



Faculty of Engineering

Department of Textile Engineering

**STUDY OF PHYSICAL CHANGES IN DENIM  
FABRIC AFTER ENZYME & BLEACH  
WASHING PROCESSES**

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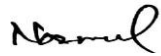
**A thesis submitted in partial fulfillment of the requirements for the degree of  
Bachelor of Science in Textile Engineering**

Advance in Wet Processing Technology

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## DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Sumon Mozumder**, Department of Textile Engineering, Faculty of Engineering, Daffodil International University. We also declare that, neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma



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## LETTER OF APPROVAL

This project report prepared by **Mir Nazmul Islam Nazim (Id:161-23-4585)** and **Panna Talukder (Id: 161-23-4641)**, is approved in Partial Fulfillment of the Requirement for the Degree of **BACHELOR OF SCIENCE IN TEXTILE ENGINEERING**. The said students have completed their project work under my supervision. During the research period I found them sincere, hardworking and enthusiastic.



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Finally, we would like to express a sense of gratitude to our beloved parents and friends for their mental support, strength and assistance throughout writing the project report.

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## DEDICATION

*This projects report is dedicated to  
our Beloved Parents*

## **ABSTRACT**

Raw denim fabric obtained after finishing is mostly impossible to wear before wash because of the rigidity and stiffness of finished denim. Finished denim is also very dull looking before wash. So, it is usually a must for denim to go through different washing processes not only for changing the physical property but also for the change of aesthetic property of denim. This project is done for comparing the physical properties like EPI, PPI, weight and shrinkage% of denim fabric with different constructions after Enzyme and Bleach wash. This is a survey-based project as no experiment is done to complete this project. Different washing processes like Enzyme, Bleach, Stone washes were observed and the visual change is seen. The information about the change in physical properties like EPI, PPI, weight & shrinkage% were collected from the Details Sheet provided by the QC section of Shasha Denims Ltd. After compiling and comparing all the necessary data, it is seen that the increase in EPI averaging at 21.36% is more drastic than the change in PPI averaging at 3.15% after both Enzyme and Bleach wash. These two washes have similar impact on EPI, PPI, weight and shrinkage after wash. Among the three shrinkage types, width shrinkage averaging at 15.76% is the most extreme compared to length and skew shrinkage averaging at 2.66% and 0.86% respectively after Enzyme and Bleach washes. This extreme width shrinkage is also the reason behind the drastic increase of EPI after both Enzyme and Bleach Wash.

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# **CHAPTER-1**

# **INTRODUCTION**

# **CHAPTER-1**

## **INTRODUCTION**

Denim is a compact cotton twill weave warp faced textile fabric in which the weft yarn goes under two or more warp yarns and creates a diagonal line effect that differentiates it from plain weave cotton and is considered as very stiff and hard felt fabric [1, 2]. Popularity of the washing of garment specially of denim garment in the global market is rising frequently. To fulfil the rising requirement of buyer a large number of washing factories is being developed in Bangladesh. In short, technology of washing is used to change the aesthetic property, size, look, comfort ability and fashion of the garments and mostly used on denim products and any other garments to avail a glassy look as well as undertaking the key treatments like the removal of insoluble matters, matters which are already in the solution or other impurities which are present in the fabric [3-5]. It is one of the most commonly used treatments for finishing that have mostly used because of its effect on aesthetic property and feel. Denim garments are not comfortable to wear before washing because of the effects weaving, printing and dyeing processes. It is essential for denim to go through a finishing treatment for making it soft and smooth which improves the comfort of the wearer [6, 7].

Denim has a very valuable part in the increase of active wear. Increase of the usage fields of denim fabrics that gained distinguished views with different techniques and effects of washing must not be neglected even though the production share of classic blue denim still has the highest value. Also, relying on the developments in the Textile and Apparel industry, requirements of customers from a garment has risen and comfort of clothing concept has got more importance [8]. The modification in the structure of the fabric because of different kinds of washing techniques are considered that effect on different parameters like air permeability, thermal comfort. People select garments depending on multiple parameters like fashion, aesthetic quality, comfort and price. Comfort is one of the most desired and an important property that raises the value of denim goods [9].

## 1.1 Objectives of the Study

- ❖ To know about different washing techniques of denim in Bangladesh.
- ❖ To analyze the change in EPI & PPI of denim with different constructions after Enzyme & Bleach washes.
- ❖ To analyze the change in weight per unit area in Oz/Yd<sup>2</sup> of denim with different constructions after Enzyme & Bleach washes.
- ❖ To analyze the shrinkage% of denim with different constructions after Enzyme & Bleach washes.
- ❖ To compare the parameters with one another for understanding the changes after Enzyme & Bleach washes.

**CHAPTER-2**  
**LITERATURE REVIEW**

## **CHAPTER-2**

### **LITERATURE REVIEW**

#### **2.1 Denim Wash**

Garment washing is one of the most popular processes followed in the textile industry. Dirt, dust, impurities and infectious particles can be removed from denim goods by the help of industrial garments washing. Multiple techniques of wash can be followed as per the requirement of style and fashion, for enriching special aesthetic property on garments [10]. Normally denim washing is done after stitching garment. According to the demand and need of consumers, buyers ask for different garment washing. An example of that can be, H&M buyer asked for different washes look like – Acid wash, stone wash, enzyme wash, vintage wash, pp wash, softener wash etc. different types of appearance are seen on the surface of denim goods after every wash. The Physical Changes of denim wash mainly depends on the types of fabric and fabric construction [11].

