Report on:
‘‘Investigation on changes of physical properties of various types of denim fabric by different types of wash’’

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Advance in Apparel Manufacturing Technology.

December, 2019

PROCLAMATION

We hereby announce that; this thesis is fully made by us**.** We are declaring that neither this thesis nor any part of this thesis has been submitted elsewhere for award of any degree or diploma.

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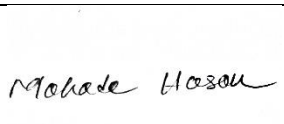
Mahade Hasan	161-23-4581	

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APPROVAL SHEET

This project is named **''Investigation on changes of physical properties of various types of denim fabric by different types of wash'' at Daffodil International University, November 2019''** prepared and submitted by **Md. Asif Jaman; 161-23-4544 & Mahade Hasan; 161-23-4581** in partial fulfillment of the requirement for the degree of **Bachelor of Science in Textile Engineering** has been examined and hereby recommended for approval and acceptance.

Md. Abdullah Al Mamun

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ACKNOWLEDGEMENTS

This is our humble freedom to submit this thesis report titled **''Investigation on changes of physical properties of various types of denim fabric by different types of wash''**. We are expressing our sincere thankfulness to **Md. Abdullah Al Mamun, Assistant Professor, Department of Textile Engineering, Daffodil International University** for supervising this project, leading the actual path and allowing us countless freedom to finish the task. Any kind of mistake is done are entirely our responsibility.

We are also thankful to the management of Ananta Denim Technology for allowed us the access to their washing plant and helping us to collect the materials which are needed and also allowed perform tests.

DEDICATION

We dedicate this project to our beloved and respected Parents who give us unlimited support, love and care in our life and gave us the chance to make carrier in Textile Engineering.

We also dedicate this work to all garments workers who working very hard for their livelihood and provide a huge contribution in our textile sectors.

ABSTRACT

Garments washing are very useful for modifying garments especially which is made by denim fabric. By doing wash we can change the appearance, outlook and comfortability. 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. On the other-hand bleach wash and acid wash also very much effective on denim fabric. Bleaching is done by strong oxidization agent and make the garments blue light shade and acid wash is done for irregular fading in garments. This paper presents the impact of acid, enzyme and bleach wash on various types cotton denim. The physical and mechanical properties of the tested denims were analyzed using standard test methods. The properties that were analyzed ***include tear strength, tensile strength, and shrinkage percentage and fabric weight variation before and after wash. And also found that, maximum denim fabric after wash tensile and tear strength increases on the contrary after washing fabric shrinks. The weight of the fabric after wash increased slightly.***

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1. INTRODUCTION

Denim is a type of cotton twill textile, in which the weft passes under two or more warp threads. Warp threads of denim fabric are dyed in indigo while weft threads remain plain white. That is why denim is blue on the one side and white on the other. When used for jeans, denim is turned blue on the outside and because of the way it is made it fades in a characteristic way. It has been used in America since the late 18th century, colored blue with indigo dye to make blue "jeans", a type of cotton pants. In the 1800s, in the time of the Gold Rush, American gold miners needed clothes that were strong, lasted longer and did not tear easily. Levi Strauss, a businessman, and Jacob Davis, a tailor, supplied miners with denim pants that were made from durable material and reinforced with rivets at the places where pants tended to tear which prolonged life of pants. This marked the beginning of the legend of jeans and brand Levi Strauss is still hugely successful today.

The jeans which was made by denim using indigo vat was very stiff and uncomfortable because of the finishing process used in denim fabric. The customers who bought this product took home and made them soften by washing several times. Today denim garments are very often found by pre washing. This process makes a revolution in the denim sector. Pre washed denim has slightly faded appearance, good hand feels and comfortable.

In 1978 garments washing became very popular to the consumers due to its several washing effect on denim garments. When a garments made by denim fabric then it goes to washing Different types of washing methods are applied and it also depends on the product nature and usage.

1.1 Backdrop

We are very much attracted to denim fabric because at the beginning of the course we are very much curious about denim washing. Different types of look, wash out effect on denim, new style invention pushes us to the denim washing. By changing the washing recipe and techniques there can be produce a new style and look of denim garments.

1.2 Purposes of this project

1) To know the different washing techniques.

2) To understand the different types of washing effect.

3) To identify the difference between washed and non-washed garments.

4) To explore the change of physical properties of garments.

5) To know about different washing chemicals and parameters which are used in acid, enzyme and bleach wash.

1.3 Project area:

In this project we will find the changes of physical properties of denim fabric by using acid, bleach and enzyme wash. We will investigate the changes of physical properties such as tear strength, tensile strength and shrinkage percentage variation before and after wash in both warp and weft direction.

1.4 Restriction of this project:

It is our first experience in this type of working area. Maximum procedure is new to us. When we making this project by doing several test it was very hard to cooperate with lab technicians due to the industrial task. They were busy to handle buyer provided test but they also tried to find some times to helping us for complete the test report. For this reason, we can't find all technical knowledge from them.

2. LITERATURE REVIEW:

This project is related to denim washing (acid, enzyme and bleach). To understand the physical properties which is change before and after washing. The main difference area will be carry out for tensile strength, tear strength and shrinkage percentage. We have decided to choose various wash to find out the various result. In past there were many experiment have done. To find the maximum effect and less damaging the fabric nowadays rubber balls are using instead of stone.

2.1 Previous work:

In December 2015 Sezan Ahmmed ID: 121-23-2931, SK. Mahmud Hasan ID: 121-23-2936 and Gazi Mohiuddin Alamgir ID: 121-23-2943 made a project which is investigation on the different properties changes of denim by enzyme wash. This study is only carried out by enzyme wash. They had taken 3 sample fabric sample A, B and C which are 6, 10 and 13 oz/sq.yd. After treating with enzyme wash they have found shrinkage change before and after wash. The results are: sample A, B and C = 3.7%. 4% and 3.5% warp wise and 2.5%, 2% and 2.7% weft wise. For tensile strength: sample A, B and C= 22%, 12% and 14% warp wise and 25%, 19% and 15% weft wise.

Another report was produced on the defects caused by washing and their remedies of denim garments. This report was produced by Avijit Ghosh Id: 133-23-3654 and Kulsum Akter 133-23-3631. On this work they have found different types of fault and the percentage of faults are:

Fabric damage 3%, after wash hole 6%, bleach spot 10%, PP spot 13%, stain mark 9%, crease mark 20% and shade variation 38%

2.2 Related Knowledge:

2.2.1 All about denim fabric:

Denim is a strong cotton fabric made using a twill weave, which creates a subtle diagonal ribbing pattern. The cotton twill fabric is warp-facing, meaning that the weft threads go under two or more warp threads, and the warp yarns are more prominent on the right side. The diagonal ribbing is what makes denim fabric different from canvas or cotton duck, which is also a sturdy woven cotton fabric.

How is denim made:

When cotton fibers are harvested they are prepared for spun into yarn. After yarns are made then they are dyed often by indigo dye to making their color blue for identifying as denim. The denim which are made by shuttle loom is known as selvedge denim. The weft yarns are insert through the warp yarns. By using this method, a smooth selvedge can be found. On the other hand, denim fabric can be produced by projectile loom. In this method single weft thread is for every row and edge needs to lock by sewing.

Most of the time Indigo dye is used for denim because indigo make a good bond with cotton fabric and most of the cases different types of dirt are not visible due to its darker shade.

Different types of denim:

Stretch Denim: In this type of denim spandex is used for stretching and more flexibility. To produce skinny type of jeans, stretch denim is used.

Crushed denim: This type of denim is produced to look like wrinkle effect.

Indigo denim: Most of the denim fabric is dyed by indigo dye. The warp yarns of fabric dyed by indigo and weft yarns remain white. So the denim fabric looks like blue because warp yarns are visible in the upper side.

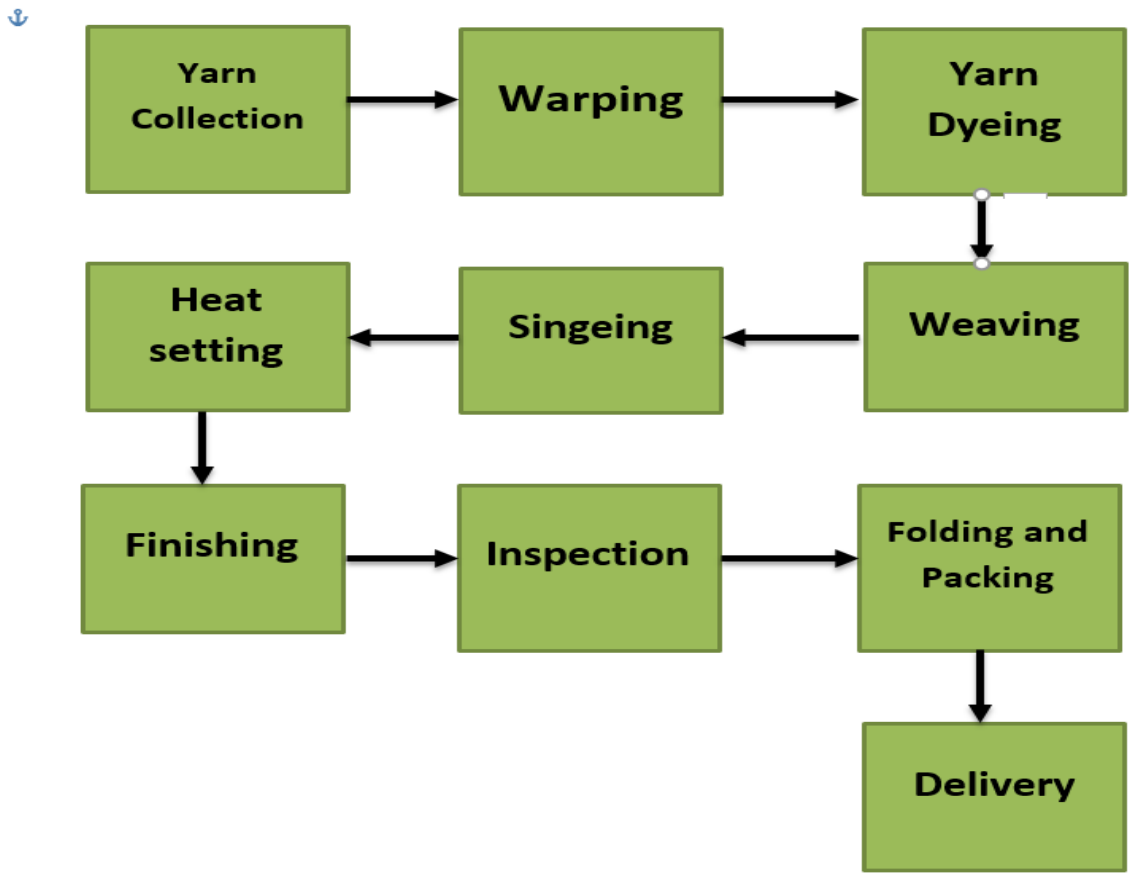
Raw denim: This type of denim is not washed after dyeing. It exerts the raw look of the garments.

Whole process of manufacturing denim:

First of all, yarn is produced in a spinning factory. Then warping is done so that yarns of related length can be collect on a single beam. After that yarns are ready for dyeing. In this process only warp yarns are dyed. Then weaving is done by warp and weft yarn. Different types of weaving structure can be done such as twill, broken twill etc. Then singeing is done.

Equalization done to control the shrinkage percentage of fabric. After that finishing is done. Finally, it goes for inspection. After that folding and packing is done. At last delivery goods to the buyer.

Flow chart of producing woven fabric:



2.2.2 Washing:

The process or method which is used to modify the outlook, appearance and the comfortability of garments is known as washing. Garments are being washed so that it can be made useable and comfortable to all consumers. Denim washing can be two types. Mechanical and chemical washes are mostly used in the washing plant.

