

# Effect of Enzyme Washing Combined With Pumice Stone on the Physical, Mechanical and Color Properties of Denim Garments

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**Abstract-**Garments washing is being used as a novel process to modify the appearance, to impart worn-out look and to improve the comfort ability of the garments, especially denim garments. Enzyme washing of denim garments helps in bio- polishing and to fade the color of the denim to a desired degree depending on the processing time and conditions. Adding pumice stone with the enzyme extends the degree of fading and adds special effect in the multi ply areas like different seams and hems. This paper presents the impact of enzyme-pumice stone combined treatment on 100% cotton denim. Garments were washed using an enzyme concentration of 1.5, 2.0 and 2.5 g/l for 40 minutes in 55°C temperature with addition of 0.5 owg (On the weight of garments) pumice stone. The physical and mechanical properties of the treated denims were analyzed using standard test methods. The properties that were analyzed include hand feel, tensile strength, seam strength, fabric weight, stiffness, dimensional stability and color shade. Enzyme- stone washed garments exhibit a great difference in the physical and mechanical properties than the unwashed garments.

**Index Terms-** Denim garment; Enzyme wash; Garments washing; Physical Property of Denim; Pumice stone

## 1. INTRODUCTION

The denim garments have a lot of demand in the market of regular garments as well as in the fashion market. People of all ages, especially the youth have a great interest on the denim. Different value adding processes like industrial washing makes the denims not only look beautiful but also imparts some functional properties to the garments [1]. Already made garments from solid color, from dyed or pigment printed fabrics, the garments are washed by different garments washing technique. Thus color, outlook and comfort ability of the garments are modified [2]. As a result new outlook and appearance is produced in the garments, which is not possible in any other method. Moreover, starch present in the garments is removed by the washing [2]. Moreover washed garments could be worn after purchase directly from the store or shop. Some garments shrink after wash, hence washed garments could be purchased as per required size without consideration of further shrinkage [3].

Among different techniques of garments washing, enzyme is chosen to fade color from all over the garments in a regular manner and to polish the surface of the fabric [4]. In stone washing, denim garment is washed along with pumice stone in industrial washing machine [2-3]. During washing, the denim and pumice stones are spun together in the washing machine and produce better distressed look. To minimize the unwanted wear and tear of the garments due to the presence of pumice stone in the wash bath,

the washing conditions should be set correctly and carefully [5].

Using pumice stone causes wear and tear of the garments and the machine surface [6]. Enzymatic treatments have a lot of advantages over the stone washing [7] but the stone has a different irregular effect on the garments which is very difficult to achieve with only enzyme. As only stone causes harm to the garments and machine, then using enzyme with the stone can bring the desired effect quickly with minimum harm to the garments and machine. So, using enzyme and stone both in the same bath helps to achieve the required shade in comparatively short time with wear and tear of the garments within a tolerable range.

This paper investigates the impact of enzyme-pumice stone wash on the physical and mechanical properties of denim garments as these properties determines the wearers feel and life of the end product. The paper also investigates the optimum use of enzyme with the fixed proportion of pumice stones. The minimum loss in the strength and fabric weight is preferable as well as other functional properties should be unharmed or should improve. Besides, the outlook of the garments should be as per the demand. Meeting these parameters in an acceptable point is a very difficult task but better and optimum process control in enzyme- stone washing can solve that.

## 2. MATERIALS AND METHODS

### 2.1. Materials

100% cotton denim leg panels were used. These comprised blackish denim fabric, GSM (Grams per Square Meter) 390, 3/1 warp faced S- twill, construction 72 x 40 / 9 x 7, fabric width 57 inch. The leg panels were desized using the standard recipe. Then the denim leg panels were washed using enzyme and pumice stone in a combination. Liquid Acid Enzyme (Jiangsu OGO Biotech Co. Ltd., China), detergent (Hostapur WCTH, Germany), desizing agent (Luzyme FR-HP, BASF, Germany), anti-back staining agent (Antistain- LP30, GDS, India) and Pumice stones (Indonesia and Turkey) of medium size (4-5 cm) were used.