Without denim the present design is absolutely fragmented. Denim clothing comes in all structures, looks and washes to coordinate with each dress. For making denim the style symbol that it is today an enormous number of innovative elements have contributed—remembering immense upgrades for spinning, weaving, finishing and so forth. The most significant piece of recreation of the vogue denim goods is the washing. Presently washing has such a crucial influence in the denim segment on account of such a large number of impacts that the shoppers are searching for on their denim goods. Each and every progression in denim article of clothing washing has a tremendous effect since indigo color has an exceptionally poor wet fastness and dry rubbing. Every one of the parameters are exceptionally basic to keep up for monotonous outcomes [12]. Denim washing method now daily's makes new design, for example, blasting, tagging, whickering, deep dye, tie dye, potassium permanganate spray, potassium permanganate sponging permanent wrinkle, destroy, grinding, hand crapping and so on. These washing procedures have some critical physical change in denim articles of clothing [11].

Enzyme wash, rinse wash, bleach wash, potassium permanganate wash, acid wash, normal wash, stone wash, stone-enzyme wash and so forth are the most generally denim washing strategies. Among these washing strategies, dye washing strategy is broadly utilized technique in the business particularly for denim washing by hypochlorite fading to get the necessary shading conceal. The procedure of denim bleach can be utilized to decolorize indigo from denim [13].

This paper examines the effect of enzyme, stones & bleach on the physical and mechanical properties of denim clothing as these properties decide the actual feel and life of the final product. The paper additionally explores the ideal utilization of chemical with the fixed extent of pumice stones.

### **2.1.1 The Change in Appearance after Different Denim Wash**

Denim wash gives tasteful completion. It upgrades the intrigue. It additionally gives quality. With the time being the texture will be blurred in such a way like, that way which is falsely fixated denim patterns to likewise. With dry denim, notwithstanding, such kind of blurring is impacted by the individual's body who wears the denim clothing and furthermore their day by day life exercises. This can make what numerous individuals feel to be an increasingly one of a kind, regular look than the pre-troubled denim.

Article of clothing produced using denim can experience such huge numbers of procedures so as to get pragmatist fading impact or various kinds of exceptional wash impacts [15].

### **2.1.2 Enzyme wash**

The cellulose treatment diminishes the properties of the elasticity and extension to break [17]. The chemical fills in as an impetus in the washing procedure which is a living biochemical substance. From the outset step in the washing procedure chemical hydrolysis the cellulose and furthermore expel the anticipating strands from yarn, by this wash thusly faded impacts are found. To get the correct blurring impact on denim articles of clothing, the most basic wash is chemical wash in the piece of clothing industry [14].



Enzyme wash is done on clothing which are produced using substantial textures simply like denims. This wash expels the size materials from the pieces of clothing and evacuate the starch exhibits on the articles of clothing texture. By this wash we can accomplish the high-low scraped area (stone impact) on piece of clothing and furthermore crease scraped area in sewing territory. Enzyme assaults not precisely, it assaults synthetically and consequently low harm/wastage at that point stone wash.

Enzyme wash is done for several other reasons. For accomplishing the delicate inclination to wear the denim clothing. To accomplish the purchaser's prerequisite example. To expand the rubbing fastness and wash fastness, extraordinarily build up the "Bio-Polishing" impact of cotton/denim. This also builds up the properties of clothing hostile to pilling. This attacks more on the textures surface and furthermore gives an exceptionally smooth surface [16].

### **2.1.3 Bleach Wash**

Bleach wash is appointed to blur a high level of shading among different procedures of denim washing. In such a higher degree it is troublesome, to blur the shading from everywhere throughout the pieces of clothing at one wash without bleach wash. Be that as it may, having some disservice, for example, it crushes the texture as it disintegrates the cellulose, will in general make the texture yellowish, should be neutralized consequently builds cost and incorporates more advance to the preparing time the detergent wash can't be covered. Other than these downsides, bleaching operators like chlorine bleaching is harmful for wellbeing and the procedure groupings are risky to the earth. To control the procedure is exceptionally extreme and unsurpassed it is beyond the realm of imagination to expect to get similar outcomes in each bunch considerably in the wake of following a similar formula [14].



**Fig.2.1:** Random Bleach Wash Effect

Rigidity, solidness, prolongation at break, weight reduction, dimensional strength, shading blurring, water retention and dampness recover properties of the treated and untreated article of clothing were analyzed. As indicated by the outcomes, this washing and without washing uncovered large contrasts in elasticity, solidness, GSM, shading blurring and surface harshness [17].

#### **2.1.4 Stone wash**

This is as yet the most renowned washing of all. The denim goods are washed with oval or round pumice stones which should all have generally a similar arrangement. The pumice stones are exceptionally light with an unpleasant surface. At times, when the last quality overseers at the pants production line neglect to clean the pockets, you may even discover some buildup of these stones in the pockets of your new pants. During the washing procedure these stones will scrap off a slim layer of the denim in this manner indicating a portion of the white strings from the piece of the material where the indigo coloring stuff was not ready to penetrate [17]. It additionally makes the impact called splendor. One may likewise experience words like profound stone or

excessively stone wash, which are a sign of to what extent the pants have been stone-washed. The more extended the wash, the lighter the denim goods.



