

Investigation on Simultaneous Effect of $Kmno_4$ Concentration and Processing Time on Tensile Strength, Weight and Stiffness of Denim Jeans During Acid Washing with Pumice Stone

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ABSTRACT

This present investigation deals with the effect of processing time and concentration of potassium permanganate on tensile strength, weight and stiffness of denim garments. Three 100% cotton denim jeans were treated with stone acid wash with the variation of processing time (1.5, 2 & 2.5 minutes) and concentration (1.5, 2 & 2.5g/l) of potassium permanganate after typical enzyme bleach wash. Tensile Strength, Weight and Stiffness (bending length) were investigated before and after each treatment (concentration and respective time) according to standard test methods. It was found that change in processing time and concentration reveals big difference of these properties between treated and untreated garments.

Keywords: Potassium Permanganate, Processing Time, Tensile Strength, Weight and Stiffness, Stone acid Wash, Denim Jeans.

1. INTRODUCTION

Among all the textile products, no other fabric has received such a wide acceptance as denim Jeans. ^[1] It can be considered as the most widely used garment in the fashion business. It is well known that denim and jeans have had a major influence on the lives of consumers since their inception. Jeans have become symbols for cowboys, women, youth and economic status. Through the ages, jeans have evolved from work wear to casual wear and then to premium wear and functional wear. Consumers evaluate jeans based on style, brand, and country of origin and company ethics. As with any other apparel, denim garment companies target specific market segments, however, no other garment can

claim the social culture that denim has already set. Designer jeans as well as premium jeans first influenced a small group of luxury consumers, but now consumers from all social and economic classes embrace them. Challenges faced by denim apparel manufacturers and fashion designers include the need for reinventing products for niche markets, and meeting consumer demands for better apparel sizing. ^[2]

Denim Jeans washing is a novel process to impart worn-out look, to modify the appearance and to improve the comfort ability of the garments. ^[3] It is one of the finishing methods applied on garment, with the use of new technologies and equipment enables to obtain the desired results. ^[4] Recently, textile manufacturers start fading

i.e. discoloration on shade of denim jeans which become very popular amongst young customers. [5] Therefore, companies have been trying in recent years to develop various techniques to improve the visual aspect of fabrics especially the faded looks. [6-8]

Potassium permanganate is an inorganic chemical compound with the chemical formula KMnO_4 . [9] It is a strong oxidizing agent and used to make color fading effect on denim jeans. [10-12] Sometimes it is used at the point of hand sand area or without hand sand area. Though it is a great oxidizing agent, after applying it is necessary to neutralize the garments by any good neutralize agent. [13]

Xiang-Rong Xu et al. (2005) experimented decolorization of dyes and textile wastewater by potassium permanganate and found that Concentration of potassium permanganate and temperature had significant effects on the decolorization efficiency. [14]

Jiming Yao et al. (2013) investigated the effects of potassium permanganate decoloration on denim shade. The results showed that the brightness of denim generally was enhanced by increasing processing time, KMnO_4 and H_3PO_4 concentrations. [15]

However, the effect of change in concentration of KMnO_4 and processing time on tensile strength, weight and stiffness was not studied in the past research. These two parameters play important role on KMnO_4 oxidation which further affects denim performances.

In this present study, three kinds of denim jeans dyed by indigo were treated using different concentration of KMnO_4 with constant amount of H_3PO_4 solutions with different processing time and changes of tensile strength; weight and stiffness were recorded and evaluated.

2. MATERIALS AND METHODS

2.1 Materials: 100% cotton denim jeans were used. These comprised indigo dyed denim fabric, GSM (Grams per Square Meter) 310, 3/1 warp faced twill, construction 72 x 40 / 12 x 11, fabric width 57 inch.

Genzyme SL (a cellulase enzyme, Sri Lanka); Jet (an anionic detergent, Bangladesh); Bio.D. (a desizing agent, Germany); soda ash (China), acetic acid (China), Bleaching powder (KCI bleach, India); Sodium Meta bisulphite (India), Sodium hyposulphite (India), Potassium permanganate, phosphoric acid (laboratory grade) were used for this experiment. The fresh pumice stones (Turkey) of medium size (3-5cm) were used for soaking.

