

Behaviors of Physical and Mechanical Characteristics of Denim Apparel After Acid Wash Treatment

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Abstract— Denim apparel is the today's most recognized fashion. Day to day the demand of the consumers for denim fashion is rapidly changes. They expect more variation from the technologists. So it becomes a crucial issue for the technologists to modify the denim apparel but they are to keep in mind the comfort, serviceability of the product. The aim of this study was to assess the physical and mechanical characteristics of the denim apparel (jeans) after a acid wash treatment via phosphoric acid (1ml/l), potassium permanganate (6 gm/l) combined with pumice stone 200% (on the weight of material). The assessment was accomplished according to British and American standards. Each parameter was analyzed and discussed the findings. It has been found that denim apparel achieves a frosty look after acid wash treatment. It was also investigated from the experiment that some properties such as tensile strength, GSM, stiffness, color depth were decreased and count, dimensional stability, EPI (Ends per inch), PPI (Picks per inch) and soft feeling were increased due to acid wash treatment.

Keywords— Denim apparel; acid wash; pumice stone; physical & mechanical characteristics.

I. INTRODUCTION

Since the first pair of denim garment (jeans) appeared in America about one and half century ago, now-a-days it is the trendiest name in the clothing industry [1]. The nature of today's youth is that they become fretful about their current fashion of denim apparel. They want to accept a more fashionable item than the previous one. The textile engineers are incessantly working to fulfill the quick change of current demands of the wearer. As a result they have to apply different chemical treatment to modify the denim apparel and to create a new look for the fashion concern. The technologists are to concern not only denim manifestation but also the characteristics of clothing both physical and mechanical to fulfill the requirements of buyer. The objective of this paper is to describe the process of acid wash treatment for denim apparel (jeans) and find out the behavior (physical and mechanical) due to acid wash treatment.

Typically denim fabrics are produced from indigo dyed, coarse, cotton yarn [2]. Denim is very strong, stiff, hard wearing woven fabric [3]. Denim dyeing is a unique process as dyeing is done on the surface only remaining a white core. After dyeing; sizing process is applied to improve tenacity, elasticity for subsequent weaving stage [1]. So, unwashed denim apparel is uncomfortable to wear. Denim washing as a

chemical treatment is now widely used finishing treatment in textile sector because of creating special appearance and making wear comfortable [4].

The common washing methods are bleach wash, enzyme wash, acid wash, normal wash, stone wash etc [5]. Among various types of washing we have chosen the acid wash treatment for this experiment. Because many papers have been published about the effect of bleach wash, enzyme wash, and stone wash treatment. But only few researchers have been working to analysis the acid wash behavior. Acid wash is a chemical treatment on denim which stripped the top layer of color and makes a white surface while the color remained in the lower layers of the material giving it a faded look [6]. In this work phosphoric acid (H_3PO_4) and potassium permanganate ($KMnO_4$) were used for carrying out acid wash treatment combined with pumice stone 200% (on the weight of material).

Pumice is volcanic rock that consists of highly vesicular rough textured volcanic glass [7]. To make successful the mission of the paper (analysis of the physical and mechanical characteristics) manifold types of testing were done according to British and American standards.

II. MATERIALS AND METHODS

A. Materials

-100% cotton indigo dyed 3/1 twill denim apparel (jeans) was selected for the experiment. It was collected from the University of Textiles (BUTEX, Dhaka, Bangladesh). Construction of the denim fabric was 70×47/10×9 and the GSM was 310.

- The apparel were desized by desizing agent NE (Bangladesh) with detergent super-excel (Bangladesh) following the standard recipe [8]

- The fresh pumice stone (Thailand) of small size (1-3 cm) were soaked by phosphoric acid (H_3PO_4 , china) and potassium permanganate ($KMnO_4$, India).

- Sodium meta-bisulphate ($Na_2S_2O_3$, India) was selected for neutralizing the denim apparel.