### 2.2. Methods

Sections, sub-sections and sub-subsections are numbered in Arabic. Use double spacing before all section headings, and single spacing after section headings. Flush left all paragraphs that follow after section headings.

#### 2.2.1. Desizing Process

Denim leg panels were desized using detergent and desizing agent. This pretreatment was conducted in liquor containing detergent, Hostapur WCTH (0.5 g/l); desizing agent, Luzyme (1.5 g/l) and anti-back staining agent, Antistain- LP30 (0.2 g/l). Material to liquor ratio was 1:10 in a small scale front loading industrial washing machine (Sutlick, Singapore). This treatment was carried out at temperature 60°C for 20 min. After desirable time the liquor was dropped out. The leg panels were then washed with hot water at 50°C for 3 min then washed twice with cold water for 3 min each.

#### 2.2.2. Enzyme- stone washing process

Desized denim leg panels were treated using acid enzyme. This process was conducted in liquor containing Acid enzyme (1.5/ 2.0/ 2.5 g/l); acetic acid (1.5 g/l); anti-back staining agent, Antistain- LP30 (0.2 g/l) at pH 4.5- 5.0, and material to liquor ratio of 1:10 in the washing machine. Temperature was kept 55°C and treatment time 40 min. The denim garments were then washed with hot water at 70° C for 4 minutes then washed twice with cold water for 3 minutes each

#### 2.2.3. Hydro-extracting and Drying Processes

Enzyme- stone washed denim leg panels were squeezed in a laboratory scale hydro-extractor machine (Zanussi, Roaches International Limited, England) at 200 rpm for 3-4 min. Then dried at 75°C for 40 min in a steam drier (fabcare, India).

Treated denim leg panels were then analyzed to determine their physical, mechanical and color properties using standard test methods.

### 2.3. Testing and Analysis

Treated all denim leg panels were conditioned in 65% RH and 20°C for 24 hour before testing according to BS EN 20139 and ASTM D1776.

Tensile strength (breaking force) was determined by the US Standard Grab test method according to ASTM D 5034. Seam strength of the samples was measured by seam strength tester according to ISO 13935-2: 2014. Weight change (%) in fabric / GSM was calculated from the difference in fabric weight before and after the treatment according to ASTM D 3776. Dimensional changes / shrinkage (%) was calculated from the difference in fabric length before and after washed garment according to AATCC test method 96. Stiffness was measured from the bending rigidity in fabric by Shirley stiffness tester according to BS 3356. Change in the original color shade of the fabric was rated using Heal's Grey Scales for Assessing Change in Color (Batch C04) according to ISO 105 – A02: 1993.

## 3. RESULTS AND DISCUSSION

### 3.1. Changes of fabric hand after washing

The hand feeling of the fabric improves a lot after performing the enzyme- stone treatment. The sturdy and harsh hand feel was gone and a softer feeling was experienced when the washed garments were hold between the thumbs.

### 3.2. Changes of fabric weight and shrinkage after washing

The changes in the fabric weight (GSM) and Shrinkage (%) before and after enzyme- stone washing are represented in the figure below-