**Figure 2.2:** Natural Pumice Stone

**CHAPTER-3**  
**METHODOLOGY**

## CHAPTER-3

### METHODOLOGY

#### 3.1 Materials and Machines Used in the Washing Section

##### 3.1.1 Fabric and Garment Samples

Majority of the samples were collected from Shasha Denims Ltd. and a few samples were collected from One Denim Mills Limited. Finished fabrics were washed for different tests and garments were washed to fulfil buyer's requirement.



**Fig.3.1:** Fabric Samples of Different Wash

##### 3.1.2 Chemicals Used for Enzyme & Bleach Wash

- ❖ Caustic Soda
- ❖ Meta
- ❖ Powder Enzyme
- ❖ Liquid Enzyme
- ❖ RM
- ❖ Bleaching Powder

- ❖ Lycra Protector
- ❖ Novofiss FF
- ❖ Hydrogen Peroxide
- ❖ Acetic Acid

### 3.1.3 Functions of the Chemicals

- **Caustic Soda:** Used for controlling pH and scouring agent.
- **Meta:** Used for the neutralization of Bleaching agents
- **Powder Enzyme:** Used as the main ingredient of Enzyme wash for effects.
- **Liquid Enzyme:** Used for Bio-polishing of denim.
- **RM:** Used as anti-back staining agent for protecting pocket of garments from staining the removed colors in wash.
- **Bleaching Powder:** It is a bleaching agent used for the Bleach wash of denim.
- **Lycra Protector:** It is used for protecting the spandex fiber within the denim fabric while going through different washing processes.
- **Novofiss FF:** It is company name of a fixing agent used for fixing the dye on fabric.
- **Hydrogen Peroxide:** It is a strong bleaching agent for Bleach washes of denim.
- **Acetic Acid:** It is used for controlling pH while using liquid enzyme as it requires acidic media.

### 3.1.4 Machines Used & Their Functions

- ❖ **Production Washing Machine:** It is a large washing machine used in the washing plants for bulk production. This was used in the factory for shrinkage test specially.
- ❖ **Sample Washing Machine:** It is a smaller washing machine used for different washes in a small quantity.
- ❖ **Hydro Extractor:** It is used for removing the excess water from denim after washing and before drying.

- ❖ **Steam Dryer:** It is a large drying machine used for drying the washed denim fabric up to temperature of 80<sup>0</sup> centigrade.

### 3.2 Recipe

It is seen that the recipe for denim washing entirely depends on the expected or required wash effect rather than following the same recipe again and again for a particularly named wash. The recipe and methods vary to produce required effect on denim. In most cases the garments or fabrics go through several wash processes to create or recreate an effect. An example of those recipes is shared below which were acquired from Shasha Denims Ltd.

**SHASHA DENIMS LTD**  
184 – 193, DEPZ (EXTN), SAVAR, DHAKA

WASH RECIPE

Buyer H&M-Tusuka

Washing Process	Chemical	Stem/Time
Fixing Wash	Acetic Acid (25gm)	Cool
	Stone (10kg) Fixing (200gm)	03 Min (Dip)
No Drain		
Enzyme Wash	Enzyme JQ-200 (150gm), Powder Enzyme (200gm)	45 <sup>0C</sup> 30 Min
Rins-2 (Out-Hydro Dyer)		
Rinse Wash	Water	Cool 3 Min
Out Hydro		
Acid Wash	Potash (Per Litre 3gm) Stone (25kg)	5 Min (Check)
Rins-2		
Neutral Wash	Meta Basf (300gm)	50 <sup>0C</sup> 5 Min
Rins-2		
Tin Wash	Brown GG (300ml) Red BWS (50ml) Red Brightener (20gm) Salt (200gm)	50 <sup>0C</sup> 2 Min
Out Hydro Dyer		

**Fig.3.2:** Typical Recipe of Wash

**Table no 3.1: Typical Recipe of Denim Wash**

<b>Washing Process</b>	<b>Chemical</b>	<b>Temperature &amp; Time</b>
Fixing Wash	Acetic Acid – 25gm Stone – 10kg Fixing Agent – 200gm	Cool 3 min (Dip)
No Drain		
Enzyme Wash	Enzyme JQ-200 -150gm Powder Enzyme – 200gm	45 <sup>0</sup> C 30 min
Rins-2 (Out-Hydro Dryer)		
Rinse Wash	Water	Cool 3 min
Out Hydro		
Acid Wash	Potash – 3gm/L Stone – 25kg	5 min (check)
Rins-2		
Neutral Wash	Meta Basf – 300gm	50 <sup>0</sup> C 5 min
Rins-2		
Tin Wash	Brown GG – 300ml Red BWS – 50ml Red Brightener – 20gm Softener – 100gm Salt – 200gm	50 <sup>0</sup> C 2 min
Out Hydro Dryer		

Table 3.1 shows a typical recipe used for producing a certain effect for a certain buyer. The processes may vary according to requirements. The effects gained by this recipe cannot be compared with different fabrics as this recipe is applicable for a certain order. So, for comparing some physical changes of different construction fabric which went through same wash, we collected reports regarding two different washes. They are Enzyme and Bleach Wash. The



parameters which we compared are Oz/Yd<sup>2</sup>, EPI, PPI, Shrinkage % (Length, Width, Skew) & Weight loss % after these two washes. We collected data of these parameters before wash and after wash of denim fabrics with different constructions.