- The cationic softener Basu-soft (BASF, Germany) and acetic acid were applied to the apparel for softening. All the chemicals using for this treatment were supplied from Apparel manufacturing lab of BUTEX.

B. Method of pretreatment:

The first process of the acid wash treatment was desizing which is essential to remove sizing agent. Because the main purpose of sizing the warp yarn is to encapsulate it with a protective clothing [1]. Desizing was carried out by desizing agent NE (1.5gm/l) and detergent (1gm/l) containing M: L (1:10). The treatment was accomplished in a sample washing machine (Ngai-shing , Model- NS2205, Hong Kong) at 60°C for 15 min. Then a hot wash was conducted at 70°C for 5 min following a cold wash for 3 min to remove adhering sizing material on the sample (Denim apparel). Hydro – extracting process was carried out in a sample hydro-extracting machine (Zanussi, England) at 200 RPM for 3 min to remove excess water from the sample. Then the damp samples were dried in a steam drier (OPTI-DRY, England) at 70°C for 15 min following a cold dry for 5 min.

C. Method of soaking:

The soaking process of pumice stone was carried out by shuffling in a bath of liquor (M: L= 1:2) containing potassium permanganate (6gm/l) and phosphoric acid (1ml/l) for 10 min. The solution was picked up by stone very quickly as it is naturally 90% porous [7].

D. Method of stone treatment:

The pumice stone were applied to the completely dry desized apparel. This treatment was conducted to the same sample washing machine. There is no addition of water and the duration of the treatment was 20 min. After the completion of the process the samples and the pumice stones both are unloaded from the machine.

E. Method of neutralization and softening:

The treated samples were neutralized from potassium permanganate by applying the sodium meta-bisulphite (3gm/l) at room temperature for 5 min. After neutralizing a detergent wash (55°C, 5 min) was conducted to remove breaking stone dust from the samples. Softening process was conducted by cationic softener (1gm/l) and acetic acid (0.5gm/l) at room temperature. To improve fabric handle and other valuable properties, softeners are widely used in the finishing process [9]

F. Method of hydro-extracting and drying:

Again the neutralized samples were hydro-extracted and dried following the same process used in pre-treatment.

III. CHARACTERIZING THE TREATED SAMPLES

The acid wash treated samples were conditioned to moisture equilibrium directed in ASTM D1776 [10]

- Tensile strength was calculated according to ASTM D5034 (Grab test principle)[11]
- Gram per meter² was measured following the direction of ASTM D 3776 [12]
- Stiffness of the denim fabric was measured by Shirley stiffness tester using the method of ASTM D 1388.
- To measure the warp and weft count from the denim apparel Beesleys direct reading balance was used according to ISO 7211/4: 1984.
- The shrinkage or growth percentage was calculated by AATCC test method 96 [13]
- EPI & PPI of the denim apparel was measured by the counting glass.
- The color fading of the treated sample was assessed directed in AATCC test method 61 [14]
- Fabric handle property of the treated denim was assessed by feel of touch.

IV. RESULTS AND DISCUSSION

The physical and mechanical properties of acid treated denim apparel were evaluated by various testing method and each parameter was analyzed. The characteristic of each parameter was discussed by a comparative study between the treated and untreated samples and a graphical presentation technique was applied to present the results.

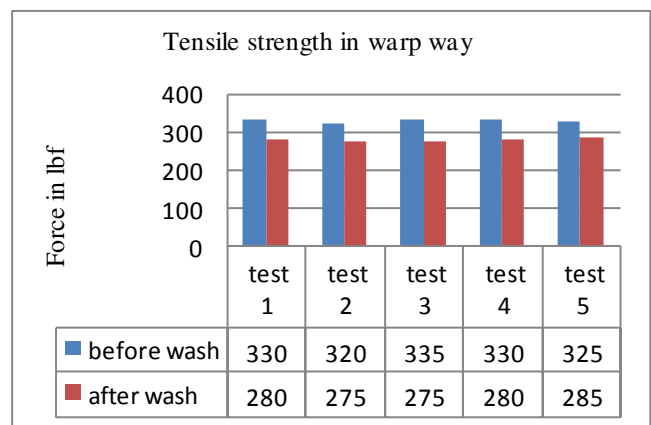
A. Tensile strength

Figure 1: Bar chart of tensile strength in warp way.

