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A Comprehensive Study on the Effects of Stone Enzyme Wash on Different Thickness Cotton Denim Pants

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Abstract

Garment washing is a significant area of the apparel industry. Washing is vital for denim and other casual garments for bringing some interesting washed-down effects. Unwashed condition does not exhibit customer's desired look, but after washing, the same garment becomes prominent in improved appearance, softness, comfort, light and dark shade, and patchy look that creates customer's absolute satisfaction. Garment washing process increases the appeal with a lucrative outlook brought about by mechanical or chemical treatments in dry or wet conditions. This study gives an indication of different types of washing processes and the change of physical and chemical properties due to application of wet and dry washing processes as an imparting desired effect on garments. The aim of the project is to find out the changes that occur in physical properties of denim when it is subjected to stone enzyme wash on 12-ounce, 10-ounce and 8-ounce denim pants. Three different shades, namely dark shade, medium shade and light wash, were taken into consideration. Different behaviors and properties of the garments were found in the physical properties of the samples.

Keywords

Stone Enzyme Wash, Denim Pants, Dark Wash, Medium Wash, Light Wash

1. Introduction

Stone wash means washing garments with special stones, so that garments achieve a very strong washed effect. To get a faded look on the garment surface, white stones are used with enzymes during washing. During washing, the fabric comes in contact

with stones and the color fades by the rubbing action. Stonewashing effects, as achieved by pumice stones, can be duplicated by the action of celluloses, which artificially "age" the fabric by chemically degrading the cotton and thereby releasing indigo dye particles, giving an abraded, washed-out look [1]. Now, in Bangladesh, maximum denim garment washing is done by stone enzyme wash. It is the most popular wash for buyers. Sometimes, bleach is added to the wash, so that the color fades in a more pronounced manner. This is done to turn navy blue jeans into a more faded light blue color. Such a wash requires a lot of skill, experience, workmanship and expertise, so that desired results are achieved [2]. In stone wash, the following points should be carefully checked:

1) Size of the stones: Stone sizes have a varied effect on the garment being washed. Larger stones give tough abrasion, while smaller ones lend less abrasion. Stones should be selected based on the required abrasion effect as well as the type of fabric of the garments. Larger stones may damage comparatively lightweight fabric [3].

2) Garment-stone ratio: This is the weight of the stones relative to the weight of garment. A wash with more stones may lead to a more apparent blue/white contrast on the fabric [4].

3) Washing time: The longer the washing period, the more the abraded effects on the garments.

4) Quantity of the bleach: Use of more bleach can shorten wash time, leading to more productivity [5]. Bleach, however, cannot be used indiscriminately. Disproportionate amount of bleach may lead to loss of the desired blue/white contrast on the fabric. To get better results, one should cut a balance between the quantity of bleach, stone size and the amount of stone.

2. Background

The need for doing laundry arose when people stopped wearing skins and started to wear fabric clothes. As man developed, he increasingly felt the need to keep himself and his clothing clean.

In the beginning, only clean water was used for washing clothes; the clothing was soaked, pounded, and rinsed in the water [6]. Over time, people began to notice that the addition of certain substances in the water during the soaking stage helped accelerate and simplify the removal of dirt from the clothing. The invention of soap represented a giant step forward, even if this wasn't soap as we know it today. For a long time, soap was used as a cosmetic agent. The greatest advance in the history of laundry was the invention of washboards. Washboards were made of various materials in different periods; these include wood, fired clay, stone, metal, glass, and artificial materials. We are not exactly sure when washboards were first created and used, but in this country, they were used regularly in the 1950s, at which point they were replaced entirely by washing machines. The first attempts at simplifying and, above all, accelerating laundry work began in the mid-18th century in England when Stander designed the first washing

machine [7].

3. Literature Review

The fashion sector has experienced a considerable impact from the application of stone enzyme wash on denim Pants [8]. It has been the go-to technique for creating a damaged and vintage look. This procedure gives the denim a distinctive, worn-in look with fading and abrasions while also softening it and improving comfort [9]. On the other hand, it can lessen the fabric's resistance to abrasion, which could compromise its durability. Because stone enzyme wash is in line with customer desires for stylish distressed looks, it has become more and more popular. Notably, compared to conventional stone washing methods, this approach uses less water and is therefore more environmentally friendly [10].

In this work, it is tested that how quality of the fabric is changed after going through Enzyme wash. As cotton is natural fibers. Denim is one of the world's oldest fabrics, which is most commonly associated with jeans. Denim is very strong, stiff and processed hard-wearing fabrics [11]. Denim wear has gained popularity all over the world. As a result, jeans wear is one of the most prominent apparel items in the world. The evolution of the denim market has led to the development of some unique and creative denim fabrics and opened new worlds of possibility for finishes.