### 3.3 Description of the Samples

The data used in this project were collected from the technical data sheet of 9 different samples with difference in construction.

**Table no 3.2:** Details of the samples

Sample	Types of warp	Types of weft	Warp Ratio	Weft Ratio	Weave	Color
S1	3	1	3:3:6	Full	3/1 RHT	Black
S2	2	1	6:4	Full	3/1 RHT	Black
S3	3	2	2:1:4	1:1	3/1 RHT	Dark Indigo
S4	3	2	2:1:9	1:1	3/1 RHT	Indigo
S5	3	2	3:3:6	1:1	3/1 RHT	Black
S6	2	1	4:3	Full	3/1 RHT	Dark Indigo
S7	2	1	4:8	Full	3/1 RHT	Black
S8	3	2	3:3:6	1:2	3/1 RHT	Black
S9	3	1	2:1:9	Full	3/1 RHT	Charcoal Blue

From table 3.2 we can see that the fabrics were made of 2 or more types of warps that varies in either count or spinning methods. All the warp yarns are cotton but some of the wefts are polyester. Weave structure of the samples are 3/1 Right Hand Twill.

Different warp and weft ratios were used in weaving for these fabrics. The colors of these samples are not same even though they are described with similar words.

### **3.4 Determination of EPI & PPI**

At first the finished fabric is collected for testing. Then one-inch area is marked using a marker. After that using a counting glass and needle the number of warp yarns is counted very carefully and noted accordingly. The same procedure is repeated for counting the number of weft yarns in one inch.

After that the finished fabric goes to the washing section for washing. After washing and drying, the procedure is repeated again for the determination of EPI and PPI after wash.

### **3.5 Determination of Oz/Yd<sup>2</sup>**

At first the finished fabric is collected for testing. Then a portion of the sample was cut using a GSM cutter. After that using a digital balance the weight of that cut portion was measured in Ounce. Then the weight of the portion was divided by the area of the GSM cutter in Yd<sup>2</sup>. The result gave us the weight of fabric in Oz/Yd<sup>2</sup> and it was noted down.

After that the finished fabric goes to the washing section for washing. After washing and drying, the procedure is repeated again for the determination of Oz/Yd<sup>2</sup> after wash.

### **3.6 Determination of Shrinkage%**

At first the finished fabric is collected for testing. Then 2 points were marked at a distance 50cm once along the length and once along the width of the fabric.

After that the finished fabric goes to the washing section for washing. The marked points are examined with the same scale used before to see if the distance is increased or decreased and shrinkage% calculated using the proper formula. This procedure is done both for length and width shrinkage.