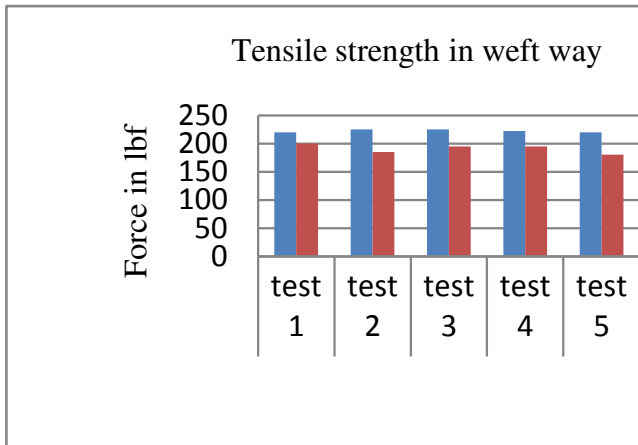


Figure 2: Bar chart of tensile strength in weft way

From the observation it has been investigated that acid wash treatment decreases the tensile strength of the denim fabric both in the warp and weft way. The cotton polymer is a linear cellulose polymer. The strength of the cotton fibre is attributed to the good alignment of its long polymer. But this alignment is weakened due to acidic action [15]. On the other side, during machine running the rubbing action of the stone also decreases the strength of warp and weft. As the sample is 3/1 warp face twill, the strength decreases more in the warp way than the weft way.

B. Gram per meter² (GSM)

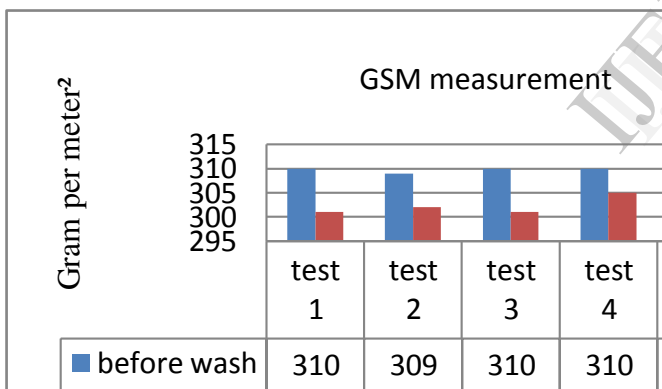


Figure 3: Bar chart of gram per meter² measurement

Cotton fibre has a distinct cuticle, well developed primary and secondary walls. The cuticle is the skin of the cotton fibre. It is composed of cotton wax and responsible for the protection from the chemical degradation. During manufacturing from fibre to fabric most of the cuticle was removed. Subsequent laundering will gradually remove most of the remaining cuticle. As the extent of the cuticle is decreased further, deterioration of the cotton increases. As a result the gram per meter² of the denim fabric has decreased due to acid wash treatment [15].

