Faculty of Engineering

Department of Textile Engineering

Thesis on

"Studies on Effect of Various Washes on Denim Garments."

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

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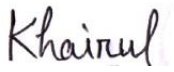
Declaration

We attest that this thesis report is totally our own work, except where we have given fully documented references to the work of others and that the materials contained in this report have not previously been submitted for assessment in any formal course of study. If we do anything, which is going to breach the first declaration, the examiner/supervisor has the right to cancel my report at any point of time.



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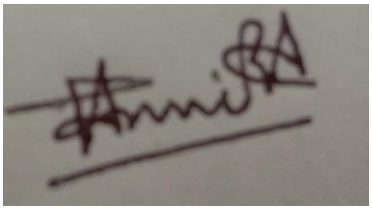
LETTER OF APPROVAL

This thesis report prepared by Md. Khairul Islam (ID.: 191-23-590) and Md. Tanzil Hossen (ID.: 191-23-613) is approved in Partial Fulfillment of the Requirement for the Degree of **BACHELOR OF SCIENCE IN TEXTILE ENGINEERING**. The said students have completed their thesis work entitled **"Effect of Various Washes on Denim Garments."** under my supervision.

During the research period I found them sincere, hardworking and enthusiastic.



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DEDICATION

This thesis report is dedicated to our beloved parents and teachers.

Abstract

Due to the rigidity and hardness of finished denim, it is generally impossible to wear raw denim cloth before washing. Before washing, finished denim has a fairly lifeless appearance. Therefore, it is typically necessary for denim to undergo various washing operations in order to change both its physical and aesthetic properties.

This project is done for comparing the physical properties like GSM, weight, shrinkage%, Dimensional Stability, physical appearance, Colorfastness to rubbing, Colorfastness to ozone, Colorfastness to washing and finally tensile and tearing strength of denim garment with different constructions after Acid. Different washing processes like Enzyme, Bleach, Acid washes were observed and the visual change is seen. The information about the change in physical properties like GSM, weight, shrinkage%, Dimensional Stability, physical appearance, Color fastness to rubbing, Colorfastness to ozone, Colorfastness to washing and finally tensile and tearing strength were tested from "In house Lab of Crown Wears (Pvt.) Ltd."

After compiling and comparing all the necessary data, it is seen that Tensile Strength has increased after wash process about 220.51% in warp side and 265.08% in the weft side. On the other side, tearing strength has decreased after washing process about 43.24% in warp side and 20.88% in weft side. In the colorfastness to washing test we have been observed that colorfastness to washing after washing process is very much better than the before washing process. Colorfastness to rubbing also got very good results in after washing process which is fulfilled the buyer requirement too. Colorfastness to ozone gave very bad result (2.5) in before wash test but which is improved in the after-wash test result (3.5) where buyer requirement is minimum 4.00. In the before washing test the GSM of this sample was 9.47 oz/yd^2, but after washing process it has decreased about 9.11 oz/yd^2. In the experiment of appearance after home laundering we got the satisfactory results and all requirement have been passed. And the last one is dimensional stability test. By this test we can observed that, the dimensional stability has been reduced slightly after washing process. That's way the Shrinkage has done slightly in waist -0.8%, in out seam -2.4%, in the in seam -1.3% and also in HIP -0.6%.

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1 INTRODUCTION

1. Introduction

1.1 Background of Study

The history of jeans starts in two European cities in the middle of the nineteenth century. France's Nîmes is one of them. They invented this material and gave it the name "Serge de Nîmes," which was later transformed to "Denim." In Italy, Genoa is where the color is from. The French name for this shade is "Bleu de Gênes," which translates to "blue jeans." The Jeans and Denim are created when the fabric and color come together. Denim is employed as heavy labor clothing for cowboys and miners in the 1870s. In the 1920s and 1930s, denim gained popularity as casual clothing on a global scale, and now it is a classic style. Right now, wearing denim encompasses a complete way of life.

The Bangladeshi ready-made clothing industry has been generating significant quantities of foreign currency, with the assistance of the washing industrial units. Nearly all woven things are washed, while the sweater receives its usual wash. Some value-added knitwear items now go through the washing process. In Bangladesh, the denim industry is expanding. The backward linkage industries are expanding quickly together with the denim manufacturing business. In Bangladesh, the washing sub-sector, which has a backward link to the garment industry, particularly the woven one, has risen quickly and assisted in the production of more trendy apparel with added value.

When various washing techniques are applied, denim clothing becomes more appealing. Denim cleaning is essential for modifying the clothes' appearance, fit, outlook, comfort, and style. When a garment is washed, it acquires a rich, practical, worn-out, distressed, and glossy aspect. Washing is a crucial operation that must be completed to satisfy customer demands; as a result, many washing factories are opening in Bangladesh. Because of the size and weaving effects, clothing is uncomfortable to wear without washing. Different washing techniques are used on denim clothing to improve wearer comfort. To give denim raw clothing a vintage or worn-out appearance, the dry washing procedure includes treatments such as whiskering, sandblasting, brushing, scraping, spraying potassium permanganate, spots, rubbing, tacking, net wrapping, damages, grinding, destruct effect, 3D crinkling, etc. Normal washing or rinsing, acid, bleach, enzyme, stone, stone enzyme, towel, pigment, caustic, silicon, tinting, and garment dyeing are all done with clothing in the wet washing process to improve appearance or effects.

1.2 Objectives of this Study

- To investigate the different changes of physical properties of denim garment after acid wash process.
- To know the different washing effects of denim garments.
- To know the function of different chemicals used during washing.
- To find out the physical changes of denim garment for wash process
- In order to comprehend the changes following enzyme, bleach and acid washes, it is necessary to compare the parameters with one another.

1.3 Significant

It is crucial for a textile engineer to understand how garments behave both before and after washing. This information will help us usually in planning, occasionally in manufacturing, and occasionally to fully satisfy the needs of the customer. However, we now have a wonderful opportunity to work for a denim washing plant. Therefore, having knowledge of denim washing will be very beneficial for our future careers.

2 LITERATURE REVIEW

2.1 Denim Wash

Garment washing is one of the main industrial procedures used in the textile industry. Industrial garment washing can get rid of contaminants including dust, filth, and infectious substances from clothing. Various washing processes can be used to enhance unique looks on clothing depending on design requirements. Normal garment washing occurs after sewing. Customers request that the garments be washed based on demand and fashion trends. Always specify the sort of garment cleaning you want for your purchase when ordering clothing. Here is an example: JJill buyer requested that the wash have the following looks: Acid wash, Vintage wash, softener wash, or Cloud wash. Each wash produces a new appearance on the fabric's surface. Clothing wash types' physical changes are primarily influenced by the products used.

Today's fashion would be absolutely lacking without denim. Denim clothing is available in a variety of shapes, colors, and washes to complement every dress. Numerous technological developments, such as significant advancements in spinning, weaving, finishing, etc., have helped to make denim the fashion standard that it is today. The washing process is crucial in the production of stylish denim jeans. Nowadays, washing is so important in the denim industry because of all the effects that customers want on their jeans. Because indigo dye has a very poor wet fastness and a dry rubbing, even the smallest adjustments in denim garment washing can have a significant impact. For consistent results, it's crucial to keep track of all the parameters. Today's denim washing techniques produce new trends including deep dye, tie dye, potassium permanganate spray, potassium permanganate sponging, lasting, tagging, whickering, permanent wrinkle, destruct, grinding, and hand crapping. These washing procedures cause some noticeable physical changes in denim garments. The most popular denim washing techniques include enzyme wash, bleach wash, acid wash, regular wash, stone wash, etc. Among these washing techniques, bleach washing is a common one in the business, particularly for washing denim with hypochlorite bleaching to get the desired color shade.

2.2 Types of Denim Washing Process:

2.2.1 Dry Process or Mechanical Washing Process:

Dry processes or mechanical processes are ones that have been used in the washing of garments without the use of any chemicals or garment-loading washing machines. On occasion, the mechanical approach can be used to complete the dry process. The most crucial finishing step in the dry washing process involves applying whisker, scraping, tacking, spraying, grinding & manual damaging, 3D crinkle, and other effects to clothing or denim items. In order to create specific effects in the garments, a variety of wet and dry washing methods were performed to raw samples. The resulting changes in mechanical or physical qualities were then analyzed. The most crucial finishing step for a garment that affects its mechanical characteristics is dry-washing.

- **Whiskers:**

One of the most crucial steps in the denim drying process is whiskering, which comes first. The hip and thigh regions of jeans are where these worn-out lines or effects, produced using various techniques, are most noticeable. One of the most significant patterns on the surface of the garment is the whisker. To get the whiskered or fading effect, a variety of whisker patterns are created in accordance with the design, and the garment is scrubbed over the prepared pattern with abrasive paper or emery paper.

Figure 01: Before and after wash effect of whisker process

- **Scraping:**

In order to give clothing a worn-in appearance, denim fabric is colored off the surface through the process of scraping. Different techniques are used to create this effect, but it is quite challenging to get the desired level of uniformity for the consumer. An experienced operator should carry out this operation. We utilize abrasive paper, a horizontal air dummy, gum tape, and our hands. This method is increasingly frequently employed because sandblasting is prohibited because it poses a health risk.

Figure 02: Before and after wash effect from scraping process

- **Laser:**

All people still love ripped jeans. Customers today seek for the various shades and treatments that denim can provide. As a result, denim manufacturers do their utmost to satisfy customers by providing a variety of washed jeans in various colors. Numerous methods are used to finish denim, including sandblasting, stone washing, mill washing, moon washing, bleaching, faded looks, whisker effects, 3D effects, and more. These methods all required more water and energy. An amazing technique called laser washing can produce extraordinary jeans while lessening the industry's environmental impact. The denims are washed using lasers instead of water, rocks, or sand. A laser is used to burn the wash into the denim as it passes over them. The process moves quickly, and the washes are gorgeous. This water-free method can give the denim a much-desired "distressed" or "vintage" appearance.

Figure 03: Laser effect

- **Tacking:**

These days, tacking, or more often tag pinning, is a highly popular design for denim clothing. A swift tag machine does the tacking. Tacking is the procedure used when clothing hasn't been washed. We will see its results after washing. The clothing is folded in accordance with specifications and fastened or locked via folds. The clothing is then cleaned and dried. After the tag pin is removed, a permanent fold is visible. As a result of decreased friction and chemical contact, the interior of the fold is darker. The folded sections have faded effects. The corners of the front pocket, back pocket, back yoke, waistline, and bottom hem are the most popular regions.

Figure 04: Tacking Effect

- **Potassium Permanganate Spray / Rub & Bleach Spray:**

Denim are sprayed with potassium permanganate to give the sandblast area a dazzling appearance. One crucial aspect of potassium permanganate spray is that it is frequently used as a sporting procedure to enhance the impact of the sandblast. Using a typical spray gun, potassium permanganate solution is applied to the denim garment's blast-damaged areas. Initially appearing pink on the fabric, this potassium permanganate spray turns dirty brown when it dries.

Depending on the desired outcomes and the type of cloth, potassium permanganate spray concentrations might range from 0.25 grams per liter to 15 grams per liter. Black sulphur cloth must be treated with high concentrations as opposed to indigo-dyed fabrics, which are typically treated with modest amounts. Potassium permanganate does not significantly alter sulfur; hence it requires high concentrations and occasionally numerous spraying procedures.