**CHAPTER-4**  
**DISCUSSION OF RESULTS**

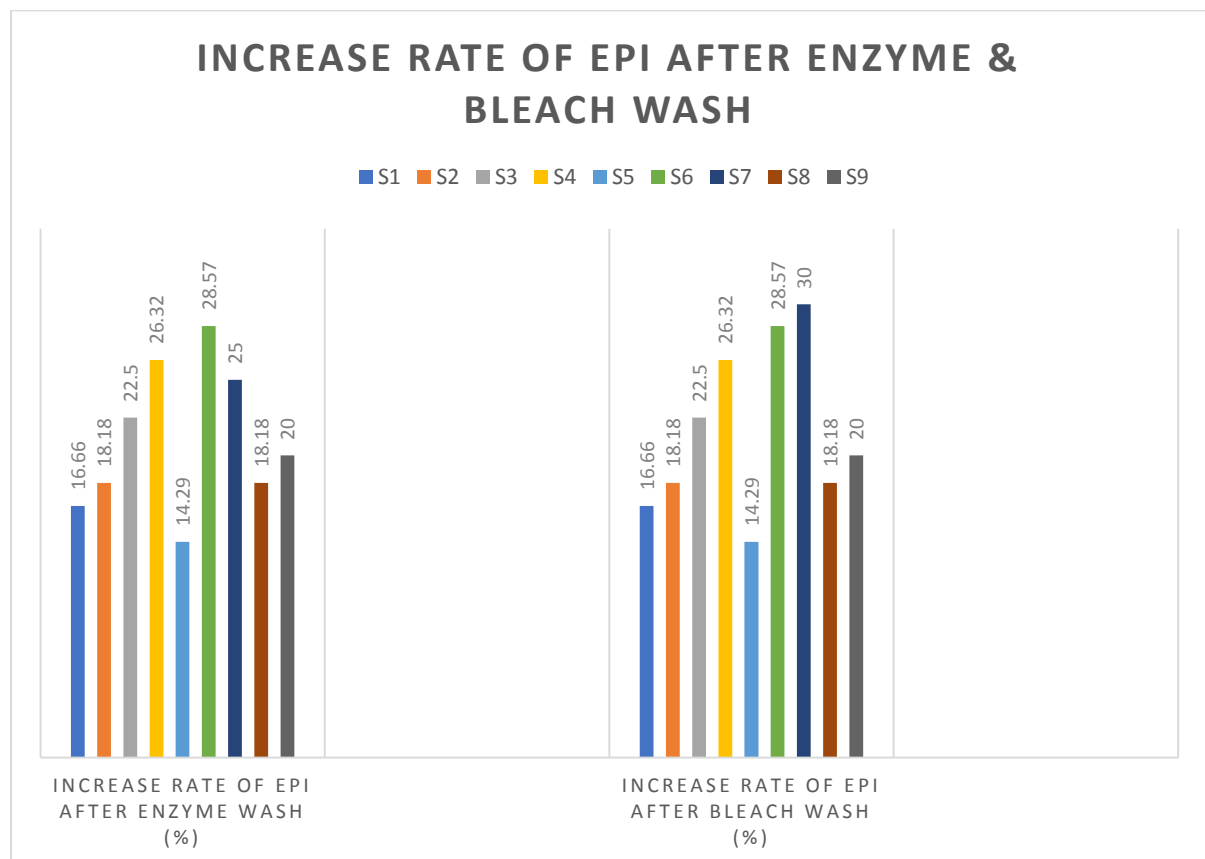
## CHAPTER-4

### DISCUSSION OF RESULTS

#### 4.1 Change in EPI after Enzyme & Bleach Wash

From the table A1 in appendix we can see the increase of warp yarns per inch after Enzyme wash. The highest percentage of EPI increase is obtained for sample S6 with the value of 28.57% and the lowest is seen for sample S5 with 14.29%. The average increase in EPI is 21.08%. From the table A2 in appendix we can see the increase of warp yarns per inch after Bleach wash. The highest percentage of EPI increase is obtained for sample S7 with the value of 30% and the lowest is seen for sample S5 with 14.29%. The average increase in EPI is 21.64%.

The increase rate of EPI after both Enzyme and Bleach Wash are not very different.



**Fig.4.1:** Increase Rate of EPI after Enzyme & Bleach wash

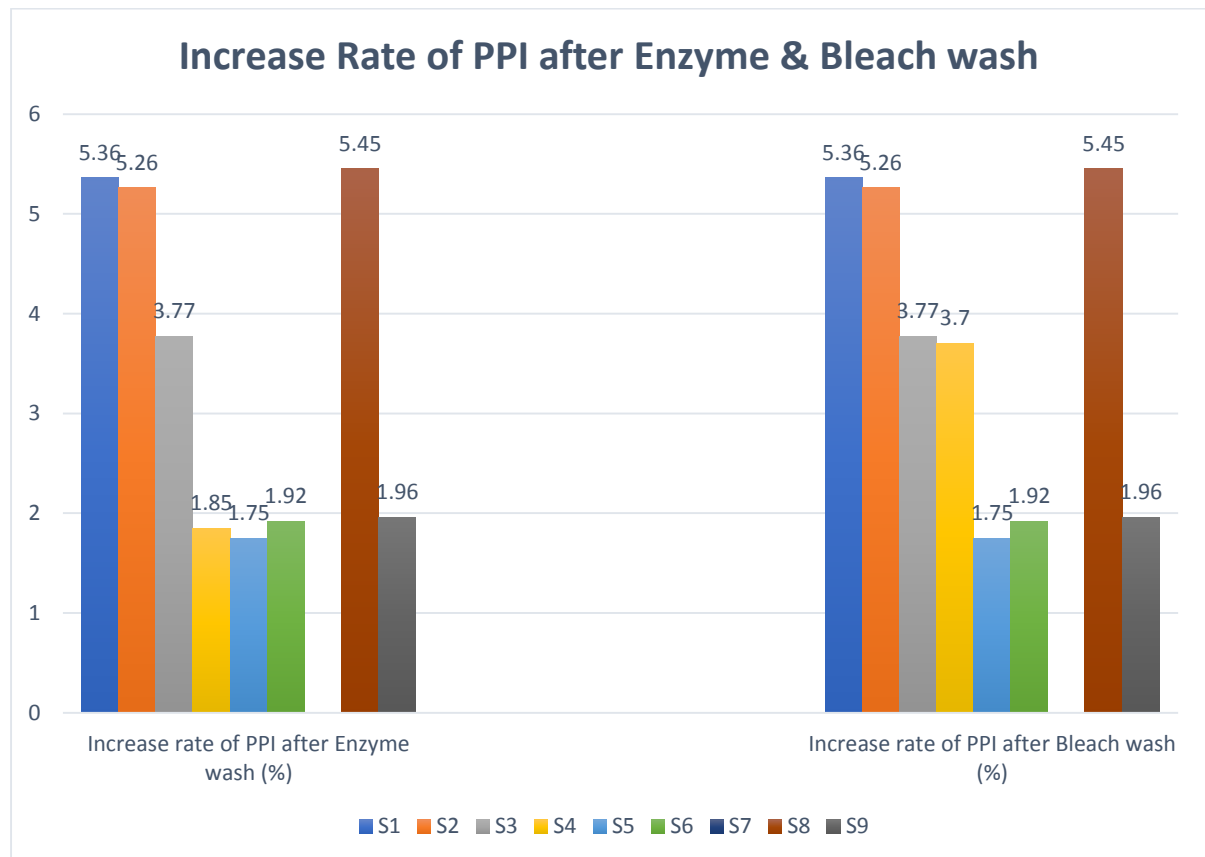
The figure 4.1 is a bar chart comparing the EPI increase rate after Enzyme and Bleach wash. In This Bar chart, all of the colors represent the individual samples.