C. Stiffness

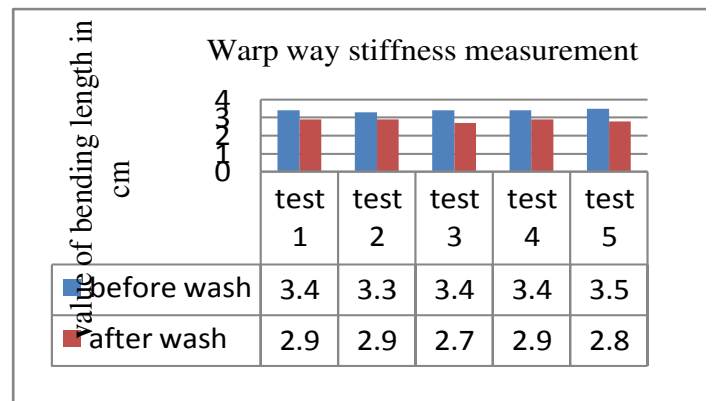


Figure 4: Bar chart of warp way stiffness measurement

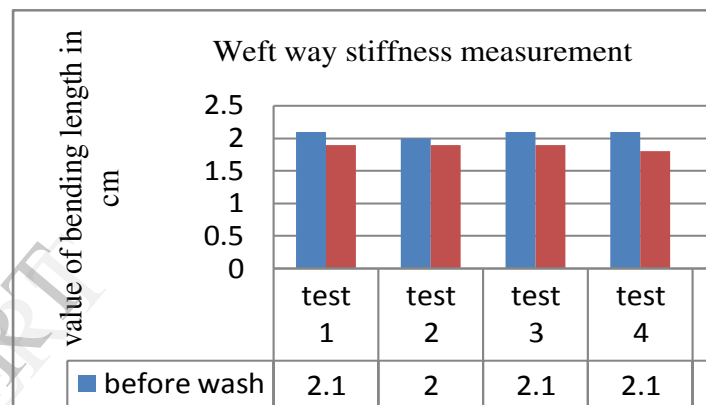


Figure 5: Bar chart of weft way stiffness measurement.

The stiffness of the denim fabric both in the warp and weft way was calculated from the bending length by Shirley stiffness tester. Size material is applied to the warp yarn to make it strong, stiff for facilitating the weaving process [16]. During desizing process size materials were removed from the warp yarn. On the other hand, the warp and weft yarn became soft during softening process. As a result the bending length or stiffness was decreased. It has been noticed from the observation that bending length is decreased more in the warp way than the weft.