Industrial garment washing is one of the major processes followed in the textile sector. By industrial garments, washing, dust, dirt and infectious materials can be removed from garments. For improving special look on garments as per fashion requirement, a variety of wash techniques can be followed [12]. For washing of denim garments, a range of treatment methods such as enzymatic treatment, bleaching treatment, acid treatment, and silicone treatment, are used widely. They all are aimed at new possible effects of fabric appearance. Particularly the dry finishing creates many effects on denim fabric; it will stimulate the customers to buy, and also it increases the market potential of the denim market.

In garment industry, there are mainly two types of washing process for garment products. Those processes are wet washing. In garment industry, there are mainly two types of washing process for garment products. Those processes are wet washing and dry washing process. Most common and applied wash in garment is normal wash, which is also known as detergent wash. In the wet washing process enzyme wash, stone wash and bleach wash are most popular to the buyer and the manufacturer [13]. On the other hand, potassium permanganate spray and hand scraping are common for dry washing process in the garments industry. Garments washing is being used as a novel process to modify the appearance to impart worn-out look and to improve the comfortability of the garments, especially denim garments. Enzyme washing of denim garments helps in bio-polishing and fading the color of the denim to a desired degree depending on the processing time and condition. Enzymatic treatments have a lot of advantages over the stone washing 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 shape in comparatively short time with wear and tear of the garments within a tolerable range.

4. Problem Statement

Use of chemicals is an integral part of garment washing. These are detrimental for human body with increased hygiene problems. Alongside, they also put some problems for the garments as well. Stone enzyme wash creates several problems, like back staining and re-deposition, wear and tear effects on the garments and stone damage in washing machine [14].

5. Objectives

The aims are:

- To observe the physical properties of washed garments compared with the unwashed ones.
- To turn raw denim into stylish, comfy, and environmentally friendly clothing with distinctive visual results.

6. Significance of the Research

The significance of researching the "A Study on the Effects of Stone Enzyme Wash on Different Thickness Cotton Denim Pants" lies in its multifaceted impact on the textile industry, fashion market, and environmental sustainability. Firstly, it directly influences the denim manufacturing sector by providing critical insights into refining processes, optimizing resource utilization, and enhancing the quality of finished products [15]. This contributes to the industry's ability to meet consumer demands for unique and aesthetically pleasing denim garments.

Secondly, the research is highly relevant in the context of evolving consumer preferences towards sustainable and eco-friendly fashion. Understanding the environmental implications of stone enzyme wash allows the industry to make informed choices that align with global sustainability goals [16]. This is particularly crucial as consumers increasingly prioritize environmentally conscious products, fostering a positive image for brands adopting such practices.

Ultimately, the significance of this research extends beyond the immediate scope of denim manufacturing. It addresses the broader industry trends of innovation and sustainability, shaping the future of textile practices towards more efficient, visually appealing, and environmentally responsible approaches.

7. Materials

12-ounce, 10-ounce, 8-ounce cotton denim pants are used to make all samples in this work. Different-ounce pants have different GSM. This experiment was

done in Crown Wears (Pvt) Ltd. Desizing agent (Soda ash, Anti Back Staining), Stone Enzyme (Anti Back staining), (LNS, Pumice Stone) Neutral agent (L-MAX), Tint (Glaubar salt), Brown GTL, Softener, Bleaching agent, Sodium Metabisulfite, Neutral agent, Soda ash, Caustic soda were the materials used in this experiment.

8. Methods

1) Desizing treatment

Denim leg panels were desized using desizing agent. And it's a mandatory pretreatment before subsequent washing. Desizing agent, detergent and material to liquor ratio 1:20 was used in a small-scale front-loading industrial washing machine. This treatment was carried out at temperature of 50˚C for 10 min. After completing the predetermined time, the liquor was dropped out. Then, treated denim leg panels were rinsed two times.

2) Stone enzyme wash

At first, we load the leg panels into the washing machine and load with water maintain the liquor ratio 1:5; then we put the pumice stone into the machine and added some LNS, ABS and run the machine for 15 minutes, this treatment held in room temperature, so we don't need to fix the temperature on this. After that it rinsed two times.

3) Neutralization

After completing stone enzyme wash, then fabric is neutralization at 5 min and in this process are also used in max or Meta bisulphate to neutralize this product [1].

4) Softener

Softener is used to improve the hand feel of garment. We collect all specimens from the wash we done before and put into the solution where we put L.K.C-5 GM/1 softener then we run this treatment for 3 min and completed the treatment with cold rinse wash [2].