From this chart, it is seen that the highest increase rate of EPI from the samples after Enzyme Wash is 28.57% and the lowest is 14.29%. But the highest rate of increase of the same samples after Bleach wash is 30% and the lowest is 14.29%. The average rate of increase in EPI after both washes are 21.08% and 21.68% respectively which proves to have similar effect after both of the washes.

#### 4.2 Change in PPI after Enzyme & Bleach Wash

From the table A3 appendix we can see the increase of weft yarns per inch after Enzyme wash. The highest percentage of PPI increase is obtained for sample S8 with the value of 5.45% and the lowest is seen for sample S7 with 0%. The average increase in PPI is 3.04%. From the table A4 in appendix we can see the increase of weft yarns per inch after Bleach wash. The highest percentage of PPI increase is obtained for sample S8 with the value of 5.45% and the lowest is seen for sample S7 with 0%. The average increase in PPI is 3.25%.

The increase rate of PPI after both Enzyme and Bleach Wash are pretty much the same.



**Fig.4.2:** Increase Rate of PPI after Enzyme & Bleach wash

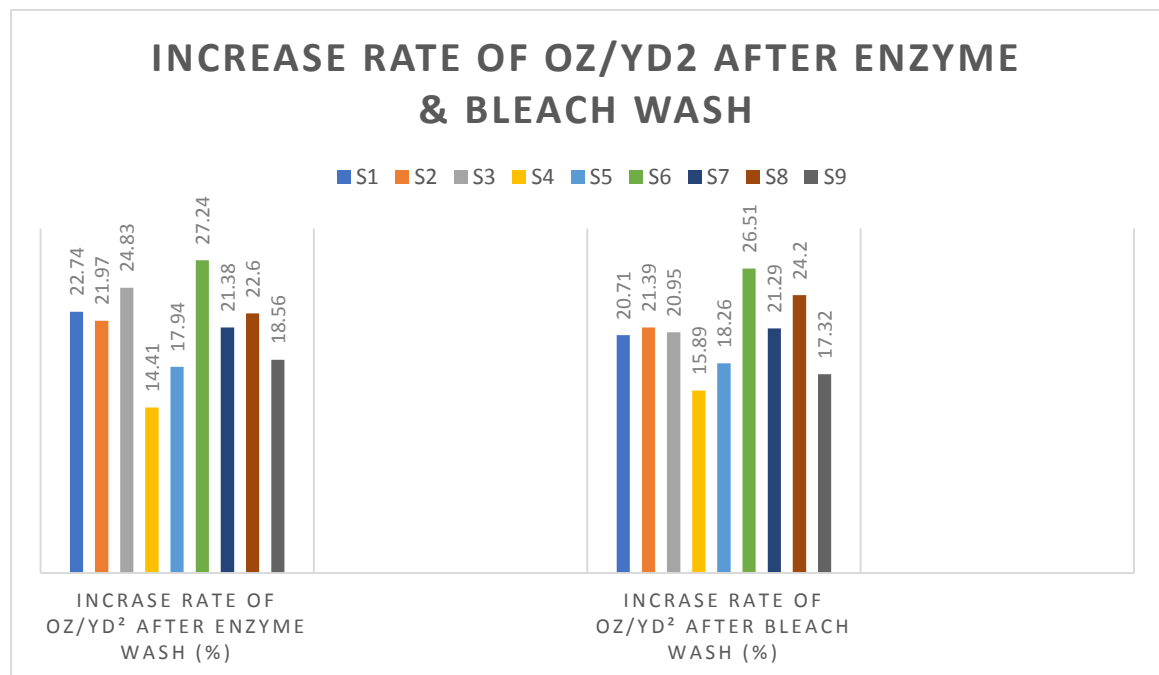
The figure 4.2 is a bar chart comparing the PPI increase rate after Enzyme and Bleach wash. In This Bar chart, all of the colors represent the individual samples.

From this chart, it is seen that the highest increase rate of PPI from the samples after Enzyme Wash is 5.45% and the lowest is 0%. But the highest rate of increase of the same samples after Bleach wash is 5.45% and the lowest is 0%. The average rate of increase in PPI after both washes are 3.04% and 3.25% respectively which proves to have similar effect after both of the washes.

### 4.3 Change in Oz/Yd<sup>2</sup> after Enzyme & Bleach Wash

The table A5 in appendix shows the weight before and after Enzyme wash in Oz/Yd<sup>2</sup>. The weight has increased after the wash in all the samples. The highest percentage of weight gained per Yd<sup>2</sup> is obtained for sample S6 with the value of 27.24% and the lowest is seen for sample S4 with 14.41%. The average increase in weight per Yd<sup>2</sup> is 21.3%.