D. Count (Warp and Weft)

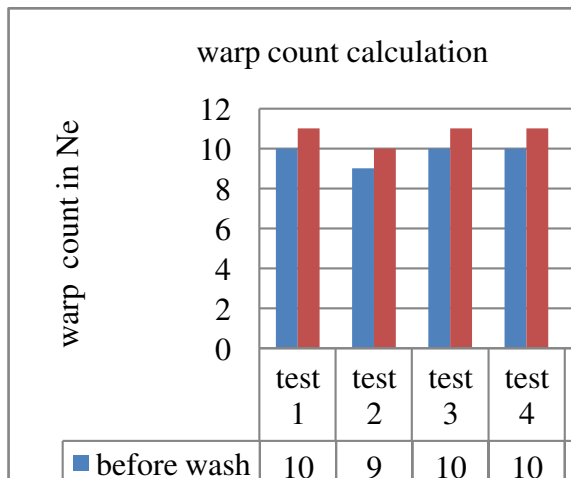


Figure 6: Bar chart of warp count measurement

E. Shrinkage percentage

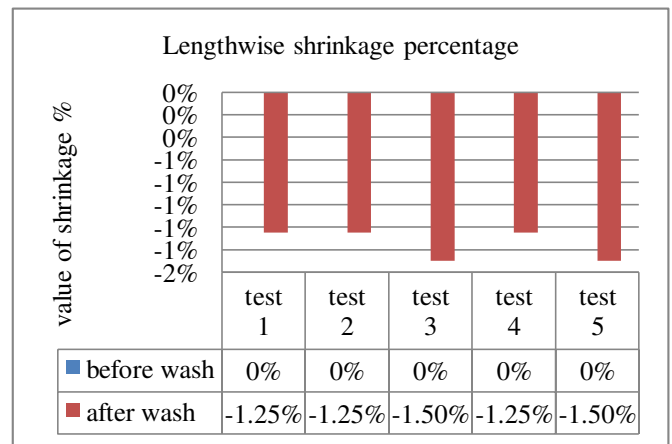


Figure 8: Bar chart of lengthwise shrinkage percentage measurement

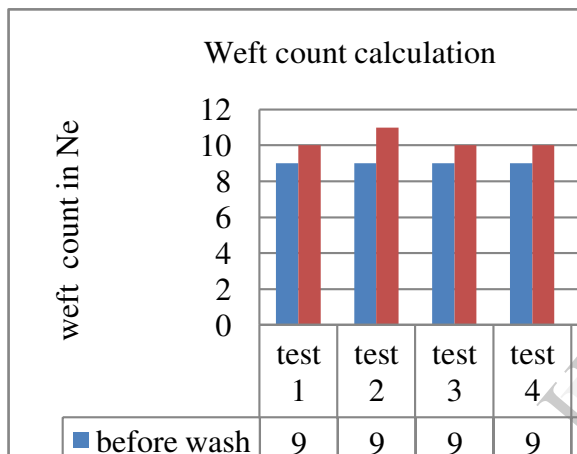


Figure 7: Bar chart of weft count measurement

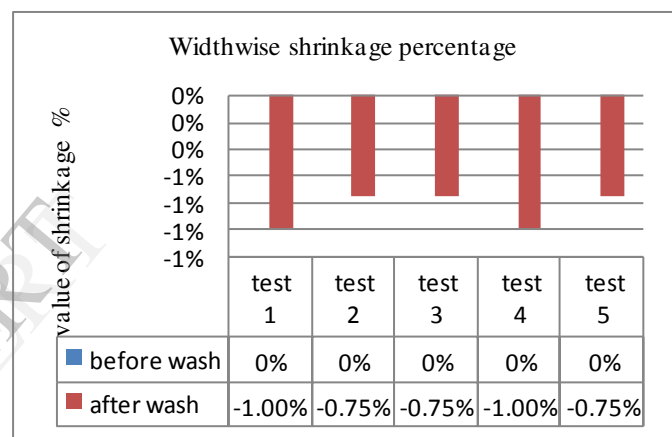


Figure 9: Bar chart of widthwise shrinkage percentage measurement

In this experiment the count measuring unit was English count Ne which was measured from the direct reading of the beesleys yarn balance [17]. The findings of the observation that there is slightly an increase in the count both in the warp and weft way as the yarns become soft for subsequent washing process.

Swelling shrinkage results from the swelling and de- swelling of the constituent fibres of a fabric due to absorption and desorption of water. Relaxation shrinkage is a dimensional change accompanying the release of fibre strains imparted during manufacturing [18]. This strain is more in the warp direction than the weft. From the experiment it has been explored that the lengthwise shrinkage% is more than the widthwise shrinkage% as a result of acid wash treatment.