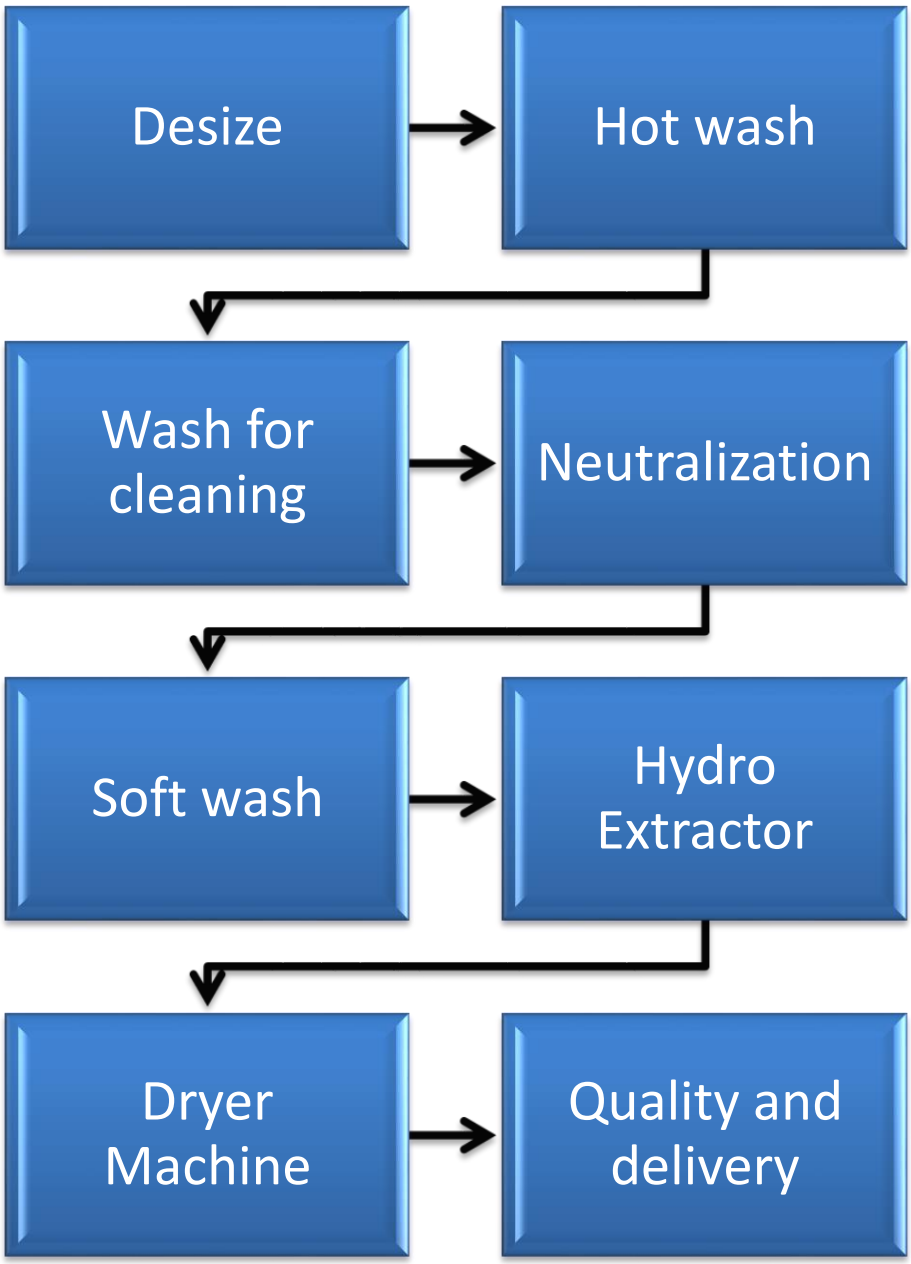
Reasons of garments washing:

- By washing we can remove size materials from the garments.
- To make a new look of the garments.
- Foreign buyers want their denim jeans should be old look, by washing garments we can produce faded or old looking garments.
- Once washing is done to a garments then there will be no possibility for further shrinkage.
- After washing we can change the garments color by using tint. So that it can be more attractive to the buyer.
- If there any kind of simple spot and dirt occurs in the garments it can be easily removed by washing.

2.2.3 Acid wash:

Nowadays acid wash is more popular because its irregular fading effect. There are many kind of washing methods which is not as like as acid wash or random wash because its fading effect. We can wash easily the heavy garments like thick denim, canvas and twill. In acid wash pumic stones can be used for irregular fading. There produces high low area on the garments. Where the stones brush the garments more fading effect can be seen and where the stones brush less the garments less fading effect seen. In this process collar, cuff, pocket etc. area is brushed more and produces more fading effect.

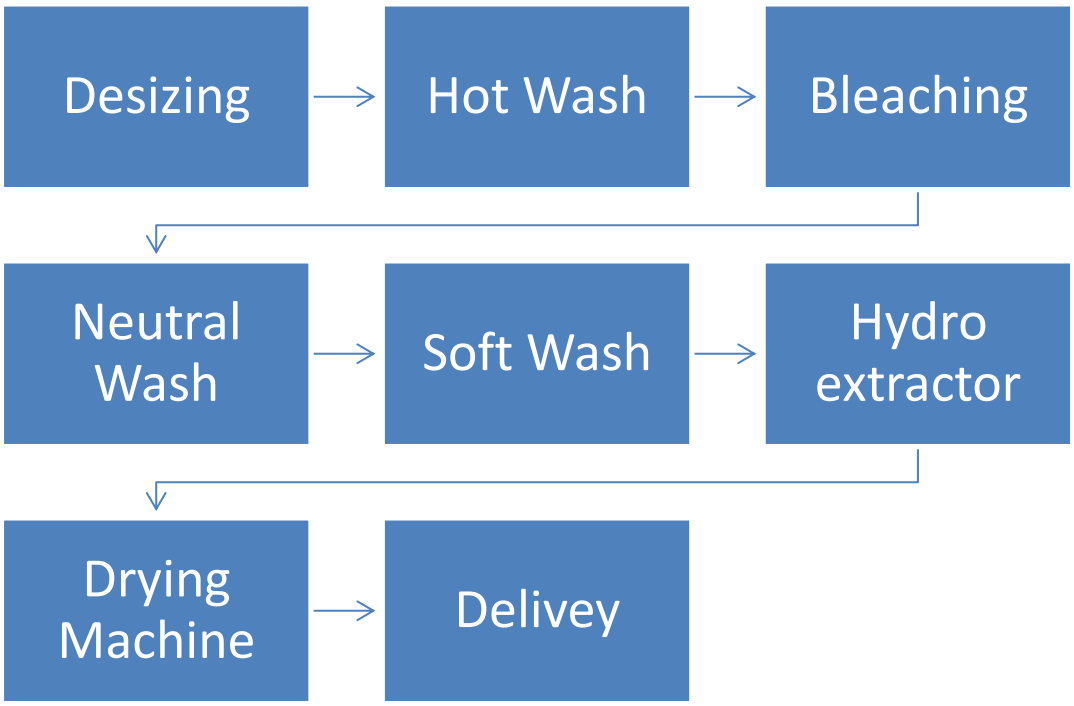
Flow chart of acid wash process:



2.2.4 Bleach Wash

Bleach wash also a popular washing method in washing plant. Bleach wash done by bleaching agent which is a chemical form added during washing. Sodium hypo chlorite, calcium hypo chlorite and Hydrogen peroxide is used as bleach wash. During bleach wash it can remove color from the garments very fast makes the garments whiten by oxidation method. By this process a raw denim can be turned into light blue shade.

Process flowchart of bleach wash:

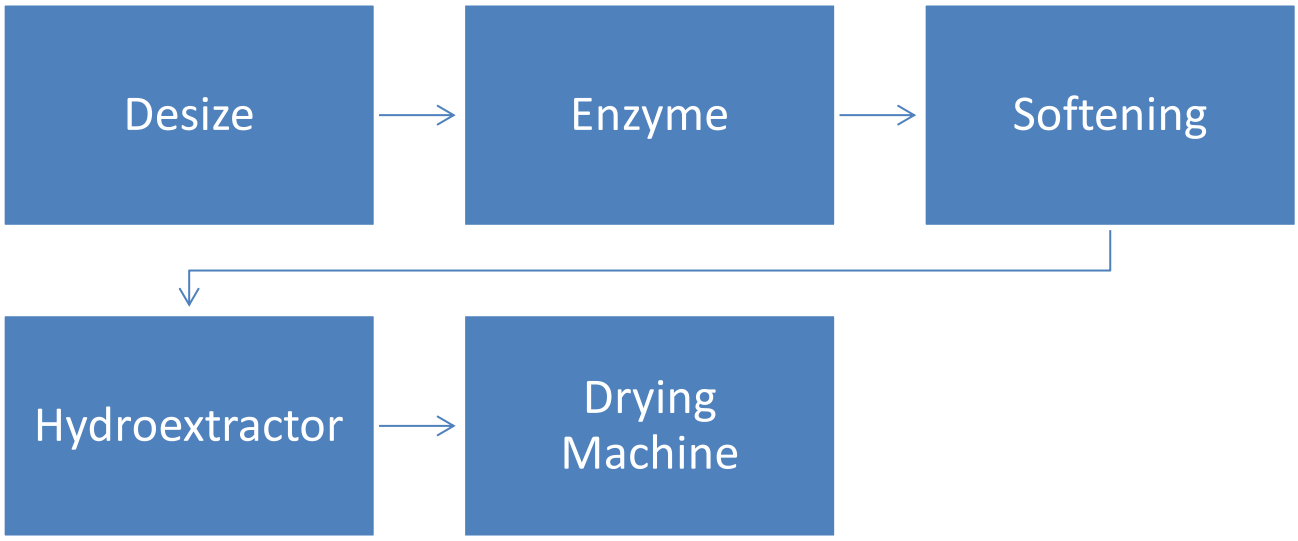


2.2.5 Enzyme Wash:

Enzyme is a substance which act as like catalyst in washing process. It is now very much attractive to the buyer because it is environment friendly. There is no toxic elements in enzyme wash and it is totally biodegradable. During enzyme wash pumic stones can be used. There is two types of enzymes acid enzyme and neutral enzyme. Cid enzyme can be found in liquid form. On the other hand, neutral enzyme can be found in powder or liquid form.

During enzyme wash enzyme hydrolyses the cellulose by attacking protruding fibers. After that it attacks yarn parts and by attacking yarn portion it gradually hydrolyse it to produce fading effect.

Process flow chart of Enzyme wash:



2.3 An overview on physical properties of denim:

2.3.1 Fabric Shrinkage:

Dimensional change means the increase or decrease of denim fabric in the length wise or width wise. The fabric with good dimensional stability can be use and wash many times. Shrinkage occurs when fabric with poor dimensional stability occurs. It can be done during washing. When a fabric with poor dimensional stability send for washing it can be shrunk after washing.

When a fabric became smaller than its original size then it is known as shrinkage. Most of the cotton fabric undergo by shrinkage problem. Shrinkage and crease problems are most common problem of the cotton fabric. Shrinkage also occurs in warp wise and weft wise of a woven fabric.

Factors affecting of shrinkage:

1) Moisture absorption
2) The tightness of yarn not direct cause of shrinkage but indirectly responsible for shrinkage.
3) Tension of the fabric.
4) Temperature.
5) Different types of raw materials.

Shrinkage can be calculated:

$$\text{Shrinkage\%} = \frac{(\text{Before wash length}) - (\text{After wash length})}{(\text{Before wash length})} \times 100$$

2.3.2 Tensile strength

Tensile strength is very important physical properties of a fabric. Tensile strength is measurement force per cross sectional area. The strength of fabric depends on its molecular structure, composition of material. Tensile strength of a sample is determining the behavior of a sample when it is remaining under axial load. Generally tensile test is used for woven fabric. Warp way tensile strength and weft way tensile strength can be determined separately. The test method is very simple. The test specimen is extended until it breaks for both (warp and weft).

Tensile strength test is two types

1) Strip test
2) Grab test

Strip test:

1) Five fabric samples are extended in a direction parallel to the warp and five parallel to the weft
2) Samples are clamp between two jaws.
3) Downward forces are applied until the specimen breaks.
4) Finally, average is calculated.

Considering Points:

1) Jaw size should be full width.
2) Precise 2-inch width of sample is maintained.
3) If any breakage occurs within 0.25 inch from any jaw the result must be cancel.

Grab Test:

1) First take a sample of 6×4 inch. No of samples: 5+5=10
2) Then the sample is indicated by pencil at 1.5 inch.
3) Then fix the specimen between the jaws.
4) Both jaws are not fixed. One of them is moveable.
5) Then the moveable jaws begin to move outward till the sample is broken.

Considering Point:

1) Breaking time should be 20±3 sec.
2) Gauge length: 1st jaw to 2nd jaw length must be maintaining 3 inch.
3) Must be one jaw should be fixed.

2.3.3 Tear strength:

Tear strength is the average force required to continue a tear in the fabric which is previously started. Elmendorf tear is used for determining the tear strength. In this machine samples are clamped between two jaws. One of them is fixed and another is moveable. When the pendulum moves then the moveable jaws also moves and tear the sample. The pointer attached to the pendulum which is graduated to read the tearing force directly. By this method we can determine the tear strength of woven fabric. Another tear testing method is known as Hydraulic Bursting Tester and this test method is used for only knit fabric.

2.3.4 Color fastness to wash:

Colorfastness can be defined as how much color of a dyed fabric can be retained after washing. There are many fabrics which can hold color after washing. Among of them denim is most popular for color fastness. The resistance to the loss of dye or color of dyed fabric to wash is known as wash fastness. On the contrary dye particles is not fixed into the fabric then poor wash fastness occurs.

There are many standard methods for colorfastness to wash. Color fastness to wash can be determined in grey scale.

3. METHODOLOGY:

3.1 Raw material:

The research paper is done with the help of different types of denim fabrics. We collected our desired denim fabric from the garments factory of store section. We collected denim fabric with different weight and different construction. The quantity of sample is 5 pieces. Due to the lack of some test equipment we did not perform the tests of all basic specification but we collected the information from store which was given by supplier.

3.2 Fabric weight test:

We all know denim is a woven fabric and the length calculation remain in yard and to express thin and thick area of fabric ounce is used. After collecting the samples, we measure the weight of each sample before wash.

