycle will have significant influence on fabric or garment performance. On the other hand, this may also lead intensive destruction fibres takes place and leads to intensive wear of articles and softeners are used to increase fabric handle and other properties [4]. Generally, the finishes are applied for sewn garments and therefore, it is very important to know the impact made by particular washing on the sewn garment in order to preserve the quality of sewn product [5].

Juciene *et al*, worked on the influence of industrial washing on denim properties and reports that among the different treatment, the enzyme washing had the greatest influence on the fabric thickness [6]. The mechanism of washing techniques of denim has showed that for heavy weight denim fabric large and hard stones are suitable and also last longer. Similarly, smaller and softer stones are suitable for light weight denim fabrics. Further, the degree of colour fading during stone washing depends on several factors, such as, garment to stone ratio, washing time, size of stones, material to liquor ratio and load of garments [1]. Selin *et al*, tested the wicking properties of the industrial washed denim fabric samples and found that wicking rates of rigid fabrics were same as resin washed fabrics and rates were higher than bleached fabrics. Softener fabrics had the highest wicking rate. Also there was a positive correlation for weight differences. As the fabric weight increased, transfer wicking rates also increased. Thick softener denim fabric had the highest wicking rate but bleached fabrics had the lowest rate for thin, medium and thick weights [7]. Harmindar mentioned drawbacks of the stone washing and specification of the stone for stone washing along with latest developments in the Denim Washing [8]. Al-Amin Khan worked on garment washing and reported that the variety of natural and synthetic stones used for washing is pumice or volcanic rock, they slowly disintegrate, reducing the severity of the stonewash effect over a period of time. The stones not only abrade the fabric but also gradually abrade the inside of the rotary drum and a machine used for stonewashing should not be used to dye delicate articles or when abrasion would be detrimental to the fabric [9].

Rahman studied the effect of industrial enzyme wash on denim apparel characteristics. Denim trousers were chosen as apparel and after washing, changes on characteristics of denim trousers has been observed. It is concluded that after enzyme wash the denim fabric changed from harsh to softer [10]. Sumithra carried out the study on Antimicrobial Finishing of Denim Fabric using Methanolic and Aqueous Extract of Selected Medicinal Herbs and reported that three natural herbs i.e. Euphorbia hirta, Senna auriculata and Jatropha curcas were found to be effective in antimicrobial efficiency. The selected herbal extracts were combined to provide maximum antibacterial activity on the denim fabrics. The results indicated that the combination of 1:3:2 of the selected herbs were found to show highest antibacterial activity [11]. Nickolai worked on the importance of the machine used in the wet processing of Denim and concluded that Goller Modular Denim is the first choice in woven denim continuous wet processing which improves the production efficiency and the quality of the final products at the dye houses [12]. Kavitha and Ambika reported that Denim washing and finishing is the most difficult of all apparel fabrics. Control of fabric quality requires a higher level of control which begins at weaving of fabric. In each step of garment treatment all the conditions like moisture, temperature, time etc should be monitor and controlled. With the invention of washing and finishing of denim garments it has become very easier to the textile industry [13]. Jiming and Sainan studied the decoloration of denim fabric with potassium permanganate. Three denim fabrics were treated by $KMnO_4$/ H_3PO_4 solution used for the study. The process was controlled by process time, $KMnO_4$ and H_3PO_4 concentrations and they found that the brightness of denim fabric enhanced by increasing processing time and concentrations. Colour shade changed depends on denim types [14]. It is clear from the above description that a number of studies are represented on washing aspects of denim in different conditions and using different materials. Although considerable information on washing of denim is available, in the study effect of $KMnO_4$ and acetic acid on cotton denim is scanty in the literature. Hence the thrust of the present investigation is to study the role played by the $KMnO_4$ and acetic acid. As it is known that $KMnO_4$ is a best example of washing agent, is used in the present study along with acetic acid in equimolar proportions. Potassium permanganate being an oxidative under acidic or alkaline conditions generates active oxygen that could make denim decolouration. Its oxidative ability increases in the acidic medium [14]. The reaction is described as following equation.

