Faculty of Engineering

Department of Textile Engineering

Studies on the Effect of Bio-Polishing on the Physical Characteristics of Knit Fabric

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Submitted by:

Name	Id
Anik Chandra Das	201-23-934
Md. Al-fahid Chowdhury	201-23-959

Supervised by:

Tanvir Ahmed Chowdhury

Assistant Professor

Daffodil International University

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Advance in Wet Processing Engineering

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DECLARATION

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

Anik Chandra Das

Id: 201-23-934

Department of Textile Engineering

Daffodil International University

Md. Al-fahid Chowdhury

Id: 201-23-959

Department of Textile Engineering

Daffodil International University

LETTER OF APPROVAL

This project report prepared by Anik Chandra Das (ID: 201-23-934) and Md. Al-fahid Chowdhury (ID: 201-23-959), is approved in Partial Fulfillment of the Requirement for the Degree of BACHELOR OF SCIENCE IN TEXTILE ENGINEERING. The said students have completed their project work under my supervision. During the research period I found them sincere, hardworking and enthusiastic.

Tanvir Ahmed Chowdhury

ASSISTANT PROFESSOR

DEPARTMENT OF TEXTILE ENGINEERING

FACULTY OF ENGINEERING

DAFFODIL INTERNATIONAL UNIVERSITY

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This projects report is dedicated to our beloved Parents & Teachers

ABSTRACT

This study examines how the bio-polishing process affects the physical characteristics of textile fibers. Bio-finishing, an eco-friendly fabric treatment that improves fabric properties, is becoming a growing trend. The study examines enhancements in weight loss, WPI and CPI, reflectance value, and strength test before and after the bio-polishing process. Bio-finishing is a promising method that uses enzymes to cure fabrics. De-fuzzing fabric through enzymatic activity to eliminate protruding filaments. Bio-polishing can improve the quality of cotton and various natural and manmade materials. The bio-polishing process provides benefits like the removal of hairiness, fluffs, and pills, as well as improvements in handling, shine, and sewability. The thesis is titled "Studies on the Effect of Bio-Polishing on the Physical Characteristics of Knit Fabric". We choose four distinct types of knit fabric samples: single jersey, viscose, cvc, and interlock. We tried to determine the disparity in fabric characteristics before and after conducting bio-polishing. This study provides useful insights into textile engineering and sustainable practices by analyzing physical characteristics before and after bio-polishing in controlled tests.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER- 1

INTRODUCTION

1.1 Introduction

Bio-finishing is a trendy method of treating textiles using enzymes. Enhancements in bio-finishing of cellulosic fabrics have enhanced many surface properties. The primary goal of bio-finishing is to enhance the fabric by eliminating protruding filaments. Conventional techniques to get rid of remaining fibers require chemical treatment or singeing. Conventional methods are impermanent, potentially harmful, and lead to fibers reappearing and causing fuzziness after a few washes. Lint on the fabric's surface is the main reason for customer dissatisfaction. Enzymes can permanently remove fuzz from fabric by extracting the projecting strands during the finishing process. Enzyme treatment improves the texture, color, softness, and draping properties of textile or garment products, leading to a higher quality product. It helps preserve the fabric's look during multiple wash cycles. The colorfastness of cotton fabric is affected by the bio-polishing process, which may happen either before or after dyeing.

1.2 Objectives

The following report shows the Bio-polishing scenario. This thesis report aims to study the effects of before and after bio-polishing and also about the physical characteristics of the fabrics. Beside this –

- To learn about the bio-polishing process of different knitted fabrics.
- To examine the weight loss of different fabrics after the bio-polishing procedure.
- Compare the fabric sample before and after bio-polishing.

1.3 Limitations of the Study

- It is based on knit fabric.
- All experiments were carried out using the cellulase enzyme
- Focused on before and after bio-polishing & their physical characteristics.

CHAPTER- 2

LITERATURE REVIEW

2.1 Bio-polishing

2.1.1 What is Bio-Polishing?

The textile finishing procedure referred to as "Bio-polishing." Bio-polishing is a textile finishing process that improves the quality of fabric by reducing the fuzziness and tendency to pill of knitted cellulose materials. Cellulose-based textiles are treated with an enzyme-based finishing process to create long-lasting results. This procedure improves the smoothness of knitted textiles, decreases pilling, softens the fabric's texture, and eliminates projecting fibers and defects.

Figure:2.1- Bio-polished Knit fabrics

2.1.2 Objectives of Bio-polishing in Textile

- To eliminate slubs and protruding strands.
- To remove pills, fluff, and hairiness.
- To prevent adhesion of materials.
- To enhance the grip and make the fabric softer.
- To enhance the surface's luster and smoothness.
- To improve the material's relaxation and flexibility by improving its texture.

2.1.3 Chemical used in Bio-polishing

Sequestering Agent- It is a chelating agent that deactivates metallic salts of water, hence reducing water hardness.

Figure 2.2 - Sequestering Agent

Cellulase Enzyme- A naturally occurring microorganism is used in cotton bio-polishing to eliminate surface hairiness and reduce the tendency of materials to pill.

Figure 2.3 - Cellulase Enzyme

Wetting Agent- Although it's cleansing abilities, it is susceptible to moisture, similar to detergents. Glycerin and TR oil are examples of wetting agents.

Figure 2.4 - Wetting Agent

Acetic Acid- These are classified as weak acids because of their organic composition and are used in wet processes to maintain the solution's acidity.

Figure 2.5 - Acetic Acid

2.1.4 Flowchart of Bio-polishing

There are two forms of Bio-polishing:

1. Bio-polishing after dyeing.

2. Bio-polishing before Dyeing.

2.1.4.1 Flowchart of Bio-polishing after dyeing-

Scoured &bleaching sample

↓

Dye addition

↓

Salt addition

↓

Soda ash addition

↓

Dyeing

↓

Hot wash

↓

Cold wash

↓

Enzyme treatment

Cold wash

↓

Drying

2.1.4.2 Flowchart of Bio-polishing before Dyeing-

Scoured & bleaching sample

↓

Bio-polishing

↓

Cold wash

↓

Drying

↓

Dye addition

↓

Salt addition

↓

Soda ash addition

↓

Hot wash

↓

Soaping

↓

Hot Wash

↓

Cold wash

↓

Drying

2.2 Fabric Specification

2.2.1 Cotton Fabric-

Cotton fabric is made from the fibers of the cotton plant. Due to its adaptability, comfort, and durability, this fabric is very popular and often used worldwide. Cotton fabric is well-known for its soft texture and ability to allow air to pass through, making it suitable for a range of clothing items such as shirts, skirts, pants, and undergarments. It is also visible in beds, towels, and curtains. Cotton has become popular for its moisture-absorbing qualities, which provide comfort when worn in hot and humid conditions. Cotton is a biodegradable and environmentally friendly fiber when compared to synthetic ones. Traditional cotton production can have negative environmental impacts because of the application of pesticides and water-intensive agricultural practices. Organic cotton, manufactured without synthetic fertilizers and pesticides, is a more environmentally responsible choice.

2.2.2 Viscose Fabric-

Viscose fabric, often known as rayon, is a semi-synthetic material manufactured from natural cellulose fibers, mainly obtained from wood pulp or bamboo. Its smooth, silky feel and great drape make it a popular choice for garments and home textiles.

Here are some key characteristics and uses of viscose fabric:

- **Softness and Comfort-** Viscose is comfortable because to its silky and smooth feel. It has a texture comparable to silk and cotton, both of which are natural fibers.
- **Breathability-** Viscose fabric is breathable, allowing air to flow through it. Therefore, it is a suitable choice for clothing in warm weather.
- **Drapability-** Viscose has excellent draping characteristics, allowing it to flow and hang smoothly. This feature makes it a popular choice for garments with comfortable designs including blouses, dresses, and skirts.
- **Absorbency-** Viscose is more comfortable in hot and humid circumstances due to its moisture-absorbing properties. It should be laundered carefully because it may weaken when wet.
- **Versatility-** Viscose might look like the physical characteristics of natural materials such as cotton, silk, and wool. It can be used into a variety of outfits, which can be formal to informal.

- **Blend possibilities-** Viscose can be blended with other fibers like cotton, polyester, or spandex to improve particular characteristics such as strength, stretch, or durability.
- **Environmental Consideration-** Viscose is derived from natural sources but is produced by chemical methods. Production operations affect the environment. Some viscose is made using eco-friendly methods, but others might involve the use more chemicals.

Viscose is commonly utilized in the fashion industry to produce dresses, blouses, and scarves. It offers an excellent appearance with breathability and comfort.

2.2.3 CVC Fabric-

The fabric known as "Chief Value of Cotton" is commonly referred to as CVC fabric. This fabric is a combination of polyester and cotton fibers. CVC fabric often contains a larger amount of cotton, ranging between 60% and 80%, and a lower percentage of polyester, usually between 40% and 20%.

CVC fabric blends with the most excellent properties of polyester and cotton:

- **Comfort of Cotton-** Cotton fibers are known for their soft texture, ability to allow air to pass through, and pleasant feel on the skin. Cotton's breathability makes it ideal for hot climates and sensitive skin.
- **Durability of Polyester-** Polyester fibers provide the cloth with durability, elasticity, and lasting quality. Polyester improves the overall performance and durability of the fabric by reducing wrinkles, shrinkage, and color fading.
- **Easy Care-** CVC fabric is easy to maintain as it can usually be machine washed and dried without much shrinkage or wrinkling.
- **Versatility-** CVC fabric's versatility allows for the production of various garments and textile goods including casual wear, uniforms, shirts, and pants.
- **Cost Effectiveness-** CVC fabric provides a cost-effective alternative to 100% cotton fabrics, achieving a balance between the performance characteristics of cotton and polyester.

2.3 Process Variable

Concentration, Temperature, pH, M:L, Time

In order to attain the finest possible bio-polishing, the following procedure have been mentioned below-

Concentration- Concentration of Enzymes- 1.2%

Temperature- Temperature are 60^0C

pH - 4.5 – 5.5

M:L - 1:30

Time- 45 min

2.3.1 Standard recipe for Bio-polishing

Concentration- Concentration of Enzymes-3%

Temperature- Temperature are 55^0C

pH - 4.5 – 5.5

M:L - 1:10

Time - 50 min

2.4 Factors affecting Bio-polishing

Several factors influence bio-polishing. The main factors are process variables, fabric type, and enzymes. Temperature, pH, treatment duration, material to liquid ratio, enzyme concentration, and mechanical agitation are the main factors that affect bio-polishing. The authors employed the following approaches to conduct bio-polishing to assess the influence of the aforementioned parameters-

- Keeping a constant M:L ratio, pH, and temperature and changing the enzyme concentration.
- Keeping a consistent pH and temperature while changing the material to liquid ratio.
- Changing the temperature while keeping a constant M: L ratio.
- Changing the pH of the solution while keeping a constant M: L ratio and temperature.
- Keeping all these factors constant and varying the treatment duration..

2.4.1 Effect of Concentration-

The efficiency of the bio-polishing process on the knitted fabric is greatly impacted by the enzyme concentration. Various types of enzymes are available in the market. Each enzyme has an optimal pH, temperature range, and concentration. By adjusting the cellulose concentration while keeping other variables constant, such as pH, temperature, time, and the material to liquid ratio. To examine the impact of enzyme concentration on bio-polishing knit fabric samples treated with different concentrations of Cellusoft-SO like 0.5%, 1%, 1.2%, 2%, 2.5% and 3%.

2.4.2 Effect of Temperature-

Temperature affects cellulase activity. Each enzyme has an optimal temperature range for maximum activity. Hence, determining the optimal temperature is crucial. Enzyme activity decreases quickly as temperature rises, becoming nearly zero at 80°C, which results in permanent deactivation of the enzymes. While the enzyme's reaction speed decreases at low temperatures, it remains active and is not deactivated. Thus, employing an extended cycle at a reduced temperature is possible. Cellusoft-SO's activity is reduced to 50% at 40°C. Each 10°C increase in temperature results in a doubled rise in enzyme activity, unless the enzyme is deactivated. To determine the impact of temperature on bio-polishing, the knit fabric samples were treated at temperatures of 40°C, 50°C, 55°C, and 60°C.

2.4.3 Effect of pH-

pH is another crucial factor that affects the efficiency of bio-polishing. Optimal cellulase activity depends on a certain pH range. To investigate the impact of pH on bio-polishing of the knit fabric sample treated with 3% Cellusoft-SO at pH levels ranging from 3-4, 4-5, and 5-6. Enzyme activity maximum at pH 4.5-5.5.

2.4.4 Effect of M:L-

The ratio of M:L has a major impact on bio-polishing. As the liquor ratio increases, the bath concentration of cellulase decreases and the fabric weight loss reduces. The dilution has a considerable impact on enzymatic activity. To investigate the impact of liquor ratio (M:L) on bio-polishing the knit fabric samples treated with 3% Cellusoft-SO at different M:L ratios of 1:5, 1:10, 1:15, and 1:20.

2.4.5 Effect of Duration-

To determine the impact of different durations of enzymatic treatment on bio-polishing the knit fabric samples treated with 3% Cellusoft-SO for 30, 40, 50, and 60 minutes.

2.4.6 Effect of Enzyme treatment on Dyeing property-

To observes the impact of enzyme treatment on the dyeing properties of bio-polished knit fabric has been carried out , both before and after dyeing.

2.5 Why we use Bio-polishing?

Textile bio-polishing enhances fabric qualities by eliminating projecting filaments and fuzz. Enzymes are used in bio-polishing to degrade cellulose fibers, leading to a smoother surface, decreased pilling, and enhanced fabric quality. This technique improves the fabric's softness, decreases wrinkling, and results in a more comfortable and attractive final product.

2.5.1 Importance of Bio-polishing

Bio-polishing compounds are essential in the textile industry since they improve fabric softness and visual attractiveness. This treatment minimizes pilling, the formation of fiber balls around protruding ends, resulting from repeated washing or rubbing. These agents enhance the appearance and strength of textiles by creating a smoother and more uniform surface. The process, applied post-dyeing, involves enzymes reacting with acid dyes to achieve optimal textural improvement without compromising color integrity. This chemical treatment provides clothing with a soft and silky texture, while also reducing fraying and avoiding shrinking or stretching.

2.5.2 Advantages of Bio-polishing

- Remove hairiness, fluff, and pills.
- Enhanced grip.
- Achievement of surface smoothness and distinct structural appearance.
- Enhanced luster.
- Enhanced sewing capability.
- Enhance flexibility to achieve a softer feel.

2.5.3 Disadvantages of Bio-polishing

- Weight loss.
- Strength loss.