8.1. Instruments and Tools

1) Denim fabric samples
2) Stone enzymes
3) Tensile strength tester
4) Statistical software
5) Documentation tools

8.2. Machines

1) Front loading machine
2) Side loading machine
3) Hydro-dryer machine
4) Hydro-extractor machine

8.3. Testing Instruments

1) GSM cutter
2) Elmendorf tear tester
3) Mechanical shaker
4) PH meter

8.4. Washing Process

1) Dark shade

Desizing

Soda ash = 1 g/L
Anti-back staining agent = 2 g/L
Temperature = 50˚C
Time = 10 min
Water = 80 L

Stone enzyme wash

LNS = 1 g/L
Anti-back staining agent = 2 g/l
Use stone = 5 kg
Temperature = 45˚C
Time = 15 min
Water = 80 L

Neutralization

L-max = 3 mg
Temperature = RT
Time = 5 min
Water = 70 L

Tint

Brown GTL = 100 mg
Yellow = 30 mg
G. SALT = 300 gm
Temperature = 45˚C
Time = 3 check
Water = 60 L

Softener

L.K.C. = 5 gm/l
Temperature = 40˚C
Time = 3 min
Water: 60 L

2) Medium shade

Desizing

Soda ash = 1 g/l
Anti-back staining agent = 2 g/l
Temperature = 50˚C

Time = 10 min
Water = 80 L

Stone enzyme wash

LNS = 1 g/l
Anti-back staining agent = 2 g/l
Use stone = 5 kg
Temperature = 45˚C
Time = 15 min
Water = 80 L

Bleaching

K.C.I. = 200 gm
Temperature = 50˚C
Time = 10 min
Water = 60 L

Neutralization

L-max = 3 mg
Temperature = RT
Time = 5 min
Water = 70 L

Tint

Brown GTL = 100 mg
Yellow = 30 mg
G. SALT = 300 gm
Temperature = 45˚C
Time = 3 check
Water = 60 L

Softener

L.K.C. = 5 gm/l
Temperature = 40˚C
Time = 3 min
Water: 60 L

3) Light shade

Desizing

Soda ash = 1 g/l
Anti-back staining agent = 1 g/l
Temperature = 40˚C
Time = 10 min
Water = 60 L

Stone enzyme wash

Neutral enzyme = 1 g/l
Anti-back staining agent = 1 g/l
Use stone = 20 kg
Temperature = 45˚C

Time = 30 min
Water = 60 L

Bleaching

K.C.I. = 500 gm
Temperature = 45˚C
Time = 10 min
Water = 60 L

Neutralization

L-max = 2 mg
Temperature = RT
Time = 5 min
Water = 70 L

Cleaning

Soda ash = 2 g/l
Peroxide = 2 g/l

Softener

L.K.C. = 5 gm/l
Temperature = 45˚C
Time = 3 min
Water: 60 L

9. Results and Discussion

Figure 1 illustrates the impact of stone enzyme wash on fabric GSM. GSM indicates the weight of fabric in Grams per Square Meter. GSM of before-wash samples in dark, medium and light wash were 431, 334 and 342, respectively. They decreased after stone enzyme wash and fell to 428, 329 and 330, respectively.

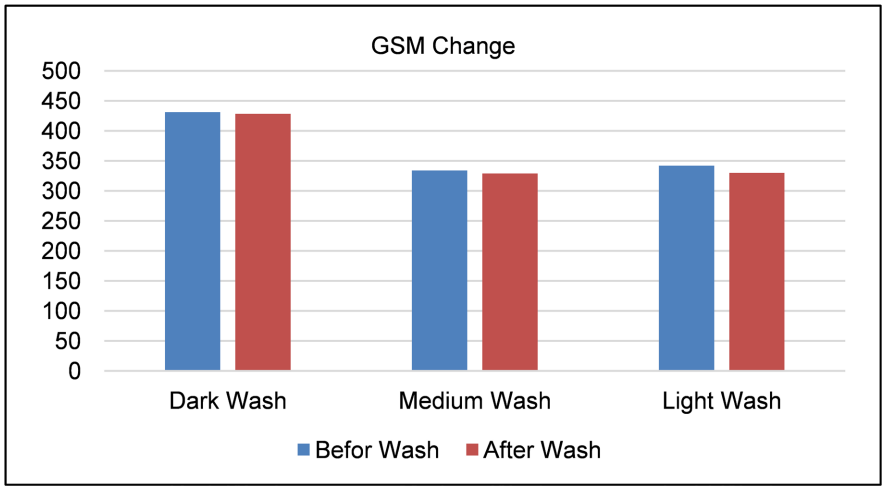

Figure 1. Impact on GSM after washing.