The action of $KMnO_4$ and acetic acid is explained as [14] follows:

$$2MnO_4^- + 6H^+ \longrightarrow 2Mn^{2+} + 3H_2O + 5[O] \quad (1)$$

In this study, the effect of potassium permanganate spray on denim fabric has been analysed. Present study considered the effective concentration of $KMnO_4$ and acetic acid on physical properties like bending length, crease recovery, abrasion resistance and tear strength. The purpose of selecting flexural rigidity and crease recovery is to estimate the effect of treatment on fabric aesthetic properties. Further, as denim is a most popular wear is washed frequently by different method. Thus the effect of treatment on was and wear is expected through abrasion resistance and tear strength. However, the present study does not include relation between number of washes and properties like abrasion resistance and tear strength. Further, the effects of different add- on levels of potassium permanganate finish is also studied.

EXPERIMENTAL MATERIALS

The experimental material was Mill Denim fabric supplied by a local leading Denim producer. Table 1 gives the details of the Mercerized cotton denim fabric used in the study.

Table -1 Geometrical Properties of Control Fabric

Fabric	Count (Tex)	Threads/Inch	Linear density (g/m^2)	Thickness (mm)	Crimp (%)
	N_1 * N_2	n_1 * n_2			C_1 * C_2
Control	59X37	82X50	320	70	19X16

Coding of the Fabrics

D_1, D_2, D_3 and D_4 are the fabric with Concentration of 3gpl, 6gpl, 9gpl and 12gpl respectively.

METHODS

Preparation of Fabric

The Potassium Permanganate solution is prepared at four add-on levels (3 gpl, 6 gpl, 9gpl and 12 gpl) and are co-applied with equal levels, i.e. 3 gpl, 6 gpl, 9 gpl and 12 gpl of acetic acid. The most widely used method scraping of denim fabric, i.e. the hand scraping used for scraping process. The fabric samples are placed on inflated air tube and emery paper is used to scrape the fabric. After scraping, the potassium permanganate solution is sprayed at different add-on levels with help of spray gun and allowed it for some time. Each fabric sample is treated with sodium bisulphate with 3 gpl at 40^o C temperature for 10 minutes for neutralization. After neutralization, the fabric is washed with water. The mercerized cotton denim fabric of 320g/m^2 weight samples are tested before and after washing for tear strength, crease recovery, abrasion resistance and flexural rigidity.

TESTING

Conditioning of Experimental Materials Meant FOR Testing

All the control and treated samples were conditioned at standard temperature 27 ± 2 ^{0} C and 65 ± 2 % as per IS: 6359-1971.

Characterization of Products

The control and treated samples were characterized for various physical properties as mentioned below.

Determination of Fabric Set

The parameter is defined the average distance between two consecutive threads in a fabric. Ends per inch and picks per inch are measured using densimeter. The average of many observations selected randomly is reported as the final value which is later converted to threads per inch was expressed in centimeters. Fabric set was determined as per IS: 1963-1969 and an average of 5 measurements were reported.

Determination of Yarn Linear Density

IS: 3442-1986 was referred to measure the yarn linear density and averages of 5 replications re considered for the result

Determination of Fabric GSM

Fabric GSM was determined and the value reported is an average of measurements (IS: 1964-1970).

Measurement of Yarn Crimp

The crimp of yarns unravelled from the test fabric was measured on Shirley crimp as per IS: 3442-1966. Measurements were taken in both warp and weft ways. The average was given in percentage using formula.

$$\% \text{ Crimp} = \{(L_2-L_1)/L_1\} *100 \tag{2}$$

Where L_1=length of yarn in the fabric, L_2= stretched length of the yarn

Measurement of Fabric Drape

Curies drape tester is used (ASTM –D3691) in the present study to investigate the effect of bleaching action due to $KMnO_4$ and acetic acid on Drape coefficient of treated fabric and the values reported is the average of at least ten observations. Drape co-efficient (F) is calculated using the formulae

$$F = \mathbf{= W_s - W_d / W_D - W_d} \tag{3}$$

Where Ws is actual projected weight of specimen (Paper weight), W_d is the weight of supporting disc (paper weight), W_D is the weight of Cloth specimen (paper weight)

Measurement of Tearing Strength

Tear strength was measured as per ASTM D 1424-9 test method. Experiment was repeated for 10 times and the average is reported

Measurement of Abrasion Resistance

ASTM standard D 3885 was followed in measuring abrasion resistance. Results show the average of at least 10 replications.

Measurement of Flexural Rigidity

Flexural rigidity of the test specimen is performed according to the ASTM standard D1388 by cantilever principle. We considered 10 observations before arriving at average value.