2.6 What is Enzyme?

Enzymes are proteins that function as catalysts in chemical processes. They are essentially elongated chains of amino acids connected by peptide bonds. Enzymes, similar to other catalysts, function by reducing the activation energy of a reaction, leading to a significant acceleration of the process.

Enzymes are significantly more specialized than most other catalysts. Enzymes have been demonstrated to catalyze about 4,000 biological processes. Organisms produce proteins known as enzymes. A synthetic enzyme created in a laboratory to perform a certain function. Most catalysts have limited stability and eventually lose their activity, becoming inactive. Most enzymes are typically used only once and then wasted.

Various types of enzymes are compatible with specific stains. Enzyme cleaning breaks down the stain into small molecules that can be easily washed away with water or normal soap.

Enzymes have been utilized in many ways in textile applications in recent years. Denim stone washing and surface modification of cellulosic fabrics are commonly used to improve their appearance and texture. Cellulose-based bio-finishing is used on both clothing and knitted goods. This can be accomplished either prior to or following death. Enzyme-treated fabrics have reduced surface hairiness and significantly enhanced handle flexibility.

Enzymes are ecologically friendly as they decay easily. Bio-finishing, also known as bio-polishing, is a finishing method that utilizes enzymes to produce permanent effects.

2.6.1 The history of Enzyme in Textile

- Amylase Desizing was introduced in 1952.
- Protease Wool was introduced in 1984.
- Cellulose Bio-stoning was introduced in 1987.
- Catalase Bleach cleanup was introduced in 1993.
- Laccase Denim Bleaching was introduced in 1996.
- Peroxidase Enzymatic Rinse was introduced in 1999.

2.6.2 Various enzyme used in Textile wet processing

- **Celluase enzyme:** A naturally existing microorganism is utilized in cotton bio-polishing to decrease fabric pilling and reduce surface hairiness.
- **Amylase enzyme:** This living microorganism breaks down the size components of woven fabric to enhance the fabric's water absorption ability in the cotton enzymatic desizing process.
- **Catalase enzyme:** After peroxide bleaching, this microorganism is employed to reduce any residual peroxide from the fabric, enhancing color stability.
- **Pectinase enzyme:** This enzyme is utilized in the cotton bio-scouring procedure to cleanse and make the cotton fiber more water-attracting by removing natural impurities including oil, fat, wax, dust, and dirt.
- **Lipases:** It decomposes fats and oils into alcohol and organic acids via hydrolysis.

2.6.3 Enzyme for Bio-polishing

Celluloses originate from bacterial and fungal origins. These enzymes are widely utilized on cellulosic materials and are believed to contribute about 1% of the finishing process, resulting in various impacts. They are also utilized in the food, pharmaceutical, and paper industries. Celluloses utilized in the bio-finishing of cellulosic textiles are sourced from over 10 distinct fungus species. The fungus species vary in their component makeup, application pH, and effects produced. Trichoderma reesei celluloses are commonly utilized in textile finishing due to their superior productivity in industrial settings. Celluloses are complex protein bio-catalysts with large molecular weight in compound form. Industrial celluloses consist of a combination of various celluloses, cellobiase, and related enzymes, with molecular weights ranging from 10,000 to 4 million. Their composition is completely non-uniform. Removing surface fibers results in a smoother cloth surface and a softer feel. The degree of strength loss is strongly related to the rate of weight loss.

2.6.4 Enzyme Inactivation

Bio-polishing involves the removal of protruding fibers from fabric surfaces using cellulase enzymes. These proteins, known as enzymes, can break down cotton cellulose by hydrolysis. After bio-polishing, the short fibers protruding from the fabric's surface are weakened to allow their removal after washing. This technique enhances the smoothness of the texture and decreases the chance of pilling or frizzing. This approach is suitable for garments made of cotton and cotton mixes. There are two commercially available forms of cellulose: acid cellulose, which is most effective in an acidic medium with a pH range of 4.5 to 5.5, and neutral cellulose, which is most effective in a pH range of 5.5 to 8.0. Both cellulose are active between temperatures of 45°C and 60°C.

It is essential to deactivate the enzyme at the end of the treatment procedure to prevent damage to the fabric after the finishing process. If the enzyme is not completely deactivated after the process, the fibers will be damaged. The material could be completely destroyed under severe conditions. Hence, the enzyme's deactivation is crucial from a technical standpoint.

There are two process of Enzyme inactivation-

- Hot treatment at 80^0C for 5 minutes
- By increasing pH to 11-12

2.6.5 Changes in Physical properties due to the Bio-polishing Enzymes

Pilling- After bio-polishing the knitted fabrics, it was observed that there was minimal difference in the pilling resistance ratings between the fabric samples made from open-end yarns and combed yarns. Knitted fabrics made from open-end yarns and combed ring-spun yarn showed better pilling resistance than those made from carded ring-spun yarn. Increasing the Martindale Instrument's spins to 5000t/m resulted in higher pilling values for both ring and open-end yarns.

Strength- Cotton exhibits a form of partial hydrolysis in the bio-polishing process, causing a decline in the fabric's strength. Combed yarn fabrics provide outstanding durability. Fabrics made from combed yarns exhibited superior strength values during both neglected and enzymatically treated conditions across three phases, in compared with textiles utilizing carded and open-end yarns. The fabric sample strength tends to decrease via approximately 11% after enzymatic treatment following pre-treatment or dyeing processes, depending on fabric types. By undertaking pre-treatment and dyeing procedures, cloth samples often exhibit a 25% reduction in strength following two cycles of enzyme treatment. Fabric samples produced from combed yarn demonstrate a far significant decline in strength.

Fabric Weight- Approximately one to five percentage of the fabric's weight is lost after completing the bio-polishing process. Fabric samples treated with enzymes before dying exhibited significantly higher weight loss compared to fabric samples treated with enzymes after dying. The removal of fuzz from the yarn surface is achieved by a lengthy period of being processed, a large number of processing stages, and great mechanical pressures. The open-end yarn revealed a minimal weight reduction, while the fabric produced from carded yarn had the highest weight loss value when examining weight reduction depending on the yarn spinning system. The combination enzymatic treatment caused a far greater percentage of weight loss.

Color Change- After enzyme treatment, the K/S value of carded yarn fabrics appeared to be higher, resulting in a darker color. However, the K/S value maintained constant in terms of weight loss for fabrics dyed with vat dyes and after cellulose treatment with direct and reactive dyes. The K/S values decreased to a lesser extent in materials pre-treated with celluloses before dyeing compared to untreated fabrics, particularly after 20-30 wash cycles.

Water absorbency- Bio-polishing affects a fabric's water absorbency and absorption qualities compared to control fabrics, influenced by the fabric's construction and hydrolysis rate. Cellulase-treated fabrics exhibit increased energy release when moist, boosting thermal comfort in humid conditions. Surface peeling and microfibril splitting enhance the water absorption of cotton and cotton/linen by 24–28%. Enzyme hydrolysis removes accessible amorphous components, leading to a reduction in moisture adsorption over time. Combining enzyme and softener processes reduces the fabric's moisture-holding ability during bio-polishing. The drop in time required for medium weight fabrics is from 4.52 seconds to 0.78 seconds, while for heavy weight materials, it goes from 20.1 seconds to 12.9 seconds.

CHAPTER- 3

EXPERIMENTAL DETAILS

3.1 Materials

We have done our thesis in our lab and factory. In our lab we followed a recipe for Bio-polishing. In this project, we used different types of knit fabric. We collected our before bio-polishing fabric sample and experimental data on the basis of that recipe.

3.1.1 Materials & Equipment

Figure 3.1-Bio-polishing Enzyme

Figure 3.2-Acetic Acid

**Figure 3.3-
Sequestering Agent**

**Figure 3.4-Wetting
Agent**

**Figure 3.5-pH
meter**

**Figure 3.6-Glass
Rod**

**Figure 3.7-
Thermometer**

Figure 3.8-Digital Balance

Figure 3.9-Scissor

Figure 3.10-Dye Bath

Figure 3.11-Measuring Cylinder

3.2 Method

3.2.1 Method of Data Collection

First we collect our required fabric sample from our lab. Then we cut these fabric sample by using scissor to our required weight (5 gm). Then we calculate the recipe. Then we collect our required chemicals like enzyme, wetting agent, sequestering agent, acetic acid. We take required fresh water in a beaker and mix all the chemicals in this beaker by using a glass rod. Then we take the pH value. After this we take a pot and put it on a gas burner. Then we start our experiment. When temperature is rise up to 40^0C we add our fabric sample and rise the temperature up to 55^0C and run this experiment for 45 minutes and then bath drop and rinsing. Again this fabric sample goes for hot wash and rise the temperature up to 80^0C for 5 minutes. Then drying this sample.

3.2.2 Process Flowchart

Collect fabric sample as required

↓

Set Water level

↓

Add enzyme

↓

Add sequestering agent

↓

Add wetting agent

↓

Add acetic acid

↓

Add fabric sample

↓

Rise temperature up to 60^0C

↓

Run for 45 minutes

↓

Bath drop

↓

Rinsing

↓

Hot wash at 80^0C for 5 minutes

↓

Drying

3.3 Method of testing

3.1.1 Apparatus

- Beaker
- Measuring Cylinder
- Pipette
- Pot
- Tri-pod stand
- Gas Burner
- Digital Balance
- Scissor

3.3.2 Recipe for testing

SL	Chemical/Process Parameter	Unit	Dossing
01	Cellulase Enzyme	%	1.2
02	Acetic acid	g/L	0.8
03	Wetting agent	g/L	1
04	Sequestering Agent	g/L	1
05	Sample Weight	gm	5
06	M:L	-----	1:30
07	Temperature	°C	60
08	Time	min	45
09	pH	5.5	---

Table:3.1- Recipe for testing

3.3.3 Recipe Calculation for Single jersey-

Total Liquor = Material Weight × Liquor

= 5.26 × 30

= 157.8 mL

Cellulase Enzyme = $\frac{5.26 \times 1.2\%}{100}$ mL

= 0.0631 mL

Acetic Acid = $\frac{157.8 \times 0.8}{1000}$ mL

=0.126 mL

Wetting Agent = $\frac{157.8 \times 1}{1000}$ mL

= 0.157 mL

Sequestering Agent = $\frac{157.8 \times 1}{1000}$ mL

= 0.157 mL

Initial Water= Total Liquor - (chemicals)

$=157.8 - (0.0631 + 0.126 + 0.157 + 0.157)$ ml

= 157.8 – 0.5031mL

=157.29 mL

3.3.4 Recipe Calculation for Viscose-

Total Liquor = Material Weight × Liquor

= 5.15 × 30

= 154.5 mL

Cellulase Enzyme = $\frac{5.15 \times 1.2\%}{100}$ mL

= 0.061 mL

Acetic Acid = $\frac{154.5 \times 0.8}{1000}$ mL

=0.123 mL

Wetting Agent = $\frac{154.5 \times 1}{1000}$ mL

= 0.154 mL

Sequestering Agent = $\frac{154.5 \times 1}{1000}$ mL

= 0.154 mL

Initial Water= Total Liquor - (chemicals)

$=154.5 - (0.061 + 0.123 + 0.154 + 0.154)$ ml

= 154.5 – 0.492mL

=154.00 mL

3.3.5 Recipe Calculation for CVC-

Total Liquor = Material Weight × Liquor

= 5.18 × 30

= 155.4 mL

Cellulase Enzyme = $\frac{5.18 \times 1.2\%}{100}$ mL

= 0.062 mL

Acetic Acid = $\frac{155.4 \times 0.8}{1000}$ mL

=0.124 mL

Wetting Agent = $\frac{155.4 \times 1}{1000}$ mL

= 0.155 mL

Sequestering Agent = $\frac{155.4 \times 1}{1000}$ mL

= 0.155 mL

Initial Water= Total Liquor - (chemicals)

$=155.4 - (0.062 + 0.124 + 0.155 + 0.155)$ ml

= 155.4 – 0.496mL

=154.90 mL

3.3.6 Recipe Calculation for Interlock-

Total Liquor = Material Weight × Liquor

= 4 × 30

= 120 mL

Cellulase Enzyme = $\frac{4 \times 1.2\%}{100}$ mL

= 0.048 mL

Acetic Acid = $\frac{120\times 0.8}{1000}$ mL

=0.096 mL

Wetting Agent = $\frac{120 \times 1}{1000}$ mL

= 0.12 mL

Sequestering Agent = $\frac{120 \times 1}{1000}$ mL

= 0.12 mL

Initial Water= Total Liquor - (chemicals)

$=120 - (0.048 + 0.096 + 0.12 + 0.12)$ ml

= 120 – 0.384 mL

=119.61 mL

3.4 Experimental Data of WPI & CPI

All the samples are collected from our lab (100% cotton knit fabric).

Apparatus-

- Pen
- Counting Glass

WPI- WPI stands for wales per inch. The term "wales per inch" (WPI) refers to the number of wales in an inch of knitted fabric.

CPI- CPI stands for course per inch. The term "course per inch" (CPI) refers to the number of courses in an inch of knitted fabric.

3.4.1 Working Procedure-

- First, we take the fabric according to its direction course and wales.
- Then set the point of the counting glass and counting the yarn through 1 inch by the help of the counting glass.
- At last, we find the WPI and CPI.

Fig: 3.12- Counting Glass

Counting Glass- We can measure the Wales Per Inch (WPI) and Courses Per Inch (CPI) of the knit fabric using a counting glass.

Fig: 3.13- Needle

Needle- We can simply determine the WPI and CPI of the fabric by using a needle.

3.5 Experimental data of Spectrophotometer

A spectrophotometer is a device used to measure electromagnetic energy at specific wavelengths of light with accuracy. It detects colors and the quantity of each color in a light beam by utilizing the properties of light and energy. A spectrophotometer consists of two primary parts: a photometer and a spectrometer.

Spectrometer: A lens directs a beam of straight light toward a prism, which split it into its individual wavelengths. The wavelengths that have been selected by a wavelength selector are then sent towards the photometer.

Photometer: The component of the machine that measures the amount of photons absorbed and transmits that information to a digital display is called the photometer.

3.5.1 Working Procedure of Spectrophotometer

- In spectrophotometer, we achieve the Reflectance value of the bio-polish fabric.
- First, we attached the fabric using a sample holder.
- The spectrophotometer measures the light intensity of a sample by passing a laser beam across it.
- These instruments are used in the process of measuring color and for monitoring color accuracy throughout production.