Figure 2 shows the percentage of shrinkage in three samples. This shrinkage is tested in both length and width ways. Length-wise shrinkage percentages are the

same (3%) in dark, medium and light wash. Medium wash exhibits 2% shrinkage in width ways. Dark and light wash shrinkage percentages are 3% for each. For denim fabrics, 3% shrinkage is tolerable.

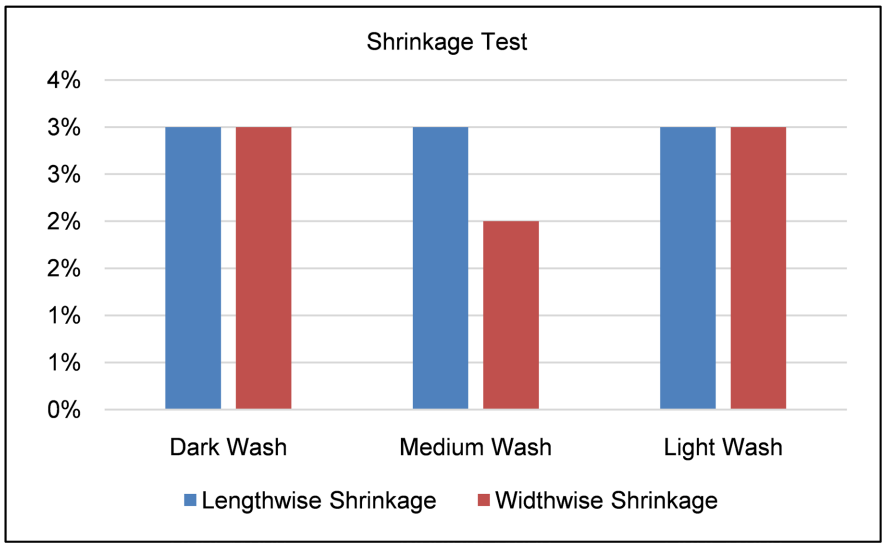

Figure 2. Impact on shrinkage.

Figure 3 shows, as GSM decreases after wash, there must be changes in weight. The pie chart shows this GSM loss in percentages. This is 0.70% for dark shade, 1.49% for medium wash and 3.51% for light wash samples. This weight loss occurs due to fabric shrinkage, removal of desizing agents and other washing actions.

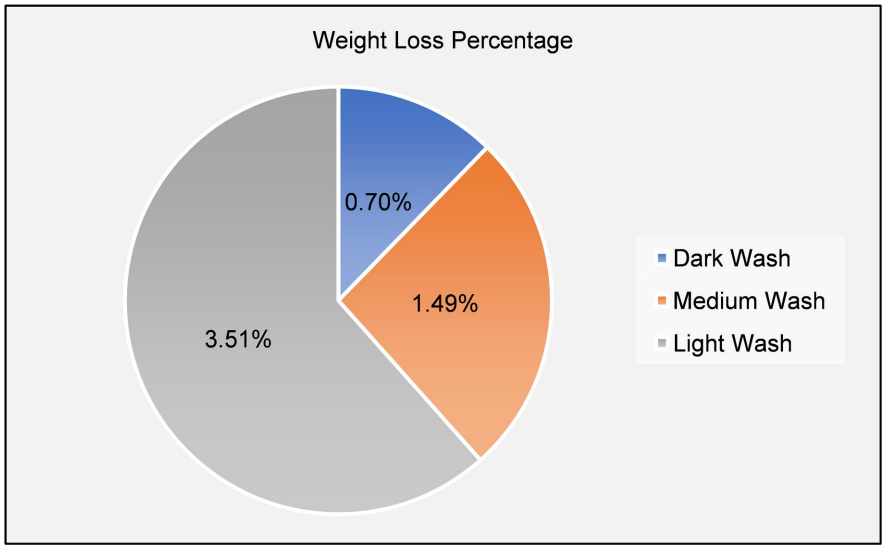

Figure 3. Weight loss percentage after washing.

Figure 4 indicates the colorfastness to wash in dark wash samples is very good. The requirement of color change after wash is 4 and it is maintained in both the samples.