The variables in spray process are as follow:

- Distance of spray gun to garment- A nearer distance will provide a sharper, more defined appearance, while a farther distance will produce a softer, more blended effect. The separation is between one and two and a half feet.
- Air to Water Ratio of Gun - This needs to be adjusted extremely precisely. High air pressure will generate extremely low bright spray effect to locations where it is not needed, but low air pressure may cause KMnO4 drop on garment resulting in excessively dazzling white spots.
- Potassium Permanganate Solution Concentration -obviously, this will determine how bright things are.

On denim clothing, PP spray is applied to make the abraded patch seem whiter than the indigo color of the background. This can be applied with a spray gun or by rubbing a towel dipped in PP solution on the required region before neutralizing it with a wet procedure. After performing a hand scrape or in the middle of the wash, this procedure can be carried out stiff.

Figure 05: PP Spray and its effect after washing

Figure 06: Organic Bleach Spray and its effect after washing

- **Grinding:**

The procedure of grinding involves removing denim from its edges. When we examine worn-out jeans, we find that the bottom, belt, fly, and pocket edges are all badly damaged. This common effect, which can be achieved on denim by grinding them, is crucial for high fashion clothing. By using stone tools in the shape of pens, clothing is ground. You can do it in the middle of the washing. It is typically completed in many workshops as the initial step after stitching, before any washing process. With a few modifications to their design, stone tools used in the wood and stone industry are used to work on clothing. The edges of the garment, such as the pocket edges and bottom hem edges, are where grinding is generally done. To accomplish this, rub the bottom hem and pocket edges against rough surfaces or stones to create a worn-out appearance. For

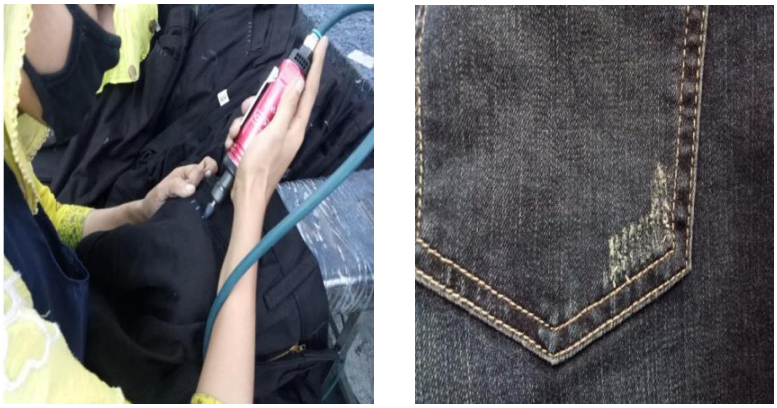
massive output, fixed grinding machines are employed. The user of this machine rubs the edges in order to rotate the stone wheel and produce the desired result. Before the final washing step, the grinding phase is completed.

Figure 07: Grinding pocket edges after washing

- **Manual Damage:**

A pen grinding machine performs this operation, destroying only the warp yarns in the fabrics or garments. The twist machine, sometimes referred to as the pen type grinding machine, uses air power to work. After washing, the look of manual damage on the clothing is clearly visible.

- **Necessary Tools to Manual Damage:**
  - Pen grinding machine
  - Marking Chalk
  - Pattern board



- **Destroy:**

A laser machine is used to damage after the first wash. The laser-damaged clothing is dispatched to destroy the area after the final wash. The garments are laid out for the subsequent procedure after being received. The damaged area is initially cut with an NT cutter. The damaged portion is transported to high pressurized air for blowout after being cut. The damaged area is taken out, and the garments are then sent for blowout. Utilizing air at high pressures, blowout is done. After being adequately blown out with high pressure air, clothing is sent for quality inspection. A patch may occasionally be applied to the affected region. In this instance, the patch is first carefully covered in glue before being securely fastened to the body.

Figure 08: Garments destroy

- **3D effect**

3D effects, commonly referred to as crinkle effect or permanent creases on denim surface, are highly sought-after on the market for jeans. Denim is treated with resin to keep this appearance even after washing. The fabric appears old and worn as a result. Chemicals and equipment that manipulate the denim fabric and wrinkle it in the correct places are used to achieve the wrinkled-jeans effect [31]. Viscous liquids with the ability to permanently harden are called resins. The two primary categories of resins are deposition-type resins and other resins. This kind of resin is used as the surface coating that is applied to the fabric. The resin and fiber won't interact in any way. They consist of vinyl resins, phenol formaldehyde resins, urea-formaldehyde resins, alkyd resins, and ketone resins. Another is resins of the cross-linking variety. By chemically reacting

with the fiber, these resins cross-link the molecules of the fiber. The finished product is strong and far superior to the deposition kind. Due to the methylol groups' (-CH2OH) attachment to the nitrogen, these substances are also referred to as N-methylol compounds. Although pre condensate is the right word, cross-linking substances are more frequently referred to as resins. Resins are created by the pre condensates' subsequent polymerization.

How resin works: Since weak intermolecular bonds are what cause wrinkles to appear, the crosslinking resin may create a memory in the fiber that will enable it to revert to its previous size and shape. The purpose of resin finishing for wrinkle-resistant fabric is to increase the cellulose chain's "memory" so that it can go back to its original position. To replace the frail hydrogen bonds between the cellulose strands, the resin finishing creates covalent bonds through crosslinking. As a result, the bonding would be more stable and the chain of molecules would be more likely to return to its initial location. Intermolecular crosslinks will get stronger when cellulose cotton fiber is treated with a resin agent because of the bonding. As a result, the nearby molecular chains might be held in place by cellulose chains, which could then move back to their original position. Figure below provides an illustration of cellulose being crosslinked using N, N-dimethylol 4, 5-dihydroxy-ethylene urea (DMDHEU).

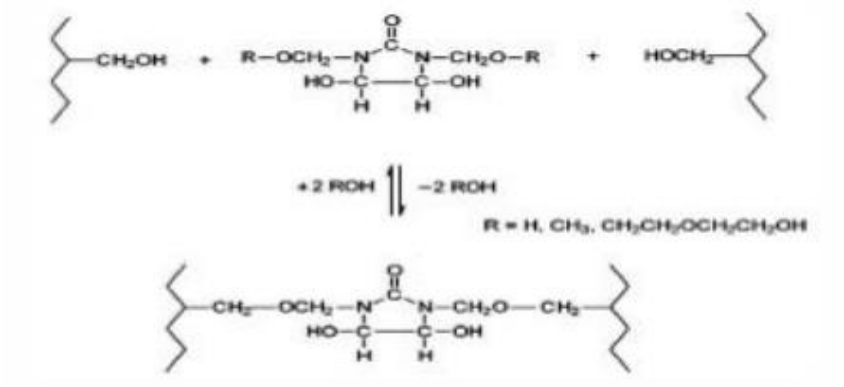


Figure: Crosslinking of cellulose with DMDHEU

Figure 09: Before and after 3D effect

2.2.2 Wet Process or Chemical Washing Process:

One of the most popular processes is the wet or chemical washing process, which may be carried out using a variety of chemical products and garment-loading washing machines. The wet washing procedure is the most crucial finishing step for the garment to enhance the appearance, which affects the chemical characteristics of clothing. The wet washing of clothing to give them a better appearance or effects by regular washing or rinse washing, pigment washing, caustic washing, silicon washing, enzyme washing, stone washing, stone enzyme washing, bleach washing, and acid washing.

The function of chemicals used in washing plant:

Detergent: Fatty alcohol polyglycol ether is the chemical makeup of this aqueous, glycolic solution. All forms of fiber and their mixtures can be continuously and intermittently pre-treated with detergent. It is used to clean the clothing of pollutants, pollution from mineral oil, and sizing.

Enzyme: The operations of the enzyme during the cellulose's breakdown during an enzyme wash. It begins by attacking and hydrolyzing the fibers that are protruding. The yarn component inside the fabric is next attacked, and it is hydrolyzed. As a result, color leaks from the yarn component, giving the piece a faded and make abrasive appearance.

Bleaching powder: Bleaching powder is an oxidizing agent. Oxidizing agents include bleaching powder. It is applied in washing machines to remove color from denim garments. On the clothing, we can achieve various color tones (Dark, medium, light shade).

Acetic acid (CH3COOH): To neutralize the effects of the alkaline condition on the garments and to regulate the pH level in the wash bath, acetic acid is utilized.

Anti-stain: In addition to acting as an anti-creasing agent, antistain is used to prevent stains on the weft yarn of denim (white yarn), white pockets of garments, levels, and contacted fabrics of garments.

Sodium hyposulphite: To neutralize the chlorine bleach on the garment, sodium hyposulphite is used.

Soda ash: For the breakdown of pigment dye, soda ash generates an alkaline medium. Soda ash aids in the uniformity of the bleach bath's bleaching activity. It provides cleansing properties and lessens the impact of the garment's color fading. Additionally, it is employed in the dye bath to fix colors.

Caustic soda: Caustic plays a key function in the bleaching process without changing the color of the garment and has strong cleaning capabilities. It acts as a quickly appearing fading or old-looking effect on garments.

Sodium bicarbonate: For light-colored denim, sodium bicarbonate is utilized in bleach baths with bleaching powder since the color fades quickly. As a result, costing is low and productivity improves.

Flax softener: The use of softeners gives the textiles used to produce clothing a delicate, soft surface feel that also has good lubrication capabilities. Use cationic or non-ionic flax softener that has been diluted in hot water in the machine.

Potassium permanganate (PP): Potassium permanganate (PP) is used in the acid wash with a pumice stone/thermosol ball/towel for color out from the garment. It is used in the spray chamber by nozzle for color out (reating a white impression) from the garments.

Sodium chloride: It helps to exhaust dye into the fiber

Hydrogen peroxide: Hydrogen peroxide is used to clean, bleach, or prepare gray fabric items for dyeing. A crucial part of the bleach wash method is played by hydrogen peroxide. A fading effect is created when hydrogen peroxide breaks down in an alkaline media and releases some per hydroxyl ions, which discolor the coloring agents. It is also used to neutralize an alkaline condition on clothing.

Stabilizer: When the temperature is higher than 90 °C, hydrogen peroxide performs well; however, when the temperature reaches 90 °C, the hydrogen peroxide breaks down. In order to prevent hydrogen peroxide from being broken down, a stabilizer is required.

Buffer: In washing, buffer is used to regulate the pH of the enzyme, softener, and desizing baths.

Microemulsion silicon: The fundamental component of the textile finishing agent amino silicon is silicon that has been amino-modified. It improves wear and easy-care qualities and imparts enduring softness, lubricity, elastic handle, anti-pilling, dimensional stability, tearing resistance, and anti-pilling properties to fabrics when applied.

Fixing agent: For unfixed dye to fix to fabrics, a fixing agent is used. When fabric color is properly fixed, color fastness and rubbing fastness are both improved.

Catanizer: It is used in pigment exhaust method processing. The pigment is color, not dyestuff. Pigment colors have no affinity to the fabric. When catalyzer is utilized in the fabric, the affinity between pigment colors and fabrics increases.

Resin: The resin is based on etherified dimethylol glyoxalin monoureine urea and is highly effective. Denim and other cellulose fabrics can be given semi-permanent wrinkles by using resin. Cotton and polyester cloth are also used. After washing, a fabric's soft handling is retained.

Sodium Metabisulphite: In the washing, potassium permanganate is neutralized by using sodium metabisulphite.

Desizing agent: Starches, CMC, waxes, lipids, pectins, minerals, and unfixed indigo dye are the principal substances that a desizing agent is used to remove from denim, twills, poplin, and canvas fabrics.

Optical brightener: The washing plants uses red and blue optical brighteners, which are both different types of brighteners. To increase the brightness of clothing, optical brighteners are primarily used.