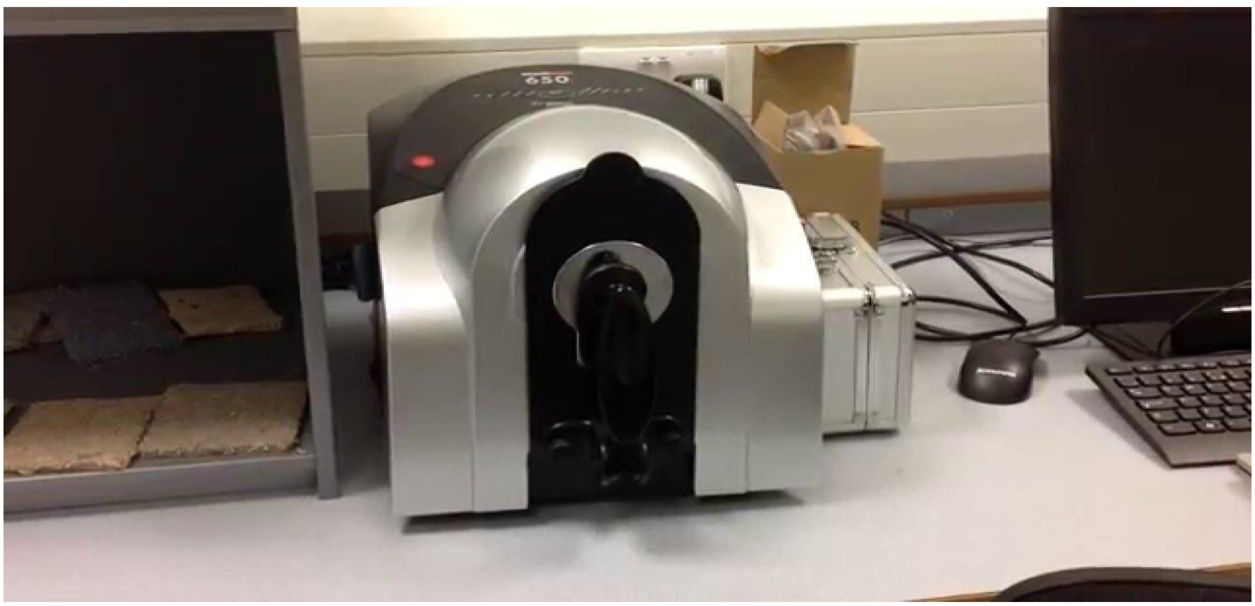


Fig: 3.14- Spectrophotometer

3.6 Experimental data of Ball Brusting Test

All the samples are collected from our lab (100% cotton knit fabric).

3.6.1 Working Procedure

- First, we followed the UST guidelines to cut the sample to a normal size and shape.

- Ensure that the grips or clamps are suitable for the sample material before attaching them to the UST.
- Ensure the bio-polish sample is accurately positioned in the center while inserting it into the grips.
- Provide the UST with the required load rate, crosshead speed, and testing procedure.
- Input relevant data into the testing program.
- Activate the UST to begin the test. Monitor the sample closely when pressure or force is applied by the UST. The UST will measure various parameters according to the test setups.
- Examples of data that the UST software should record are force, stress, and strain.
- Throughout the test, alert yourself to any unexpected or strange conduct.
- Examine the results once the test is complete for information on the bio-polish sample's strength properties.
- Then we achieve the value of brusting test result.

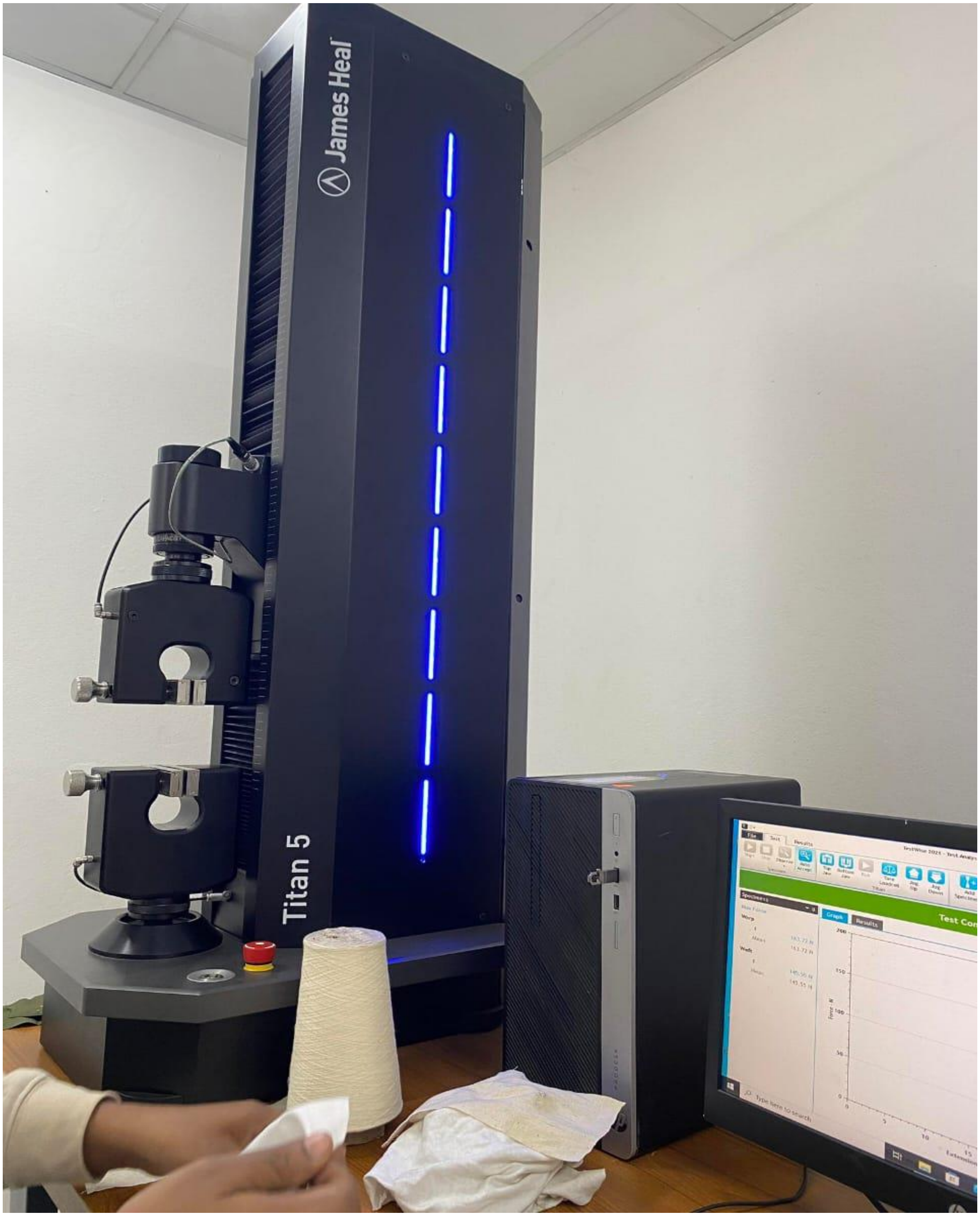


Figure:3.15- Universal Strength Tester

3.7 Attached Sample Before and After Bio polishing

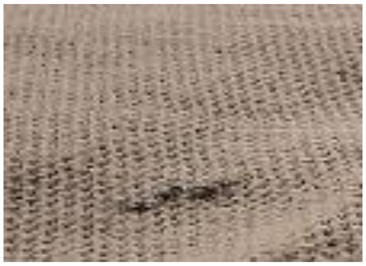
Sample No.	Types of Fabric	Before Bio-polishing	After Bio-polishing
01	Single Jersey		
02	Viscose		
03	CVC		
04	Interlock		

Table 3.2- Sample Before and After Bio polishing

CHAPTER- 4

RESULT & DISCUSSION

4.1 Difference in Weight loss

Sample No.	Fabric Sample Name	Before Bio-polishing Sample	After Bio-polishing Sample	Weight Loss%
01	S/J	5.26 gm	5.16 gm	1.90
02	Viscose	5.15 gm	5.02 gm	2.52
03	CVC	5.18 gm	5.06 gm	2.31
04	Interlock	4.00 gm	3.89 gm	2.75

Table 4.1- Difference in Weight loss

To find out the weight loss, first we take our required sample and cut the fabric sample and measured in digital weight balance. Then we bio-polish all the fabric and then dry all the sample. When all of the sample will be dry then we measured all the sample one by one in digital weight balance. We can see before bio-polishing the single jersey weight is 5.26 gm and after bio-polishing the weight is 5.16 gm and their weight loss is 0.10 gm. For viscose fabric we see before bio-polishing the weight is 5.15 gm and after bio-polishing the weight is 5.02 gm and their weight loss is 0.13 gm. For CVC fabric we see before bio-polishing the weight is 5.18 gm and after bio-polishing the weight is 5.06 gm and their weight loss is 0.12 gm. We can also see the interlock fabric before bio-polishing the weight is 4.00 gm and after bio-polishing the weight is 3.89 gm and their weight is 0.11 gm.

4.1.1 Change in Weight Before and After Bio-polishing

After bio-polishing the change of Weight loss of different fabrics were recorded in the table(4.1). The change of weight loss has been used here to drawn the following chart.

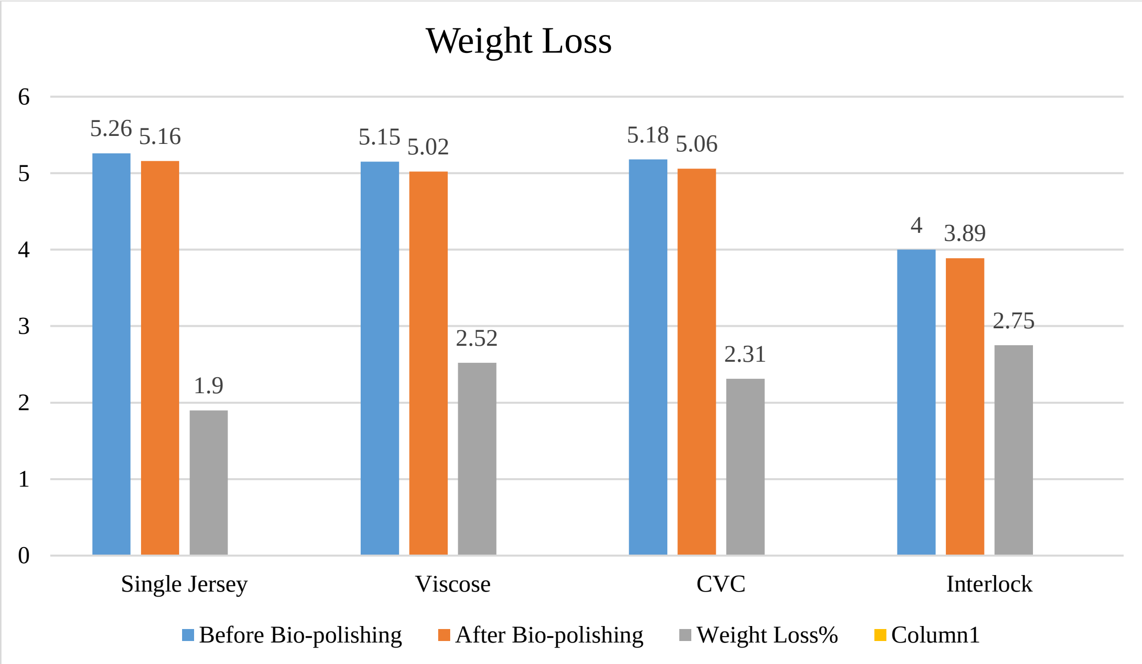


Figure: 4.1 Column diagram shows the change of Weight loss

The X-axis in the column diagram represents the Sample type, while the Y-axis represents the Fabric Weight. The blue column indicates the fabric weight before bio-polishing, whereas the orange column indicates the fabric weight after bio-polishing and the grey column indicates the weight loss%. Weight loss is observed in each fabric sample during the bio-polishing process. The enzyme will remove the protruding fibers from the surface of the fabric. Here we see all the sample- The weight of the single jersey fabric is 5.26 gm, and after bio-polishing, it decreases to 5.16 gm. The weight of the viscose fabric is 5.15 gm, and after bio-polishing, it decreases to 5.02 gram. The CVC fabric weight is 5.18 grams, and after bio-polishing, it decreased to 5.06 grams. The interlock fabric weight is 4.00 gm, and after bio-polishing, it decreases to 3.89 gm.

4.2 Difference in WPI and CPI

Sample No.	Fabric Sample Name	Before Bio-polishing Sample		After Bio-polishing Sample		Change		Change %	
		WPI	CPI	WPI	CPI	WPI	CPI	WPI	CPI
01	S/J	41	39	39	46	2	7	4.87	17.9
02	Viscose	40	38	34	42	6	4	15	10.52
03	CVC	30	37	35	41	5	4	16.66	10.81
04	Interlock	30	46	32	44	2	2	6.66	4.34

Table 4.2- Difference in WPI and CPI

WPI- WPI stands for wales per inch. The term "wales per inch" (WPI) refers to the number of wales in an inch of knitted fabric.

To calculate WPI, we took 1 inch of sample and then count the wales lengthwise. By this way, we got before and after bio-polishing WPI for each sample. Then we compared the after bio-polishing WPI with the before WPI of the sample.

The table (4.2) shows that the highest percentage is 16.66% of the CVC. The sample's WPI was 30 before bio-polishing and after bio-polishing WPI of the sample is 35. The minimum percentage is 4.87% of the single jersey fabric. The sample's WPI was 41 before bio-polishing and after bio-polishing WPI of the sample is 39. Viscose fabric was seen with a WPI of 40 before bio-polishing and a WPI of 34 after bio-polishing, resulting in a 15% change. Before bio-polishing, the interlock fabric had a WPI of 30 and after bio-polishing, the WPI is 32, resulting in a change of 6.66%.

4.2.1 Change in WPI Before and After Bio-polishing

After bio-polishing the change of WPI of different fabrics were recorded in the table (4.2). The change of WPI has been used here to drawn the following chart.