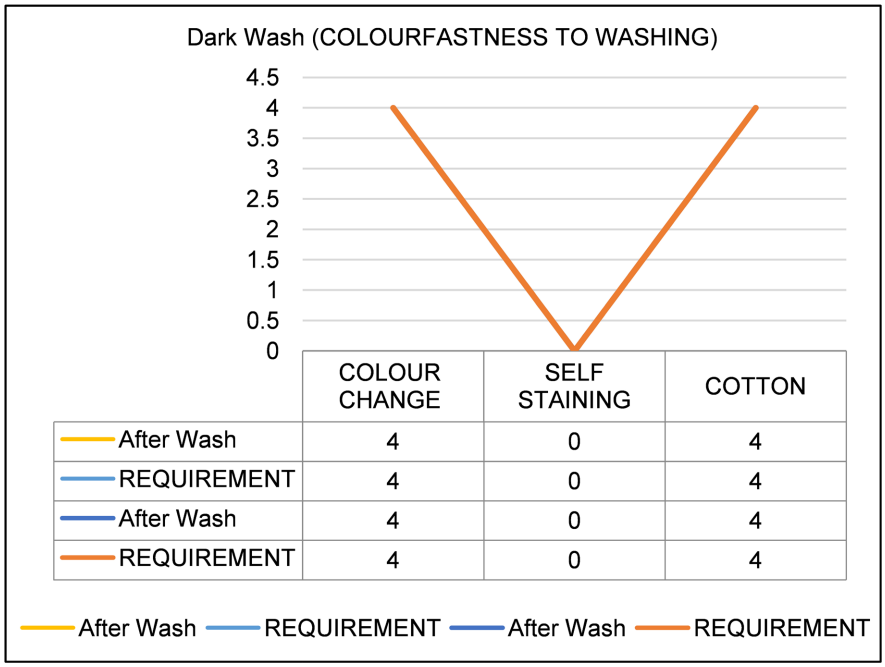

Figure 4. Impact of color fastness to washing (dark wash).

From the below bar chart (**Figure 5**), we find that color fastness to rubbing at dry conditions requirement is 4 in the grey scale. The sample exhibits 4.5 for both length and width wise directions. This is well above the requirement. Color fastness to rubbing at wet conditions requirement is 3 in the grey scale. The sample exhibits 2.5 for both length and width wise directions. This is a bit below the requirement.

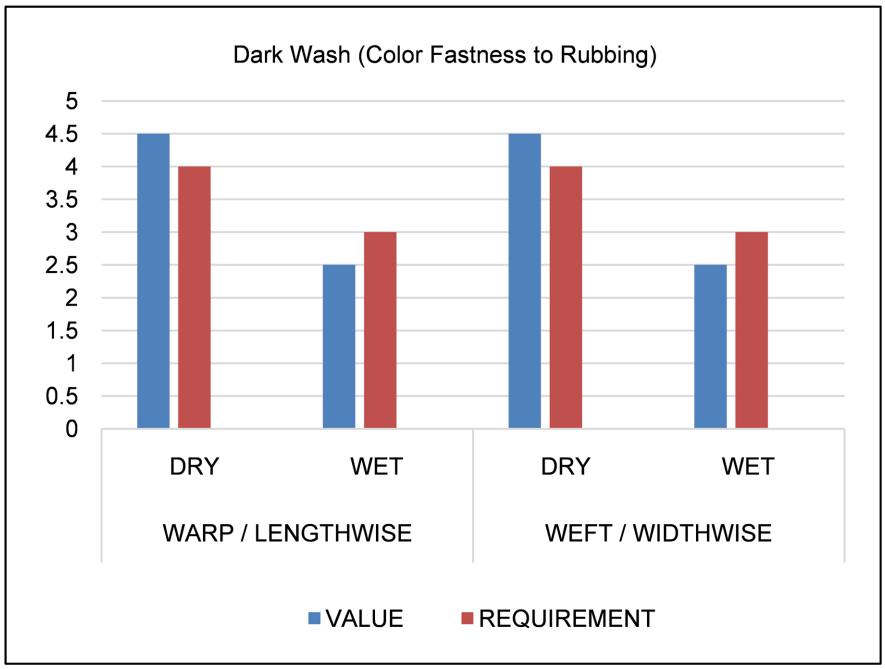

Figure 5. Impact of color fastness to rubbing (dark wash).

From Figure 6, the warp wise tear strength is found 4.6 daN and the weft wise tear strength is found 2.9 daN. The tear strength requirement for above 200 GSM fabric is 1.5 daN for both warp and weft directions. So, the warp and weft wise values are above the requirements.