Instruments: 1) GSM cutter 2) Weight balance

Procedure: At first we cut sample fabric with GSM cutter. We collect cut swatch from every sample pieces with the help of GSM cutter. The diameter of the GSM cutter was 11.2. Then we take the weight of each cut swatches with the help of digital weight balance. Then we found weight value in gm. After that we multiplied the weight value by 100 ti find the GSM. At last we converted the GSM value in oz./sq. yards.

Oz/square yards = $\frac{\textbf{sample GSM}}{\textbf{33.9}}$

By following this method, we took every samples individual GSM and also calculated the weight in oz/sq. yards.

Report:

Sample No	Fabric Specification	oz/sq.yards.
1	Ref: 3426-A 99% cotton and 1% spandex	14
2	Ref: 1223-XP 82% cotton ,17% polyester and 1% spandex	13
3	Ref: 422A 99% cotton and 1% spandex	12
4	Ref: 10041 98.5% cotton and 1.5% spandex	11
5	Ref: FD73ST6 99% cotton and 1% spandex	10

Table: 3.1: Fabric Specification and weight

3.3 Preparation for washing:

Before washing we made leg panels by stitching. We have taken 50×50 cm samples from each collected fabric for tear and tensile strength test and then again taken 50×50 cm samples from each fabric for shrinkage test. For shrinkage test we locked the edge of cut sample by sewing. We collected all samples like this process for individual wash.

3.4 Acid Wash:

3.4.1 Process and recipe:

Desizing:

Dispersol Max (desizing agent) 50gm

Supralase 1200l 50 gm (anti back staining agent) 50gm

Time: 10 min

Temp: 45° c

Rinse wash for two times.

Acid wash:

Potash 30 gm with stone.

Water 1 litre,

Time : 7 min and temp: 30°c

Neutral wash:

Sodium meta bisulphite 200gm

Time: 5 minute with cold temperature.

Softening:

Softener (Eps con 4040) 50gm

Time: 5 min, temp normal.

Hydro extractor machine:

It is used to reduce water from the fabric.

Time: 5 min

Dryer:

At last the fabric samples sent to dryer machine.

Time: 29 min

Temp: 65-75˚c

3.5 Bleach Wash:

3.5.1 Process and recipe:

Desizing:

Dispersol Max (desizing agent) 50gm

Supralase 1200l 50 gm (anti back staining agent) 50gm

Time: 10 min

Temp: 45˚c

Rinse wash for two times.

Bleach wash:

KCI bleach for blue light shade 800gm

Time: 2-3 min

Temp: 60˚c

Neutral wash:

Sodium meta bisulphite 200gm

Time: 3 min, Temp: normal

Softening:

Softener (Eps con 4040) 50gm

Time: 5 min, temp normal

Hydro extractor machine:

It is used to reduce water from the fabric.

Time: 5 min

Dryer:

At last the fabric samples sent to dryer machine.

Time: 29 min

Temp: 65-75˚c

3.6 Enzyme wash:

3.6.1 Process and recipe:

Desizing:

Dispersol Max (desizing agent) 50gm

Supralase 1200l 50 gm (anti back staining agent) 50gm

Time: 10 min

Temp: 45˚c

Rinse wash for two times.

Enzyme with stone washing:

Lava Cell NHC cold (Enzyme) 500gm

Dispersol Max (desizing agent) 300gm

Temp: 45˚c

Time: 15-20 minute

Softening:

Softener (Eps con 4040) 50gm

Time: 5 min, temp normal

Hydro extractor machine:

It is used to reduce water from the fabric.

Time: 5 min

Dryer:

At last the fabric samples sent to dryer machine.

Time: 29 min

Temp: 65-75˚c

3.7 Experiment details:

3.7.1 Shrinkage test:

For shrinkage test we have followed ISO 3759 method. From each fabric sample we have collected 50×50 cm for individual wash and secured the sample edge area by sewing.

Apparatus needed for this test are:

1) Shrinkage rule (Model M223C1)
2) Stability shrinkage template
3) Measuring tape
4) Scissors and
5) Permanent marker.

Figure 3. 1: Stability shrinkage template and shrinkage ruler

Working steps:

At first we put the samples (50×50 cm) collected from fabric on a table. Then using stability shrinkage template, we marked six areas on each sample with the help of permanent marker. We marked every sample by this process and send them for different types of wash (acid, enzyme and bleach).

Assessment:

After washing of all samples have completed then we collected samples to measure warp and weft length. We have measured each fabric samples for 3 times. We marked six area of a sample and took measurement from upper area, middle area and lower area distance for both warp and weft. By using shrinkage ruler, we found the shrinkage or stretch percentage value. For example:

$$\text{Shrinkage\%} = \frac{(\text{Before wash length}) - (\text{After wash length})}{(\text{Before wash length})} \times 100$$

= (50-48.5) / 50× 100

=3%

Shrinkage test report (Enzyme Wash):

Fabric Specification	Shrinkage before Enzyme Wash (cm) (Warp)	shrinkage after Enzyme Wash (cm) (Warp)	Shrinkage Percentage (%) (Warp)	Shrinkage before Enzyme Wash (cm) (Weft)	Shrinkage after Enzyme Wash (cm) (Weft)	Shrinkage Percentage (%) (Weft)
Ref: 3426-A 99% cotton and 1% spandex Oz/sq.yds = 14	50	48.5	3%	50	44.5	11%
Ref: 1223-XP 82% cotton ,17% polyester and 1% spandex Oz/sq.yds = 13	50	49.25	1.5%	50	42.5	15%
Ref: 422A 99% cotton and 1% spandex Oz/sq.yds = 12	50	48	4%	50	44.75	10.5%
Ref: 10041 98.5% cotton and 1.5% spandex Oz/sq.yds = 11	50	49.25	1.5%	50	44.25	11.5%
Ref: FD73ST6 99% cotton and 1% spandex Oz/sq.yds = 10	50	42.35	15.35%	50	48.75	2.5%

Table: 3. 2: Shrinkage test report before and after wash (Enzyme)

Shrinkage test report (Acid Wash):

Fabric Specification	Shrinkage before Acid Wash (cm) (Warp)	shrinkage after Acid Wash (cm) (Warp)	Shrinkage Percentage (%) (Warp)	Shrinkage before Acid Wash (cm) (Weft)	Shrinkage after Acid Wash (cm) (Weft)	Shrinkage Percentage (%) (Weft)
Ref: 3426-A 99% cotton and 1% spandex Oz/sq.yds = 14	50	48.5	3%	50	45.25	9.5%
Ref: 1223-XP 82% cotton ,17% polyester and 1% spandex Oz/sq.yds = 13	50	46.75	6.5%	50	44.5	11%
Ref: 422A 99% cotton and 1% spandex Oz/sq.yds = 12	50	48.75	2.5%	50	44.75	10.5%
Ref: 10041 98.5% cotton and 1.5% spandex Oz/sq.yds = 11	50	47.5	5%	50	45.25	9.5%
Ref: FD73ST6 99% cotton and 1% spandex Oz/sq.yds = 10	50	43	14%	50	49	2%

Table: 3. 3: Shrinkage test report before and after wash (Acid)

Shrinkage test report (Bleach Wash):

Fabric Specification	Shrinkage before Bleach Wash (cm) (Warp)	shrinkage after Bleach Wash (cm) (Warp)	Shrinkage Percentage (%) (cm) (Warp)	Shrinkage before Bleach Wash (cm) (Weft)	Shrinkage after Bleach Wash (cm) (Weft)	Shrinkage Percentage (%) (cm) (Weft)
Ref: 3426-A 99% cotton and 1% spandex Oz/sq.yds = 14	50	48.5	3%	50	45.25	9.5%
Ref: 1223-XP 82% cotton ,17% polyester and 1% spandex Oz/sq.yds = 13	50	49	2%	50	43	14%
Ref: 422A 99% cotton and 1% spandex Oz/sq.yds = 12	50	48.75	2.5%	50	44.75	10.5%
Ref: 10041 98.5% cotton and 1.5% spandex Oz/sq.yds = 11	50	48	4%	50	44.25	11.5%
Ref: FD73ST6 99% cotton and 1% spandex Oz/sq.yds = 10	50	43	14%	50	48.75	2.5%

Table: 3. 4: Shrinkage test report before and after wash (Bleach)

3.7.2 Fabric weight variation test:

Procedure: After washing we again calculate the sample weight in oz/sq.yards which is also described in 3.3. The main differences are given below:

Enzyme Wash:

Sample No	Fabric Specification	BeforeWash oz/sq.yards.	After wash oz/sq.yards.	Gain%
1	Ref: 3426-A 99% cotton and 1% spandex	14	14.23	1.6%
2	Ref: 1223-XP 82% cotton ,17% polyester and 1% spandex	13	13.36	2.7%
3	Ref: 422A 99% cotton and 1% spandex	12	12.10	0.8%
4	Ref: 10041 98.5% cotton and 1.5% spandex	11	11.33	2.6%
5	Ref: FD73ST6 99% cotton and 1% spandex	10	10.18	1.7%

Table: 3. 5: Fabric weight variation before and after enzyme wash.

Acid Wash:

Sample No	Fabric Specification	BeforeWash oz/sq.yards.	After wash oz/sq.yards.	Gain%
1	Ref: 3426-A 99% cotton and 1% spandex	14	14.32	2.0%
2	Ref: 1223-XP 82% cotton ,17% polyester and 1% spandex	13	13.25	1.7%
3	Ref: 422A 99% cotton and 1% spandex	12	12.50	4%
4	Ref: 10041 98.5% cotton and 1.5% spandex	11	11.42	3.5%
5	Ref: FD73ST6 99% cotton and 1% spandex	10	10.11	1%

Table: 3. 6: Fabric weight variation before and after acid wash.

Bleach Wash:

Sample No	Fabric Specification	BeforeWash oz/sq.yards.	After wash oz/sq.yards.	Gain%
1	Ref: 3426-A 99% cotton and 1% spandex	14	14.67	4%
2	Ref: 1223-XP 82% cotton ,17% polyester and 1% spandex	13	13.22	1.5%
3	Ref: 422A 99% cotton and 1% spandex	12	12.09	0.7%
4	Ref: 10041 98.5% cotton and 1.5% spandex	11	11.39	3.4%
5	Ref: FD73ST6 99% cotton and 1% spandex	10	10.55	5%

Table: 3. 7: Fabric weight variation before and after bleach wash.

3.7.3 Tensile strength test:

Tensile strength test is carried out by following ASTM D5034-09 method.

Preparation for test:

After washing the leg panel is open by scissor. Then sample is cut from 2 inch from the distance of selvedge. Then we took 3 specimens from sample by using template which size is 10×15 cm. from both warp and weft direction. We took the samples from raw fabric which indicates before wash and also took sample from after wash.

Apparatus:

1) Grab test machine (James Heal).
2) Scissors.
3) ASTM D5034-09 template.

Working Procedure:

At first we prepared a false sample from another fabric which size is 10×15 cm. Then we clamped the false sample between two jaws. One of them is moveable. Then upward jaw is moved until the sample is completely break down. After that we removed false sample and put the specimen of before wash fabric between jaws. Then again upward jaws move until the specimen breaks. After breakage of specimen a reading was taken. Then average value is calculated. By following the same way, we took war and weft breaking and elongation strength reading.

Figure 3. 2: Grab Tester

Report:

Tensile Strength test report (Enzyme Wash):

Fabric Specification	Tensile strength before wash (Enzyme Wash) Max force (Kgf) (Warp)	Tensile strength after wash (Enzyme Wash) Max force (Kgf) (Warp)	Tensile strength before wash (Enzyme Wash) Max force (Kgf) (Weft)	Tensile strength after wash (Enzyme Wash) Max force (Kgf) (Weft)
Ref: 3426-A 99% cotton and 1% spandex Oz/sq.yds= 14	Max force: 89	Max force:47	Max force: 53	Max force: 38
Ref: 1223-XP 82% cotton ,17% polyester and 1% spandex Oz/sq.yds = 13	Max force: 88	Max force:43	Max force: 52	Max force:30
Ref: 422A 99% cotton and 1% spandex Oz/sq.yds = 12	Max force: 78	Max force:47	Max force: 43	Max force:43
Ref: 10041 98.5% cotton and 1.5% spandex Oz/sq.yds = 11	Max force: 60	Max force:46	Max force: 39	Max force:22
Ref: FD73ST6 99% cotton and 1% spandex Oz/sq.yds = 10	Max force: 80	Max force:31	Max force: 53	Max force:30

Table: 3. 8: Tensile strength variation before and after enzyme wash.