F. EPI (Ends per inch) & PPI (Picks per inch)

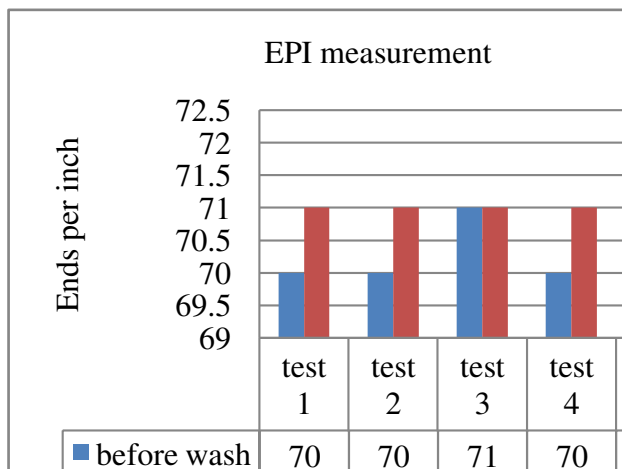


Figure 10: Bar chart of EPI measurement

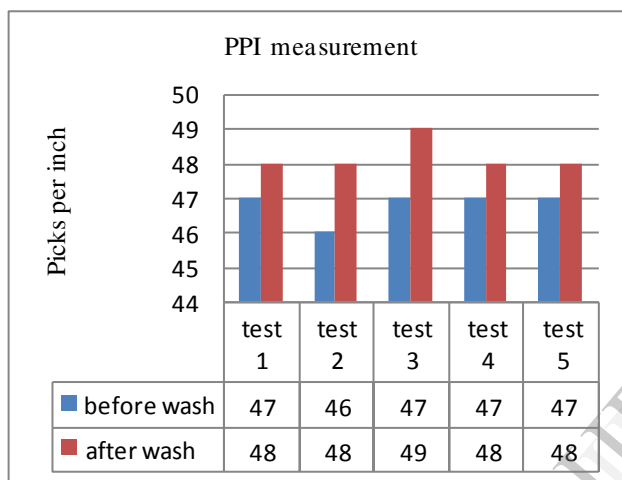


Figure 11: Bar chart of PPI measurement

It has been observed from the experiment that due to relaxation shrinkage EPI and PPI were slightly increased. So the change of EPI & PPI is less significant after acid wash treatment.

G. Change of color depth

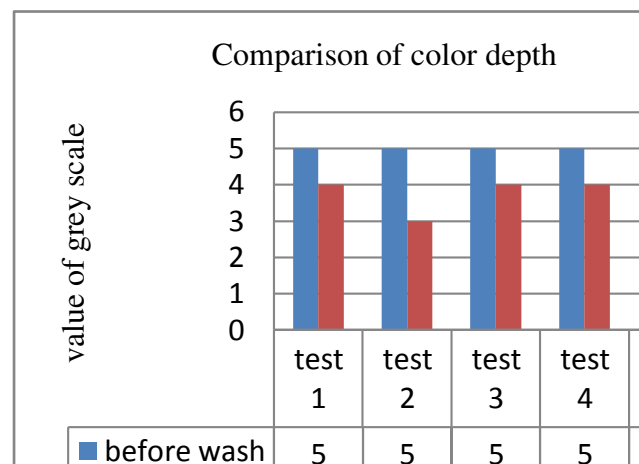


Figure 12: Bar chart of color depth comparison



Fig 13: A snap shot of before and after washed sample

It has been investigated from the experiment that a frosty look appears in the denim apparel (jeans). Color fading agent potassium permanganate, phosphoric acid combined with pumice stone were responsible for color fading. During machine running apparels and stones rotated together and stones dropped on the apparel surface. Due to brushing action of the stone, the samples become faded in the spot pattern. By the action of the potassium permanganate and acid present in the stone discolors the apparels [19].

H. Fabric handles property

Fabric handle properties of the treated samples were assessed by feel of touch. It has been found that the acid treated denim was softer than the untreated denim. Because of several times of washing and use of softener causes the apparel softer, smooth. The softening agent render the surface of the fibre smoother, resulting in a supple handle of the materials. The cationic softener produces a oily film on the negative sites of the fibre which produces a soft handle, a pliable and well lubricated surface [20].

V. CONCLUSION

Acid wash treatment is an effective chemical treatment to achieve a fashionable effect. Phosphoric acid (H_3PO_4) combined with potassium permanganate ($KMnO_4$) act as color discharging agent on the surface of the denim apparel. The findings of this paper will help the technologists to maintain the quality of the product. The effects of acid wash treatment on the denim apparel under investigation could be realized by a comparative study between the characteristics of the treated and untreated samples. After investigation it has been found that tensile strength and GSM were decreased as the acid and the rubbing action of the stone weakens the fibre. Desizing process decreased the stiffness and softening process gave a soft hand feel of the denim surface. Both of them caused an increase of warp count and weft count. Final dimensional stability was achieved after subsequent laundering process and relaxation shrinkage caused a small increase of EPI & PPI. By the findings of the paper it will be know how denim apparel (jeans) characteristics can be changed by the acid wash treatment and it will be helpful to the new researcher.

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