Anti-back staining agent (ABS): Dispersing agents are frequently used in the denim garment business to keep the molecules of indigo or dye dispersed in the bath and avoid their deposit on the garment. The dispersing agents are also known as anti-backstaining agents for this reason.

2.3 Types of wet washing process applied in garments:

One of the most popular methods is the wet or chemical washing method, which may be carried out using a variety of chemical products and garment-loading washing machines. Here are some examples of various wet washing methods used on garments:

- Normal wash or rinse wash
- Stonewash
- Enzyme wash
- Stone enzyme wash
- Bleach wash
- Acid wash
- Towel wash
- Garments dyeing

2.3.1 Normal wash or rinse wash:

The most typical, easiest, and most widely used washing method is normal washing, which also has the lowest cost. For practically all buyers, it is a requirement. Some undesired components, such as dirt, dust, and starch, are eliminated during the typical wash production process without any shrinkage. To improve color fastness on colder clothes, unfixed dyes can be removed. Sometimes a regular wash also involves softening and giving the item a worn appearance. The effect of washing on the surface of the garments can be changed by adjusting the temperature, time, and detergent amount. In some circumstances, it is possible to cause clothing to shrink on purpose. Other names for routine washing include detergent wash, common wash, normal wash, rinse wash etc.

2.3.2 Desizing

It involves removing the size material from the warp yarns. The most basic step in washing denim is this one. The warp yarn threads are subjected to sizing chemicals, which are auxiliary substances that give fabric its strength and resistance to friction during weaving. Sizing helps to coat the warp yarn with protection. Different kinds of sizing chemicals, such as starch, modified starch, polyester, poly-acrylates, polyvinyl alcohol, polyvinyl acetate, and CMC, are employed in the desizing process. To give the fabric the proper appearance, those chemicals should be removed during washing.

Objectives of Desizing:

- To remove dust, dirt, oil spot, impurities from the garments.
- To remove size materials from the garments.
- To remove starch presents on the garment fabrics.
- To achieve buyer washing standard.

2.3.3 Stone wash

As an abradant, volcanic rocks or pumice stones are added when washing. The color fading is less even but more apparent. Denim items that have been stone washed have a vintage, worn-out, or used appearance. This is caused by the garment's changing degree of abrasion. Traditionally, denim clothing is stone washed with pumice stones to produce a soft hand and appealing appearance. The pumice stones with a rough surface in an oval or circular form act as an abrasive during the washing process. Different washing results are produced in the denim fabric as a result of changes in shape, composition, hardness, and porosity. These stones scrape dye from the denim fabric's yarn's surface after washing, giving the cloth a faded, worn-out, and sparkling appearance. On the fabric surfaces, the pumice stones have a brushing effect. A greater fading effect will emerge in places with more brushing activity, while a lesser discoloration impact will develop in parts with less brushing activity. Greater brushing will occur in multi-layer fabric locations such as the collar, cuffs, pockets, plackets, side seams, etc. than in single-layer fabric areas. As a result of the pumice stone's activity, the garment begins to fade irregularly. The

United States, Turkey, Italy, Germany, Iceland, New Zealand, Japan, Indonesia, and the Philippines are among the top exporters of pumice stone in the world.

The degree of color fading depends on:

- **Effect of stone ratio**: No observable color fading in the denim garments is seen at stone ratios lower than 0.5:1. When there are several stones present, the color fading effect is increased. However, a ratio of too many stones may result in significant abrasion and fabric damage.
- **Effect of stone size:** The color fading effect is said to be better the smaller the stone size. Additionally, despite the fact that little stones can provide an even and consistent abrasion effect, their color contrast is inferior to that of larger stones.
- **Materials to liquor ratio and a load of garments:** The ratio of materials to liquor and the quantity of garments loaded into the washing machine are key factors in how quickly garments fade.

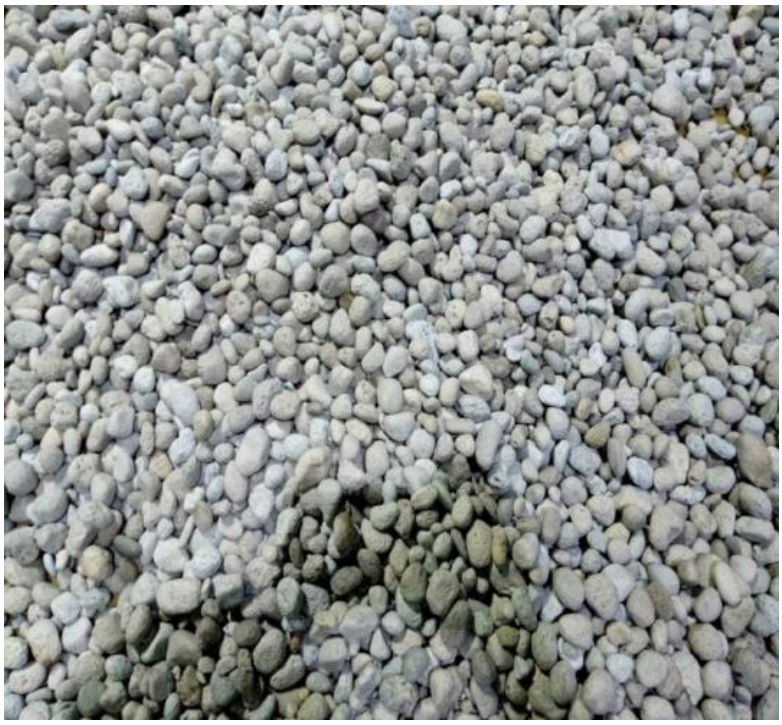


Figure 10: Pumice stone

2.3.4 Enzyme

A substance known as an enzyme serves as a catalyst in living organisms, controlling the rate at which chemical processes take place without undergoing any personal change. Since protein makes up all enzymes, heat, pH, and heavy metal ions can all affect them. They are exclusive to a single chemical reaction, unlike regular catalysts. An enzyme only works for one particular chemical reaction, whereas a regular catalyst can be employed for multiple distinct chemical reactions. For enzymes to work properly, they need the proper shape. The appropriate settings are necessary for enzymes since they change shape as the temperature or pH changes. Enzymes are classed based on the substances they break down. among the most typical are; The use of amylases Catalases act on hydrogen peroxide to break it down into water and oxygen in order to break down starches in sizing preparations. Pectinase, protease, and lipases scouring is achieved by combining substances that work on proteins, pectins, and natural waxes. For the wash-down effect on denim, laccases are utilized to break down indigo molecules, cellulases are employed to break down cellulosic chains to eliminate projecting fibers via degradation, and so on.

2.3.5 Denim Washing with Enzyme (With or without stone):

The enzyme cellulase is used to fade denim. Warp yarns colored with indigo are used to make denim. Technically known as "ring dyeing," this process involves the majority of the colors being absorbed on the fiber's surface. The undyed core of the fibers is exposed as a result of the fiber surface etching caused by cellulase enzymes, giving the denim a faded appearance. The mechanical abrasion makes dye removal even easier. Denim washed with pumice stones in the past to achieve the desired look. Cellulase enzymes have so taken the position of the utilization of stones. The solution turns dark blue as the indigo dye is released into the wash liquor during washing. Two amino groups in indigo dye have the potential to protonate in acidic conditions. Contrarily, cellulose keeps its negative charges in an acidic medium while the dyestuff obtains an overall positive charge due to protonation. In a solution, positive and negative charges are drawn to one another. As a result, indigo has a greater affinity for cotton in an acidic pH. Some of this indigo redeposited on the whiter areas of the denim cloth, ruining the stonewash effect's color contrast. This condition is referred to as "back staining." With acid cellulases, the problem of back-staining is more obvious. Due to their improved ability to control the discoloration

impact and resistance to back staining, neutral cellulases are advised to be used to manage the back-staining issue. Auxiliary chemicals aid in reducing the effect of back stains. Protease treatment reduces back staining significantly and boosts contrast when applied during rinsing or at the conclusion of the cellulase washing step.

Objectives of enzyme wash:

- To achieve different levels of abrasion on the clothing as well as in the sewing area.
- Enzymes attack chemically rather than mechanically, causing less damage and waste than stone washing.
- To increase the clothing's color fastness and rubbing fastness.
- To make the garment feels comfortable to wear.
- Enzymes improve anti-pilling properties.
- Enzyme primarily targets the fabric's surface and produces an extremely smooth finish.

Figure 11: Enzyme washing effect before and after wash

2.3.6 Bleach wash:

One process of washing garments that uses a potent oxidative bleaching chemical is called bleach wash. Bleaching agents include potassium permanganate (KMnO4) and sodium hypochlorite (NaOCl). By using a bleaching agent, color can be consistently removed from the garment and has been removed in accordance with specifications (per the buyer's wash authorization). The three types of bleaching—light bleach (where the most color is gone), medium bleach, and dark bleach—should be noted. Depending on the design, indigo-dyed denim is washed using high power Japan bleach, which includes 60% chlorine, and low power KCI bleach, which has 30% chlorine. By using a bleaching wash, a unique kind of fading effect can be created in the garment. The amount of discoloration generated varies based on the bleach liquid quality, temperature, and treatment time. Strong bleach that can be applied quickly is preferable. This method sometimes results in a yellowing effect, which can be reduced by properly rinsing the bleaching chemical. In this case, two rinses are sufficient to remove the bleaching chemical from the garment. The bleaching agent needs to be neutralized before being used. In this instance, the bleaching agent from the clothing is neutralized using sodium Meta bi-sulfite or sodium hypo. The majority of bleaches have potent bactericidal capabilities that are dangerous to human health and should only be used under strict supervision.

Mechanism of Bleaching Action: Chemical bleaches can be applied to fabric used in garments in two different ways, which have been described below-

- Breaking the chemical bonds that comprise the chromospheres is how oxidizing bleach functions. As a result, the molecule transforms into a new compound that either lacks a chromophore or has one that does but does not absorb visible light.
- The chromophore's double bonds are changed into single ones by reducing bleach, on the other hand. The chromophore's capacity to absorb visible light disappears as a consequence.

Figure 12: Bleach washing effect before and after wash

2.3.7 Acid wash:

Due to its striking contrasts and attractive appearance in color, acid wash on denim jeans is growing in popularity. It is a chemical wash technique that left the lower layer of the denim with the same color while the top layer of the denim was stripped of color, creating a white surface and giving it a faded appearance. It can be applied to foundation fabrics with indigo and sulfur dyes. Potassium permanganate, also known as KMnO4, and phosphoric acid, also known as orthophosphoric acid, are the two main compounds used in acid washing. To change the look of denim clothing, apply damp pumice stone or towels. The second washing uses sodium metabisulfate to neutralize the solution.

2.3.7.1Acid Washing Process with Pumice Stone:

Figure13: Ready stone for acid wash

Pumice stones are first loaded into the washing machine for the Acid washing process. The quantity of stone is determined by how much garment colors faded. After dry tumbling with chemical presoaked stones, garments are taken out from the washing machine and sent to the next operation. The neutralization process is mandatory after acid washing.

Figure 14: Acid washing (with stone) effect before and after wash

2.3.1.2 Acid Washing Process with thermocal balls:

During acid washing, thermocal balls are utilized in replacement of pumice stones. This method of washing is referred to as being sustainable. Following batch preparation, denim garment is brought into the wet process section. The garment is inserted into the washing machine and washed according to the predetermined recipe after being received from the Before Wash Quality Section. After the initial washing, acid washing is completed. Small thermocol balls are being used as a substitute of pumice stone in garments finishing process. Soaked Thermocol ball is shown in Figure:

Figure 15: Soaked Thermocol ball

Figure 16: Acid washing effects (with thermocol ball) of before and after acid wash

2.3.7.3 Acid Washing Process with towel:

Towels are applied to the garments using dry tumbling after being presoaked in a solution of a powerful oxidizing agent, such as potassium permanganate, and having any excess solution removed. As a result, there is a distinct blue/white contrast and a localized washing effect.