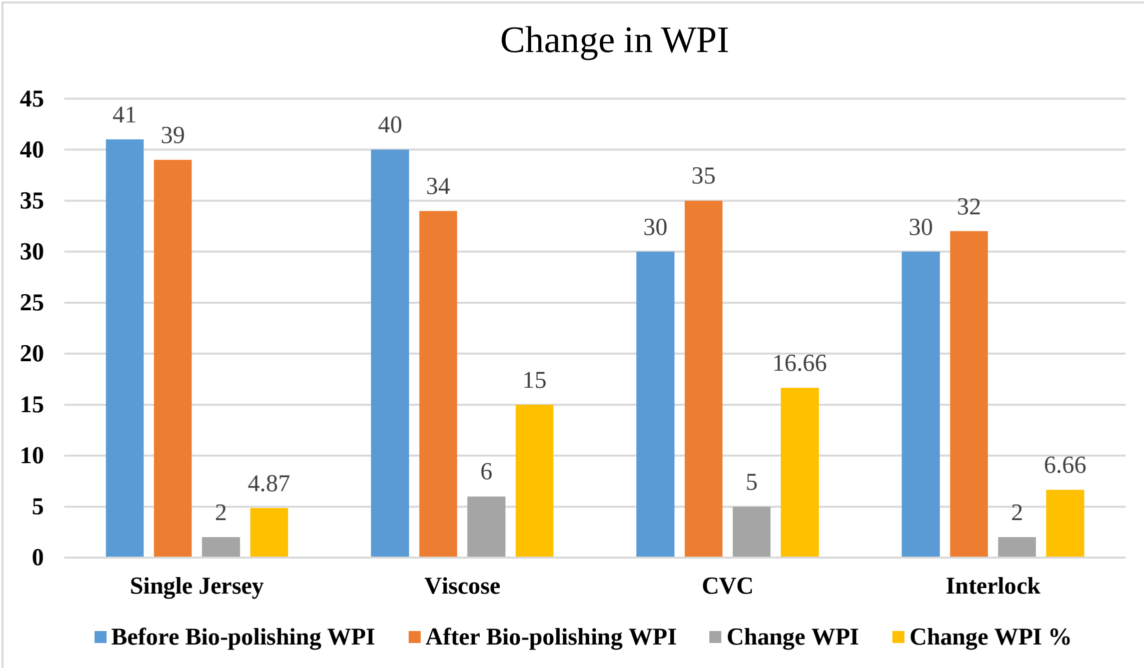


Figure: 4.2 Column diagram shows the change of WPI

The X-axis in the column diagram represents the Sample type, while the Y-axis represents the fabric WPI. The blue column represents the before bio-polishing WPI, the orange column represents the after bio-polishing WPI, the grey column represents the change in WPI, and the yellow column represents the percentage change in WPI. Before bio-polishing, the single jersey WPI is 41, and after bio-polishing, the single jersey WPI is 39, resulting in a change of 4.87%. The viscose fabric had a WPI of 40 before bio-polishing and a WPI of 34 after bio-polishing, resulting in a 15% change. The CVC fabric had a WPI of 30 before bio-polishing and 35 after bio-polishing, resulting in a 16.66% change. The Interlock fabric had a WPI of 30 before bio-polishing and 32 after bio-polishing, resulting in a 6.66% change. Here, we see the smallest percentage change in single jersey fabric.

4.2.2 Difference in WPI and CPI

CPI- CPI stands for course per inch. The term "course per inch" (CPI) refers to the number of courses in an inch of knitted fabric.

To calculate CPI, we took 1 inch square of sample and then count the wales lengthwise. By this way, we got before and after bio-polishing CPI for each sample. Then we compared the after bio-polishing CPI with the before CPI of the sample.

The table (4.2) shows that the highest rate is 17.9% for Single jersey. The sample's CPI was 39 before bio-polishing and increased to 46 after bio-polishing. The minimum percentage of the interlock fabric is 4.34%. The CPI of the sample before bio-polishing was 46, and after bio-polishing, it decreased to 44. Viscose fabric's CPI is 38 before bio-polishing and 42 after bio-polishing, resulting in a change of 10.52%. Before bio-polishing, the CVC fabric's CPI is 37, and after bio-polishing, the CPI increases to 41, resulting in a change of 10.81%.

4.2.3 Change in CPI Before and After Bio-polishing

After bio-polishing the change of CPI of different fabrics were recorded in the table (4.2). The change of CPI has been used here to drawn the following chart.

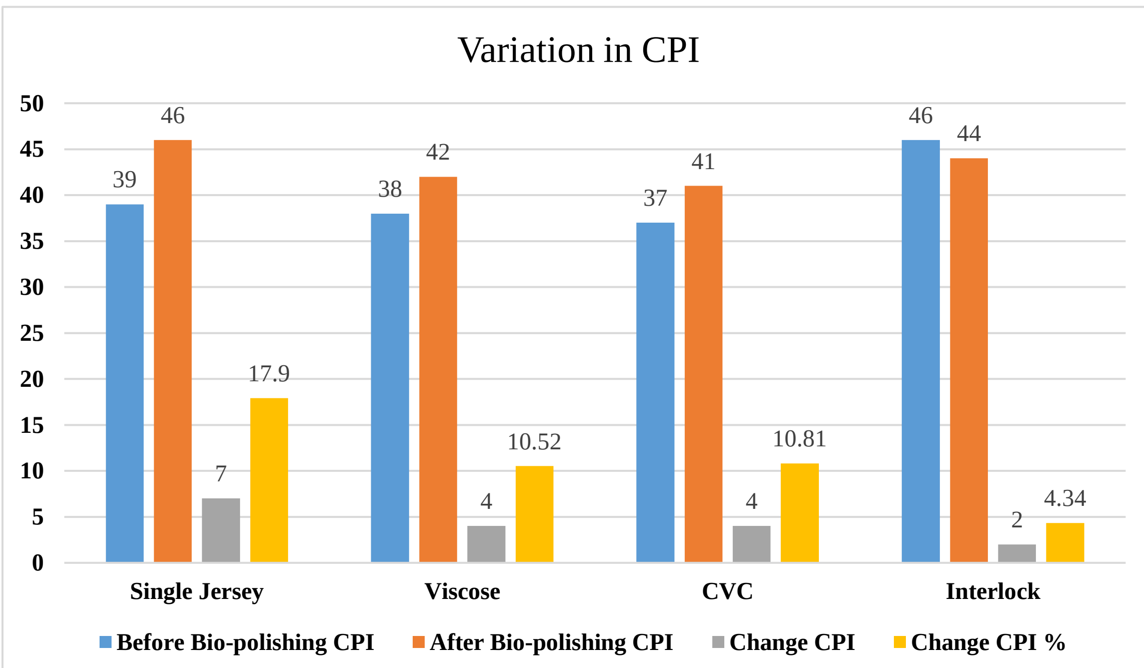


Figure: 4.3 Column diagram shows the change of CPI

The X-axis of the column diagram represents the Sample type, while the Y-axis represents the fabric CPI. The blue column represents the before bio-polishing CPI, the orange column represents the after bio-polishing CPI, the grey column represents the CPI change, and the yellow column represents the CPI percentage change. Before bio-polishing, the single jersey CPI is 39, and after bio-polishing, it is 46, resulting in a 17.9% change. Before bio-polishing the viscose fabric CPI is 38 and after bio-polishing the CPI is 42 and their change% is 10.52. The CVC fabric had a CPI of

37 before bio-polishing and a CPI of 41 after bio-polishing, resulting in a change of 10.81%. Before bio-polishing, the Interlock fabric's CPI is 46, and after bio-polishing, it is 44, resulting in a change of 4.34%. Here, we observe the smallest percentage change in interlock fabric.

4.3 Spectrophotometer Data Table

Fabric Sample Name	Before Bio-polishing	After Bio-polishing
	STD	Batch-1
Single Jersey	79.71	81.68
Viscose	78.69	81.08
CVC	80.26	82.32
Interlock	69.71	70.24

Table 4.3- Difference in Reflection

We measure the reflectance value of the bio-polish fabric using a spectrophotometer. At first we used a sample holder for fixing the fabric. The spectrophotometer measures the light intensity of a sample by transmitting a light beam through it. These tools are used for measuring color and ensuring color accuracy throughout production.

4.3.1 Change in reflection Before and After Bio-polishing

After bio-polishing the change of reflection of different fabrics were recorded in the table (4.3). The change of reflection has been used here to drawn the following chart.

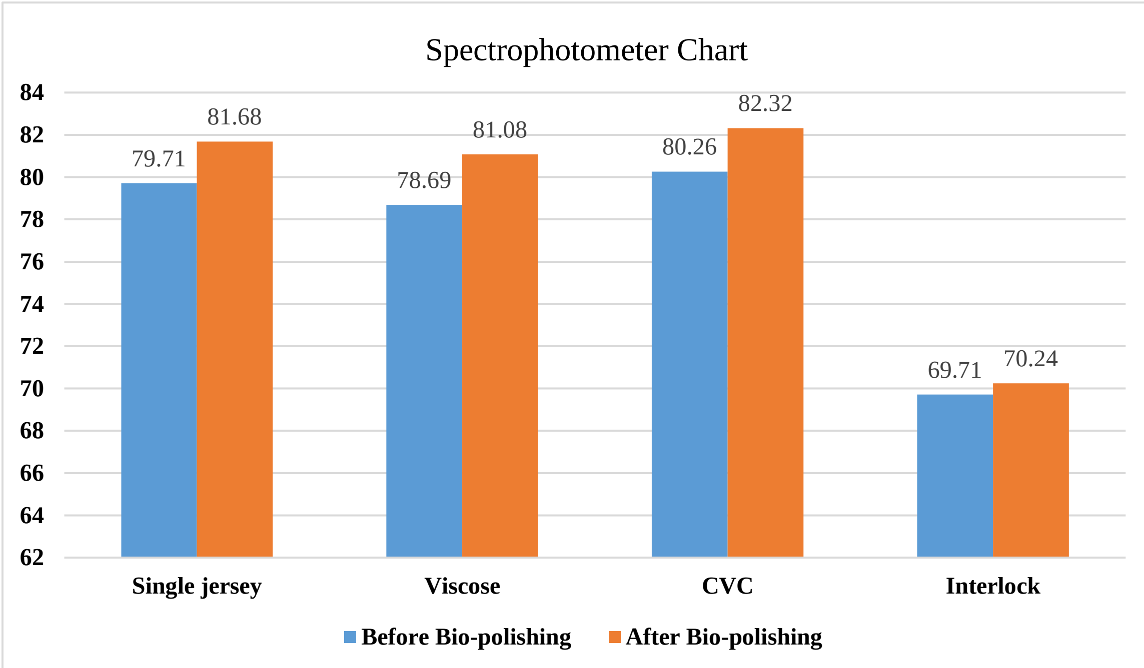


Figure: 4.4- Column diagram shows the reflection

The X-axis in the column diagram represents fabric type, while the Y-axis shows the rating of spectrometer data range. The blue bar indicates the reflectance of the fabric before bio-polishing, while the orange bar indicates the reflectance after bio-polishing. The single jersey standard reflectance is 79.71, and after bio-polishing, it increases to 81.68. The reflectance of the viscose fabric is 78.69, which increases to 81.08 after bio-polishing. The reflectance of the CVC fabric standard is 80.26, which increases to 82.32 after bio-polishing. The reflectance of the interlock fabric is 69.71, and it increased to 70.24 after bio-polishing.

4.4 Difference in Strength test

Fabric Sample Name	Before Bio-polishing	After Bio-polishing
	Force N	Force N
Single Jersey	387.04	420.99
Viscose	257.85	235.73
CVC	187.74	267.63
Interlock	393.03	256.73

Table: 4.4- Difference in Strength test

After testing, we observed significant differences in the bio-polishing strength before and after. We use four different types of samples: single jersey, viscose, CVC, and interlock. We have created four graphs representing four different fabrics to show the difference in strength before and after bio-polishing.

4.4.1 Test: Single Jersey Before Bio-polishing

After bio-polishing the change of strength of different fabrics were recorded in the table (4.4). The change of reflection has been used here to drawn the following chart.

EN ISO 3303-1

Date: 2020

Rubber- or plastics-coated fabrics - determination of bursting strength - Steel-ball method

Test Details

Test Name:	Ball Bursting	Print Date:	1/7/2024
Customer:	Sufian Siam Jipu Anik	Force Control Gain:	100
Reference:	Tanvir Ahmed Chowdhury	Jaw Pressure:	100
Material:	s/j	Load Cell:	5000 N
Comments:	Bio Polish before	Load Cell SN:	1126095
Specimens:	3	Version:	11.0.3.0
Required Directions:	Dry	Firmware:	v1.00p36
Test Time:	7:30 PM	Titan SN:	1710/05/21/1197
Test Date:	1/7/2024	Tested by:	Administrator
Jaw Scheme:	T20A		

Procedure Settings

Break Detection: 50 %

Pretension

Pretension: 0N

Pull To Load Cell Maximum

Speed: 300.00 mm/min

Dry Results

Specimen	Rupturing Force (N)	Extension at Break (mm)	Observations
1	402.63	125.19	-
2	369.22	122.69	-
3	389.27	124.43	-
Mean	387.04	124.10	

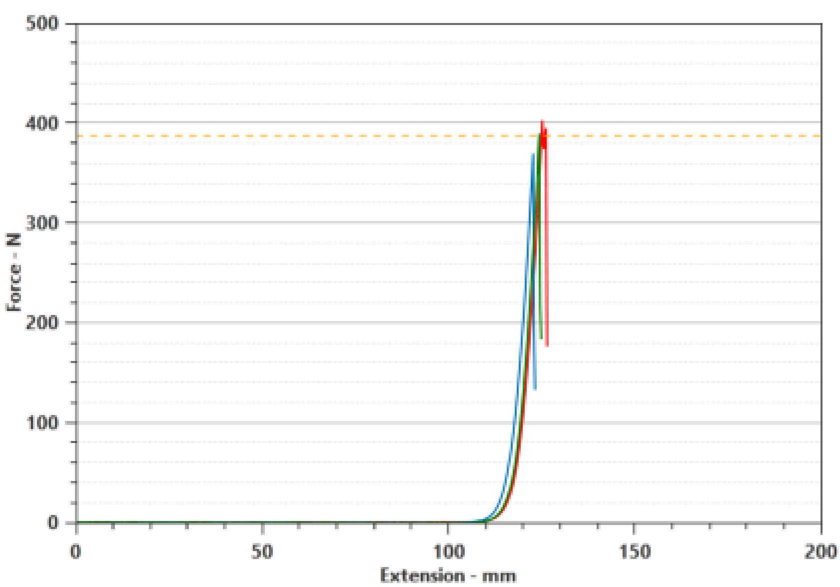


Figure: 4.5- Single Jersey Before Bio-polishing

4.4.2 Test: Single Jersey After Bio-polishing

EN ISO 3303-1

Date: 2020

Rubber- or plastics-coated fabrics - determination of bursting strength - Steel-ball method

Test Details

Test Name:	Ball Bursting	Print Date:	1/7/2024
Customer:	Sufian Siam Jipu Anik	Force Control Gain:	100
Reference:	Tanvir Ahmed Chowdhury	Jaw Pressure:	100
Material:	s/j	Load Cell:	5000 N
Comments:	Bio Polish A 1	Load Cell SN:	1126095
Specimens:	3	Version:	11.0.3.0
Required Directions:	Dry	Firmware:	v1.00p36
Test Time:	7:30 PM	Titan SN:	1710/05/21/1197
Test Date:	1/7/2024	Tested by:	Administrator
Jaw Scheme:	T20A		