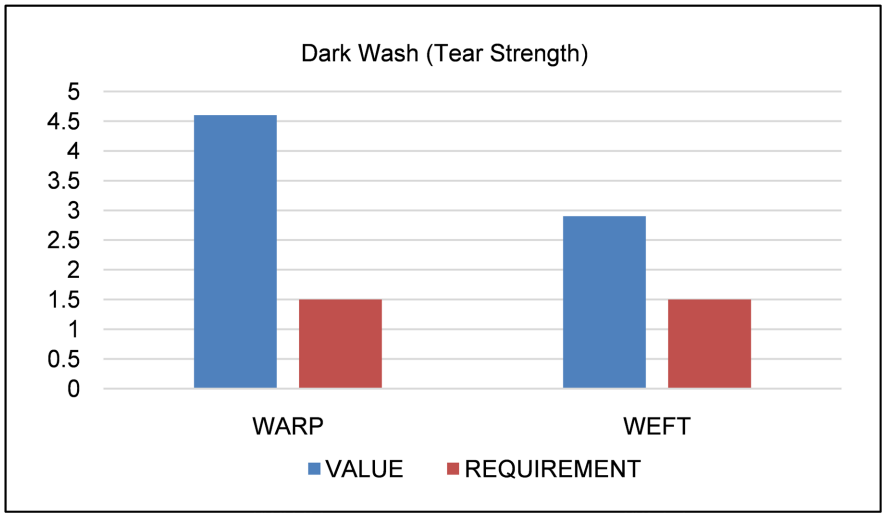

Figure 6. Impact on tear strength (dark wash).

Figure 7 shows the colorfastness to wash in medium wash samples is very good. The color change requirement is 3 and it is found exactly the same. Self-staining value is zero that ensures no staining of garment parts by the bled color.

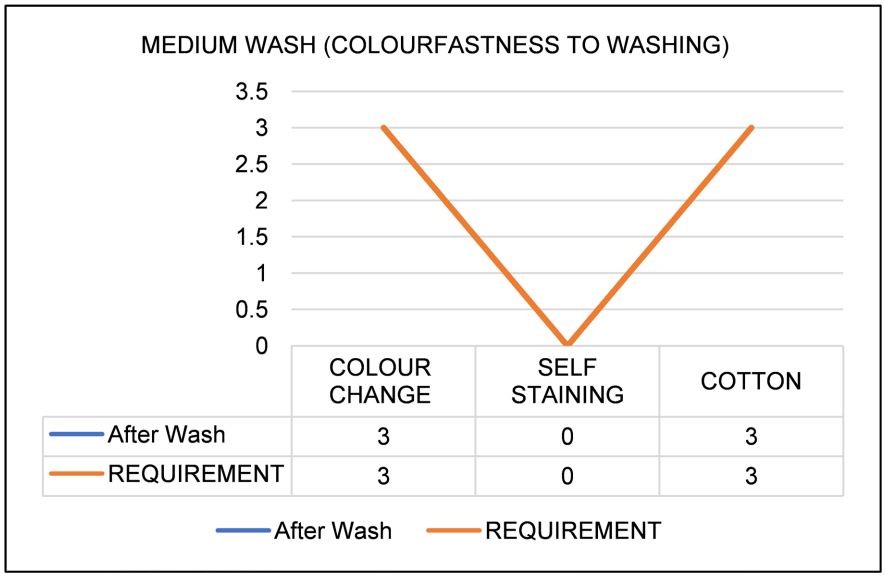

Figure 7. Impact of color fastness to washing (medium wash).

From the below bar chart (Figure 8), we find that color fastness to rubbing at dry conditions requirement is 4 in the grey scale. The sample exhibits 4.5 for both length and width wise directions. This is well above the requirement. Color fastness

to rubbing at wet conditions requirement is 3 in the grey scale. The sample exhibits 3 for both length and width wise directions. This is exactly the same as the requirement.

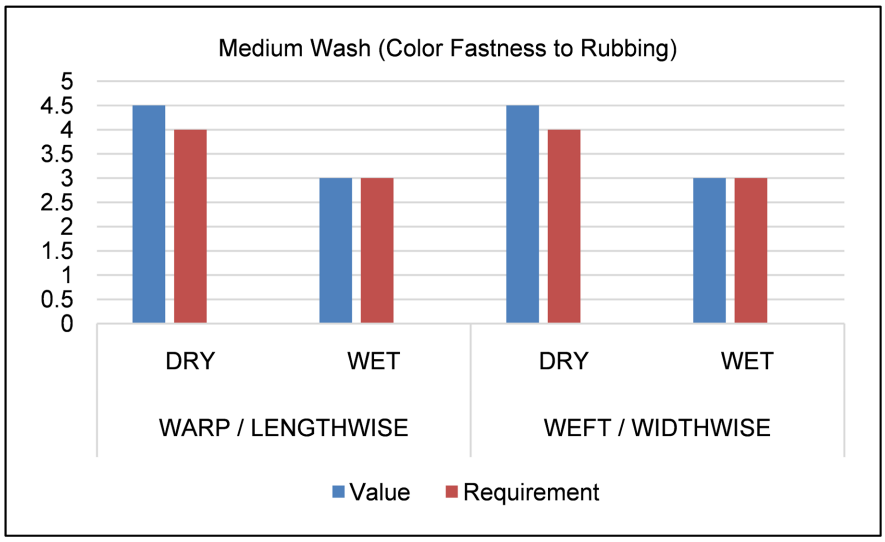

Figure 8. Impact of color fastness to rubbing (medium wash).