Figure 17: Acid washing effects (with towel) of before and after acid wash

2.3.8 Ozone wash:

O3 is the chemical formula for the inorganic molecule ozone. Strong oxidizers include ozone (O3). Modern technique called ozone wash is used to wash-in color changes. This approach can be used to bleach the item. Ozone can be used to bleach denim garments in either dry or wet conditions in a washing machine. In contrast to conventional washing, which uses water,

chemicals, time, and mechanical action to clean clothes, ozone washing uses none of these materials while using less energy and natural resources. Ozone gas is produced by combining oxygen and electricity, and it is then injected into the washing machine for processing. Instead of using chemicals, ozone is dissolved in water and applied to the washing machine. One of the key steps in textile processing that helps restore denim washing's effectiveness and cut down on its operational expenses is this transformation. The environmental impact of conventional washing system operations is reduced by ozone washing technologies.

Factors affecting ozone fading:

- **Influence of Gas Concentration:** None of the mechanical properties of denim fabric are significantly influenced by ozone gas concentration. This is due to the fact that increasing the ozone gas concentration will improve machine speed and decrease treatment time, respectively. As a result, the denim fabric's tear strength is unaffected. However, if gas concentration increases while speed and time remain constant, tear strength will undoubtedly decrease.
- **Influence of Speed:** The reason why tear strength initially increases with speed up to a level of 15 rpm before beginning to decline above this value is that ozone initially strengthens the material, but as speed increases, the tear strength decreases.
- **Influence of Time:** As time goes on, tears become weaker. Strength declines as a result of the denim's surface being abraded by the machine's increased contact with the fabric and gas.

Figure 18: Ozone Wash Effect

2.4 Machines Used in Washing:

- **Tonello Machine:**

This is the most popular washing machine in Bangladesh. All washing process is done by Tonello machine. It is not only washing machine. It is able to dye on denim garments which called tint of washing factory.

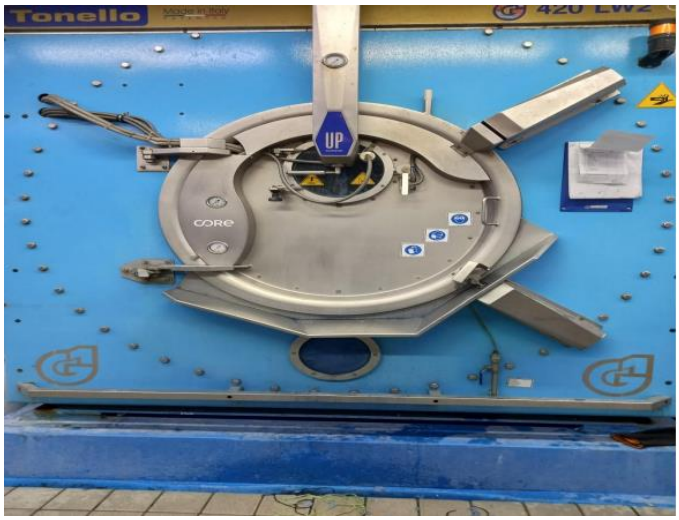


Figure 19: Tonello machine

- **Balley Machine:**

Another washing machine at the facility, it is also the most widely used washing machine for both washing and dyeing.

Figure 20: Balley machine

- **Hydro-Extractor Machine:**

The excess water in the garments is removed by the hydro-extractor. Hydro-extractor removes 70–80% of the water.

Figure 21: Hydro-Extractor machine

- **Dryer Machine:**

In a washing plant, dryers are used to dry the garments.

Figure 22: Dryer Machine

2.4.1 Some sustainable washing machine:

- **Laser Technique:**

The CO_2 laser treatment has been used in textile industry to create surface designing with desirable effect & various sizes without any causing damage. Laser fading is a popular dry process for denim now days.

Advantages:

- Hairiness is comparatively less in laser system
- Design consistency is high in laser system
- Rejection rate is almost 0% whereas manual rate around 5%
- Manpower required-Laser : Manual = 1:3
- 01 pcs gmt required max 3-5 min for w/s & h/s by laser whereas manual process need around 10 min
- Production per hour, laser = 20-25 pcs & manual = around 08-10 pcs

Figure 23: Laser machine

- **Tonello Core & UP System:**

The Core system gets the air from atmosphere & transforms it into nano-babbles. The nano-babbles come into contact with gmt & provide desired effect.

UP System, this optimizes garment washing, bringing the liquor ratio to unprecedented level (LR: 3-5) while reducing consumption, time & cost.

Uses:

- Enzyme Spray with core process
- Random Bleach with core process
- Resin Spray
- Teflon Spray
- Softener Spray
- Over dye or tint spray

Figure 24: Tonello Core machine

- **Tonello 03 Chamber Machine:**

This machine having 03 chambers for separate bath garment Dyeing/washing.

Advantages:

- 3 batches can load into the machine at same time
- Increase daily productivity

- No crease mark on garment because of more load quantity
- It's very helpful especially tops item to avoid damage, crease mark, uneven etc.
- Less time, High production

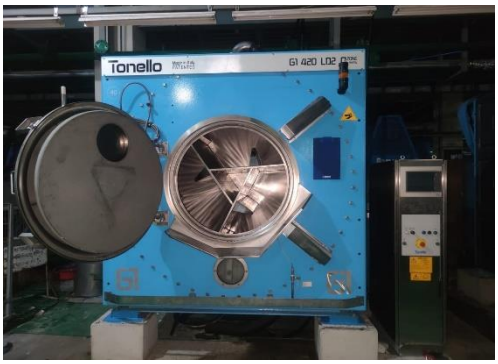


Figure 25: Tonello 03 Chamber Machine

- **Ramson Xeros Technology (No Stone):**

Xeros technologies drastically reduce water consumption, chemicals & energy. It's gives sustainability without compromising on performance or cost. It's reduces stone using % during washing.

The classic stone wash look achieved by washing jeans with lots of pumice stone. All of which degrades to a sludge after three/four time washes & must be manually disposed of.

Whereas XOrbs can be used to achieve same stone wash effect without using stones in less water & energy. These machines having lots of re-usable polymer beads which create stone effect on garment by mechanical abrasion between garments.

Figure 26: Ramson Xeros machine

Advantages of Xeros System:

- Can get same stone wash effect without using any pumice stone
- Reduce stone using % during washing
- Reduce garment rejection %
- Eco-friendly process

- **Denim Ozone Treatment/G-2 Technique:**

Ozone typically acts as mild bleaching agent. In this technique of denim washing the gmt is bleached with ozone gas in washing m/c.
Ozone fading can be achieved by plasma equipment. Under the influence of plasma treatment, to produce –OH radicals. Hydroxyl radical –OH is responsible for degradation of indigo dye in textile material.
As a result, color fading effect is achieved.
So, it's reduces the uses amount of calcium hypochlorite bleach in denim washing. Because of that no need neutralization process.

Benefits:

- A minimum loss of strength
- It is a simple method
- Water & chemical free & that is environment friendly
- Processing low energy cost
- Short treatment time
- Less back stain
- Reduce up to 60% washing time
- Reduce up to 60% water consumption

Figure 27: Ozone machine

3 METHODOLOGY /EXPERIMENTAL DETAILS:

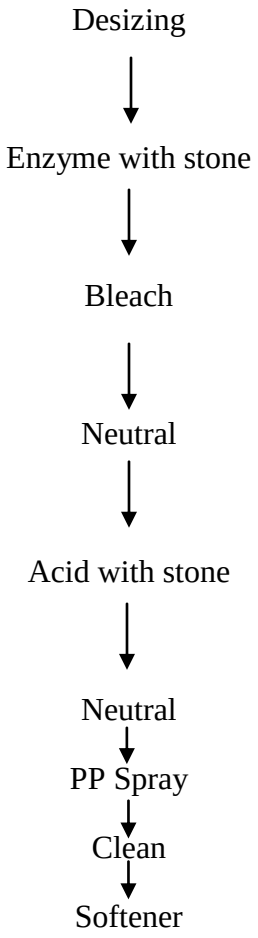
To conduct this work, we tried to compare changes of different properties before and after wash.

We completed this report by following several processes like desizing, enzyme with stone wash, bleach wash, acid (with stone) wash and PP spray etc.

3.1 Process Flow Chart:

Process flowchart is another name for an outline process diagram. By documenting the primary operation and inspection, a process flow chart can provide an overall picture.

FLOWCHART OF PROCESS



3.1.1 Sample Collection:

Wash: Acid wash

Factory: Crown Wears (Pvt.) Ltd.

Buyer Name: E Land

Style: SPTID25C51

Fabric composition: 99% cotton, 1% spandex

Before Wash Sample:

Figure 28: Front and back side of before washed sample

3.1.2 Dry wash process:

First of all, we have done the dry process:

- Whisker
- Scraping

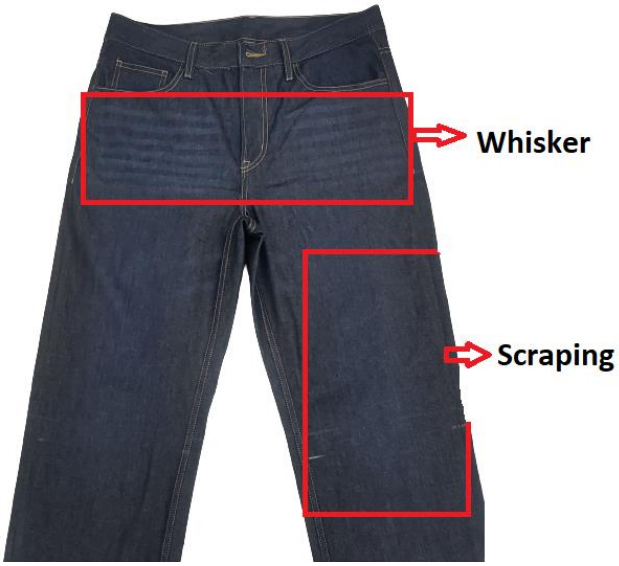


Figure 29: Whisker and Scraping effect on unwashed sample

3.2 Wet Process:

There are several steps in wet process. Like:

- Desizing
- Enzyme wash (with Stone)
- Bleach wash
- Acid wash (with stone)
- Softener wash

3.2.1 Desizing:

- **Chemicals for Desizing:**

  1. Hydrozen Per Oxyde (H2O2)

  - **Supplier:** Solvay Chemicals, Inc.
  - **Danger:** Hydrogen peroxide solutions are strong oxidizers and corrosive to the eyes, mucous membranes and skin. Consult the SDS for the appropriate Personal Protective Equipment to wear when handling hydrogen peroxide. In case of contact with the eyes, skin or clothing, flush with large amounts of water for 15 minutes. In case of ingestion, sit upright, drink large quantities of water to dilute

the stomach contents and seek immediate medical attention. Product in contact with combustible materials may cause fires.

2. Anti-Back Stain (ABS)

- **Commercial Name:** DENIMEX ABS NEW
- DENIMEX ABS NEW has outstanding dispersing properties to separated indigo and in this way reduces back staining.

- Steps of Desizing:

Add water……. 70 Liter

Temperature……. 60°C

Add H2O2…… 2 g/l

Add ABS……. 3 g/l

Time……. 10 minutes

After 10 minutes dropped the liquor.