Tensile Strength test report (Acid Wash)

Fabric Specification	Tensile strength before wash (Acid Wash) Max force (Kgf) (Warp)	Tensile strength after wash (Acid Wash) Max force (Kgf) (Warp)	Tensile strength before wash (Acid Wash) Max force (Kgf) (Weft)	Tensile strength after wash (Acid Wash) Max force (Kgf) (Weft)
Ref: 3426-A 99% cotton and 1% spandex Oz/sq.yds= 14	Max force: 89	Max force:86	Max force: 53	Max force:48
Ref: 1223-XP 82% cotton ,17% polyester and 1% spandex Oz/sq.yds = 13	Max force: 88	Max force:77	Max force: 52	Max force:49
Ref: 422A 99% cotton and 1% spandex Oz/sq.yds = 12	Max force: 78	Max force:76	Max force: 43	Max force:39
Ref: 10041 98.5% cotton and 1.5% spandex Oz/sq.yds = 11	Max force: 60	Max force:54	Max force: 39	Max force:33
Ref: FD73ST6 99% cotton and 1% spandex Oz/sq.yds = 10	Max force: 80	Max force:56	Max force: 31	Max force:27

Table: 3. 9: Tensile strength variation before and after Acid wash.

Tensile Strength test report (Bleach Wash)

Fabric Specification	Tensile strength before wash (Bleach Wash) Max force (Kgf) (Warp)	Tensile strength after wash (Bleach Wash) Max force (Kgf) (Warp)	Tensile strength before wash (Bleach Wash) Max force (Kgf) (Weft)	Tensile strength after wash (Bleach Wash) Max force (Kgf) (Weft)
Ref: 3426-A 99% cotton and 1% spandex Oz/sq.yds= 14	Max force: 89	Max force:68	Max force: 53	Max force:36
Ref: 1223-XP 82% cotton ,17% polyester and 1% spandex Oz/sq.yds = 13	Max force: 88	Max force:64	Max force: 52	Max force:28
Ref: 422A 99% cotton and 1% spandex Oz/sq.yds = 12	Max force: 78	Max force:44	Max force: 43	Max force:22
Ref: 10041 98.5% cotton and 1.5% spandex Oz/sq.yds = 11	Max force: 60	Max force:37	Max force: 39	Max force:20
Ref: FD73ST6 99% cotton and 1% spandex Oz/sq.yds = 10	Max force: 80	Max force:31	Max force: 31	Max force:18

Table: 3. 10: Tensile strength variation before and after Bleach wash.

3.7.4 Tear strength test:

We have completed tear strength test by following ASTM D1424:09 methods.

Apparatus:

1) Elma Tear (James Heal).
2) ASTM D1424:09 template (for cutting specimen. 6×10 cm).
3) Scissor.

Sample preparation: At first we cut 3 specimens from each sample (Before wash and after wash) according to the templates of ASTM D1424:09. The specimens size is 6×10 cm collected from both warp and weft. Then proceed to the test.

Working Procedure:

1. Samples are clamped into two jaws and place a 20mm cut in the sample for warp and weft.
2. Set the pointer to the starting position which is attached to the pendulum.
3. Then depressing the pendulum and allow it to swing properly for one cycle. Pendulum weight is 64N.
4. A reading is taken from the screen.
5. Repeat the process for all other specimen.

Figure 3. 3: Elma Tear

Result:

Tear Strength test report (Enzyme Wash):

Fabric Specification	Tear strength before wash (Enzyme Wash) Tear force (gf) (Warp)	Tear strength after wash (Enzyme Wash) Tear force (gf) (Warp)	Tear strength before wash (Enzyme Wash) Tear force (gf) (Weft)	Tear strength after wash (Enzyme Wash) Tear force (gf) (Weft)
Ref: 3426-A 99% cotton and 1% spandex Oz = 13.26	6465	5567	3962	3206
Ref: 1223-XP 82% cotton ,17% polyester and 1% spandex Oz = 12.5	6716	6200	6144	2791
Ref: 422A 99% cotton and 1% spandex Oz = 12	6597	6090	5289	4143
Ref: 10041 98.5% cotton and 1.5% spandex Oz = 11	4670	4334	3919	3216
Ref: FD73ST6 99% cotton and 1% spandex Oz = 10	5731	4038	2488	2514

Table: 3. 11: Tear strength variation before and after enzyme wash.

Tear Strength test report (Acid Wash):

Fabric Specification	Tear strength before wash (Acid Wash) Tear force (gf) (Warp)	Tear strength after wash (Acid Wash) Tear force (gf) (Warp)	Tear strength before wash (Acid Wash) Tear force (gf) (Weft)	Tear strength after wash (Acid Wash) Tear force (gf) (Weft)
Ref: 3426-A 99% cotton and 1% spandex Oz = 13.26	6465	6449	3962	4000
Ref: 1223-XP 82% cotton ,17% polyester and 1% spandex Oz = 12.5	6716	6677	6144	5809
Ref: 422A 99% cotton and 1% spandex Oz = 12	6597	6553	5289	4883
Ref: 10041 98.5% cotton and 1.5% spandex Oz = 11	4670	4528	3919	3918
Ref: FD73ST6 99% cotton and 1% spandex Oz = 10	5731	5471	2488	2427

Table: 3. 12: Tear strength variation before and after acid wash.

Tear Strength test report (Bleach Wash):

Fabric Specification	Tear strength before wash (Bleach Wash) Tear force (gf) (Warp)	Tear strength after wash (Bleach Wash) Tear force (gf) (Warp)	Tear strength before wash (Bleach Wash) Tear force (gf) (Weft)	Tear strength after wash (Bleach Wash) Tear force (gf) (Weft)
Ref: 3426-A 99% cotton and 1% spandex Oz = 13.26	6465	3722	3962	3000
Ref: 1223-XP 82% cotton ,17% polyester and 1% spandex Oz = 12.5	6716	4883	6144	5458
Ref: 422A 99% cotton and 1% spandex Oz = 12	6597	4369	5289	3263
Ref: 10041 98.5% cotton and 1.5% spandex Oz = 11	4670	2840	3919	2828
Ref: FD73ST6 99% cotton and 1% spandex Oz = 10	5731	3531	2488	1819

Table: 3. 13: Tear strength variation before and after bleach wash.

3.8 Sample attachment:

Figure 3. 4: Before and after enzyme wash (Sample 1)

Figure 3. 5: Before and after enzyme wash (Sample 2)

Figure 3. 6: Before and after enzyme wash (Sample 3)

Figure 3. 7: Before and after enzyme wash (Sample 4)

Figure 3. 8: Before and after enzyme wash (Sample 5)

Figure 3. 9: Before and after acid wash (Sample 1)

Figure 3. 10: Before and after acid wash (Sample 2)

Figure 3. 11: Before and after acid wash (Sample 3)

Figure 3. 12: Before and after acid wash (Sample 4)

Figure 3. 13: Before and after acid wash (Sample 5)

Figure 3. 14: Before and after bleach wash (Sample 1)

Figure 3. 15: Before and after bleach wash (Sample 2)

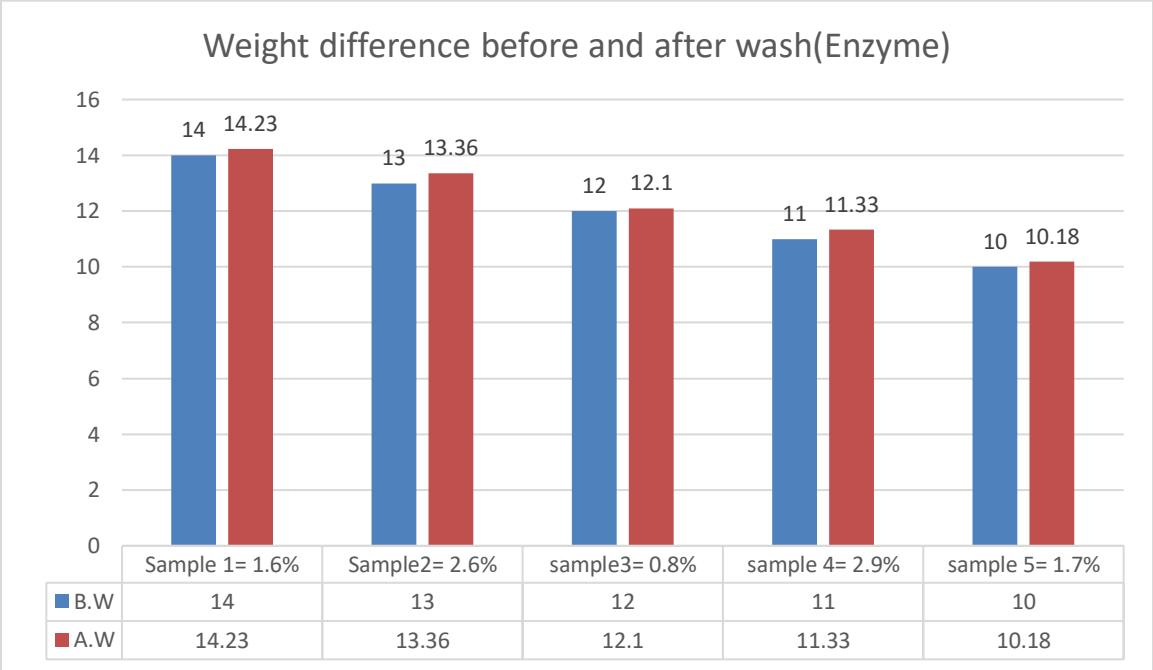
Figure 3. 16: Before and after bleach wash (Sample 3)

Figure 3. 17: Before and after bleach wash (Sample 4)

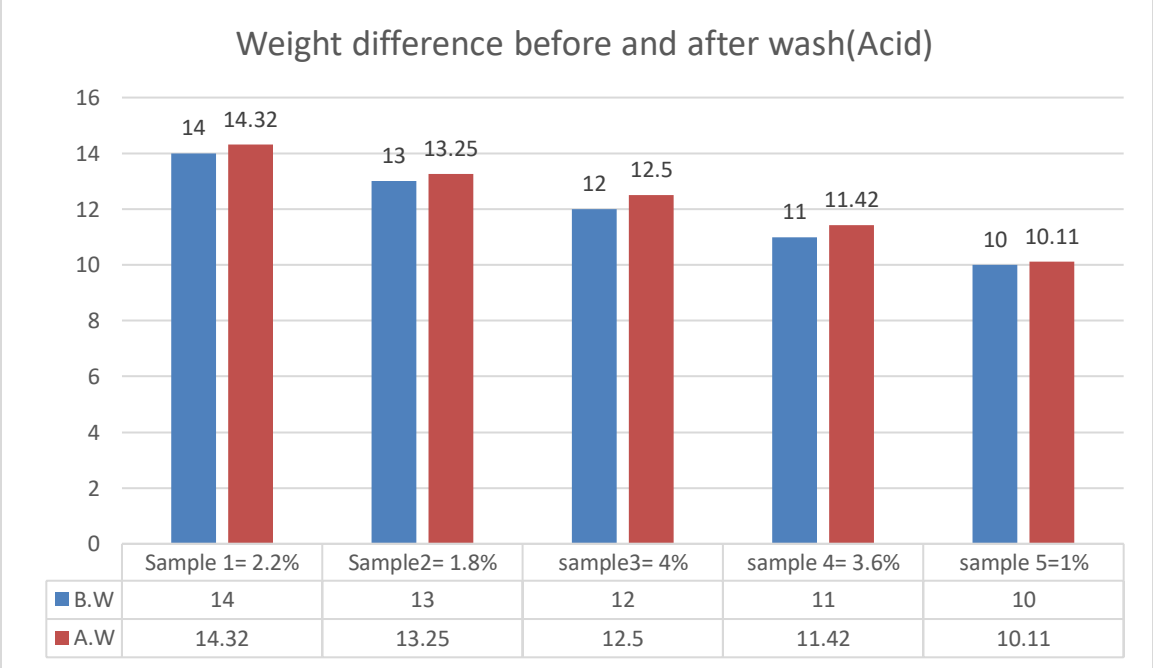
Figure 3. 18: Before and after bleach wash (Sample 5)

4. DISCUSSION OF RESULTS:

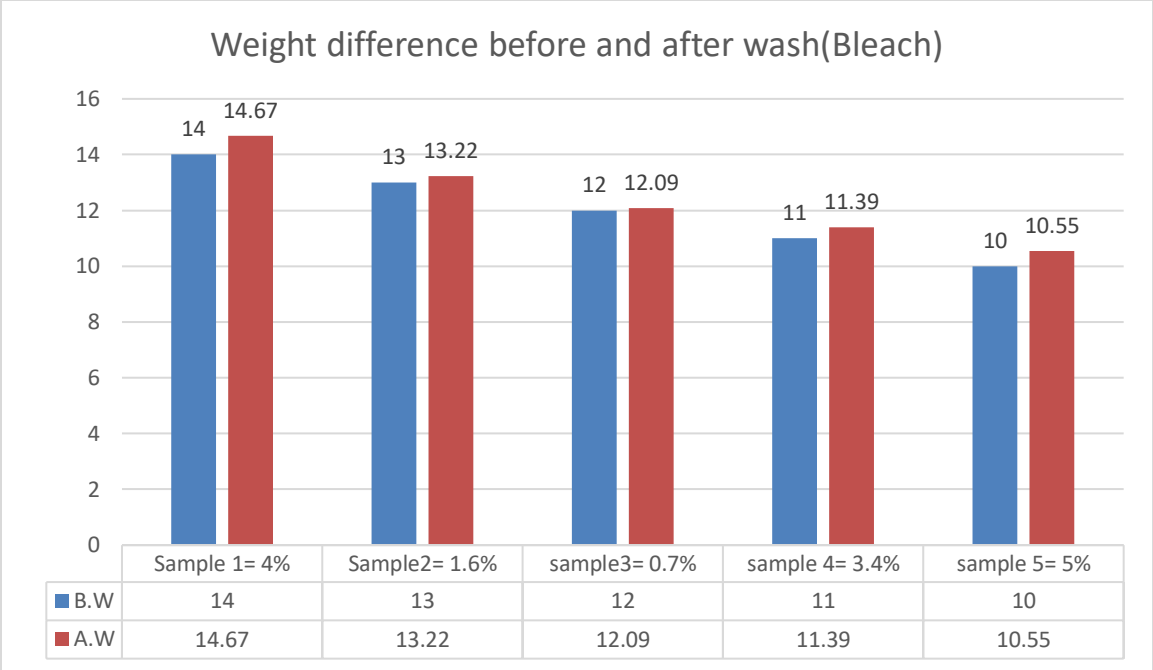
4.1 Fabric weight variation:



Graph: 4. 1: Weight difference before and after wash (Enzyme)



Graph: 4. 2: Weight difference before and after wash (Acid)

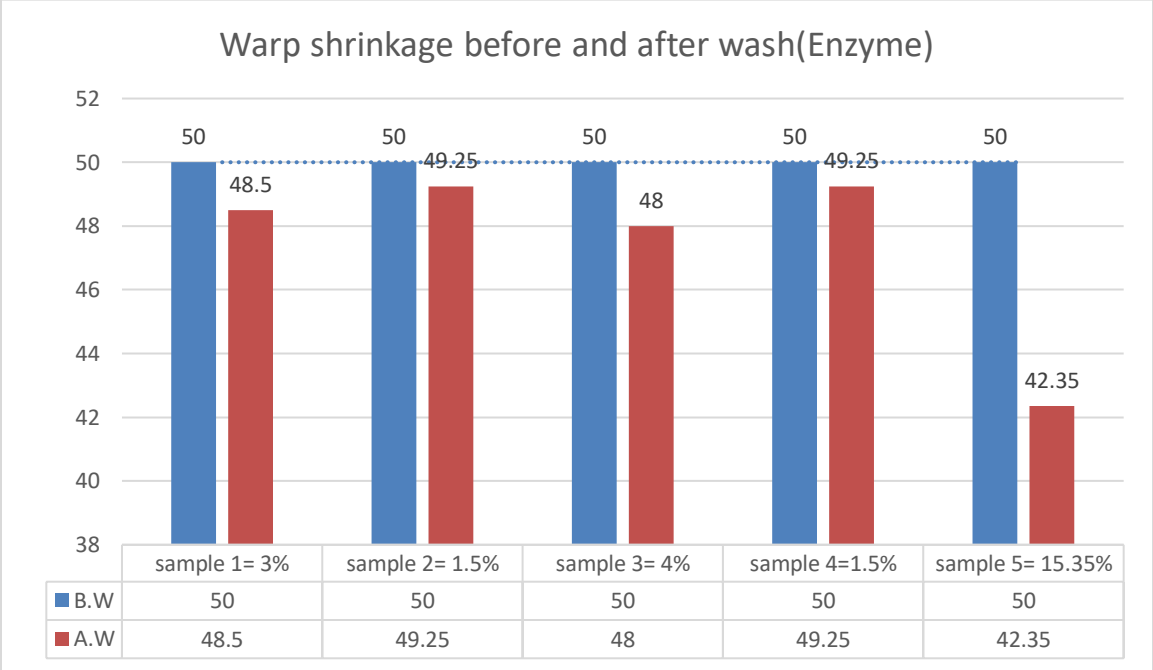


Graph: 4. 3: Weight difference before and after wash (Bleach)

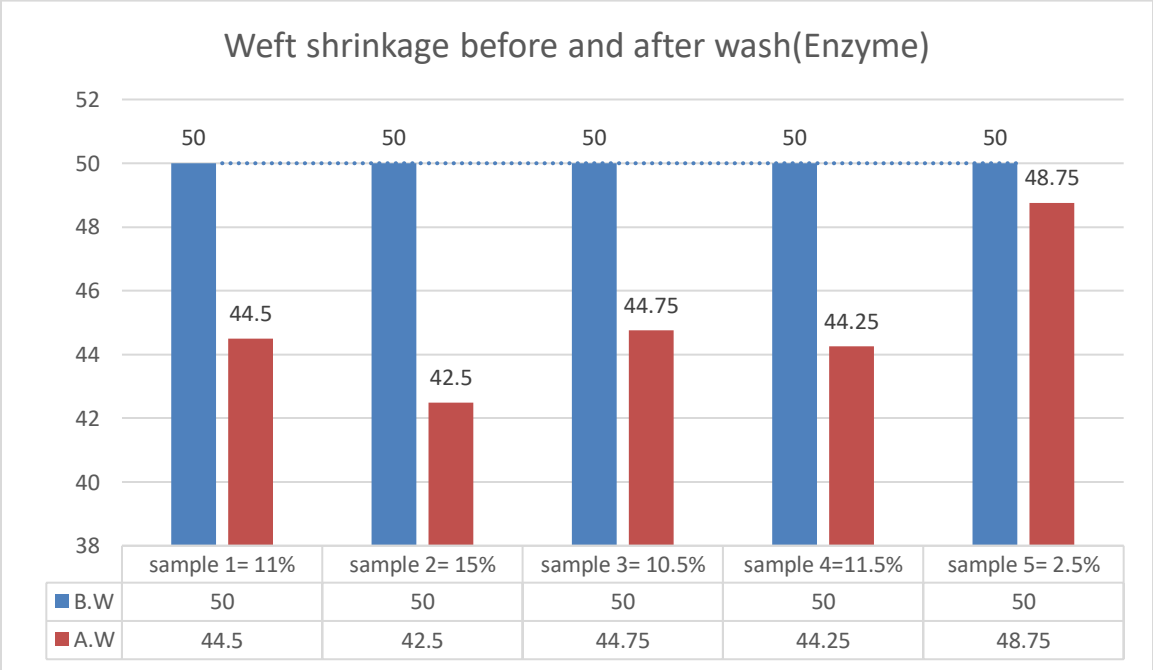
Discussion:

Though all the washing process brings faded effect by removing dyes it can be said that weight of fabric should be decrease but here we found that every sample fabric weight after washing increased very slightly. In this case the main reason of increasing weight is washing fabrics with different types of chemical. Here chemical weight may be added and shrinkage of fabric may be a reason of increasing weight of fabric

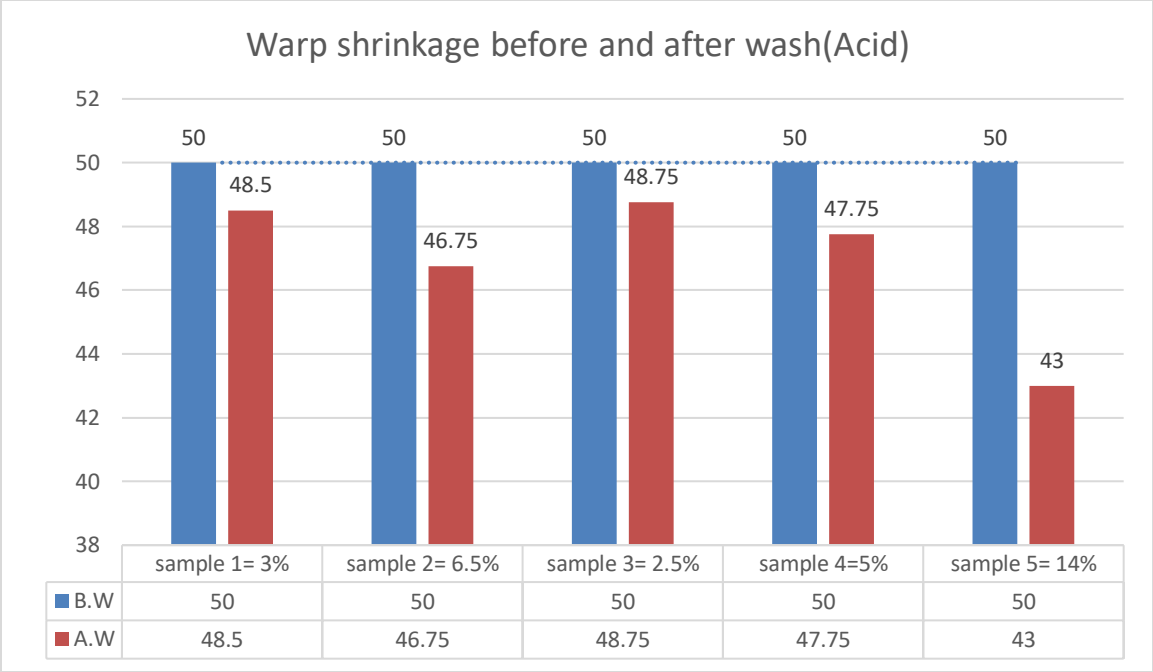
4.2 Changes in fabric dimension:



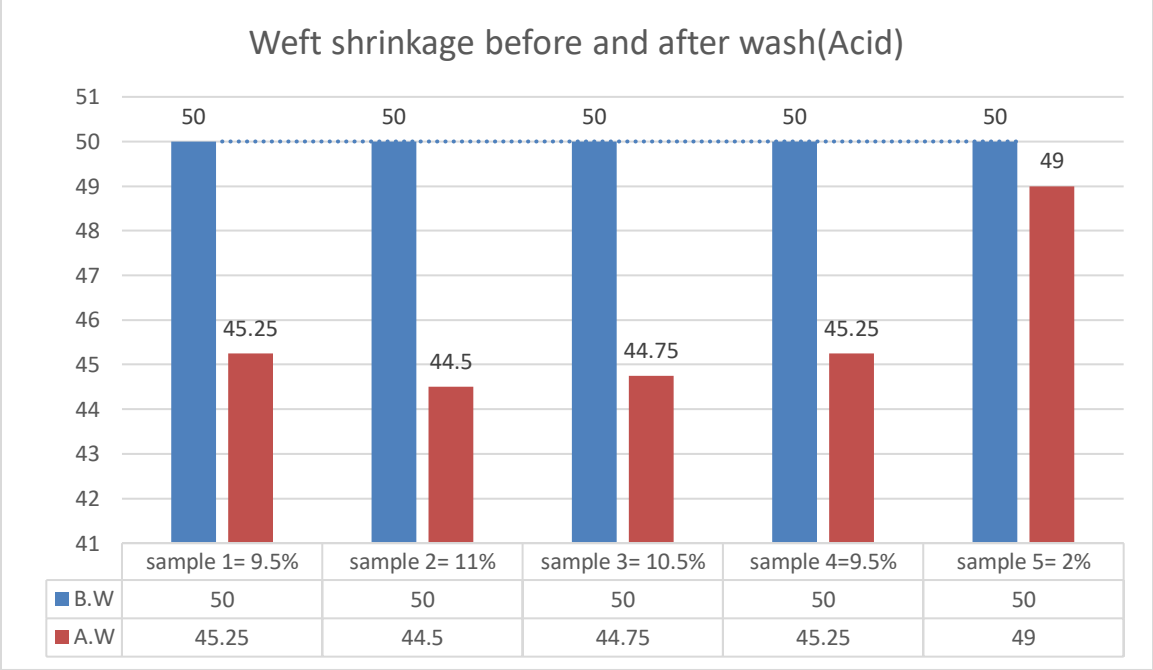
Graph: 4. 4: Warp shrinkage before and after wash (Enzyme)



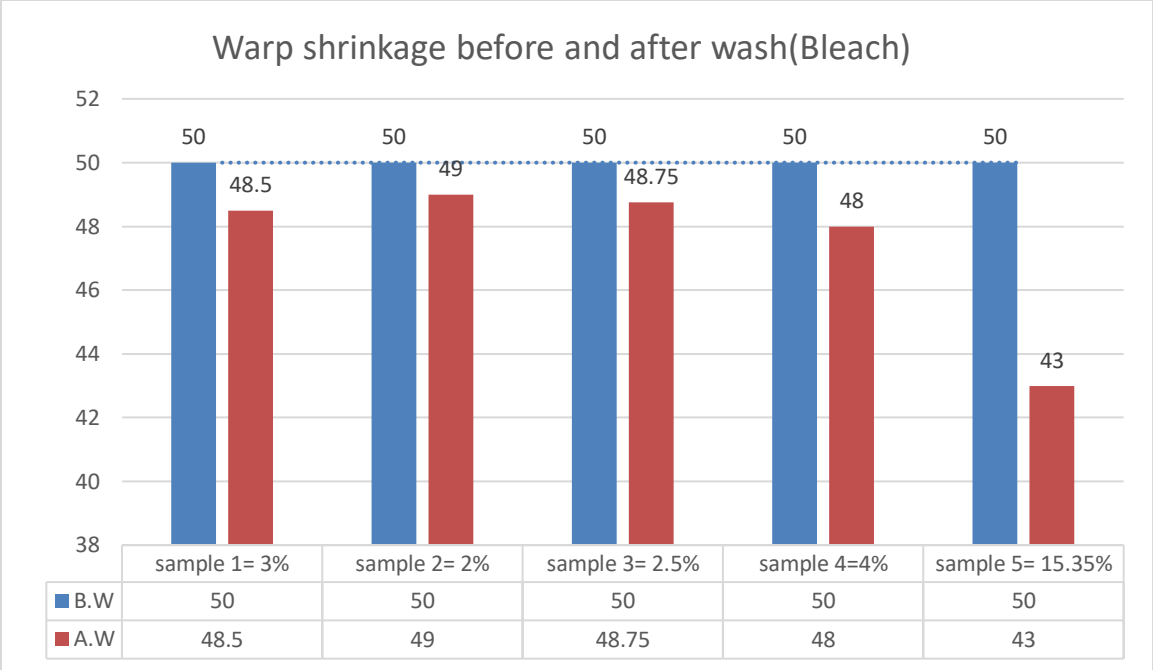
Graph: 4. 5: Weft shrinkage before and after wash (Enzyme)