The table A6 in appendix shows the weight before and after Bleach wash in Oz/Yd<sup>2</sup>. The weight has increased after the wash in all the samples. The highest percentage of weight gained per Yd<sup>2</sup> is obtained for sample S6 with the value of 26.51% and the lowest is seen for sample S4 with 15.89%. The average increase in weight per Yd<sup>2</sup> is 20.72%.



**Fig.4.3:** Increase Rate of Oz/Yd<sup>2</sup> after Enzyme & Bleach Wash

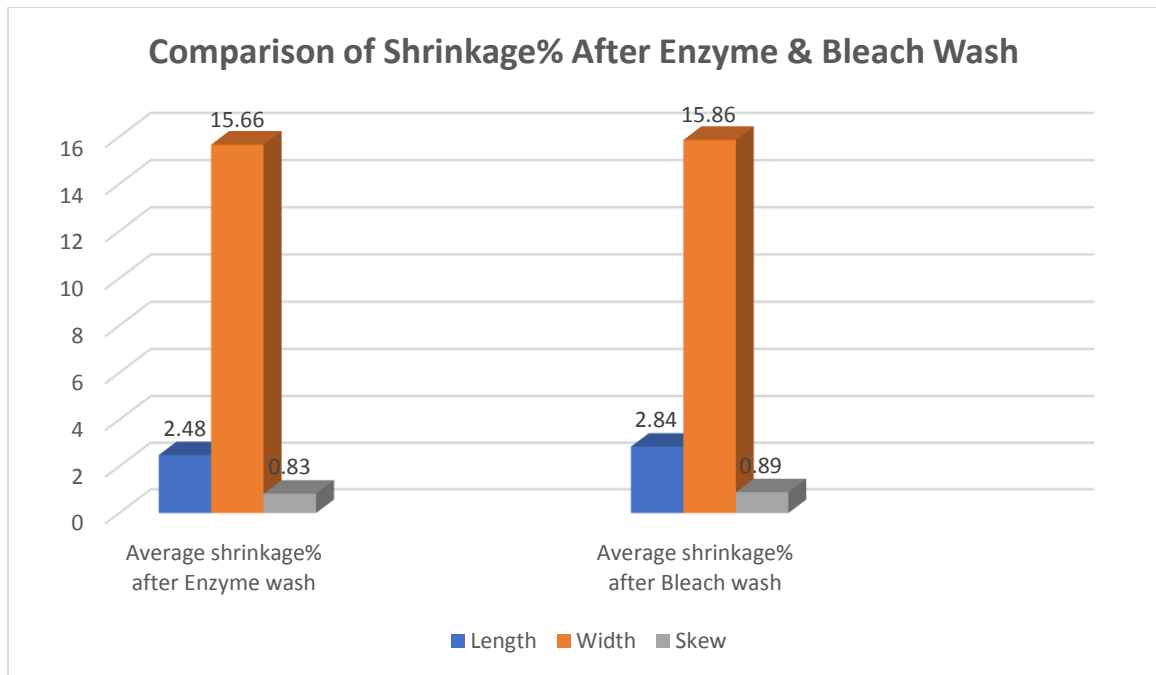
The figure 4.3 is a bar chart comparing the weight increase rate per Yd<sup>2</sup> after Enzyme and Bleach wash. In This Bar chart, all of the colors represent the individual samples.

From this chart, it is seen that the increase rate of weight after Enzyme wash averaging at 21.3% is very close to the increase rate of weight after Bleach wash averaging at 20.72%. So, it can be said that both Enzyme and Bleach wash has similar impact on weight gain per Yd<sup>2</sup>.

#### **4.4 Shrinkage% of Samples after Enzyme & Bleach Wash**

The table A7 in appendix shows three types of shrinkage% occurred for the samples after Enzyme wash. The second column shows the length shrinkage whereas the third and fourth column shows the width and skew shrinkage in percentage respectively. The highest percentage of length shrinkage is obtained for sample S8 with the value of -4.83% and the lowest is seen for sample S4 with -0.66%. The average length shrinkage is -2.48%. The highest percentage of width shrinkage is obtained for sample S6 with the value of -20.07% and the lowest is seen for sample S5 with -12.23%. The average width shrinkage is -15.66%. The average skew shrinkage is seen at -0.83%.

The table A8 in appendix shows three types of shrinkage% occurred for the samples after Bleach wash. The second column shows the length shrinkage whereas the third and fourth column shows the width and skew shrinkage in percentage respectively. The highest percentage of length shrinkage is obtained for sample S8 with the value of -5.5% and the lowest is seen for sample S4 with -1%. The average length shrinkage is -2.84%. The highest percentage of width shrinkage is obtained for sample S6 with the value of -22.02% and the lowest is seen for sample S5 with -12.76%. The average width shrinkage is -15.86%. The average skew shrinkage is seen at -0.89%.



**Fig.4.4:** Comparison of Shrinkage% After Enzyme & Bleach Wash

The figure 4.4 is a bar chart comparing the three types of shrinkage% after Enzyme and Bleach wash. In This Bar chart, the blue columns are for the length shrinkage whereas orange and grey are the width and skew shrinkage value in percentage respectively.