Procedure Settings

Break Detection: 50 %

Pretension

Pretension: 0N

Pull To Load Cell Maximum

Speed: 300.00 mm/min

Dry Results

Specimen	Rupturing Force (N)	Extension at Break (mm)	Observations
1	397.18	123.93	-
2	427.72	123.68	-
3	438.08	125.43	-
Mean	420.99	124.35	

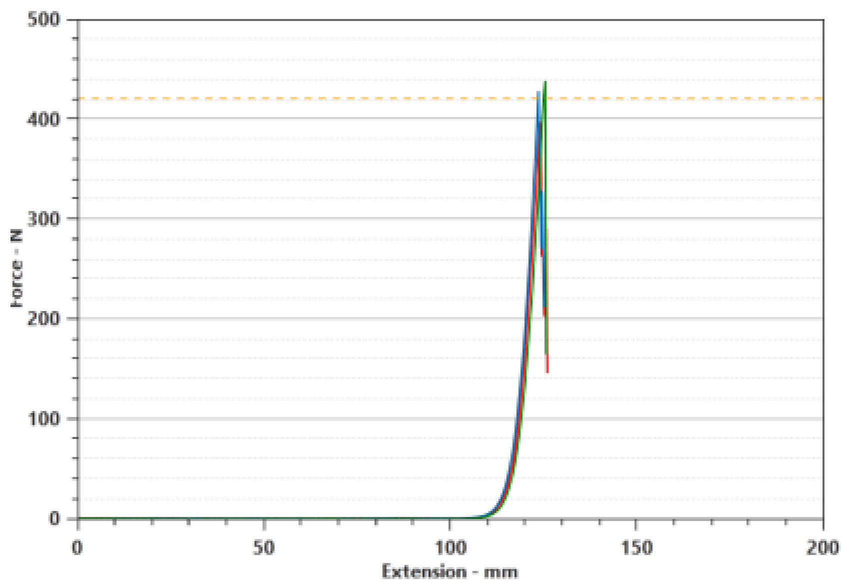


Figure: 4.6- Single Jersey After Bio-polishing

4.4.3 Test: Viscose Before Bio-polishing

EN ISO 3303-1

Date: 2020

Rubber- or plastics-coated fabrics - determination of bursting strength - Steel-ball method

Test Details

Test Name:	Ball Bursting	Print Date:	1/7/2024
Customer:	Sufian Siam Jipu Anik	Jaw Separation(s):	100.00
Reference:	Tanvir Ahmed Chowdhury	Force Control Gain:	100
Material:	Viscose s/j	Jaw Pressure:	100
Comments:	Bio Polish Before	Load Cell:	5000 N
Specimens:	3	Load Cell SN:	1126095
Required Directions:	Dry	Version:	11.0.3.0
Test Time:	7:30 PM	Firmware:	v1.00p36
Test Date:	1/7/2024	Titan SN:	1710/05/21/1197
Jaw Scheme:	T20A	Tested by:	Administrator

Procedure Settings

Break Detection: 50 %

Pretension

Pretension: 0N

Pull To Load Cell Maximum

Speed: 300.00 mm/min

Dry Results

Specimen	Rupturing Force (N)	Extension at Break (mm)	Observations
1	278.26	122.92	-
2	265.05	122.93	-
3	230.23	121.69	-
Mean	257.85	122.51	

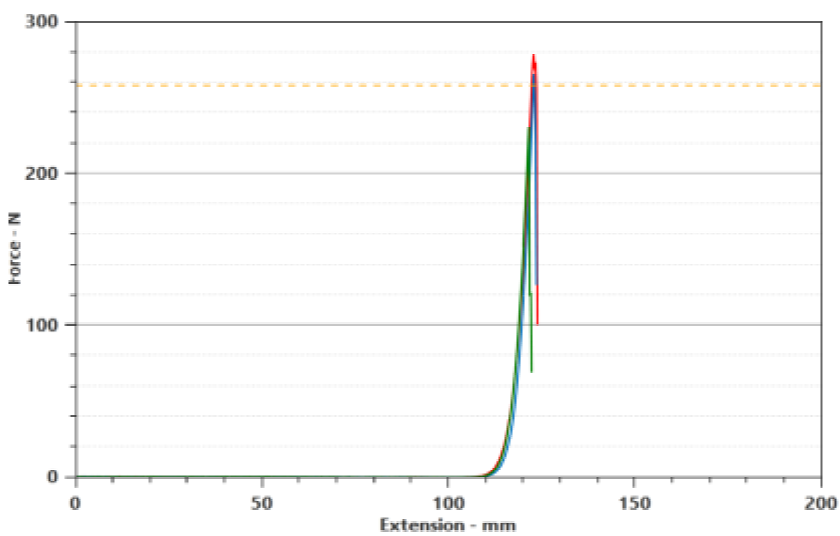


Figure: 4.7- Viscose Before Bio-polishing

4.4.4 Test: Viscose After Bio-polishing

EN ISO 3303-1

Date: 2020

Rubber- or plastics-coated fabrics - determination of bursting strength - Steel-ball method

Test Details

Test Name:	Ball Bursting	Print Date:	1/7/2024
Customer:	Sufian Siam Jipu Anik	Force Control Gain:	100
Reference:	Tanvir Ahmed Chowdhury	Jaw Pressure:	100
Material:	Viscose s/j	Load Cell:	5000 N
Comments:	Bio Polish After 1	Load Cell SN:	1126095
Specimens:	3	Version:	11.0.3.0
Required Directions:	Dry	Firmware:	v1.00p36
Test Time:	7:30 PM	Titan SN:	1710/05/21/1197
Test Date:	1/7/2024	Tested by:	Administrator
Jaw Scheme:	T20A		

Procedure Settings

Break Detection: 50 %

Pretension

Pretension: 0N

Pull To Load Cell Maximum

Speed: 300.00 mm/min

Dry Results

Specimen	Rupturing Force (N)	Extension at Break (mm)	Observations
1	250.18	120.93	-
2	229.79	121.93	-
3	227.22	121.18	-
Mean	235.73	121.35	

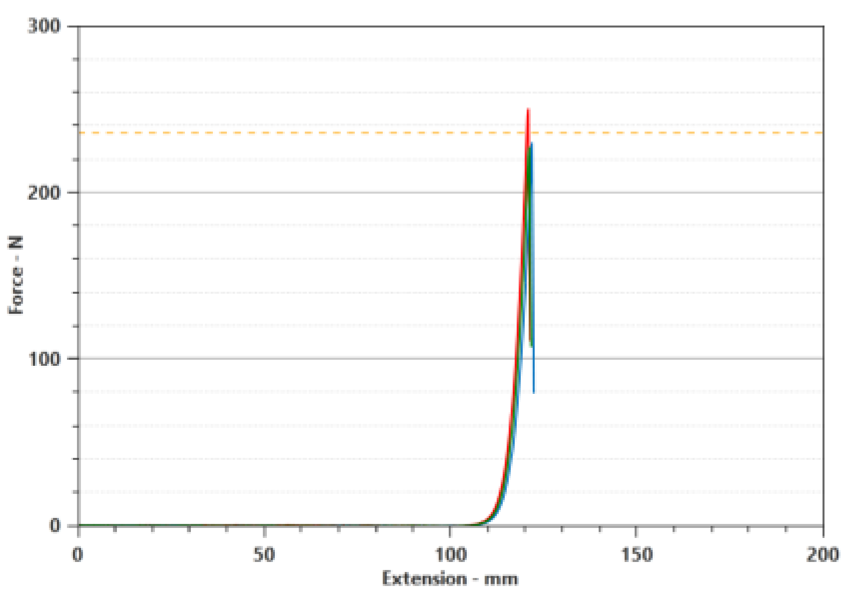


Figure: 4.8- Viscose After Bio-polishing

4.4.5 Test: CVC Before Bio-polishing

EN ISO 3303-1

Date: 2020

Rubber- or plastics-coated fabrics - determination of bursting strength - Steel-ball method

Test Details

Test Name:	Ball Bursting	Print Date:	1/7/2024
Customer:	Sufian Siam Jipu Anik	Force Control Gain:	100
Reference:	Tanvir Ahmed Chowdhury	Jaw Pressure:	100
Material:	Cvc s/j	Load Cell:	5000 N
Comments:	Bio Polish B4	Load Cell SN:	1126095
Specimens:	3	Version:	11.0.3.0
Required Directions:	Dry	Firmware:	v1.00p36
Test Time:	7:30 PM	Titan SN:	1710/05/21/1197
Test Date:	1/7/2024	Tested by:	Administrator
Jaw Scheme:	T20A		

Procedure Settings

Break Detection: 50 %

Pretension

Pretension: 0N

Pull To Load Cell Maximum

Speed: 300.00 mm/min

Dry Results

Specimen	Rupturing Force (N)	Extension at Break (mm)	Observations
1	184.23	147.92	-
2	202.87	131.93	-
3	176.11	153.43	-
Mean	187.74	144.43	

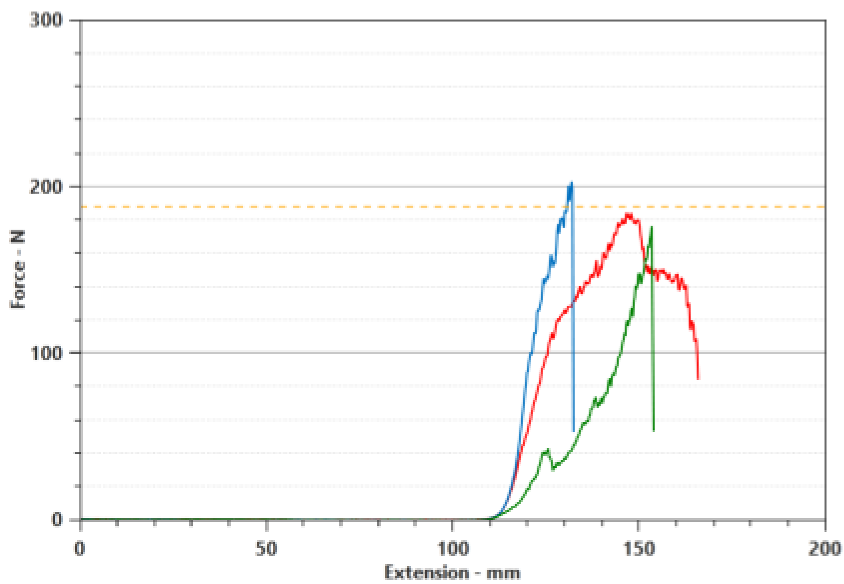


Figure: 4.9- CVC Before Bio-polishing

4.4.6 Test: CVC After Bio-polishing

EN ISO 3303-1

Date: 2020

Rubber- or plastics-coated fabrics - determination of bursting strength - Steel-ball method

Test Details

Test Name:	Ball Bursting	Print Date:	1/7/2024
Customer:	Sufian Siam Jipu Anik	Force Control Gain:	100
Reference:	Tanvir Ahmed Chowdhury	Jaw Pressure:	100
Material:	Cvc s/j	Load Cell:	5000 N
Comments:	Bio Polish After 1	Load Cell SN:	1126095
Specimens:	3	Version:	11.0.3.0
Required Directions:	Dry	Firmware:	v1.00p36
Test Time:	7:30 PM	Titan SN:	1710/05/21/1197
Test Date:	1/7/2024	Tested by:	Administrator
Jaw Scheme:	T20A		

Procedure Settings

Break Detection: 50 %

Pretension

Pretension: 0N

Pull To Load Cell Maximum

Speed: 300.00 mm/min

Dry Results

Specimen	Rupturing Force (N)	Extension at Break (mm)	Observations
1	271.38	123.42	-
2	266.26	120.43	-
3	265.25	122.42	-
Mean	267.63	122.09	

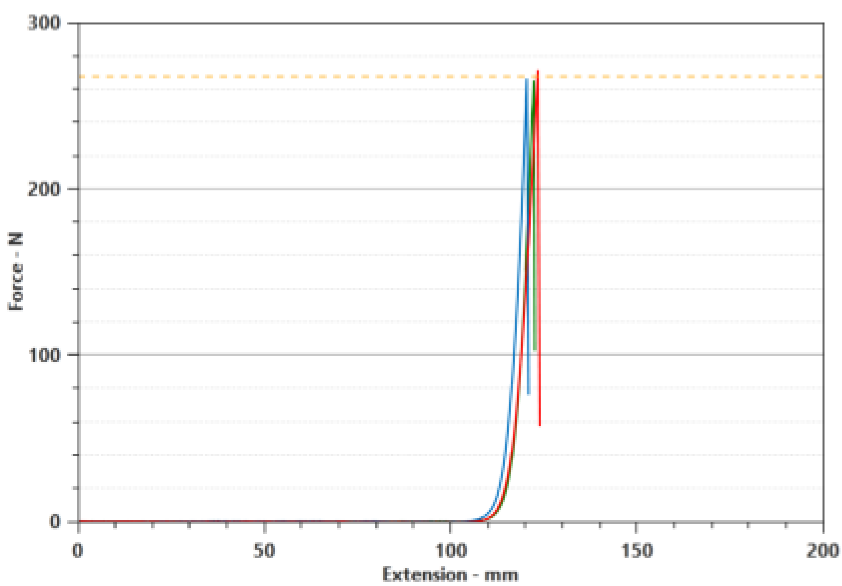


Figure: 4.10- CVC After Bio-polishing

4.4.7 Test: Interlock Before Bio-polishing

EN ISO 3303-1

Date: 2020

Rubber- or plastics-coated fabrics - determination of bursting strength - Steel-ball method

Test Details

Test Name:	Ball Bursting	Print Date:	1/7/2024
Customer:	Sufian Siam Jipu Anik	Force Control Gain:	100
Reference:	Tanvir Ahmed Chowdhury	Jaw Pressure:	100
Material:	100 % c interlock	Load Cell:	5000 N
Comments:	Bio Polish Before	Load Cell SN:	1126095
Specimens:	3	Version:	11.0.3.0
Required Directions:	Dry	Firmware:	v1.00p36
Test Time:	7:30 PM	Titan SN:	1710/05/21/1197
Test Date:	1/7/2024	Tested by:	Administrator
Jaw Scheme:	T20A		

Procedure Settings

Break Detection: 50 %

Pretension

Pretension: 0N

Pull To Load Cell Maximum

Speed: 300.00 mm/min

Dry Results

Specimen	Rupturing Force (N)	Extension at Break (mm)	Observations
1	401.47	124.19	-
2	404.84	126.67	-
3	372.78	124.67	-
Mean	393.03	125.18	