Then rinse 2 times.

Appearance changes after desizing (Before and after):

3.2.2 Enzyme Wash (With Pumice Stone):

- **Chemicals for Enzyme Wash:**

  1. ESP Enzyme

  2. Anti-Back Stain (ABS)

  - **Commercial Name:** DENIMEX ABS NEW
  - **Supplier:** Resas technology
  - DENIMEX ABS NEW has outstanding dispersing properties to separated indigo and in this way reduces back staining.

  3. Pumic Stone

For this kind of wash, we soaked the stone and enzyme jointly. We must take certain precautions during this wash to prevent edge damage. The wash includes significant abrasion. For denim specifically, use this wash. The degree of this shade will be medium.

- **Steps of Stone Enzyme:**

  Add Stone……. 5 KG

  Add water……. 60 liters

  Add ESP Enzyme……. 0.5 g/l

  Add ABS…… 02 g/l

  Temperature…….……. 45°C

  Time …….……. 30 min

  Drop the liquor and Rinse 2 times

Appearance changes after Stone Enzyme wash (Before and after):

Figure 30: Changes effect after enzyme wash

Problems:

- Sometimes hem and steam damage.
- Sometimes metal can be found after using stone.

Solution:

- Time should be properly maintained.
- Enzyme percentage should be maintained properly.
- Stone should be in right size.

3.2.3 Bleach Wash:

- **Chemicals for Bleach Wash:**
    1. **KCI Bleach**

KCI bleach was used in this operation. This color is actually light. The color will fade more in this wash. Here, bleach is used to lighten indigo or other colors.

- **Steps of bleach wash:**

Add water…… 80 Liter

Add KCI Bleach……. 300 gm (Depend up to shade)

Temperature…… 45°C

Time……02 minutes check (Depend up to shade)

Drop the liquor and Rinse 2 times.

Appearance changes after bleach wash (Before and after):

Figure 31: Changes effect after bleach wash

Problem:

- Garments can be lighter than shade.
- Hem and seam line can be damaged.

Solution:

- Bleach percentage maintain properly.
- Temperature should be taken properly.
- Timing should be maintained properly

3.2.4 Neutral Wash:

After the bleach wash, the garments should be neutral.

- **Chemicals for Neutral Wash:**

  SODIUM METABISULPHITE

  - **Supplier:** SHANDONG KAILONG CHEMICAL TECHNOLOGY DEVELOPMENT CO., LTD.
  - Commercial Name: **Meta**
- **Steps of neutral wash:**

  Add water…… 70 Liter.

  Add META…… 100 gm

  Temperature ……. Room Temperature

  Time…… 5 minutes

  Drop the liquor and Rinse 2 times.

3.2.5 Acid Wash (With Pumice Stone):

- **Chemicals for Acid Wash:**
  1. **Potassium permanganate (KMnO4)**
  2. **Phosphoric acid (H3PO4)**

Acid wash have to done in following steps:

- **Drying of Garment, Machine and Stone:** Here, depending on the shade, the extracted garment is dried using a steam dryer or gas dryer. It should be mentioned that the steam dryer is utilized for bluish shades, while reddish shades are best dried with a gas dryer. The Stone also need to be dried and the machine should be dried with over stream.
- **Soaking of pumice stone:** Here, dried pumice stones are soaked in a solution of potassium permanganate (KMnO4) and phosphoric acid (H3PO4) in a liquid ratio of 1:2

for ten minutes at room temperature. Due of their inherent porosity, pumice stones should pick up the solution extremely rapidly.

- **Damp pumice stone:** The totally dry, bleach washed garments are treated in the washing machine with soaked pumice stones at room temperature for 07 minutes following the necessary pumice stone soaking (depending on the shade). After completing this step, the clothes are removed from the machine and loaded into a different washer to neutralize them.
- **Neutralizing the garments:** The garments must be neutralized here using sodium meta-bisulfite (Na2S2O3) with the liquor ratio (M: L) for five minutes after completing the soaked pumice stone procedure (depending on the shade).

Recipe for Acid wash procedure:

Add Dry Pumice Stone……..…. 5 kg

Water ……. No Need

Add potassium permanganate (KMnO4) ……..… 5 g/l

Add phosphoric acid (H3PO4) ……. 2.5 g/l

Time……. 07 minutes (2 minutes Check)
Temperature ……. Room Temperature

Neutral:

Add water…… 70 Liter

Add META……..… 2 g/l

Time……. 5 minutes

Drop the liquor and Rinse 2 times.

Appearance changes after Acid wash (Before and after):

Figure 32: Changes effect after Acid wash

Problem:

- Main problem of acid wash is no garment is match with each other.
- Garments can be uneven.
- PP sport may come.
- Marble effect comes more or less due to stone selection.
- Garments can be damaged due to high strength

Solution:

- Timing should be maintained properly.
- PP should be mix with water properly.
- Stone selection should be according to garments effect.
- Stone should be dry properly as per required.

3.2.6 Neutral with Acitic Acid

Before sent for PP Spray, sample should be Neutral with Acitic Acid

- **Chemicals for Neutral Wash-**
    1. **Acitic Acid (CH3COOH)**
        - Commercial Name: Acetic Acid Glacial 99%

Steps for Neutral:

Add water……. ….. 70 Liter

Temperature……. Room Temperature

Add Acitic Acid ……. 0.5 g/l

Time……. 2 minutes

Drop the liquor, Rinse 2 times and go for hydro and dryer for drying the samples. After dry, these samples went for PP Spray.

3.2.7 Potassium permanganate (PP) spray:

- **Chemicals for PP Spray:**
    1. **Potassium permanganate (KMnO4)**

Preparation of stock solution-

- water taken 1 liter, say
- Potassium permanganate (.4- .15 gm/L) (standard stock soln = .4 %)
- Acetic acid (as per need)

Machines / Apparatus and requirements required:

1. P. Spray Cabin
2. Spray gun
3. Air Dummy
4. Water circulation system
5. Masks, Gloves, safety shoes and apron
6. Electricity

Process of PP Spray:

- Garment is brought to P.P. Cabin and fixed on an air dummy that is compressed air-filled so that it is fully ready to be revealed.
- For various clothing sizes and styles, such as men's shirts and pants, different size dummies are utilized.
- The cabin booths have an effective air exhaust system installed.
- The chemically mixed air is routed through a water shower in the treatment chamber where the spray is performed.
- The p. p. dissolves in water, and the door is opened with fresh air.
- Finally, the garments are sprayed with p. p. spray.

Figure 33: PP Spray

After PP Spray, the Potassium permanganate need to be neutral with META.

PP Neutral:

Add water…… 70 Liter

Add META……..… 2 g/l

Time……. 5 minutes

Drop the liquor and Rinse 2 times.

After neutral the appearance we got:

Figure 34: Appearance after PP spray and neutral PP (Front and Back)

3.2.8 Cleaning

To maintain buyer standard, sample need to be clean more.

- **Chemicals for Clean:**
    1. Hydrogen Per Oxide (H2O2)
    2. Anti-Back Staining Agent (ABS)

Steps for Cleaning:

Add water…… 70 Liter

Add H2O2……..… 2 g/l

Add ABS……..… 4 g/l

Temperature……..… 70 C

Time……. 10 minutes

Drop the liquor and Rinse 2 times.

3.2.9 Softening

- **Chemicals for Softening:**
    1. **Anti-Ozone softener**

Steps for Cleaning:

- Add water…… 70 Liter
- Add Anti Ozone Softener……..… 10 g/l
- Temperature……..… 40C
- Time……. 10 minutes
- Drop the liquor and Hydro for dryer

Finally, we have got the final sample as per buyer standard. We have done all finishing in the finishing section. The final sample are shown below (Figure 35):

3.3 Lab test of this sample (Unwashed and Washed):

3.3.1 Tensile and Tear Resistance Tests:

Tensile Strength: The load or stretching force causes the fabric to lengthen as soon as it is applied. The elongation increases as the stretching force (load) steadily rises. The fabric starts to fail when the amount of stretching force reaches a specific level. We may now define the tensile strength of a fabric as the load (or stretching force) at which the fabric starts to break when stretched to its limit. It is expressed as a force in Newtons, pounds, or kilograms. It depends on the fabric's thread count per square inch, material type, and yarn strength, among other factors. In both the warp and weft directions, the fabric's tensile strength is assessed individually.

The tensile strength of synthetic fabrics is better than that of natural fibers. The tensile strength of a fabric comprised of fine, long-staple fibers is greater than that of coarse, short fibers. The garment with more threads per square inch will have a higher tensile strength if the warp and weft count of two fabrics are equal.

Tensile strength test: The tensile strength of fabrics can be conducted using one of two methods-

1. Strip test
2. Grab test

Tearing Strength: The fabric's ability to resist tearing or the amount of effort required to spread a tear after it has started. The ability of a textile material to resist being shredded when suddenly applied force is commonly referred to as tearing strength. Both high performance and ordinary textiles, such as industrial uses, bulletproof jackets, tents, worker jeans, sacks, fashionable clothing, and many more applications, need rip strength. This is important for industrial textiles because they are used for heavy-duty labor. The high tear strength of textiles ensures that fabric punctures do not spread quickly.

> **Tearing Strength Test:** The amount of force needed to spread an existing tear is measured. A cut is made in the fabric specimens as part of the preparation process, and the force needed to prolong the cut is measured.
>
> By holding the two sides of the cut in a normal tensile tester, this is traditionally done.

Types of Tearing Strength Test of Fabric:

1. Single rip tear test / Trouser tear test
2. Wing rip tear test

3.3.2 Color Fastness to Washing:

Color fatness to washing refers to the mechanical agitation of a textile sample in a soap solution under set duration and temperature circumstances while in contact with one or two specified adjacent materials, followed by rinsing and drying. The grey scales are used to evaluate the specimen's color change as well as the staining of the nearby fabric.

In a single test that closely resembles one residential or commercial laundry, the color fastness to washing is evaluated by evaluating the color loss and discoloration on neighboring cloth caused by desorption and or abrasion action.

There are a number of ISO test for color fastness to washing-

- ISO test no-1
- ISO test no-2
- ISO test no-3
- ISO test no-4
- ISO test no-5
- ISO 105 C06

Among them ISO 105 C06 is the first choice of maximum buyers.

ISO 105 C06 Test Method:

Instruments:

- Rotawash / Gyrowash,
- Stainless Still Ball,
- Multi-fiber fabric,
- Grey scale,
- Sewing machine,
- Thermometer,
- Colour matching cabinet

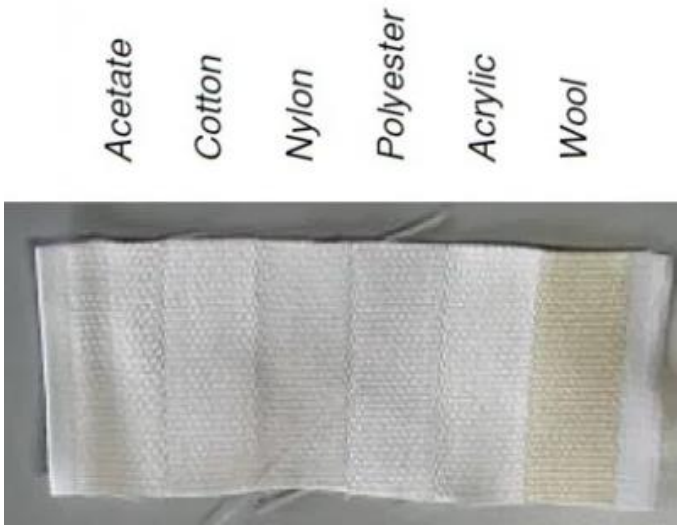


Figure 36: Multi-fibre fabric

Working Procedure of Colour Fastness to Washing:

Collecting the sample from bulk and then conditioning for 4.30 to 6 hours

↓

Making a specimen of 04 cm x 10 cm in size.