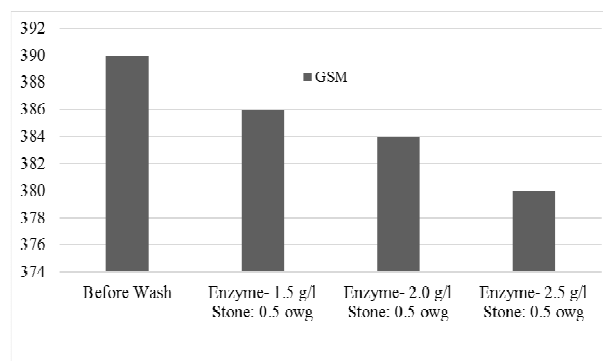


Fig. 1 Change in fabric weight (GSM) before and after enzyme- stone washing

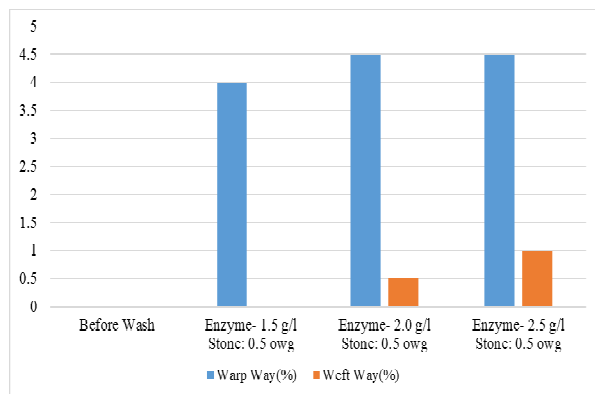


Fig. 2. Shrinkage occurred before and after enzyme-stone wash. (Before wash shrinkage is 0)

It is clear from figure 1 that the enzyme- stone washing imparts significant change in the fabric properties. The fabric weight (GSM) has been found reduced up to 2.56% as the pumice stone and enzyme both has action on the surface of the fabric and removes protruding fibers and dyestuffs from fabric surface. A significant change has been experienced in the fabric shrinkage, most significantly in warp way which is up to 4.5%. Cotton fabrics are generally subjected to a considerable tension during weaving especially in the warp direction. This stretch was increased in subsequent finishing processes like calendaring and thus the stretch temporarily set in the fabric. The fabric is then in a state of dimensional instability [8]. When the enzyme- stone washing has been performed, the thorough wetting of the denim tend to bring the fabric back to its more stable dimensions which result in the contraction of the yarns. This effect is generally greater in the warp direction compared to the weft. This is known as relaxation shrinkage [8].

### 3.3. Changes of tensile strength after washing

The tensile strength in both warp and way has been decreased significantly. The strength loss is experienced as a result of the rubbing action between the fabric and the pumice stone. More over the enzyme action assists in the strength loss as enzymes hydrolyzes the protruding fibers. . Warp yarns are more affected by enzyme- stone washing than weft due to the weaving character of warp faced twill fabric. As the warp yarns floats more in a warp faced twill, the strength loss is found more in warp way (Up to 22.79%). However the weft yarns are not completely unaffected. The highest strength loss is found 11.29% in weft way. The effect of enzyme-stone wash on the both warp way and weft way strength are shown below-

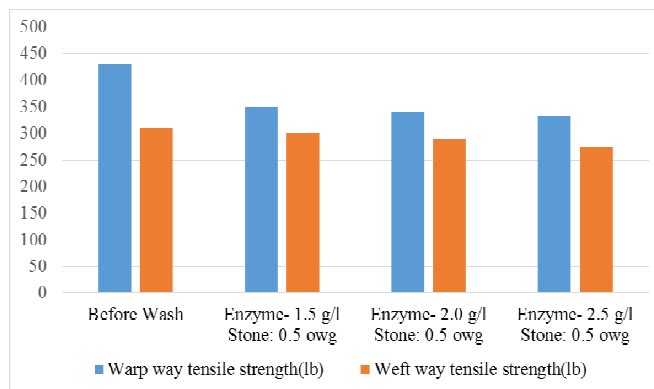


Fig. 3. Change in tensile strength before and after enzyme- stone wash

### 3.4. Changes of seam strength after washing

Enzyme- stone wash has influence in the decrement of the seam strength. The reduction in the seam strength has primarily been assisted by the friction between the pumice stones and the sample leg panels. The most significant decrement (25.51%) in the seam strength occurred with an enzyme concentration of 2.5 g/l and 0.5 owg pumice stones. Change in seam strength after enzyme- stone washing are represented in the following chart-