From **Figure 9**, the warp wise tear strength is found 3 daN and the weft wise tear strength is found 2 daN. The tear strength requirement for above 200 GSM fabric is 1.5 daN for both warp and weft directions. So, the warp and weft wise values are above the requirements.

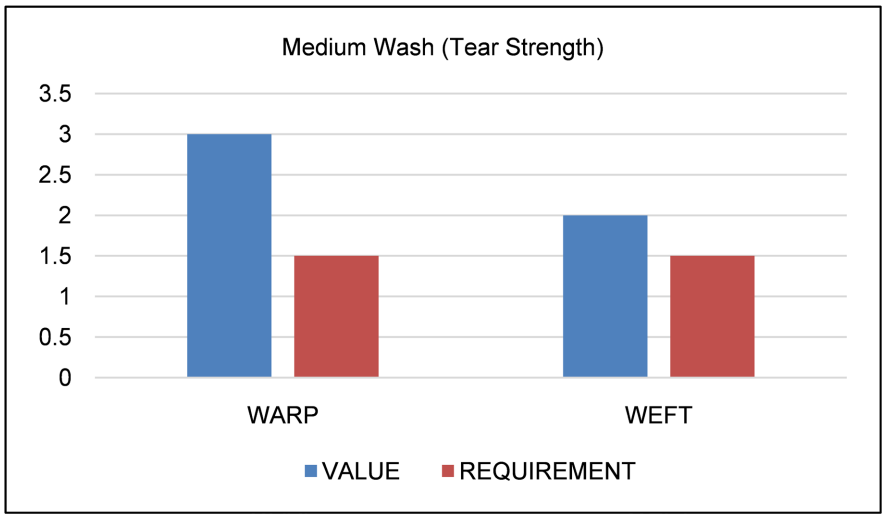

Figure 9. Impact on tear strength (medium wash).

Figure 10 shows the colorfastness to wash in light wash samples is very good. The color change requirement is 4 and it is found 4.5 that is above the reference value. Self-staining value is zero that ensures no staining of garment parts by the bled color.

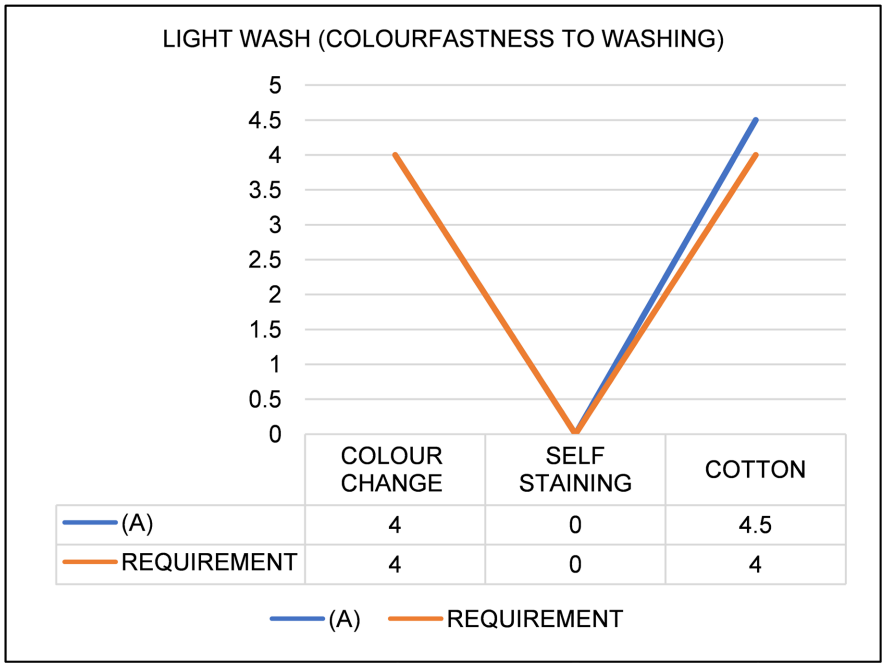

Figure 10. Impact of color fastness to washing (light wash).

From the below bar chart (**Figure 11**), we find that color fastness to rubbing at dry conditions requirement is 4 in the grey scale. The sample exhibits 4.5 for both length and width wise directions. This is well above the requirement. Color fastness to rubbing at wet conditions requirement is 3 in the grey scale. The sample exhibits 3 for both length and width wise directions. This is exactly the same as the requirement.