Measurement of Compressibility

It is normally desired to have good compressibility for an apparel fabric. EMC (Compressibility) was measured using Shirley thickness gauge as per the standard test method ASTM standard D5736. The result shown is an average of at least 50 random measurements. EMC of control and treated fabric samples are being determined using:

$$EMC (\%) = (T_o - T_m) / T_o \quad X\ 100 \tag{4}$$

Where T_o =Thickness at 0.5 gf / cm ^{2} T_m =Thickness at maximum load

RESULTS & DISCUSSION

Effect of Potassium Permanganate on Fabric Properties

Tear Strength

The effect on tear strength of the fabric treated with different levels of Potassium permanganate finish is shown in Table 2. It is observed that the tear strength decreases as the concentration increased. The loss in tear strength is shown as percentage shift in parenthesis. Increase in add- on levels of Potassium permanganate finish shows significant decrease in tear strength for all samples in both warp and weft direction. This is attributed to the bleaching action as pointed out earlier. Further, the reduced thickness resulting from the improper hand scraping and change in molecular structure of celloboise. The results are analyzed through statistically and found to be significant at 95% confidence level (Table 2).

Flexural Rigidity

The effect of potassium permanganate finish on flexural rigidity of fabric samples shown in Table 2. It is observed that the flexural rigidity of the fabric samples decreases with the decrease in thickness. As the add-on level of potassium permanganate finish increases the flexural rigidity of the fabric samples decreases. This may be attributed due to the uneven hand scraping which removes the outer layer of the fabric and bleaching action would have resulted into soft finish and showing linear trend with add-on levels of finish. The results are statistically significant at 95% confidence level.

Crease Recovery

It is observed from Table 2 that as increase in add-on levels of potassium permanganate result in increased the crease recovery angle for all the fabric samples in both warp and weft direction, this may be the application of finish which may enhanced fabric handle.

Abrasion Resistance

It is observed from the Table 2 that abrasion resistance of the fabric sample increase with increase in add – on levels of Potassium permanganate finish in both abrading surfaces i.e., fabric to fabric and fabric to emery paper. This is may be attributed due to particles of potassium permanganate finish form a durable complex cross link layer on the treated fabric surface resulting in higher abrasion resistance.

Drape Coefficient

Drape coefficient of the treated fabric samples are shown in Table 2. It is observed that the drape coefficient of the fabric samples decreased with decreases in thickness. As the concentration of potassium permanganate finish increases the drape coefficient of the fabric samples decreases. This may be attributed due to the uneven hand scraping which removes the outer layer of the fabric, reduced thickness (Table 2) and bleaching action would have resulted into soft finish and showing linear trend with add-on levels of finish. The results are coinciding with the values of flexural rigidity of the treated fabric samples

Table -2 Effect of Potassium Permanganate on Fabric Properties

Sample	Flexural Rigidity	Abrasion resistance		Crease recovery		Tear Strength		Drape Coefficient	Thickness (mm)
		fabric - fabric	fabric - Emery	Warp	Weft	Warp	Weft		
D0	1542.7	0.97	1.1	78	50	5040	3080	1.12	71
D1	1330.7*	0.92	1.05	81	57	4693	2666	0.98	69
D2	1218.9	1.02	1.1	83	52	3754	2768	0.91	65
D3	1098.6	1.05	1.26	90	64	3840	2336	0.87	67
D4	1008.5#	1.25	1.7	88	63	3128	2022#	0.84	64

'*' Results are statistically insignificant at 95% confidence level with respect to previous add-on level
'#' indicates that means are statistically insignificant at 95% confidence level with respect to the unfinished fabric

CONCLUSION

Mercerized cotton denim fabric with and without application of potassium permanganate finish are studied for their comfort and hand properties in terms of tear strength, crease recovery, flexural rigidity and abrasion resistance. It is observed that flexural rigidity decreases as the add-on levels increases resulting in imparting the softness to the fabric and the fabric treated with 12 gpl offer highest abrasion resistance in both the cases i.e. fabric to fabric and fabric to emery. The tear strength of the treated fabric samples decreases as the increase in add-on level, fabric samples treated with 12 gpl resulting in the lower tear strength values in both warp and weft. Fabrics treated with 12 gpl offer highest crease recovery angle in both cases.

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