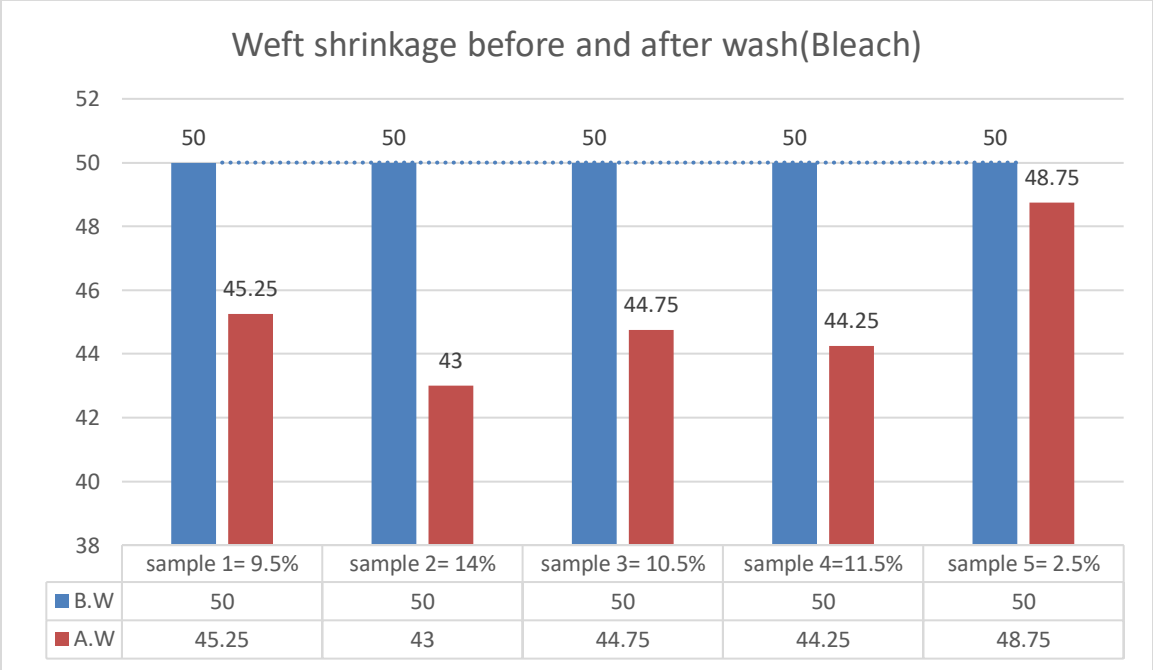
Graph: 4. 6: Warp shrinkage before and after wash (Acid)



Graph: 4. 7: Weft shrinkage before and after wash (Acid)



Graph: 4. 8: Warp shrinkage before and after wash (Bleach)



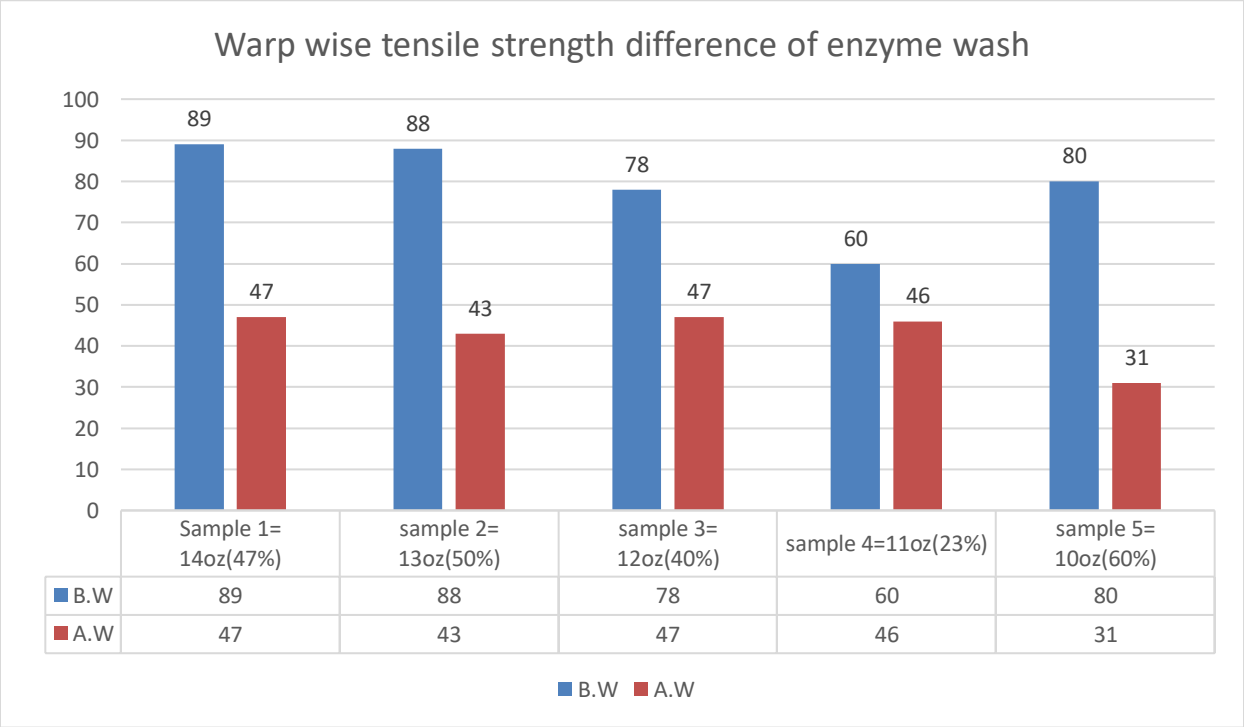
Graph: 4. 9: Weft shrinkage before and after wash (Bleach)

Discussion:

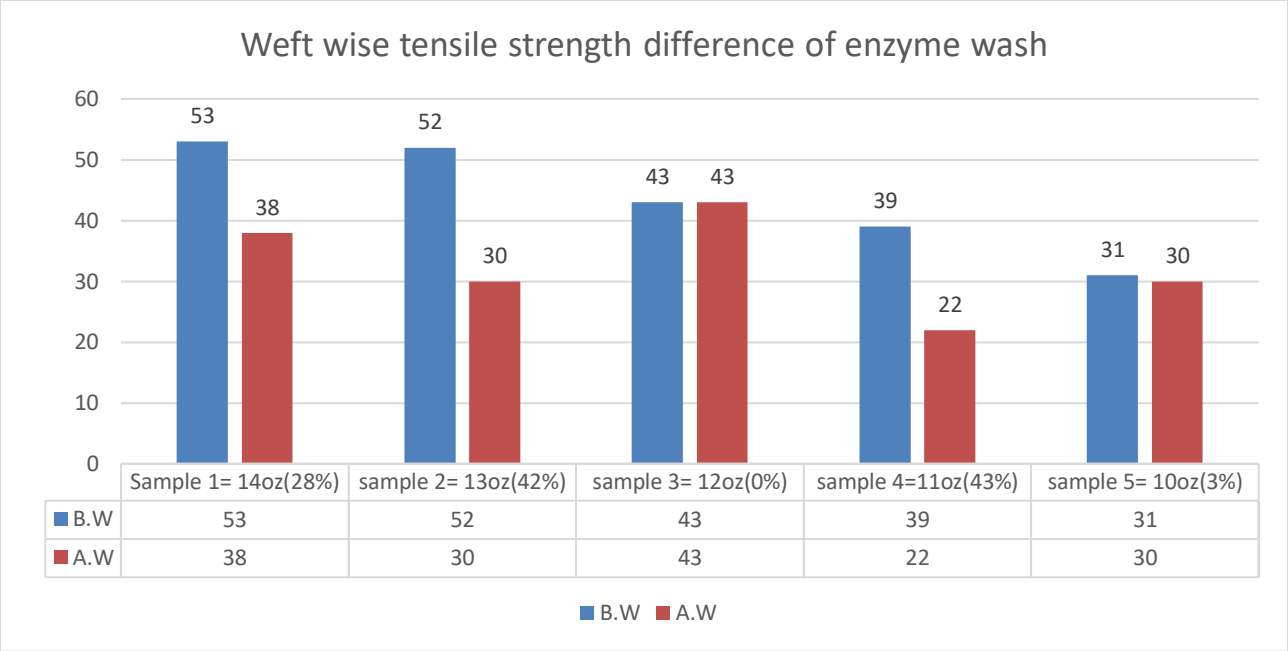
By analyzing all the charts, we can see that weft shrinkage percentage is more than warp shrinkage percentage except sample 5. But most of the cases weft wise shrinkage is always more than warp wise. Because spandex percentage was given in the weft wise yarn that's why after washing its shrinks more than warp yarn. In sample 5 spandex percentage was given in warp yarn more than the weft yarn that's why warp wise shrinkage was more than the weft wise.

4.3 Difference in Tensile strength:

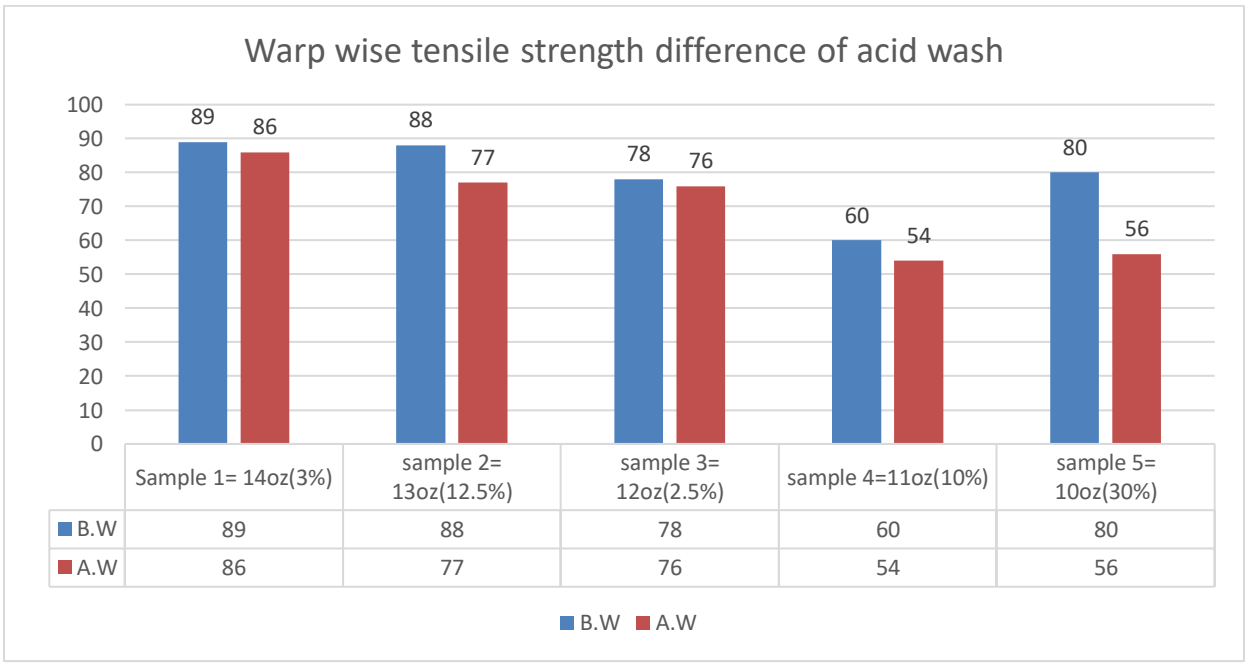
During tensile test we took 3 specimens from each fabric sample and make an average value to find tensile strength before and after wash for warp and weft both. There is graphical representation of table 08,09 and 10 shown below:



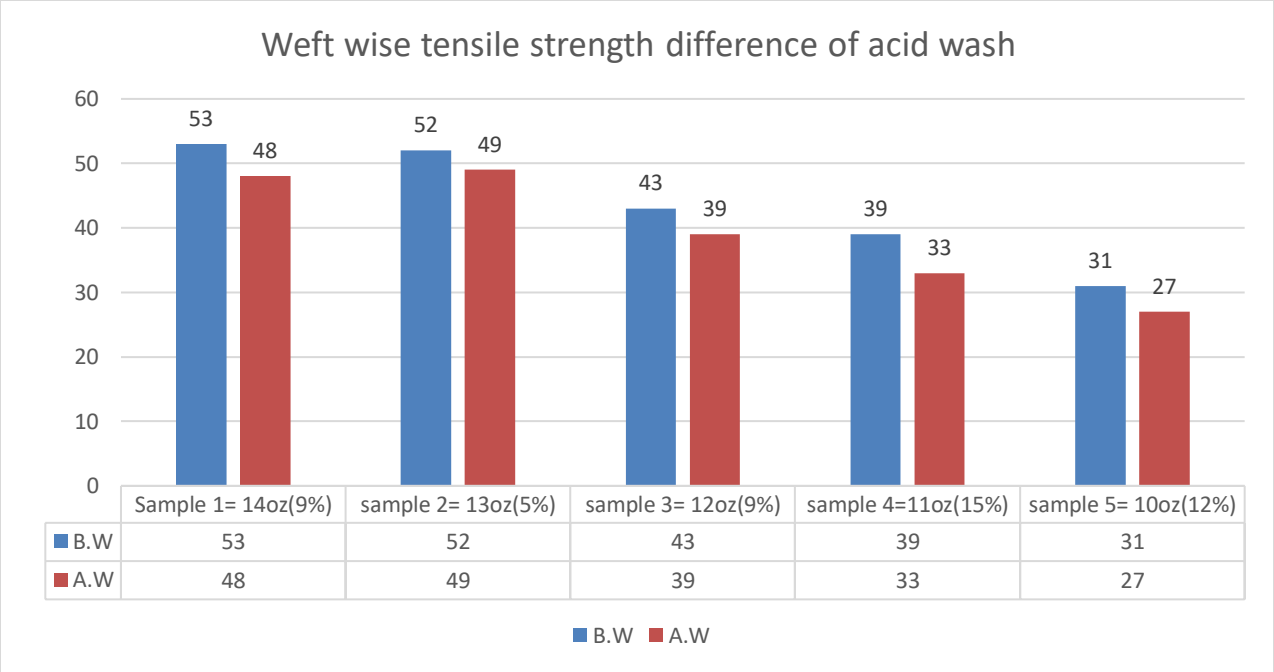
Graph: 4. 10: Warp wise tensile strength difference of enzyme wash



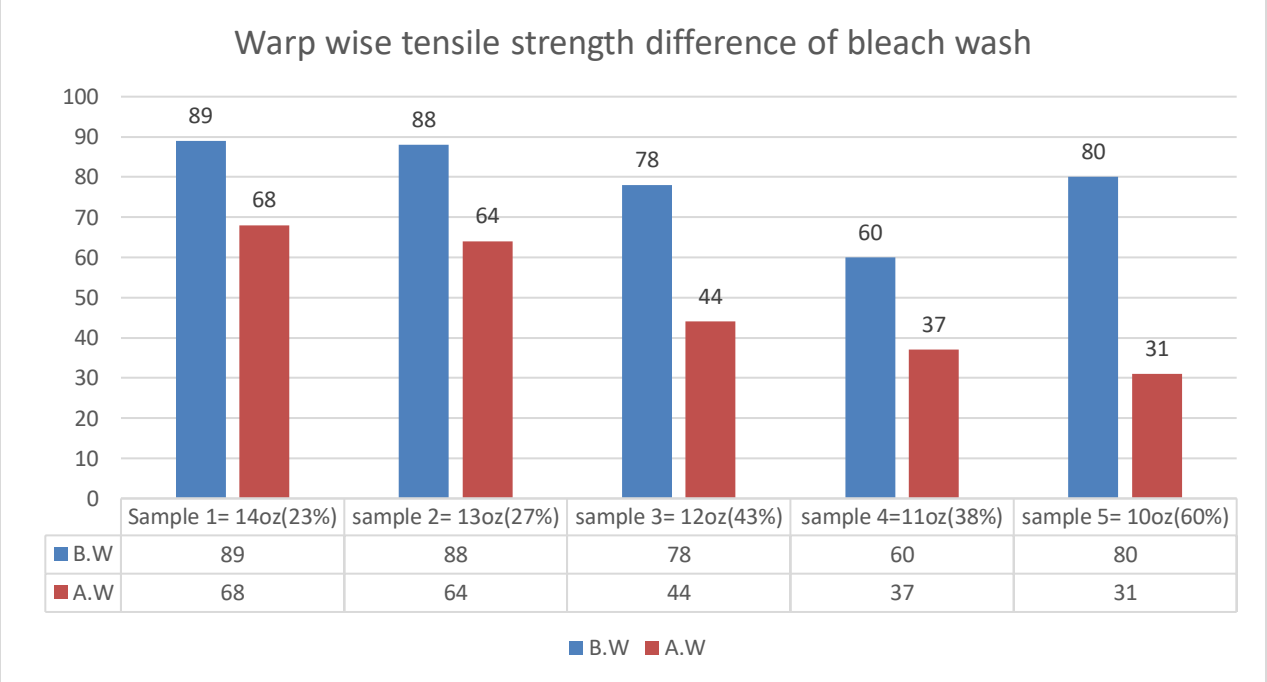
Graph: 4. 11: Weft wise tensile strength difference of enzyme wash



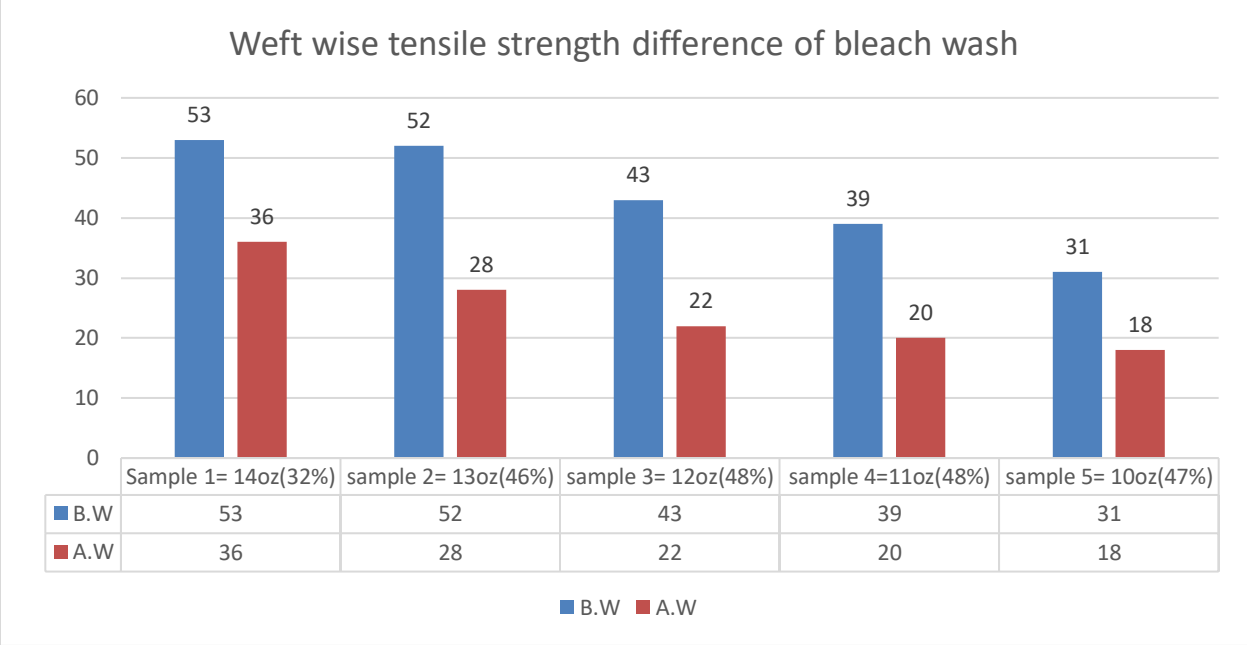
Graph: 4. 12: Warp wise tensile strength difference of acid wash



Graph: 4. 13: Weft wise tensile strength difference of acid wash



Graph: 4. 14: Warp wise tensile strength difference of bleach wash



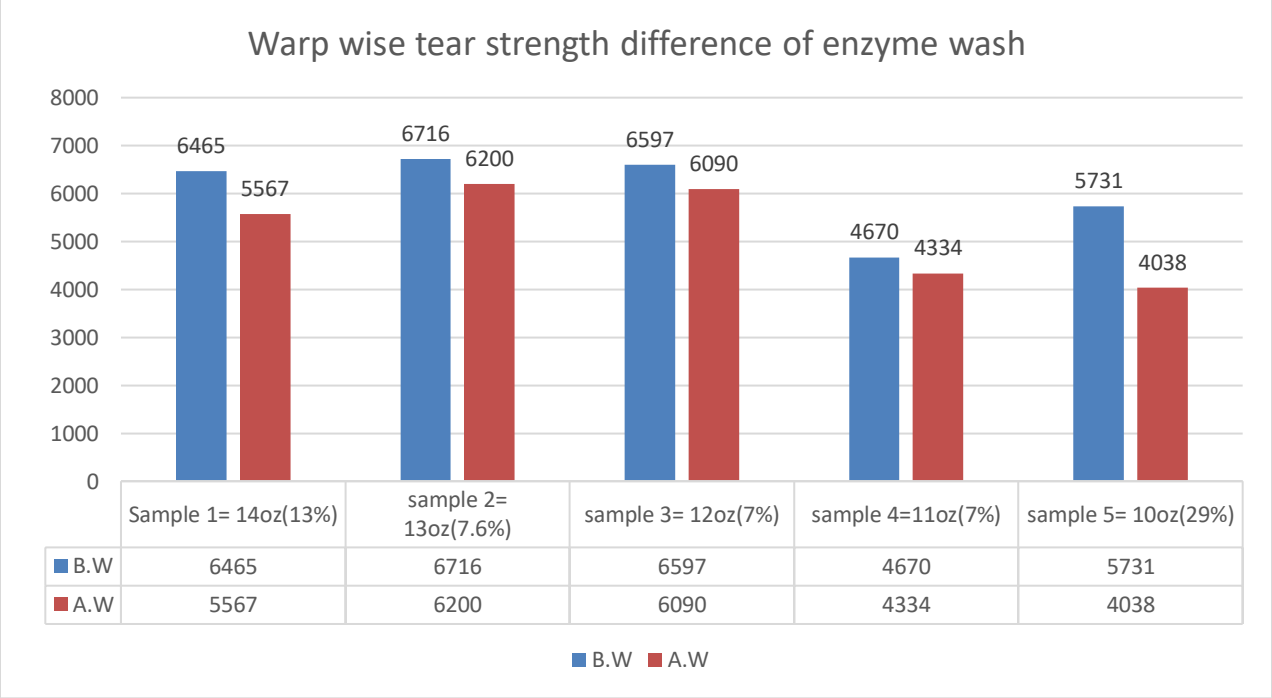
Graph: 4. 15: Weft wise tensile strength difference of bleach wash

Result discussion:

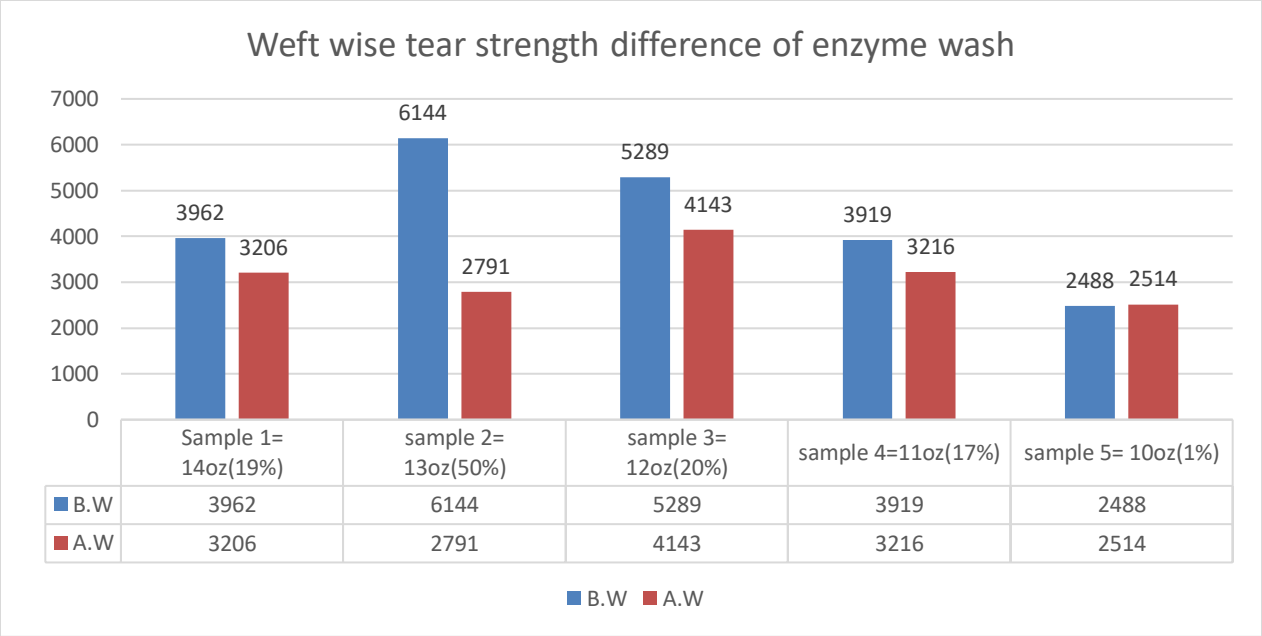
After analyzing the tensile strength charts we can say that after washing strength is less than the before washing strength. For enzyme washing it attacks the yarn portion and hydrolyses. For bleach wash strength lost very much because bleaching fades out most of the dye particles and make fabric portion more faded. On the other hand, acid wash acted as irregular fading of color and cause the lost in strength of fabric. We can also add that most of the heavy weight fabric losses less strength.