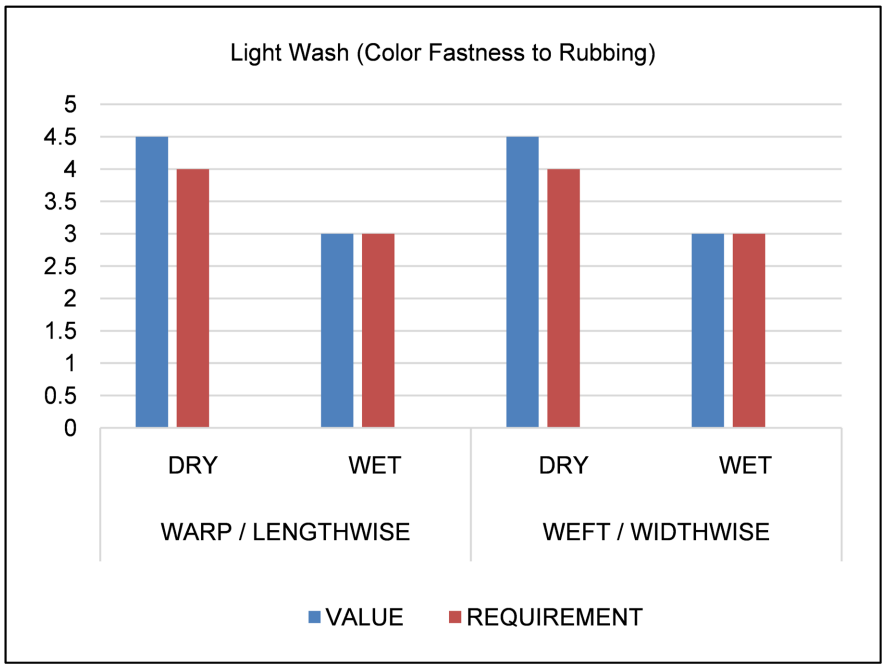

Figure 11. Impact of color fastness to rubbing (light wash).

From Figure 12, the warp wise tear strength is found 3.4 daN and the weft wise tear strength is found 2.5 daN. The tear strength requirement for above 200 GSM fabric is 1.5 daN for both warp and weft directions. So, the warp and weft wise values are above the requirements.

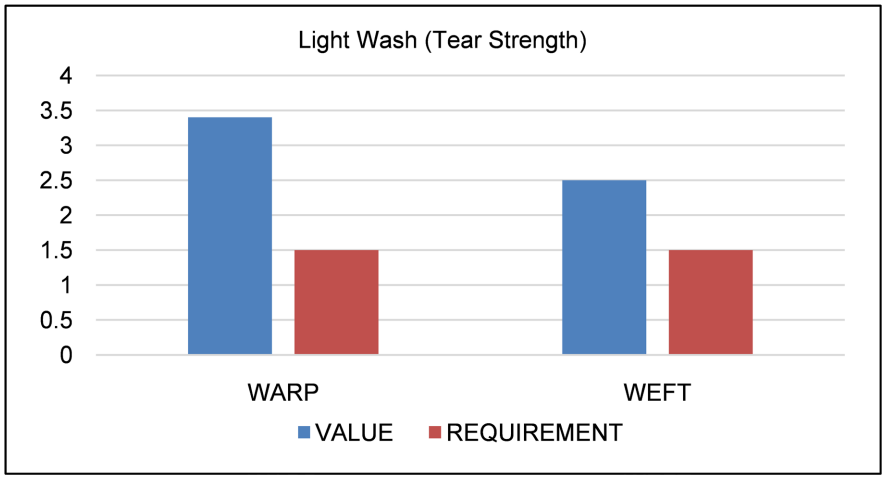

Figure 12. Impact on tear strength (light wash).

10. Conclusions

The enzyme stone washing treatment has a great influence on different properties of denim garments. We can conclude the research by stating that:

- GSM changes or weight losses occur for dark, medium or light washes. The more the wash intensity, the more the weight loss.
- Shrinkage percentages for all three options of stone enzyme washes are within 3%, which is acceptable for woven fabrics.
- Color fastness to washing value is within the tolerable limit.
- Rubbing fastness improves after washing.
- Tear strength falls but remains within the tolerable limit for all three washes.

11. Future Scope

Advanced Enzyme Formulations: Investigate and experiment with novel enzyme formulations to expand the range of effects achievable through stone enzyme wash. This could include enzymes designed for specific denim characteristics or incorporating enzymes with enhanced sustainability profiles.

Life Cycle Assessment (LCA): Conduct a comprehensive life cycle assessment to evaluate the overall environmental impact of stone enzyme wash, considering factors such as raw material extraction, production processes, and end-of-life disposal. This would contribute to a holistic understanding of the sustainability of the entire denim manufacturing process.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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