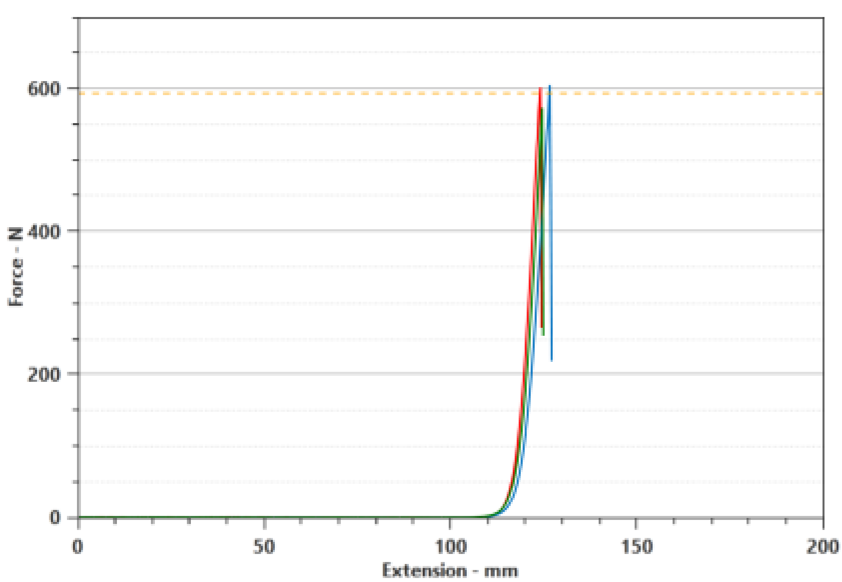


Figure: 4.11- Interlock Before Bio-polishing

4.4.8 Test: Interlock After Bio-polishing

EN ISO 3303-1

Date: 2020

Rubber- or plastics-coated fabrics - determination of bursting strength - Steel-ball method

Test Details

Test Name:	Ball Bursting	Print Date:	1/7/2024
Customer:	Sufian Siam Jipu Anik	Force Control Gain:	100
Reference:	Tanvir Ahmed Chowdhury	Jaw Pressure:	100
Material:	100 % c interlock	Load Cell:	5000 N
Comments:	Bio Polish After 2	Load Cell SN:	1126095
Specimens:	3	Version:	11.0.3.0
Required Directions:	Dry	Firmware:	v1.00p36
Test Time:	7:30 PM	Titan SN:	1710/05/21/1197
Test Date:	1/7/2024	Tested by:	Administrator
Jaw Scheme:	T20A		

Procedure Settings

Break Detection:	50 %
Pretension	
Pretension:	0N
Pull To Load Cell Maximum	
Speed:	300.00 mm/min

Dry Results

Specimen	Rupturing Force (N)	Extension at Break (mm)	Observations
1	224.12	132.18	-
2	264.46	124.95	-
3	280.53	124.93	-
Mean	256.37	127.35	

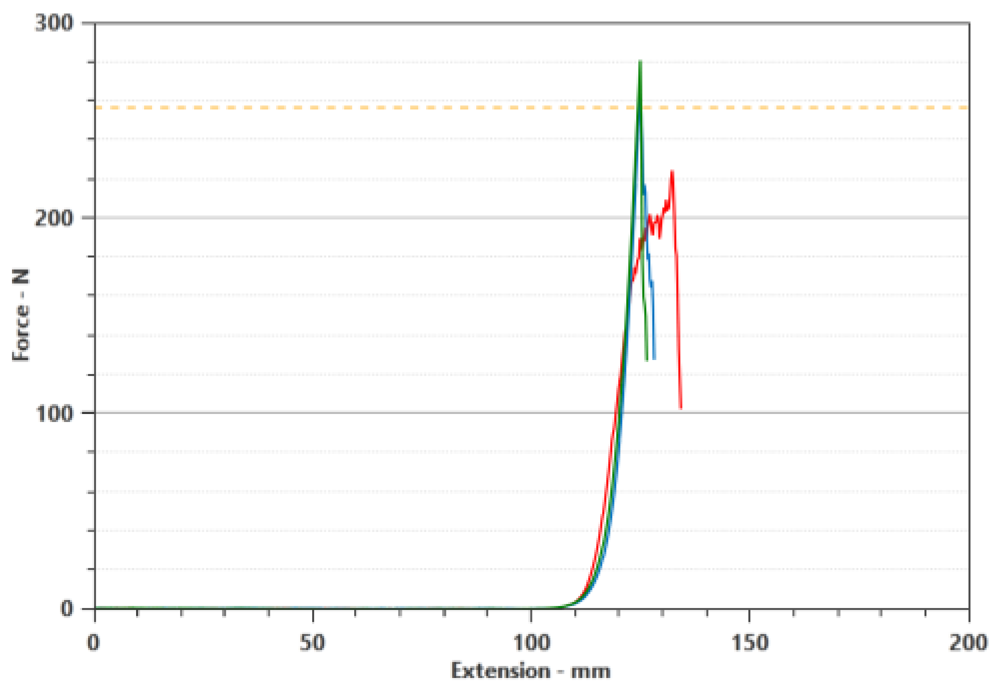


Figure: 4.12- Interlock After Bio-polishing

The single jersey fabric's strength was tested at 387.04 N before bio-polishing and 420.99 N after bio-polishing. The viscose fabric's strength was 257.85 N before bio-polishing and 235.73 N after bio-polishing. The force for CVC fabric was 187.74 N before bio-polishing and 267.63 N after bio-polishing. Before bio-polishing, the interlock fabric showed a force of 393.03 N and 256.37 N after the bio-polishing process.

CHAPTER- 5

CONCLUSION

The study indicates that bio-polishing has a significant impact on textile materials and is considered a sustainable and environmentally friendly finishing procedure. The study aimed to analyze the basic physical characteristics of fabric samples before and after bio-polishing, with a specific focus on parameters such as weight loss, WPI (Wales per Inch) and CPI (Courses per Inch), reflectivity, and strength. The study observed that reducing protruding fibers decreased the weight of the fabrics, resulting to changes in the WPI and CPI depending on the kind of fabric. Bio-polishing improves fabric qualities by decreasing hairiness, improving handling and shine, and strengthening sewing ability, demonstrating its potential advantages across various textile types. This study will be advantageous for our upcoming projects.

- ❖ In weight loss table we see the maximum change% is 2.75% which is interlock and the minimum change% is 1.90% which is single jersey fabric.
- ❖ In WPI data table we see the maximum change% is 15 which is viscose and the minimum change% is 4.87 which is single jersey.
- ❖ In CPI data table we see the maximum change% is 17.9 which is single jersey and the minimum change% is 4.34 which is interlock.
- ❖ In light reflection data table we see the maximum reflection is 82.32 which is cvc and the minimum reflection is 70.24 which is interlock.
- ❖ In brusting data table we see the maximum load which is 420.99 of single jersey and the minimum load which is 235.73 of viscose.

REFERENCE

1. https://textilelearner.net/bio-polishing-on-cotton-knit-goods/
2. https://textilelearner.net/biopolishing-in-textile-process-advantages/
3. https://www.textileflowchart.com/2015/08/flow-chart-of-bio-polishing-process.html
4. https://www.slideshare.net/MdRafsanJany/bio-processing-of-textiles-rafsan-6th-39515183
5. https://diutestudents.blogspot.com/2016/09/bio-polishing-of-100-cotton-knitted.html?m=1
6. https://www.htfine-chem.com/list-of-chemicals-used-in-textile-industry/biopolishing-enzymes.html

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Faculty of Engineering Department of Textile Engineering Studies on the Effect of Bio-Polishing on the Physical Characteristics of Knit Fabric Course Code: TE 4214 Course Title: Project (Thesis) Submitted by: Name Id Anik Chandra Das 201-23-934 Md. Al-fahid Chowdhury 201-23-959 Supervised by: Tanvir Ahmed Chowdhury Assistant Professor Daffodil International University A thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Textile Engineering Advance in Wet Processing Engineering Spring-2024 DECLARATION We hereby declare that, this project has been done by us under the supervision of Tanvir Ahmed Chowdhury, Assistant Professor, Department of Textile Engineering, Faculty of Engineering, Daffodil International University. We also declare that, neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma. Anik Chandra Das Id: 201-23-934 Department of Textile Engineering Daffodil International University Md. Al-fahid Chowdhury Id: 201-23-959 Department of Textile Engineering Daffodil International University i LETTER OF APPROVAL This project report prepared by Anik Chandra Das (ID: 201-23-934) and Md. Al-fahid Chowdhury (ID: 201-23-959), is approved in Partial Fulfillment of the Requirement for the Degree of BACHELOR OF SCIENCE IN TEXTILE ENGINEERING. The said students have completed their project work under my supervision. During the research period I found them sincere, hardworking and enthusiastic. Tanvir Ahmed Chowdhury ASSISTANT PROFESSOR DEPARTMENT OF TEXTILE ENGINEERING FACULTY OF ENGINEERING DAFFODIL INTERNATIONAL UNIVERSITY ii ACKNOWLEDGEMENT Firstly, we express our gratefulness to almighty Allah for his divine blessing makes us possible to complete this project successfully. We are grateful to our supervisor Tanvir Ahmed Chowdhury, Assistant Professor Department of Textile Engineering, Faculty of Engineering, Daffodil International University. Deep knowledge and keen interests of our supervisor in the field of textile dyeing and finishing influenced us to carry out the project work. His endless patience, scholarly guidance, continual encouragement, energetic supervision, constructive criticism, valuable advice, reading many inferior draft and correcting these at all stages have made it possible to complete this project. We would like to deliver thanks to our entire course mates in Daffodil International University, who took part on the discussion while completing the course work. Finally, we would like to express a sense of gratitude to our beloved parents and friends for their mental support, strength and assistance throughout writing the project report. iii This projects report is dedicated to our beloved Parents& Teachers iv ABSTRACT This study examines how the bio-polishing process affects the physical characteristics of textile fibers. Bio-finishing, an eco-friendly fabric treatment that improves fabric properties, is becoming a growing trend. The study examines enhancements in weight loss, WPI and CPI, reflectance value, and strength test before and after the bio-polishing process. Bio-finishing is a promising method that uses enzymes to cure fabrics. De-fuzzing fabric through enzymatic activity to eliminate protruding filaments. Bio-polishing can improve the quality of cotton and various natural and manmade materials. The bio-polishing process provides benefits like the removal of hairiness, fluffs, and pills, as well as improvements in handling, shine, and sewability. The thesis is titled "Studies on the Effect of Bio-Polishing on the Physical Characteristics of Knit Fabric". We choose four distinct types of knit fabric samples: single jersey, viscose, cvc, and interlock. We tried to determine the disparity in fabric characteristics before and after conducting bio-polishing. This study provides useful insights into textile engineering and sustainable practices by analyzing physical characteristics before and after bio-polishing in controlled tests. v TABLE OF CONTENTS Contents DECLARATION LETTEER OF APPROVAL ACKNOWLEDGEMENT DEDICATON ABSTRACT TABLE OF CONTENTS LIST OF FIGHURES LIST OF TABLES CHAPTER-1: INTRODUCTION 1.1 Introduction 1.2 Objectives 1.3 Limitations of the study CHAPTER-2: LITERATURE REVIEW 2.1 Bio-polishing 2.1.1 What is Bio-polishing? 2.1.2 Objectives of Bio-polishing in Textile 2.1.3 Chemical used in Bio-polishing 2.1.4 Flowchart of Bio-polishing 2.1.4.1 Flowchart of Dyeing followed by Bio-polishing 2.1.4.2 Flowchart of Bio-polishing before Dyeing 2.2 Fabric Specification 2.2.1 Cotton Fabric 2.2.2 Viscose Fabric 2.2.3 CVC Fabric 2.3 Process Variable 2.3.1 Standard recipe for Bio-polishing Page No. i ii iii iv v vi ix x 1 2 2 2 3 4 4 5 5 8 8 9 10 10 10 11 12 12 vi 2.4 Factors affecting Bio-polishing 12 2.4.1 Effect of Concentration 13 2.4.2 Effect of Temperature 13 2.4.3 Effect of pH 13 2.4.4 Effect of M:L 13 2.4.5 Effect of Duration 14 2.4.6 Effect of Enzyme treatment on Dyeing property 14 2.5 Why we use Bio-polishing? 14 2.5.1 Importance of Bio-polishing 14 2.5.2 Advantages of Bio-polishing 14 2.5.3 Disadvantages of Bio-polishing 15 2.6 What is Enzyme? 15 2.6.1 The history of Enzyme in Textile 16 2.6.2 Various enzyme used in Textile wet processing 16 2.6.3 Enzyme for Bio-polishing 16 2.6.4 Enzyme Inactivation 17 2.6.5 Changes in Physical properties due to the Bio-polishing Enzymes 17 CHAPTER-3: EXPERIMENTAL DETAILS 19 3.1 Materials 20