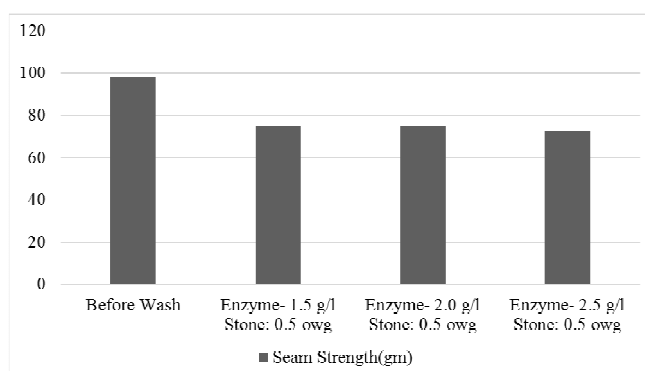


Figure 4. Change in seam strength before and after enzyme- stone wash

### 3.4. Changes of fabric stiffness (Bending Length) after washing

The change in the stiffness of the fabric after enzyme-stone treatment for both warp and weft way are listed in the following table as per their face and back value-

Table 1. Effects of enzyme- stone wash on stiffness

Enzyme- Stone conditions	Warp Way (cm)		Weft Way (cm)	
	Face	Back	Face	Back
Before Wash	3.88 (0)	3.70 (0)	2.33 (0)	2.73 (0)
Enzyme- 1.5 g/l Stone: 0.5 owg	3.40 (-12.37%)	2.78 (-24.86%)	2.31 (-0.9%)	2.65 (-2.93%)
Enzyme- 2.0 g/l Stone: 0.5 owg	3.22 (-17.01%)	2.64 (-28.65%)	2.25 (-3.43%)	2.63 (-3.66%)
Enzyme- 2.5 g/l Stone: 0.5 owg	3.20 (-17.53%)	2.58 (-30.27%)	2.25 (-3.43%)	2.62 (-4.03%)

The cotton fibers are loosened by enzymatic treatment as the fibrils are degraded and partly detached from the main fiber chain, and softness increased. Also the size materials (Starch) are also removed from the warp yarns. Moreover the rubbing action between the denims and the pumice stone has a great influence on the increased softness of the denim fabrics. As a result bending length was less and softness was increased. A significant change has been experienced in the warp way (Up to 17.53% reduction in bending length) as size materials have been removed from the warps and the rubbing action of pumice action is also prominent on the warp yarns as the fabrics are warp faced twill. The stiffness is generally less in the weft way and the decrement of the stiffness after enzyme-stone wash is not very prominent.

### 3.3. Changes in color shade after washing

Table 2: Effects of enzyme- stone wash on color fading

Enzyme- Stone conditions	Grey Scale Rating
Before Wash	5
Enzyme- 1.5 g/l Stone: 0.5 owg	4
Enzyme- 2.0 g/l Stone: 0.5 owg	3/4
Enzyme- 2.5 g/l Stone: 0.5 owg	3

It is obvious from Table 2 that, enzyme- stone wash has changed the color of the denim. The change is however slight in every successive washing conditions.

## 4. CONCLUSION

The enzyme- stone washing treatment has a great influence on the physical and mechanical properties of denim fabric. It also has an effect on the color properties but the change is slight. The fabric weight (GSM) gradually reduces with the increment of enzyme solution with a fixed amount of pumice stone with other parameters same. The Shrinkage occurs most significantly in the warp way. The tensile strength of the denim fabrics decreases with the

increment of enzyme solution. The decrement in the strength is more prominent in the warp way as the fabric is warp faced twill and the rubbing action of the stone affects the warps greatly. The seam strength also reduces with increased enzyme solution. The rubbing action between the stone and the seam area influences the reduction of the seam strength. A significant change in the bending length of the denim fabric is found after the enzyme- stone washing. The change is prominent in warp way and it can be said that, the softness of the fabric increases after enzyme-stone washing. The color shade changes with the increment of enzyme concentration but the change is slight. It is clear that the increase in the enzyme concentration (with other parameters and amount of stone same), the physical properties change and actually reduces the fabric strength, seam strength and GSM but the softness of the fabric increased and the color fades. The fading effect can be increased by increasing the enzyme concentration but that will reduce the serviceability of the garments. So an optimum enzyme- stone action should be chosen considering the required fading effect without compensating the important physical properties of denim.

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