2.2 Desizing: The desizing was conducted in liquor containing soda ash (1.2 g/l), detergent (0.6 g/l), and desizing agent (0.6 g/l) and material to liquor ratio of 1:30 in an industrial horizontal sample washing machine (Ngai Shing, model-NS 2205, Hong Kong) at temperature 60°C for 20 min. After that washed with hot water (70°C) followed by cold water (40°C) wash.

2.3 Enzyme (cellulase) treatment: The process was conducted in liquor containing acetic acid (1.0 g/l) at p^{H} 5.5 and material to liquor ratio of 1:30 with cellulase in the washing machine. The process was carried out at concentration of Genzyme SL of 2% at 45°C temperature for 30 min. After desired time the temperature was raised to 90°C for 1 min to stop enzymatic action then washed with hot distilled water followed by cold (40°C) distilled water.

2.4 Bleaching treatment: Enzyme treated denim trousers were then treated using bleaching powder. This process was conducted in liquor containing KCI bleach (10g/l), soda ash (5 g/l) at p^{H} 10.5, and material to liquor ratio of 1:10 in the washing machine. The bleach treatment was carried out at 50°C temperature and treatment time was 30 min. The denim garments were then neutral washed with

Hypo (2 g/l) for 5 min at 40°C. The garments were rinsed in cold water.

2.5 Acid Washing : Pumice stones (4.6 owg) are first presoaked in three solutions comprised of different concentration of KMnO_4 (1.5, 2.0, 2.5g/l) and constant amount of H_3PO_3 (2%) and then place the stones in a rotary tumble washing machine along with 'waste' fabric and tumbling for several minutes to remove the excess solution. Then three denim garments are washed separately for 1.5, 2.0, 2.5 min. Then Rinse to remove stone dust and finally neutralizing (with Sodium Meta bisulphite), hydro extracting and drying were done.

2.6 Testing and analysis: Treated all denim trousers were conditioned in 65% RH and 20°C for 24 h before testing according to BS EN 20139 and ASTM D1776. ^[16] Tensile strength was determined by the US Standard Grab test method according to ASTM D 5034. ^[17] GSM was calculated from the differences in denim fabric weight between before and after washed treated denim according to ASTM D 3776. ^[18] Stiffness was measured from the bending rigidity in fabric by Shirley stiffness tester according to BS 3356. ^[19]

3. RESULTS AND DISCUSSIONS

3.1 Changes of Tensile Strength after Washing: In this experiment, the effect of different conc. of potassium permanganate (1.5 to 2.5g/l) and processing time (1.5 to 2.5 min) on the properties of denim garments during acid washing was investigated. It can be seen from the Figure 1 that treatment of denim trouser with Potassium permanganate at 1.5g/l concentration cause significant decrease (2.22%) of tensile strength and this decrease was higher at higher PP concentrations (2.5g/l) and higher processing time (2.5 min) in both warp and weft direction.

PP decomposed cotton under the conditions used. PP first attacked on dyed yarn portion, decomposed them slowly and fibers are partly degraded from the yarn chain and step by step penetrated inside fabric. Therefore, the chemical bonds of primary wall (outer layer) are broken by the decomposition of the aqueous solution of PP. After that it attacked on secondary wall. The result of this reaction is that the primary wall (outer layer) of the cotton fiber is loosened and broken down quicker with the frictional action (mechanical forces) of rotating cylinder of the washing machine and rough surface of stone that works as an abradant in washing cycle.

3.2 Changes of Weight after Washing: The changes in the fabric weight (GSM) before and after acid- stone washing are represented in the figure 2.

It is seen from figure 2 that GSM was decreasing with the increasing concentration of potassium permanganate and processing time. The main reason for decreasing weight is that potassium permanganate reacts with cellulosic molecular chain and destroys monomer.

3.3 Changes of Fabric Stiffness (Bending Length) after Washing: Denim decomposition by measuring the stiffness from denim garments was monitored. As evident, From the Table 1, it is found that the stiffness of the denim garment decreased (12.37%) at 1.5g/l concentration significantly after treatment with PP, and the decrease was more (30.27%) pronounced at higher PP concentration and processing time up to 2.5g/l and 2.5 min respectively. By PP treatment, the cotton fibers are loosened due to fibrils are degraded and partly detached from the main fiber chain, and softness increased. After treatment with PP, the sizes (starch) of warp yarns were removed. As a result bending length was less and softness was increased.