 CHAPTER- 1 INTRODUCTION 1.1 Introduction Bio-finishing is a trendy method of treating textiles using enzymes. Enhancements in bio-finishing of cellulosic fabrics have enhanced many surface properties. The primary goal of bio-finishing is to enhance the fabric by eliminating protruding filaments. Conventional techniques to get rid of remaining fibers require chemical treatment or singeing. Conventional methods are impermanent, potentially harmful, and lead to fibers reappearing and causing fuzziness after a few washes. Lint on the fabric's surface is the main reason for customer dissatisfaction. Enzymes can permanently remove fuzz from fabric by extracting the projecting strands during the finishing process. Enzyme treatment improves the texture, color, softness, and draping properties of textile or garment products, leading to a higher quality product. It helps preserve the fabric's look during multiple wash cycles. The colorfastness of cotton fabric is affected by the bio-polishing process, which may happen either before or after dyeing. 1.2 Objectives The following report shows the Bio-polishing scenario. This thesis report aims to study the effects of before and after bio-polishing and also about the physical characteristics of the fabrics. Beside this – ‣ To learn about the bio-polishing process of different knitted fabrics. ‣ To examine the weight loss of different fabrics after the bio-polishing procedure. ‣ Compare the fabric sample before and after bio-polishing. 1.3 Limitations of the Study ‣ It is based on knit fabric. ‣ All experiments were carried out using the cellulase enzyme ‣ Focused on before and after bio-polishing & their physical characteristics. CHAPTER- 2 LITERATURE REVIEW 2.1 Bio-polishing 2.1.1 What is Bio-Polishing? The textile finishing procedure referred to as "Bio-polishing." Bio-polishing is a textile finishing process that improves the quality of fabric by reducing the fuzziness and tendency to pill of knitted cellulose materials. Cellulose-based textiles are treated with an enzyme-based finishing process to create long-lasting results. This procedure improves the smoothness of knitted textiles, decreases pilling, softens the fabric's texture, and eliminates projecting fibers and defects. Figure:2.1- Bio-polished Knit fabrics 2.1.2 Objectives of Bio-polishing in Textile ‣ To eliminate slubs and protruding strands. ‣ To remove pills, fluff, and hairiness. ‣ To prevent adhesion of materials. ‣ To enhance the grip and make the fabric softer. ‣ To enhance the surface's luster and smoothness. ‣ To improve the material's relaxation and flexibility by improving its texture. 2.1.3 Chemical used in Bio-polishing Sequestering Agent- It is a chelating agent that deactivates metallic salts of water, hence reducing water hardness. Figure 2.2 - Sequestering Agent Cellulase Enzyme- A naturally occurring microorganism is used in cotton bio-polishing to eliminate surface hairiness and reduce the tendency of materials to pill. Figure 2.3 - Cellulase Enzyme Wetting Agent- Although it's cleansing abilities, it is susceptible to moisture, similar to detergents. Glycerin and TR oil are examples of wetting agents. Figure 2.4 - Wetting Agent Acetic Acid- These are classified as weak acids because of their organic composition and are used in wet processes to maintain the solution's acidity. Figure 2.5 - Acetic Acid 2.1.4 Flowchart of Bio-polishing There are two forms of Bio-polishing: 1. Bio-polishing after dyeing. 2. Bio-polishing before Dyeing. 2.1.4.1 Flowchart of Bio-polishing after dyeing- Scoured &bleaching sample Dye addition Salt addition Soda ash addition Dyeing Hot wash Cold wash Enzyme treatment Cold wash Drying 2.1.4.2 Flowchart of Bio-polishing before Dyeing- Scoured & bleaching sample Bio-polishing Cold wash Drying Dye addition Salt addition Soda ash addition Hot wash Soaping Hot Wash Cold wash Drying 2.2 Fabric Specification 2.2.1 Cotton Fabric- Cotton fabric is made from the fibers of the cotton plant. Due to its adaptability, comfort, and durability, this fabric is very popular and often used worldwide. Cotton fabric is well-known for its soft texture and ability to allow air to pass through, making it suitable for a range of clothing items such as shirts, skirts, pants, and undergarments. It is also visible in beds, towels, and curtains. Cotton has become popular for its moisture-absorbing qualities, which provide comfort when worn in hot and humid conditions. Cotton is a biodegradable and environmentally friendly fiber when compared to synthetic ones. Traditional cotton production can have negative environmental impacts because of the application of pesticides and water-intensive agricultural practices. Organic cotton, manufactured without synthetic fertilizers and pesticides, is a more environmentally responsible choice. 2.2.2 Viscose Fabric- Viscose fabric, often known as rayon, is a semi-synthetic material manufactured from natural cellulose fibers, mainly obtained from wood pulp or bamboo. Its smooth, silky feel and great drape make it a popular choice for garments and home textiles. Here are some key characteristics and uses of viscose fabric: ‣ Softness and Comfort- Viscose is comfortable because to its silky and smooth feel. It has a texture comparable to silk and cotton, both of which are natural fibers. ‣ Breathability- Viscose fabric is breathable, allowing air to flow through it. Therefore, it is a suitable choice for clothing in warm weather. ‣ Drapability- Viscose has excellent draping characteristics, allowing it to flow and hang smoothly. This feature makes it a popular choice for garments with comfortable designs including blouses, dresses, and skirts. ‣ Absorbency- Viscose is more comfortable in hot and humid circumstances due to its moisture-absorbing properties. It should be laundered carefully because it may weaken when wet. ‣ Versatility- Viscose might look like the physical characteristics of natural materials such as cotton, silk, and wool. It can be used into a variety of outfits, which can be formal to informal. ‣ Blend possibilities- Viscose can be blended with other fibers like cotton, polyester, or spandex to improve particular characteristics such as strength, stretch, or durability. ‣ Environmental Consideration- Viscose is derived from natural sources but is produced by chemical methods. Production operations affect the environment. Some viscose is made using eco-friendly methods, but others might involve the use more chemicals. Viscose is commonly utilized in the fashion industry to produce dresses, blouses, and scarves. It offers an excellent appearance with breathability and comfort. 2.2.3 CVC Fabric- The fabric known as "Chief Value of Cotton" is commonly referred to as CVC fabric. This fabric is a combination of polyester and cotton fibers. CVC fabric often contains a larger amount of cotton, ranging between 60% and 80%, and a lower percentage of polyester, usually between 40% and 20%. CVC fabric blends with the most excellent properties of polyester and cotton: ‣ Comfort of Cotton- Cotton fibers are known for their soft texture, ability to allow air to pass through, and pleasant feel on the skin. Cotton's breathability makes it ideal for hot climates and sensitive skin. ‣ Durability of Polyester- Polyester fibers provide the cloth with durability, elasticity, and lasting quality. Polyester improves the overall performance and durability of the fabric by reducing wrinkles, shrinkage, and color fading. ‣ Easy Care- CVC fabric is easy to maintain as it can usually be machine washed and dried without much shrinkage or wrinkling. ‣ Versatility- CVC fabric's versatility allows for the production of various garments and textile goods including casual wear, uniforms, shirts, and pants. ‣ Cost Effectiveness- CVC fabric provides a cost-effective alternative to 100% cotton fabrics, achieving a balance between the performance characteristics of cotton and polyester. 2.3 Process Variable Concentration, Temperature, pH, M:L, Time In order to attain the finest possible bio-polishing, the following procedure have been mentioned below- Concentration- Concentration of Enzymes- 1.2% Temperature- Temperature are 600C pH - 4.5 – 5.5 M:L - 1:30 Time- 45 min 2.3.1 Standard recipe for Bio-polishing Concentration- Concentration of Enzymes-3% Temperature- Temperature are 550C pH - 4.5 – 5.5 M:L - 1:10 Time - 50 min 2.4 Factors affecting Bio-polishing Several factors influence bio-polishing. The main factors are process variables, fabric type, and enzymes. Temperature, pH, treatment duration, material to liquid ratio, enzyme concentration, and mechanical agitation are the main factors that affect bio-polishing. The authors employed the following approaches to conduct bio-polishing to assess the influence of the aforementioned parameters- ‣ Keeping a constant M:L ratio, pH, and temperature and changing the enzyme concentration. ‣ Keeping a consistent pH and temperature while changing the material to liquid ratio. ‣ Changing the temperature while keeping a constant M: L ratio. ‣ Changing the pH of the solution while keeping a constant M: L ratio and temperature. ‣ Keeping all these factors constant and varying the treatment duration.. 2.4.1 Effect of Concentration- The efficiency of the bio-polishing process on the knitted fabric is greatly impacted by the enzyme concentration. Various types of enzymes are available in the market. Each enzyme has an optimal pH, temperature range, and concentration. By adjusting the cellulose concentration while keeping other variables constant, such as pH, temperature, time, and the material to liquid ratio. To examine the impact of enzyme concentration on bio-polishing knit fabric samples treated with different concentrations of Cellusoft-SO like 0.5%, 1%, 1.2%, 2%, 2.5% and 3%. 2.4.2 Effect of Temperature- Temperature affects cellulase activity. Each enzyme has an optimal temperature range for maximum activity. Hence, determining the optimal temperature is crucial. Enzyme activity decreases quickly as temperature rises, becoming nearly zero at 80°C, which results in permanent deactivation of the enzymes. While the enzyme's reaction speed decreases at low temperatures, it remains active and is not deactivated. Thus, employing an extended cycle at a reduced temperature is possible. Cellusoft-SO's activity is reduced to 50% at 40°C. Each 10°C increase in temperature results in a doubled rise in enzyme activity, unless the enzyme is deactivated. To determine the impact of temperature on bio-polishing, the knit fabric samples were treated at temperatures of 40°C, 50°C, 55°C, and 60°C. 2.4.3 Effect of pH- pH is another crucial factor that affects the efficiency of bio-polishing. Optimal cellulase activity depends on a certain pH range. To investigate the impact of pH on bio-polishing of the knit fabric sample treated with 3% Cellusoft-SO at pH levels ranging from 3-4, 4-5, and 5-6. Enzyme activity maximum at pH 4.5-5.5. 2.4.4 Effect of M:L- The ratio of M:L has a major impact on bio-polishing. As the liquor ratio increases, the bath concentration of cellulase decreases and the fabric weight loss reduces. The dilution has a considerable impact on enzymatic activity. To investigate the impact of liquor ratio (M:L) on bio- polishing the knit fabric samples treated with 3% Cellusoft-SO at different M:L ratios of 1:5, 1:10, 1:15, and 1:20. 2.4.5 Effect of Duration- To determine the impact of different durations of enzymatic treatment on bio-polishing the knit fabric samples treated with 3% Cellusoft-SO for 30, 40, 50, and 60 minutes. 2.4.6 Effect of Enzyme treatment on Dyeing property- To observes the impact of enzyme treatment on the dyeing properties of bio-polished knit fabric has been carried out , both before and after dyeing. 2.5 Why we use Bio-polishing? Textile bio-polishing enhances fabric qualities by eliminating projecting filaments and fuzz. Enzymes are used in bio-polishing to degrade cellulose fibers, leading to a smoother surface, decreased pilling, and enhanced fabric quality. This technique improves the fabric's softness, decreases wrinkling, and results in a more comfortable and attractive final product. 2.5.1 Importance of Bio-polishing Bio-polishing compounds are essential in the textile industry since they improve fabric softness and visual attractiveness. This treatment minimizes pilling, the formation of fiber balls around protruding ends, resulting from repeated washing or rubbing. These agents enhance the appearance and strength of textiles by creating a smoother and more uniform surface. The process, applied post-dyeing, involves enzymes reacting with acid dyes to achieve optimal textural improvement without compromising color integrity. This chemical treatment provides clothing with a soft and silky texture, while also reducing fraying and avoiding shrinking or stretching. 2.5.2 Advantages of Bio-polishing ‣ Remove hairiness, fluff, and pills. ‣ Enhanced grip. ‣ Achievement of surface smoothness and distinct structural appearance. ‣ Enhanced luster. ‣ Enhanced sewing capability. ‣ Enhance flexibility to achieve a softer feel. 2.5.3 Disadvantages of Bio-polishing ‣ Weight loss. ‣ Strength loss. 2.6 What is Enzyme? Enzymes are proteins that function as catalysts in chemical processes. They are essentially elongated chains of amino acids connected by peptide bonds. Enzymes, similar to other catalysts, function by reducing the activation energy of a reaction, leading to a significant acceleration of the process. Enzymes are significantly more specialized than most other catalysts. Enzymes have been demonstrated to catalyze about 4,000 biological processes. Organisms produce proteins known as enzymes. A synthetic enzyme created in a laboratory to perform a certain function. Most catalysts have limited stability and eventually lose their activity, becoming inactive. Most enzymes are typically used only once and then wasted. Various types of enzymes are compatible with specific stains. Enzyme cleaning breaks down the stain into small molecules that can be easily washed away with water or normal soap. Enzymes have been utilized in many ways in textile applications in recent years. Denim stone washing and surface modification of cellulosic fabrics are commonly used to improve their appearance and texture. Cellulose-based bio-finishing is used on both clothing and knitted goods. This can be accomplished either prior to or following death. Enzyme-treated fabrics have reduced surface hairiness and significantly enhanced handle flexibility. Enzymes are ecologically friendly as they decay easily. Bio-finishing, also known as bio- polishing, is a finishing method that utilizes enzymes to produce permanent effects. 2.6.1 The history of Enzyme in Textile ‣ Amylase Desizing was introduced in 1952. ‣ Protease Wool was introduced in 1984. ‣ Cellulose Bio-stoning was introduced in 1987. ‣ Catalase Bleach cleanup was introduced in 1993. ‣ Laccase Denim Bleaching was introduced in 1996. ‣ Peroxidase Enzymatic Rinse was introduced in 1999. 2.6.2 Various enzyme used in Textile wet processing ‣ Celluase enzyme: A naturally existing microorganism is utilized in cotton bio-polishing to decrease fabric pilling and reduce surface hairiness. ‣ Amylase enzyme: This living microorganism breaks down the size components of woven fabric to enhance the fabric's water absorption ability in the cotton enzymatic desizing process. ‣ Catalase enzyme: After peroxide bleaching, this microorganism is employed to reduce any residual peroxide from the fabric, enhancing color stability. ‣ Pectinase enzyme: This enzyme is utilized in the cotton bio-scouring procedure to cleanse and make the cotton fiber more water-attracting by removing natural impurities including oil, fat, wax, dust, and dirt. ‣ Lipases: It decomposes fats and oils into alcohol and organic acids via hydrolysis. 2.6.3 Enzyme for Bio-polishing Celluloses originate from bacterial and fungal origins. These enzymes are widely utilized on cellulosic materials and are believed to contribute about 1% of the finishing process, resulting in various impacts. They are also utilized in the food, pharmaceutical, and paper industries. Celluloses utilized in the bio-finishing of cellulosic textiles are sourced from over 10 distinct fungus species. The fungus species vary in their component makeup, application pH, and effects produced. Trichoderma reesei celluloses are commonly utilized in textile finishing due to their superior productivity in industrial settings. Celluloses are complex protein bio-catalysts with large molecular weight in compound form. Industrial celluloses consist of a combination of various celluloses, cellobiase, and related enzymes, with molecular weights ranging from 10,000 to 4 million. Their composition is completely non-uniform. Removing surface fibers results in a smoother cloth surface and a softer feel. The degree of strength loss is strongly related to the rate of weight loss. 2.6.4 Enzyme Inactivation Bio-polishing involves the removal of protruding fibers from fabric surfaces using cellulase enzymes. These proteins, known as enzymes, can break down cotton cellulose by hydrolysis. After bio-polishing, the short fibers protruding from the fabric's surface are weakened to allow their removal after washing. This technique enhances the smoothness of the texture and decreases the chance of pilling or frizzing. This approach is suitable for garments made of cotton and cotton mixes. There are two commercially available forms of cellulose: acid cellulose, which is most effective in an acidic medium with a pH range of 4.5 to 5.5, and neutral cellulose, which is most effective in a pH range of 5.5 to 8.0. Both cellulose are active between temperatures of 45°C and 60°C. It is essential to deactivate the enzyme at the end of the treatment procedure to prevent damage to the fabric after the finishing process. If the enzyme is not completely deactivated after the process, the fibers will be damaged. The material could be completely destroyed under severe conditions. Hence, the enzyme's deactivation is crucial from a technical standpoint. There are two process of Enzyme inactivation- ‣ Hot treatment at 800C for 5 minutes ‣ By increasing pH to 11-12 2.6.5 Changes in Physical properties due to the Bio-polishing Enzymes Pilling- After bio-polishing the knitted fabrics, it was observed that there was minimal difference in the pilling resistance ratings between the fabric samples made from open-end yarns and combed yarns. Knitted fabrics made from open-end yarns and combed ring-spun yarn showed better pilling resistance than those made from carded ring-spun yarn. Increasing the Martindale Instrument's spins to 5000t/m resulted in higher pilling values for both ring and open-end yarns. Strength- Cotton exhibits a form of partial hydrolysis in the bio-polishing process, causing a decline in the fabric's strength. Combed yarn fabrics provide outstanding durability. Fabrics made from combed yarns exhibited superior strength values during both neglected and enzymatically treated conditions across three phases, in compared with textiles utilizing carded and open-end yarns. The fabric sample strength tends to decrease via approximately 11% after enzymatic treatment following pre-treatment or dyeing processes, depending on fabric types. By undertaking pre-treatment and dyeing procedures, cloth samples often exhibit a 25% reduction in strength following two cycles of enzyme treatment. Fabric samples produced from combed yarn demonstrate a far significant decline in strength. Fabric Weight- Approximately one to five percentage of the fabric's weight is lost after completing the bio-polishing process. Fabric samples treated with enzymes before dying exhibited significantly higher weight loss compared to fabric samples treated with enzymes after dying. The removal of fuzz from the yarn surface is achieved by a lengthy period of being processed, a large number of processing stages, and great mechanical pressures. The open-end yarn revealed a minimal weight reduction, while the fabric produced from carded yarn had the highest weight loss value when examining weight reduction depending on the yarn spinning system. The combination enzymatic treatment caused a far greater percentage of weight loss. Color Change- After enzyme treatment, the K/S value of carded yarn fabrics appeared to be higher, resulting in a darker color. However, the K/S value maintained constant in terms of weight loss for fabrics dyed with vat dyes and after cellulose treatment with direct and reactive dyes. The K/S values decreased to a lesser extent in materials pre-treated with celluloses before dyeing compared to untreated fabrics, particularly after 20-30 wash cycles. Water absorbency- Bio-polishing affects a fabric's water absorbency and absorption qualities compared to control fabrics, influenced by the fabric's construction and hydrolysis rate. Cellulase- treated fabrics exhibit increased energy release when moist, boosting thermal comfort in humid conditions. Surface peeling and microfibril splitting enhance the water absorption of cotton and cotton/linen by 24–28%. Enzyme hydrolysis removes accessible amorphous components, leading to a reduction in moisture adsorption over time. Combining enzyme and softener processes reduces the fabric's moisture-holding ability during bio-polishing. The drop in time required for medium weight fabrics is from 4.52 seconds to 0.78 seconds, while for heavy weight materials, it goes from 20.1 seconds to 12.9 seconds. CHAPTER- 3 EXPERIMENTAL DETAILS 3.1 Materials We have done our thesis in our lab and factory. In our lab we followed a recipe for Bio-polishing. In this project, we used different types of knit fabric. We collected our before bio-polishing fabric sample and experimental data on the basis of that recipe. 3.1.1 Materials & Equipment Figure 3.1-Bio-polishing Figure 3.2-Acetic Enzyme Acid Figure 3.3- Figure 3.4-Wetting Sequestering Agent Agent Figure 3.5-pH Figure 3.6-Glass Figure 3.7- meter Rod Thermometer Figure 3.8-Digital Figure 3.9-Scissor Balance Figure 3.10-Dye Bath Figure 3.11- Measuring Cylinder 3.2 Method 3.2.1 Method of Data Collection First we collect our required fabric sample from our lab. Then we cut these fabric sample by using scissor to our required weight (5 gm). Then we calculate the recipe. Then we collect our required chemicals like enzyme, wetting agent, sequestering agent, acetic acid. We take required fresh water in a beaker and mix all the chemicals in this beaker by using a glass rod. Then we take the pH value. After this we take a pot and put it on a gas burner. Then we start our experiment. When temperature is rise up to 400C we add our fabric sample and rise the temperature up to 550C and run this experiment for 45 minutes and then bath drop and rinsing. Again this fabric sample goes for hot wash and rise the temperature up to 800C for 5 minutes. Then drying this sample. 3.2.2 Process Flowchart Collect fabric sample as required Set Water level Add enzyme Add sequestering agent Add wetting agent Add acetic acid Add fabric sample Rise temperature up to 600C Run for 45 minutes Bath drop Rinsing Hot wash at 800C for 5 minutes Drying 3.3 Method of testing 3.1.1 Apparatus ‣ Beaker ‣ Measuring Cylinder ‣ Pipette ‣ Pot ‣ Tri-pod stand ‣ Gas Burner ‣ Digital Balance ‣ Scissor 3.3.2 Recipe for testing SL Chemical/Process Parameter Unit Dossing 01 Cellulase Enzyme % 1.2 02 Acetic acid g/L 0.8 03 Wetting agent g/L 1 04 Sequestering Agent g/L 1 05 Sample Weight gm 5 06 M:L ----- 1:30 07 Temperature °C 60 08 Time min 45 09 pH 5.5 --- Table:3.1- Recipe for testing 3.3.3 Recipe Calculation for Single jersey- Total Liquor = Material Weight × Liquor = 5.26 × 30 = 157.8 mL Cellulase Enzyme = 5.26 ×1.2% mL 100 = 0.0631 mL Acetic Acid = 157.8 × 0.8 mL 1000 =0.126 mL Wetting Agent = 157.8 × 1 mL 1000 = 0.157 mL Sequestering Agent = 157.8 × 1 mL 1000 = 0.157 mL Initial Water= Total Liquor - (chemicals) =157.8 − (0.0631 + 0.126 + 0.157 + 0.157) ml = 157.8 − 0.5031mL =157.29 mL 3.3.4 Recipe Calculation for Viscose- Total Liquor = Material Weight × Liquor = 5.15 × 30 = 154.5 mL Cellulase Enzyme = 5.15 ×1.2% mL 100 = 0.061 mL Acetic Acid = 154.5× 0.8 mL 1000 =0.123 mL Wetting Agent = 154.5 × 1 mL 1000 = 0.154 mL Sequestering Agent = 154.5 × 1 mL 1000 = 0.154 mL Initial Water= Total Liquor - (chemicals) =154.5 − (0.061 + 0.123 + 0.154 + 0.154) ml = 154.5 − 0.492mL =154.00 mL 3.3.5 Recipe Calculation for CVC- Total Liquor = Material Weight × Liquor = 5.18 × 30 = 155.4 mL Cellulase