From this chart we can see that both washes have similar effects on the denim fabrics. But we can't overlook the fact that in both cases the width shrinkage is the highest among these three types of shrinkage averaging at 15.66% after Enzyme wash and 15.86% after Bleach Wash. To be more clear width shrinkage is more than 6 times higher than the length shrinkage which comes in second averaging at 2.48% after Enzyme wash and 2.84% after Bleach Wash. It is also around 17 times higher than the skew shrinkage averaging at 0.83% after Enzyme wash and 0.89% after Bleach Wash. This is the reason for high increase rate of EPI after both of the washes as the width shrinkage is much higher in denim than other types of shrinkage.



# **CHAPTER-5**

# **CONCLUSION**

## **CHAPTER-5**

### **CONCLUSION**

By doing this project we learned about different washing processes done in denim washing factories. We also learned about physical changes like EPI, PPI, weight and shrinkage% which occurs on denim after Enzyme and Bleach washes. After completing the survey, we have come to the following conclusions.

- ✚ The study shows that the increase rate of EPI averaging at 21.36% after both washes proves high rate of increase in EPI.
- ✚ The study also shows that the increase rate of PPI averaging at 3.15%% after both washes is much lower than the increase rate of EPI.
- ✚ Both of the washes show similar weight change with an average increase rate of Oz/Yd<sup>2</sup> of 21.01%.
- ✚ It is also found that denim tends to shrink more on width direction averaging at 15.76% rather than length averaging at 2.66% after these washes. This shrinkage is also the reason for weight change after washing.

The study would have been more informative if more samples of different construction were provided by the denim factory and more time was given by us for the study.

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## APPENDIX

**Table no A1:** EPI of the samples before & after Enzyme wash

Sample	EPI B/W	EPI A/W	Increasing %
S1	96	112	16.66
S2	88	104	18.18
S3	80	98	22.5
S4	76	96	26.32
S5	84	96	14.29
S6	84	108	28.57
S7	80	100	25
S8	88	104	18.18
S9	80	96	20

**Table no A2:** EPI of the samples before & after Bleach wash

Sample	EPI B/W	EPI A/W	Increasing %
S1	96	112	16.66
S2	88	104	18.18
S3	80	98	22.5
S4	76	96	26.32
S5	84	96	14.29
S6	84	108	28.57

S7	80	104	30
S8	88	104	18.18
S9	80	96	20

**Table no A3:** PPI of the samples before & after Enzyme wash

<b>Sample</b>	<b>PPI B/W</b>	<b>PPI A/W</b>	<b>Increasing %</b>
S1	56	59	5.36
S2	57	60	5.26
S3	53	55	3.77
S4	54	55	1.85
S5	57	58	1.75
S6	52	53	1.92
S7	53	53	0
S8	55	58	5.45
S9	51	52	1.96

**Table no A4:** PPI of the samples before & after Bleach wash

<b>Sample</b>	<b>PPI B/W</b>	<b>PPI A/W</b>	<b>Increasing %</b>
S1	56	59	5.36
S2	57	60	5.26
S3	53	55	3.77

S4	54	56	3.7
S5	57	58	1.75
S6	52	53	1.92
S7	53	53	0
S8	55	58	5.45
S9	51	52	1.96

**Table no A5:** Weight of the samples before & after Enzyme wash

Sample	Weight B/W	Weight A/W	Weight Gain %
S1	9.85	12.09	22.74
S2	10.33	12.6	21.97
S3	9.02	11.26	24.83
S4	9.44	10.8	14.41
S5	9.53	11.24	17.94
S6	10.94	13.92	27.24
S7	11.74	14.25	21.38
S8	9.38	11.5	22.6
S9	9.7	11.5	18.56

**Table no A6:** Weight of the samples before & after Bleach wash

Sample	Weight B/W	Weight A/W	Weight Gain %
S1	9.85	11.89	20.71

S2	10.33	12.54	21.39
S3	9.02	10.91	20.95
S4	9.44	10.94	15.89
S5	9.53	11.27	18.26
S6	10.94	13.84	26.51
S7	11.74	14.24	21.29
S8	9.38	11.65	24.2
S9	9.7	11.38	17.32

**Table no A7:** Shrinkage% of the samples after Enzyme wash

<b>Sample</b>	<b>Length Shrinkage (%)</b>	<b>Width Shrinkage (%)</b>	<b>Skew Shrinkage (%)</b>
S1	-3.16	-14.17	0
S2	-3.33	-14.17	+2
S3	-3	-15.51	-1.5
S4	-0.66	-18.18	-4
S5	-2.5	-12.23	-2
S6	-1	-20.07	+2
S7	-1.16	-18.13	-2
S8	-4.83	-13.62	-2
S9	-2.66	-14.83	0



**Table no A8:** Shrinkage% of the samples after Bleach wash

<b>Sample</b>	<b>Length Shrinkage (%)</b>	<b>Width Shrinkage (%)</b>	<b>Skew Shrinkage (%)</b>
S1	-3.33	-14.17	0
S2	-4	-13.98	+2
S3	-3	-14.01	-1
S4	-1	-16	-3
S5	-3.16	-12.76	-2
S6	-1.16	-22.02	+2
S7	-1.83	-19.62	0
S8	-5.5	-14.65	-4
S9	-2.66	-15.5	-2

## Garments washing

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