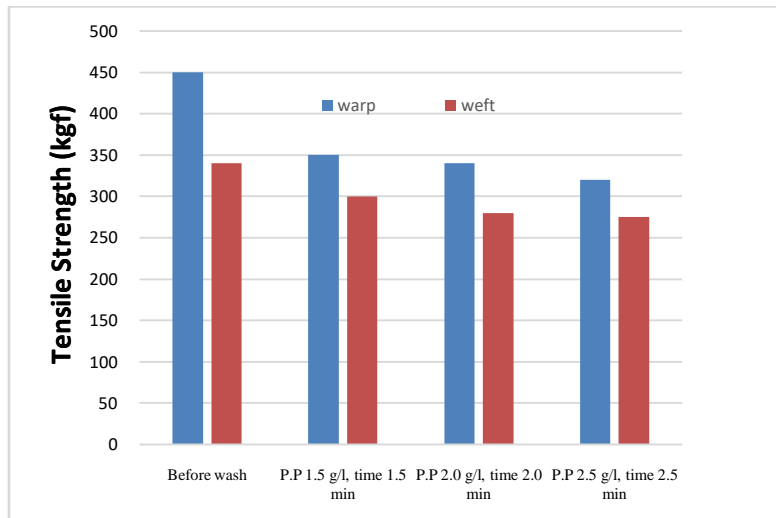


Figure 1: Changes of Tensile Strength with Simultaneous Effect of KMnO₄ Concentration and Processing Time

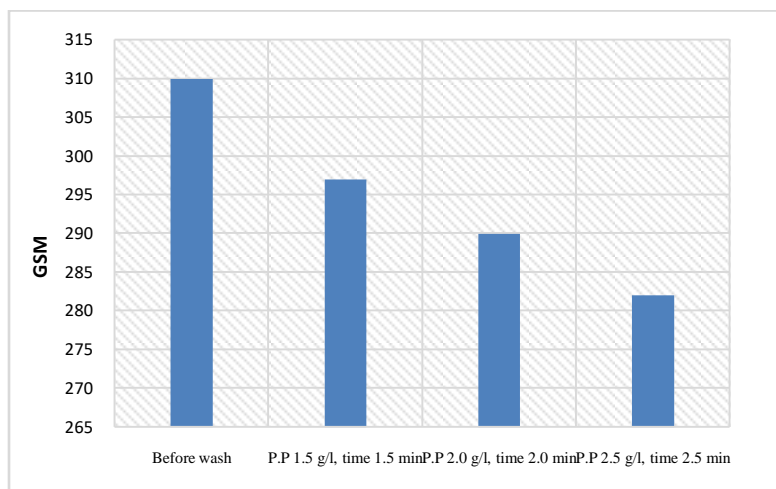


Figure 2: Changes of garments weight with Simultaneous Effect of KMnO₄ Concentration and Processing Time

Table 1: Changes of Fabric Stiffness (Bending Length) after Washing

| PP Concentration and time | Stiffness (cm) | | | |
|---|-------------------|-------------------|------------------|------------------|
| | Warp Way | | Weft Way | |
| | Face | Back | Face | Back |
| Before wash | 3.88 (0) | 3.70 (0) | 2.33 (0) | 2.73 (0) |
| Potassium permanganate 1.5g/l Time 1.5 min | 3.40 (-12.37%) | 2.78 (-24.86%) | 2.31 (-0.9%) | 2.65 (-2.93%) |
| Potassium permanganate 2.0g/l Time 2.0 min | 3.22 (-17.01%) | 2.64 (-28.65%) | 2.25 (-3.43%) | 2.63 (-3.66%) |
| Potassium permanganate 2.5g/l Time 2.5 min | 3.20 (-17.53%) | 2.58 (-30.27%) | 2.25 (-3.43%) | 2.62 (-4.03%) |

4. CONCLUSIONS

Due to strong oxidizing of KMnO₄, physico-mechanical properties of denim changed obviously during acid stone washing. Along with increasing processing time and KMnO₄ concentration, the number of released oxygen [O] increased and leading to enhance of oxidation ability that makes significant change in denim jeans

properties. The tensile strength, stiffness and fabric weight decreased after application of potassium permanganate with increasing processing time during washing treatment.

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