↓

Sewing the specimen with multi-fibre fabric of same size at one corner.

↓

Making the solution of 4gm/litre ECE detergent and 1 gm/litre sodium perborate, (If required SKFL use 0.15 gm/litre TAED).

↓

Putting the specimen with multi-fibre fabric into the solution in Rotawash m/c

(Prog.: C2S Temp.: 60oC/ 40oC Time: 30 min Still ball: 25 pcs)

↓

Rinsing with hot water respectively.

↓

Squeezing with cold water of the sample is done (Hand Wash).

↓

Then drying is done at a temperature in the air not exceeding 60oC

↓

The stitching is then broken out except on one of the shorter end.

↓

Measuring the staining and colour change by grey scale and make a test report.

3.3.3 Colorfastness to Rubbing

The process of transferring a dyed textile material's color from its surface to an adjacent region by rubbing it against another surface (often a bleached cotton cloth) is known as rubbing or crocking fastness. Crock meter testing is performed on it. It can be powered by a motor or by hand. Small abraded colored fiber particles stain the partner textile depending on the type of fiber, particularly its tensile strength. The determination of the crocking fastness rating does not take into account coarse fiber particles. Staining may also occur if the dyestuff used is water soluble and not suitably attached to the fiber. However, due to cellulose fiber abrasion, even dyeings with the best wet characteristics, such vat dyeing, have a limited or restricted wet crocking fastness.

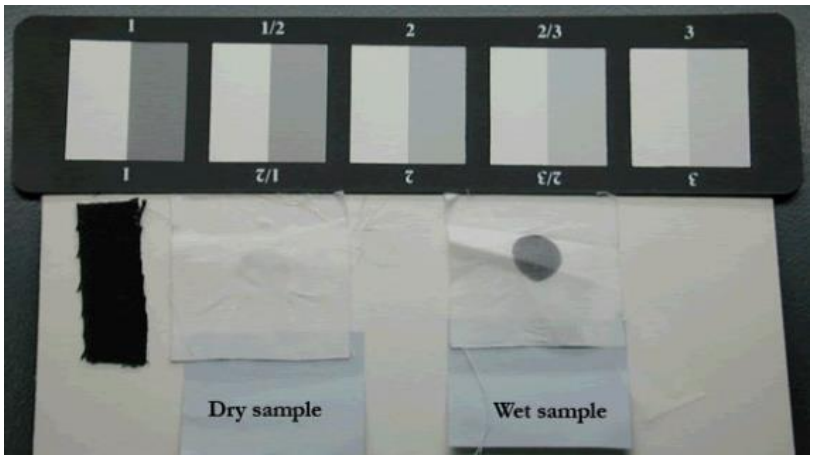


Figure 37: Grey Scale

Color Fastness to Rubbing Test Method:

Apparatus and Materials:

- Crockmeter or comparable alternate apparatus.
- Test Cloth, cut in 50 mm squares.
- Chromatic Transference Scale.
- Gray Scale for Staining.
- White Textile Blotting Paper.
- Specimen Holder for Crockmeter.
- In-house poor crocking cloth.
- Crockmeter Verification Cloth.

There are two test methods for rubbing fastness:

1. ISO-105-X12
2. AATCC-08

The wet pickup of the rubbing cloth is 100% in ISO-105-X12. While the wet pickup of the rubbing cloth in AATCC-08 is 65%. We use dry and wet procedures to inspect rubbing. In wet rubbing, the rubbing cloth is wetted in accordance with the test procedure, and the staining is compared to the grayscale to determine the rating.

The same is valid for dry rubbing; we examine the rubbing with a dry rubbing cloth and evaluate the staining using a grayscale. Every colorful cloth, whether it is printed or dyed, must always pass the main test of color fastness to rubbing.

Because rubbing is a means to check the fixing of the color on the fabric, if the color fastness to rubbing is good, then its other properties—such as washing fastness and durability—improve immediately. Therefore, a good fixation will have good washing qualities.

Fastness ratings, according to the grey scales for staining, range from 1 (poor rating) to 5 (best rating).

3.3.4 Colorfastness to Ozone

The purpose of the color fastness to ozone test chamber is to determine how well colored fabrics of all types and in all forms withstand exposure to ozone in an atmosphere with a specific temperature and humidity level. Evaluation of Ozone Resistance. It outlines a procedure for figuring out how resistant the color of textiles of all types and in all forms is to the effects of ozone in the air, both at room temperature and relative humidity levels that don't exceed 65% and at elevated temperatures and relative humidity levels that do.

Standards:

- GB/T 11041
- ISO 105-G03
- AATCC 109

3.3.5 Appearance After Home Laundering

This test is designed to gauge how well-maintained materials or apparel look after washing.

The evaluation process involves comparing the specimen's appearance to comparable reference specimens while employing standard lighting and a viewing space.

Test Method: AATCC150

- This test method is for the determination of dimensional (length and width) changes of garments when subjected to home laundering procedures. Three washing temperatures,

three agitation cycles, and three drying procedures provide standard parameters to represent common home care options.

- This method may not be applicable to garments made of certain stretch fabrics.

Assessment of Appearance After Home Laundering:

- Seam breakdown i.e. inadequate seams, partial or non-inclusion, faulty thread or stitching, fabric slippage, fraying from seam turnings, stitching damage etc.
- Puckering and roping of seams.
- Change in handle or appearance.
- Wet edge abrasion.
- Excessive creasing.
- Pilling of fabric surface.
- Breakdown of fabric surface.
- Loss of print.
- Colorfastness: shade change, cross staining between components. Apply standard values as per relevant performance test standard.
- Loss of elasticity (stretch and recovery) of ribbing.
- Differential shrinkage between components i.e. dropped or tight linings, seam pucker, distortion of components.
- Any Observed Defects etc.

3.3.6. Dimensional Stability Test

One of a fabric's most important properties is dimensional stability. Confirming a dyed fabric's dimensional stability is necessary. When a fabric is put over a substrate, its measured dimensional stability reveals whether it has the capacity to maintain its initial shape and remain stable, indicating it won't bubble or sag over time, and whether it is suitable for a certain usage. I'll talk about the dimensional stability of colored fabric to washing in this experiment.

Method:

- ISO 3759
- ISO 6330
- ISO 5077
- AATCC 150
- AATCC 135

AATCC 150 test method is for the determination of dimensional (length and width) changes of garments when subjected to home laundering procedures. Three washing temperatures, three agitation cycles, and three drying procedures provide standard parameters to represent common

home care options. This method may not be applicable to garments made of certain stretch fabrics.

Important bench mark locations for Shirts and Pants:

- **Shirt –** Collar, Collar Band, Body Lengths, Sleeve Lengths, Width at chest and Cuffs
- **Trousers –** Front rise, Back rise, Inseams, Out seams, Waist and Seat

Shrinkage:

The terms, "shrinkage" refers to a reduction in the size of a fabric or a garment. For fabric length, width, and thickness, this dimensional change may be positive (growth or elongation) or negative (shrinkage). Although a fabric's thickness can also alter after processing and throughout use, this is typically not a concern. Shrinkage refers to the loss of the length and/or width measurements for a cotton fabric. In the context of clothing, shrinkage features can also refer to other factors including seam puckering, torquing, and overall garment fit in addition to a change in fabric dimensions.

A fabric shrinks during the shrinkage process, which often occurs during the laundering process. Cotton cloth has two major drawbacks: it shrinks and wrinkles during consecutive washings. However, some textiles have a higher innate resistance to shrinking. Although they are not completely shrink-proof, synthetic fibers like polyester or nylon are often less likely to shrink than other types of fibers.

Shrinkage is determined as;

Shrinkage % = {(length of fabric before wash) – (length of fabric after wash)} / (length of fabric after wash) x 100

3.3.7. GSM (Gram per square meter)

GSM is short for grams per square meter. GSM is a unit of fabric weight. It has no restrictions but does influence several fabric qualities. In order to prevent financial loss throughout the manufacturing process, fabric weight must be regulated. For instance, ordering heavier fabric than is required for the product being created. Fabric thickness, flexural rigidity, bending rigidity, drape, air permeability, and thermal characteristics are all influenced by fabric weight, or GSM. For instance, the fabric's bending rigidity decreases with weight.

Woven Fabric GSM Calculation Method:

During calculating woven fabric GSM from fabric construction, we have needed the following formula.

GSM (Gram per square meter),

$$= \left[\left\{\frac{\text{EPI (Ends per inch)}}{\text{Warp count}} \times (\text{Warp crimp factor})\right\} + \left\{\frac{\text{PPI (Picks per inch)}}{\text{Weft count}} \times (\text{Weft crimp factor})\right\}\right] \times 23.5$$

Figure 38: GSM Cutter and Digital Balance

4 RESULTS & DISCUSSION

4.1 Tensile and Tearing Strength Tests:

Tensile Strength Test Report:

Before Wash-

TEST METHOD: BSEN ISO 13934-2

In House Test Report Color: Light Indigo	Requirement	Test Results			Rating
		No. Of Tests	Observations	Average	
Warp	140 N	01	151.3 N	154.0 N	Pass
		02	158.3 N		
		03	152.8 N		
Weft	140 N	01	80.6 N	77.9 N	Pass
		02	77.8 N		
		03	75.3 N		

Table 01: Tensile Strength Test Report (Before Wash)

After Wash-

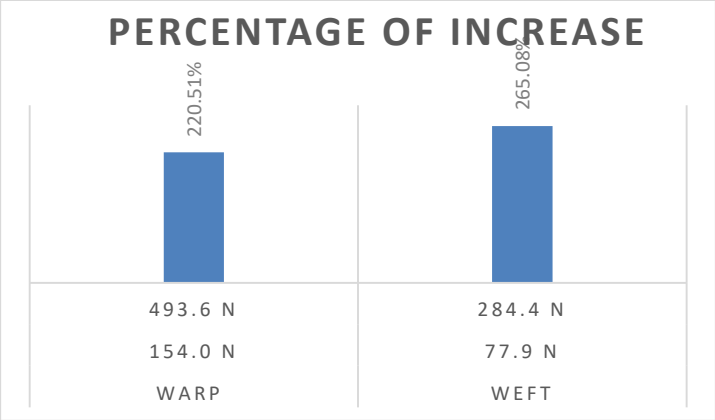
TEST METHOD: BSEN ISO 13934-2

In House Test Report Color: Light Indigo	Requirement	Test Results			Rating
		No. Of Tests	Observations	Average	
Warp	140 N	01	500.1 N	493.6 N	Pass
		02	485.2 N		
		03	495.6 N		
Weft	140 N	01	296.5 N	284.4 N	Pass
		02	265.8 N		
		03	290.5 N		

Table 02: Tensile Strength Test Report (After Wash)

Comparison of Tensile test between before and after wash (Table 03):

In House Test Report	Average Result (Before Wash)	Average Result (After Wash)	Percentage of increase/Decrease
Warp	154.0 N	493.6 N	220.51%
Weft	77.9 N	284.4 N	265.08%



From this experiment It can be observed that, the tensile strength had increased after washing process. It can be seemed that, after washing process, in warp direction the tensile strength increased 220.51% than before wash and in weft direction the tensile strength increased 265.08% than before wash.