4.4 Difference in Tear strength:

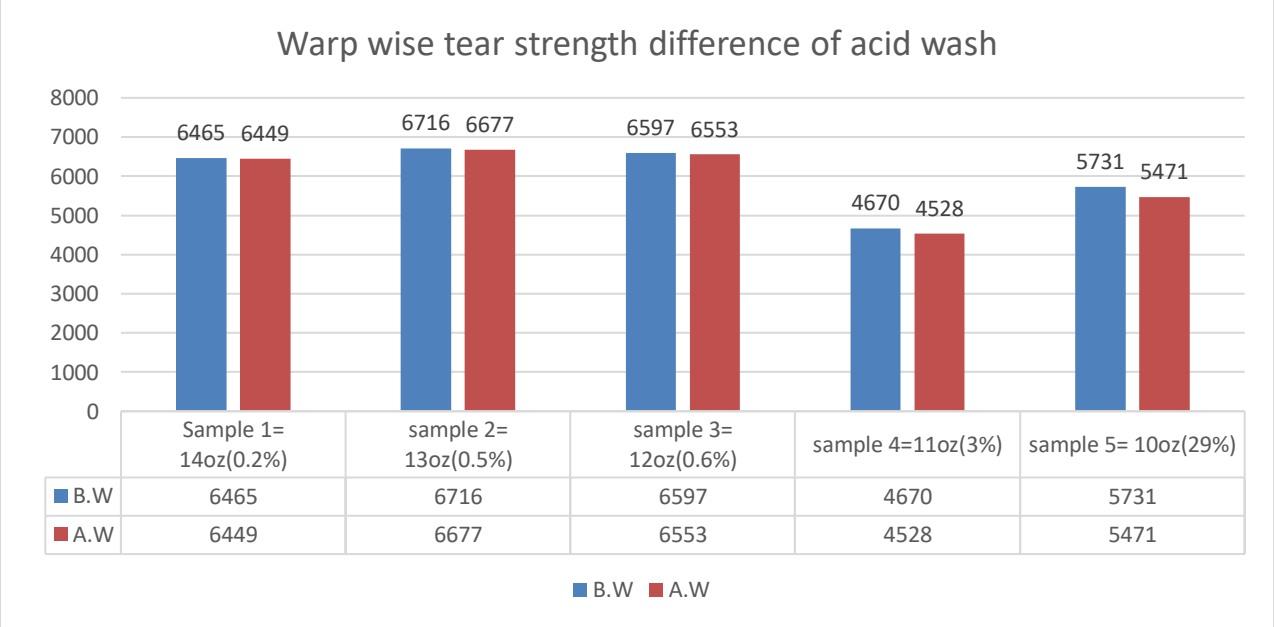
During tear test we took 3 specimens from each fabric sample and make an average value to find tear strength before and after wash for warp and weft both. There is graphical representation of table 11, 12 and 13 shown below:



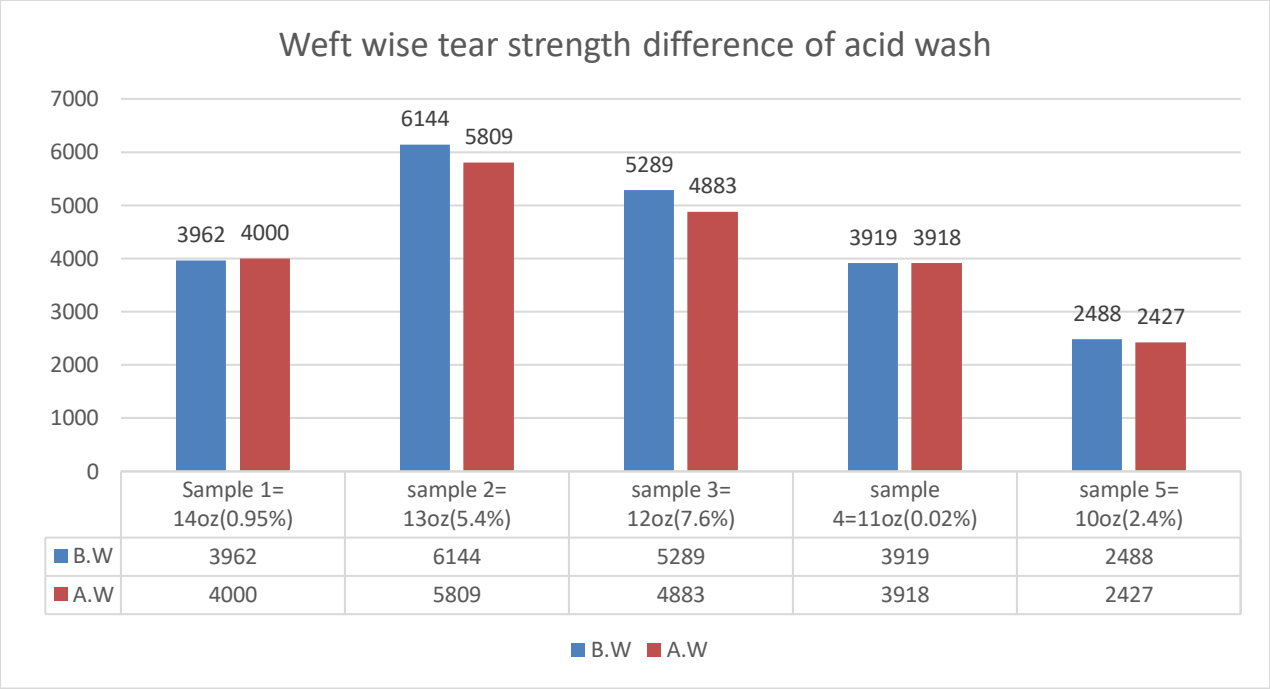
Graph: 4. 16: Warp wise tear strength difference of enzyme wash



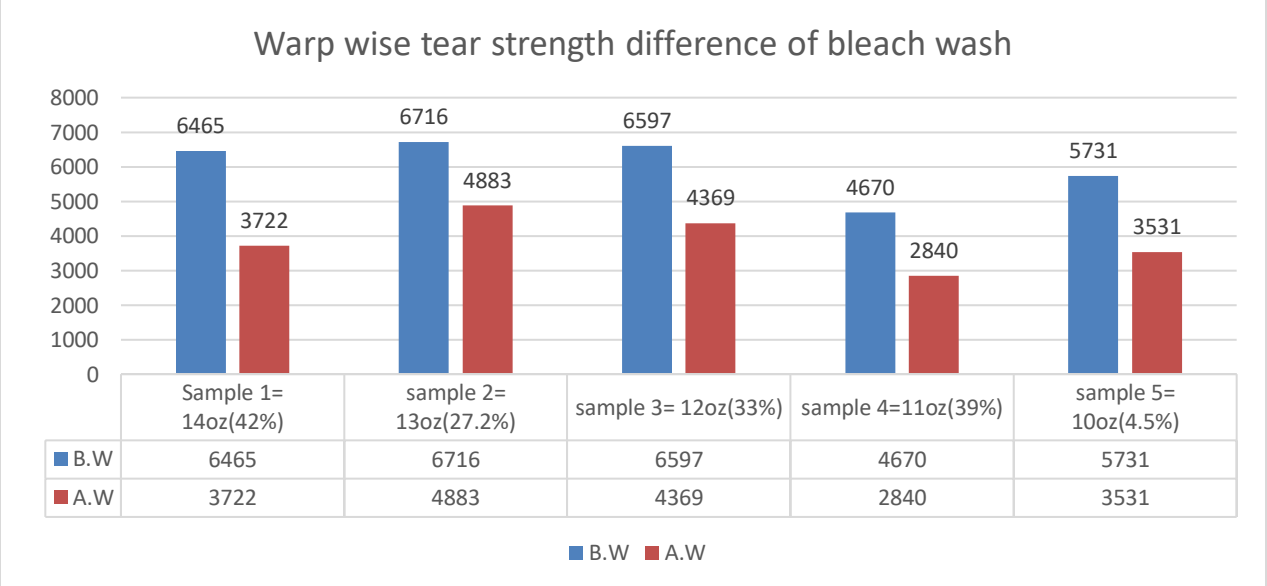
Graph: 4. 17: Weft wise tear strength difference of enzyme wash



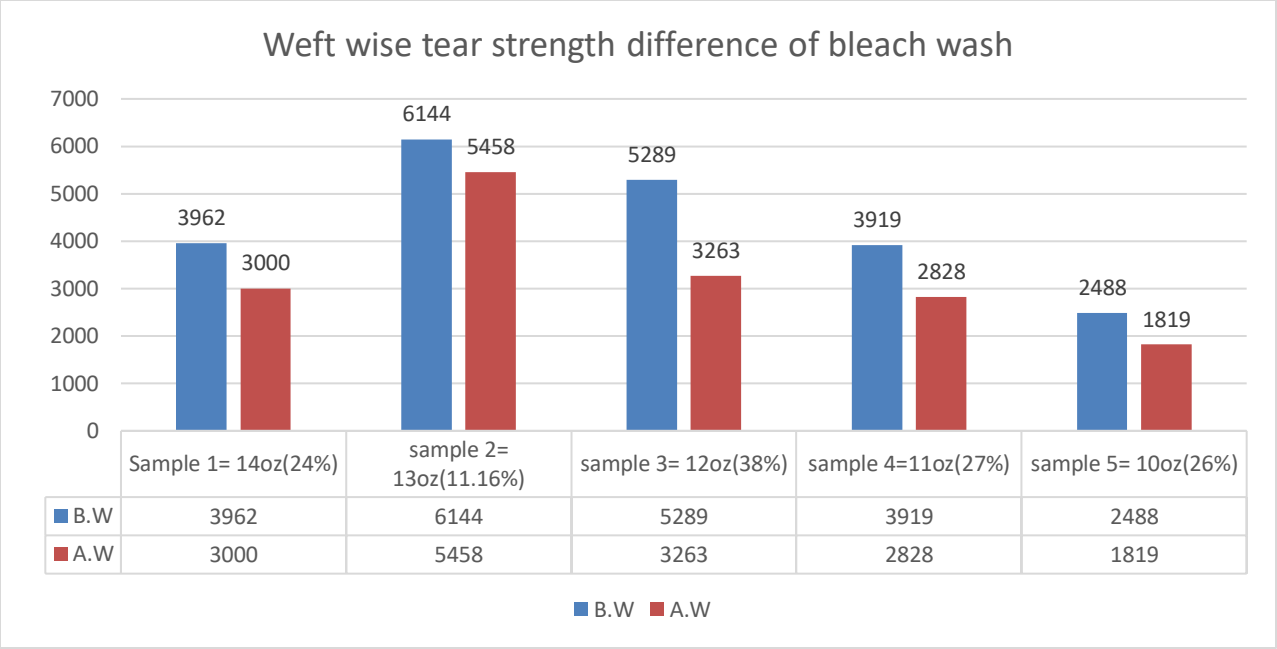
Graph: 4. 18: Warp wise tear strength difference of acid wash



Graph: 4. 19: Weft wise tear strength difference of acid wash



Graph: 4. 20: Warp wise tear strength difference of bleach wash



Graph: 4. 21: Weft wise tear strength difference of bleach wash

Result discussion:

We can see from those above charts that before washing tear strength was better than the after washing tear strength for most of the fabric samples. Some different case happens that strength increases too little. After being washed most of the fabric sample lost tear strength and some different cases happened due to the structure of the fabric or washing/test fault.

5. CONCLUSION:

Nowadays, all the foreign buyers are too much attracted with sustainable wash. Because for 150-piece garment washing 500-liter water needs approximately. But in sustainable process there will be needed less amount of water which is very eco-friendly for us. In sustainable washing process enzyme, bleach and acid wash can be done very easily with buyer satisfaction by using a very little amount of water.

In this paper we included the test result of before and after wash variation of weight of fabric, shrinkage percentage, tensile strength and tear strength. Performing all the physical change test we can say that after washing the denim fabric tear and tensile strength decreases, shrinkage occurs after washing and weight of the fabric slightly increased.

6. References:

1) http://www.historyofjeans.com/jeans-history/history-of-denim/
2) https://www.masterclass.com/articles/what-is-denim-fabric-a-guide-to-the-history-of-denim#the-history-of-denim-fabric
3) https://textilelearner.blogspot.com/