Tearing Strength Test Report:

Before Wash (Table 04)-

TEST METHOD: ISO 13937-1

In House Test Report Color: Light Indigo	Requirement	Test Results			Rating
		No. Of Tests	Observations	Average	
Warp	13 N	01	43.2 N	43.7 N	Pass
		02	43.9 N		
		03	44.0 N		
Weft	13 N	01	22.5 N	22.5 N	Pass
		02	22.3 N		
		03	22.8 N		

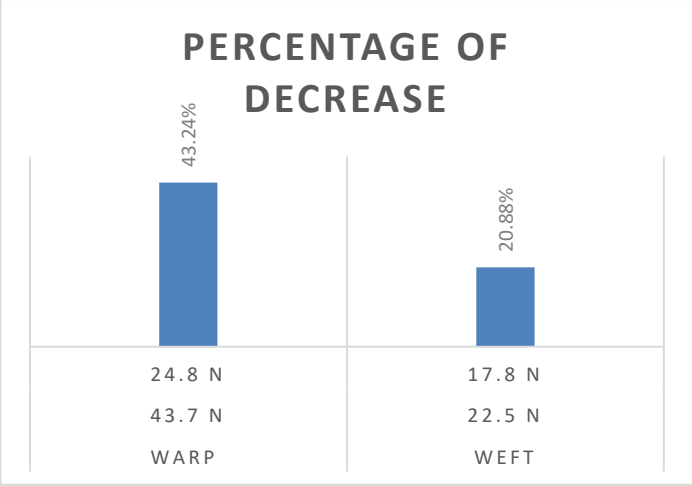
After Wash (Table 05)-

TEST METHOD: ISO 13937-1

In House Test Report Color: Light Indigo	Requirement	Test Results			Rating
		No. Of Tests	Observations	Average	
Warp	13 N	01	25.1 N	24.8 N	Pass
		02	24.8 N		
		03	24.6 N		
Weft	13 N	01	17.55 N	17.8 N	Pass
		02	17.81 N		
		03	18.0 N		

Comparison of Tearing Strength test between before and after wash (Table 06):

In House Test Report	Average Result (Before Wash)	Average Result (After Wash)	Percentage of Decrease
Warp	43.7 N	24.8 N	43.24%
Weft	22.5 N	17.8 N	20.88%



From this experiment It can be observed that, the tearing strength had decreased after washing process. It can be seemed that, after washing process, in warp direction the tearing strength decreased 43.25% than before wash and in weft direction the tearing strength increased 20.88% than before wash.

4.2 Color Fastness to Washing

Before Wash:

Test Method: ISO 105-C06

Colorfastness to Washing	Requirement	Test Results	Rating
-COLOR CHANGE	4	4.5	PASS
-SELF STAINING	4.5	4.5	PASS
-COLOUR STAINING (ACETATE)	4	4.5	PASS
-COLOUR STAINING (COTTON)	4	4.5	PASS
-COLOUR STAINING (NYLON)	4	1.5	FAIL
-COLOUR STAINING (POLYESTER)	4	1.5	FAIL
-COLOUR STAINING (ACRYLIC)	4	4.5	PASS
-COLOUR STAINING (WOOL)	4	2.0	FAIL

Table 07: Color fastness to washing (before wash) test result

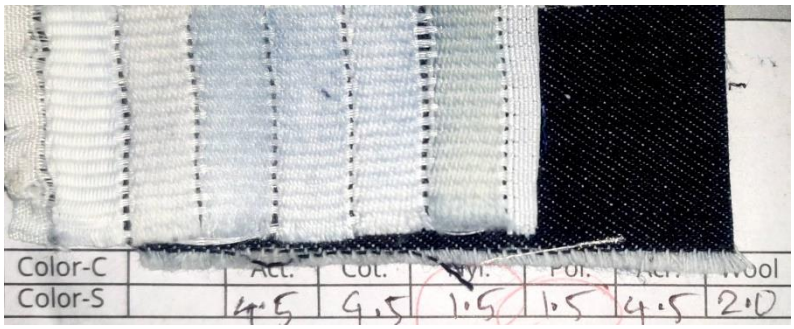


Fig: Color fastness to washing (before wash) test result

After Wash:

Test Method: ISO 105-C06

Colorfastness to Washing	Requirement	Test Results	Rating
-COLOR CHANGE	4	4.5	PASS
-SELF STAINING	4.5	4.5	PASS
-COLOUR STAINING (ACETATE)	4	4.5	PASS
-COLOUR STAINING (COTTON)	4	4.5	PASS
-COLOUR STAINING (NYLON)	4	3.5	FAIL
-COLOUR STAINING (POLYESTER)	4	4.5	PASS
-COLOUR STAINING (ACRYLIC)	4	4.5	PASS
-COLOUR STAINING (WOOL)	4	4.5	PASS

Table 08: Color fastness to washing (After wash) test result

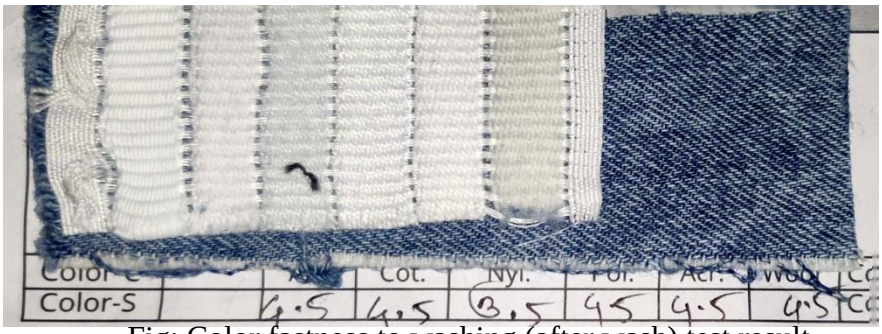
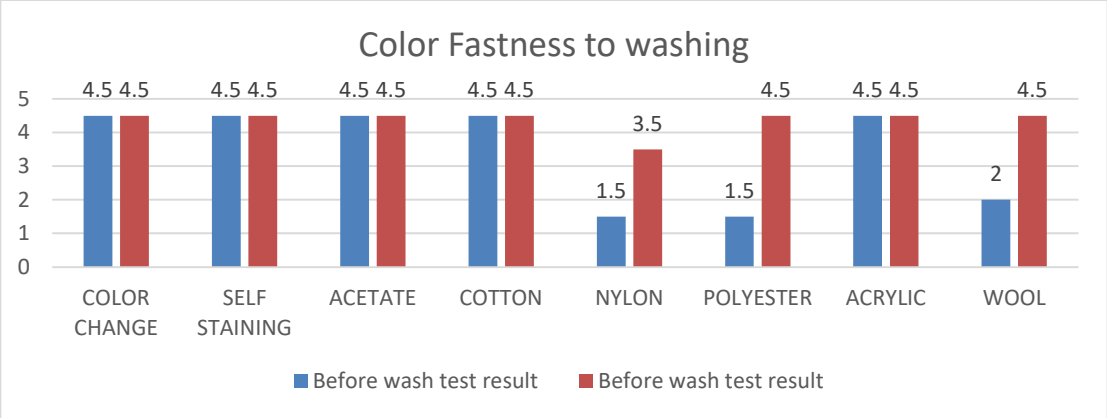


Fig: Color fastness to washing (after wash) test result

Comparison of Colorfastness to washing (Before and After):

Colorfastness to Washing	Before wash test result	After wash test result
-COLOR CHANGE	4.5	4.5
-SELF STAINING	4.5	4.5
-COLOUR STAINING (ACETATE)	4.5	4.5
-COLOUR STAINING (COTTON)	4.5	4.5
-COLOUR STAINING (NYLON)	1.5	3.5
-COLOUR STAINING (POLYESTER)	1.5	4.5
-COLOUR STAINING (ACRYLIC)	4.5	4.5
-COLOUR STAINING (WOOL)	2.0	4.5



From this experiment It can be observed that, colorfastness to washing of after wash is better than the before wash process. Here We can see that color staining to nylon (1.5) of before wash is very low and the same condition is for polyester (1.5) and wool (2.0) too. But after washing process these staining rate was very good. Like The nylon is 3.5, polyester 4.5 and wool also 4.5.

4.3 Colorfastness to Rubbing:

Before Wash:

Test Method: BS EN ISO 105-X12

Colorfastness to Rubbing	Requirement	Test Results	Rating
-Dry Crocking	3.0	2.5	Fail
-Wet Crocking	2.5	1.0	

Table 10: Colorfastness to Rubbing (Before wash)

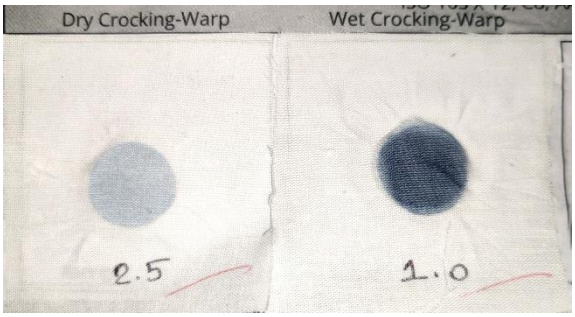


Fig: Colorfastness to Rubbing (Before wash)

After Wash:

Test Method: BS EN ISO 105-X12

Colorfastness to Rubbing	Requirement	Test Results	Rating
-Dry Crocking	3.0	4.5	Pass
-Wet Crocking	2.5	3.0	

Table 11: Colorfastness to Rubbing (After wash)

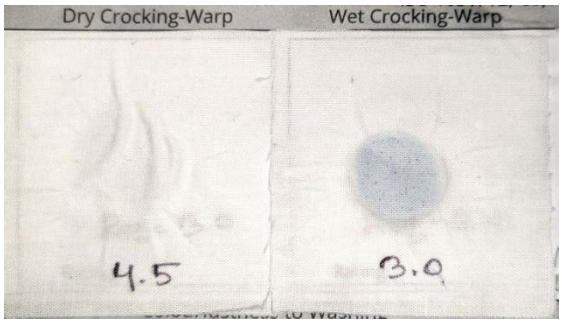
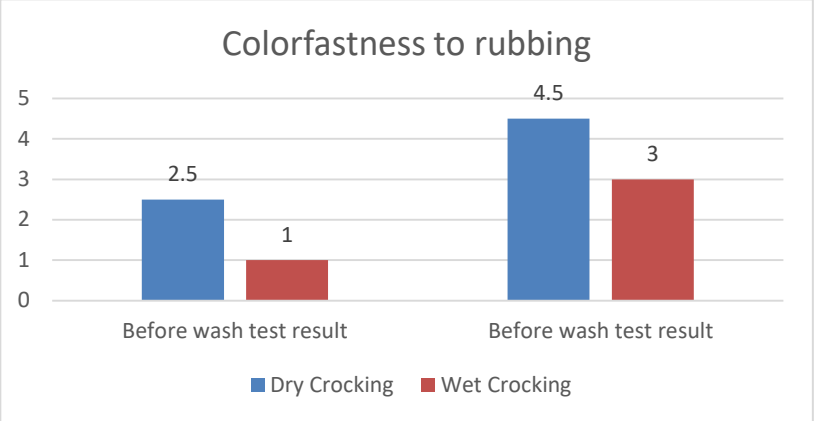


Fig: Colorfastness to Rubbing (After wash)

Comparison of Colorfastness to Rubbing (Before and After):

Colorfastness to Rubbing	Before wash test result	After wash test result
Dry Crocking	2.5	4.5
Wet Crocking	1.0	3.0

Table 12: Comparison of Colorfastness to Rubbing (Before and After)



From this experiment It can be observed that, colorfastness to rubbing after wash is better than the before wash process. Here We can see that, colorfastness of before wash sample is only 2.5 for dry crocking and 1 only for wet crocking. Which is very low. But after washing process this value was increased. After washing process, the colorfastness to rubbing is going for a good value (by Dry Crocking= 4.5 and by Wet Crocking=3.0). So, after wash process is better for colorfastness to rubbing.

4.4 Colorfastness to Ozone

Before Wash:

Test Method: AATCC 109

Colorfastness to Ozone	Requirement	Test Result	Rating
	=>4.0 @ 1 Cycle	2.5 @ 1 Cycle	Fail

Table 13: Colorfastness to Ozone (Before wash)

After Wash:

Test Method: AATCC 109

Colorfastness to Ozone	Requirement	Test Result	Rating
	=>4.0 @ 1 Cycle	3.5 @ 1 Cycle	Fail

Table 14: Colorfastness to Ozone (After wash)

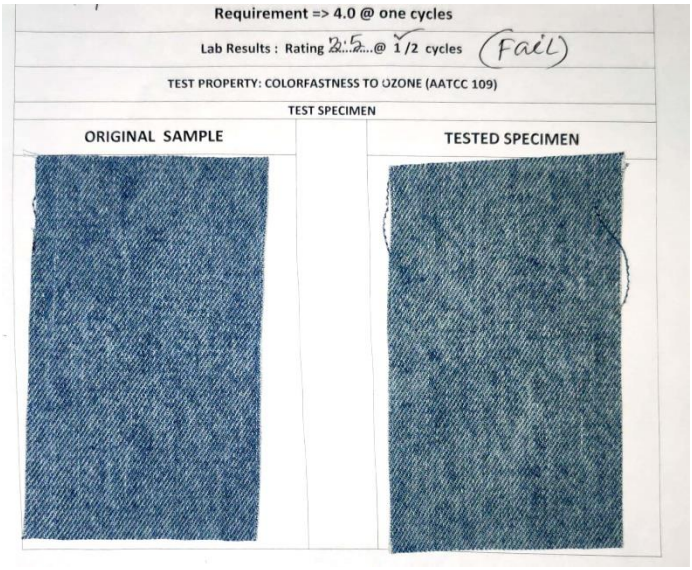
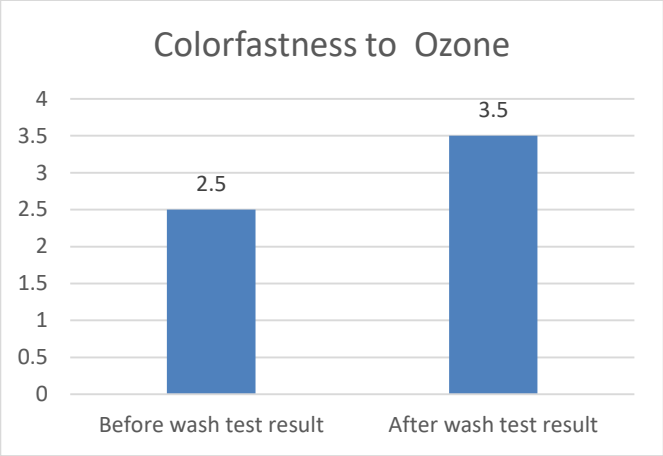


Figure: Colorfastness to Ozone test result

Comparison of Colorfastness to Ozone (Before and After):

Colorfastness to Ozone	Before wash test result	After wash test result
	2.5	3.5

Table 15: Comparison of Colorfastness to Ozone (Before and After)



It can be observed that, colorfastness to ozone is very poor on before wash test and after wash test got very good result. Through this result is not fulfilled the buyer requirement that's way we need more cleaner the garment and then again test for fulfilled it.

4.5. GSM (Gram per square meter) Measurement/ Fabric Weight

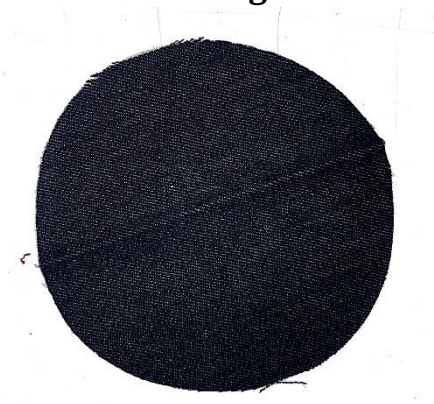
- **Before Wash,** GSM= 321 grams = 9.47 oz/yd²

  Here,

  321 grams = 11.32 ounce(s)

  and 1 square meter = 1.19599 square yard

  So, 321 g/m²(gsm) = 9.47 oz/yd²



- **After Wash,** GSM= 309 grams = 9.11 oz/yd²

  Here,

  309 grams = 10.90 ounce(s)

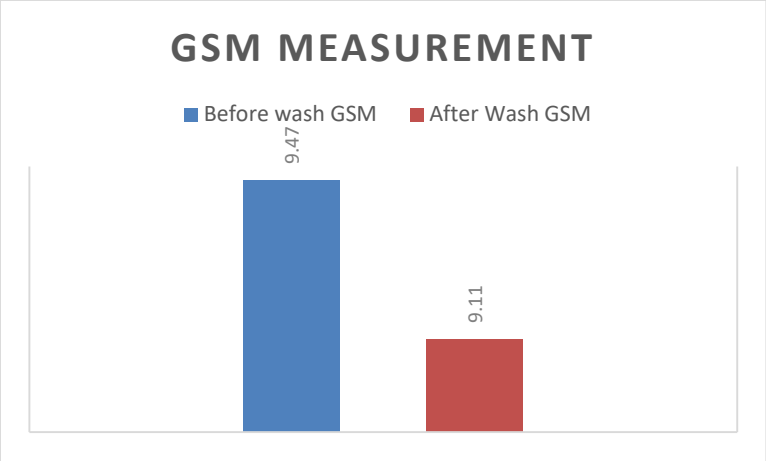
  1 square meter = 1.19599 square yard

  So, 309 g/m²(gsm) = 9.11 oz/yd²

Comparison of Colorfastness to Rubbing (Before and After):

GSM	Before wash test result	After wash test result
	9.47 oz/yd²	9.11 oz/yd²

Table 16: Comparison of GSM (Before and After)



From this experiment we have observed that, the weight before and after wash in Oz/Yd2. The weight has decreased after the wash. In unwashed sample we got the weight is 321 grams (9.47 oz/yd²) and after washing process the weight decreased at 309 grams (9.11 oz/yd²). The average decrease rate is 3.80%.

4.6 Appearance After Home Laundering

Test Method: AATCC 150

Process: TIDE DETERGENT, 3 WASHES, 3 DRIES (80 FAHRENHEIT DEGREE CELSIUS), NORMAL CYCLE, TUMBLE DRY LOW.

Appearance After Home Laundering	Requirement	Test Results	Rating
-Color Change	4.0	4.0	PASS
-Pilling		SATISFACTORY	PASS
- Multi Fiber Staining	4.5	4.5	
-Self Staining	=> 4.5	4.5	PASS
- Seam Breakage or Seam Puckering	No seam breakage/No seam puckering	NO SEAM PUCKERING	PASS

- Any Observed Defects		SATISFACTORY	PASS

Table 17: Appearance after home laundering test result

From this result, we can see that after home laundering process the physical changes in different parameters are very satisfactory and all the requirement are fulfilled. If we observed this result, we can find that the color changes, pilling, self-staining, seam puckering all are very good.

4.7. Dimensional Stability Test

Before and Washed Test:

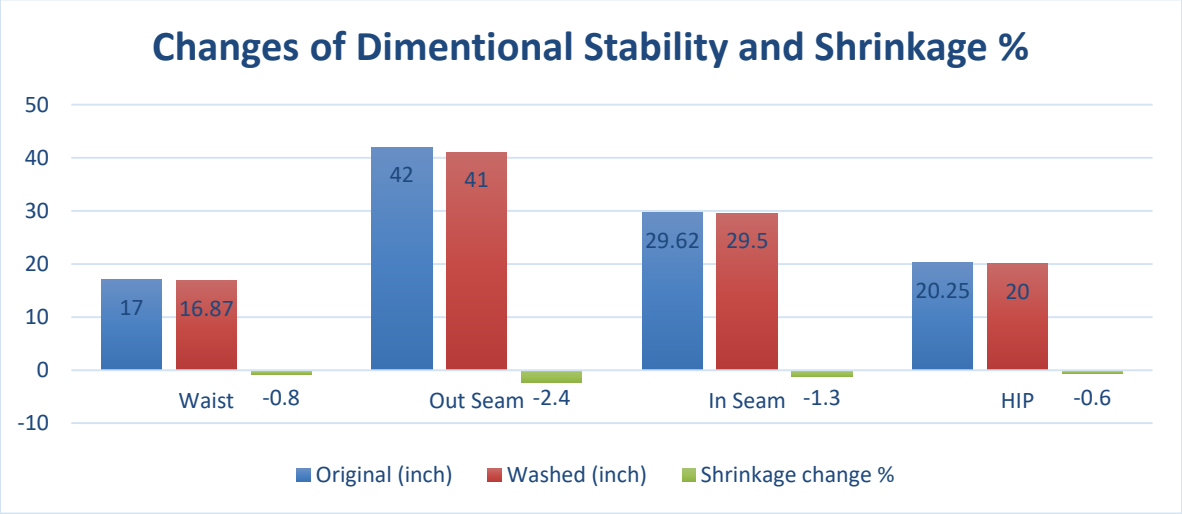
Test Method: AATCC 150

Requirement: Dimensional Change **=>-3 to 3%**

Process: MACHINE WASH COLD, GENTLE CYCLE, TUMBLE DRY LOW, DETERGENT USED: TIDE ORIGINAL

Garment Parts	Original (inch)	Washed (inch)	Shrinkage change %
Waist	17.0	16.87	-0.8
Out Seam	42.0	41.0	-2.4
In Seam	29.62	29.50	-1.3
HIP	20.25	20.0	-0.6

Table 18: Dimensional Stability test result



In this experiment we can find out the changes of dimensional stability and shrinkage % rate. From this chat, 1st column is for before wash measurement and 2nd column is for washed measurement and last one is for shrinkage %. After observation we can find that the dimensional stability has been reduced slightly after washing process. That's way the shrinkage also has done slightly like in waist -0.8%, in out seam -2.4%, in the in seam -1.3% and also in HIP -0.6%.

5 CONCLUSION

To conclude this report, we now understand how various types of washing are carried out on denim garments using various washing methods. Different washing processes showed in various shades of shade on denim garments. After the observation it is observed that, Unwashed garment is almost rigid and rough, thus it is apparent that after washing, it gains various qualities like appearance, softness, comfort, and strength. After the washing procedure is complete, fashions change extremely quickly. However, once the dry and wet processes are through, the garment develops an astonishing shade on denim garments. We can observe about the change in physical properties like GSM, weight, shrinkage%, Dimensional Stability, physical appearance, Color fastness to rubbing, Colorfastness to ozone, Colorfastness to washing and finally tensile and tearing strength. A magical element of wearing denim is the constant washing procedure. During the washing time, every washing operation must be carried out carefully. Therefore, proper quality control is required. We now have a vast amount of knowledge regarding various washing methods.

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http://dspace.daffodilvarsity.edu.bd:8080/bitstream/handle/20.500.11948/1366/P04724.pdf?isAllowed=y&sequence=1