Enzyme = 5.18 ×1.2% mL 100 = 0.062 mL Acetic Acid = 155.4 × 0.8 mL 1000 =0.124 mL Wetting Agent = 155.4 × 1 mL 1000 = 0.155 mL Sequestering Agent = 155.4 × 1 mL 1000 = 0.155 mL Initial Water= Total Liquor - (chemicals) =155.4 − (0.062 + 0.124 + 0.155 + 0.155) ml = 155.4 – 0.496mL =154.90 mL 3.3.6 Recipe Calculation for Interlock- Total Liquor = Material Weight × Liquor = 4 × 30 = 120 mL Cellulase Enzyme = 4×1.2% mL 100 = 0.048 mL Acetic Acid = 120× 0.8 mL 1000 =0.096 mL Wetting Agent = 120 × 1 mL 1000 = 0.12 mL Sequestering Agent = 120 × 1 mL 1000 = 0.12 mL Initial Water= Total Liquor - (chemicals) =120 − (0.048 + 0.096 + 0.12 + 0.12) ml = 120 – 0.384 mL =119.61 mL 3.4 Experimental Data of WPI & CPI All the samples are collected from our lab (100% cotton knit fabric). Apparatus- ‣ Pen ‣ Counting Glass WPI- WPI stands for wales per inch. The term "wales per inch" (WPI) refers to the number of wales in an inch of knitted fabric. CPI- CPI stands for course per inch. The term "course per inch" (CPI) refers to the number of courses in an inch of knitted fabric. 3.4.1 Working Procedure- ‣ First, we take the fabric according to its direction course and wales. ‣ Then set the point of the counting glass and counting the yarn through 1 inch by the help of the counting glass. ‣ At last, we find the WPI and CPI. Fig: 3.12- Counting Glass Counting Glass- We can measure the Wales Per Inch (WPI) and Courses Per Inch (CPI) of the knit fabric using a counting glass. Fig: 3.13- Needle Needle- We can simply determine the WPI and CPI of the fabric by using a needle. 3.5 Experimental data of Spectrophotometer A spectrophotometer is a device used to measure electromagnetic energy at specific wavelengths of light with accuracy. It detects colors and the quantity of each color in a light beam by utilizing the properties of light and energy. A spectrophotometer consists of two primary parts: a photometer and a spectrometer. Spectrometer: A lens directs a beam of straight light toward a prism, which split it into its individual wavelengths. The wavelengths that have been selected by a wavelength selector are then sent towards the photometer. Photometer: The component of the machine that measures the amount of photons absorbed and transmits that information to a digital display is called the photometer. 3.5.1 Working Procedure of Spectrophotometer ‣ In spectrophotometer, we achieve the Reflectance value of the bio-polish fabric. ‣ First, we attached the fabric using a sample holder. ‣ The spectrophotometer measures the light intensity of a sample by passing a laser beam across it. ‣ These instruments are used in the process of measuring color and for monitoring color accuracy throughout production. Fig: 3.14- Spectrophotometer 3.6 Experimental data of Ball Brusting Test All the samples are collected from our lab (100% cotton knit fabric). 3.6.1 Working Procedure ‣ First, we followed the UST guidelines to cut the sample to a normal size and shape. ‣ Ensure that the grips or clamps are suitable for the sample material before attaching them to the UST. ‣ Ensure the bio-polish sample is accurately positioned in the center while inserting it into the grips. ‣ Provide the UST with the required load rate, crosshead speed, and testing procedure. ‣ Input relevant data into the testing program. ‣ Activate the UST to begin the test. Monitor the sample closely when pressure or force is applied by the UST. The UST will measure various parameters according to the test setups. ‣ Examples of data that the UST software should record are force, stress, and strain. ‣ Throughout the test, alert yourself to any unexpected or strange conduct. ‣ Examine the results once the test is complete for information on the bio-polish sample's strength properties. ‣ Then we achieve the value of brusting test result. Figure:3.15- Universal Strength Tester 3.7 Attached Sample Before and After Bio polishing Sample No. Types of Fabric Before Bio-polishing After Bio-polishing 01 Single Jersey 02 Viscose 03 CVC 04 Interlock Table 3.2- Sample Before and After Bio polishing CHAPTER- 4 RESULT & DISCUSSION 4.1 Difference in Weight loss Sample No. Fabric Sample Name Before Bio- polishing Sample After Bio- polishing Sample Weight Loss% 01 S/J 5.26 gm 5.16 gm 1.90 02 Viscose 5.15 gm 5.02 gm 2.52 03 CVC 5.18 gm 5.06 gm 2.31 04 Interlock 4.00 gm 3.89 gm 2.75 Table 4.1- Difference in Weight loss To find out the weight loss, first we take our required sample and cut the fabric sample and measured in digital weight balance. Then we bio-polish all the fabric and then dry all the sample. When all of the sample will be dry then we measured all the sample one by one in digital weight balance. We can see before bio-polishing the single jersey weight is 5.26 gm and after bio- polishing the weight is 5.16 gm and their weight loss is 0.10 gm. For viscose fabric we see before bio-polishing the weight is 5 .15 gm and after bio-polishing the weight is 5.02 gm and their weight loss is 0.13 gm. For CVC fabric we see before bio-polishing the weight is 5.18 gm and after bio- polishing the weight is 5.06 gm and their weight loss is 0.12 gm. We can also see the interlock fabric before bio-polishing the weight is 4.00 gm and after bio-polishing the weight is 3.89 gm and their weight is 0.11 gm. 4.1.1 Change in Weight Before and After Bio-polishing After bio-polishing the change of Weight loss of different fabrics were recorded in the table(4.1). The change of weight loss has been used here to drawn the following chart. Weight Loss 6 5.26 5.16 5.15 5.02 5.18 5.06 5 4 3.89 4 3 2.52 2.75 2.31 2 1.9 1 0 Single Jersey Viscose Before Bio-polishing After Bio-polishing CVC Weight Loss% Interlock Column1 Figure: 4.1 Column diagram shows the change of Weight loss The X-axis in the column diagram represents the Sample type, while the Y-axis represents the Fabric Weight. The blue column indicates the fabric weight before bio-polishing, whereas the orange column indicates the fabric weight after bio-polishing and the grey column indicates the weight loss%. Weight loss is observed in each fabric sample during the bio-polishing process. The enzyme will remove the protruding fibers from the surface of the fabric. Here we see all the sample- The weight of the single jersey fabric is 5.26 gm, and after bio-polishing, it decreases to 5.16 gm. The weight of the viscose fabric is 5.15 gm, and after bio-polishing, it decreases to 5.02 gram. The CVC fabric weight is 5.18 grams, and after bio-polishing, it decreased to 5.06 grams. The interlock fabric weight is 4.00 gm, and after bio-polishing, it decreases to 3.89 gm. 4.2 Difference in WPI and CPI Sample No. Fabric Sample Before Bio- polishing Sample After Bio- polishing Sample Change Change % Name WPI CPI WPI CPI WPI CPI WPI CPI 01 S/J 41 39 39 46 2 7 4.87 17.9 02

Viscose 40 38 34 42 6 4 15 10.52 03 CVC 30 37 35 41 5 4 16.66 10.81 04 Interlock 30 46 32 44 2 2 6.66 4.34 Table 4.2- Difference in WPI and CPI WPI- WPI stands for wales per inch. The term "wales per inch" (WPI) refers to the number of wales in an inch of knitted fabric. To calculate WPI, we took 1 inch of sample and then count the wales lengthwise. By this way, we got before and after bio-polishing WPI for each sample. Then we compared the after bio-polishing WPI with the before WPI of the sample. The table (4.2) shows that the highest percentage is 16.66% of the CVC. The sample's WPI was 30 before bio-polishing and after bio-polishing WPI of the sample is 35. The minimum percentage is 4.87% of the single jersey fabric. The sample's WPI was 41 before bio-polishing and after bio- polishing WPI of the sample is 39. Viscose fabric was seen with a WPI of 40 before bio-polishing and a WPI of 34 after bio-polishing, resulting in a 15% change. Before bio-polishing, the interlock fabric had a WPI of 30 and after bio-polishing, the WPI is 32, resulting in a change of 6.66%. 4.2.1 Change in WPI Before and After Bio-polishing After bio-polishing the change of WPI of different fabrics were recorded in the table (4.2). The change of WPI has been used here to drawn the following chart. Change in WPI 45 41 40 39 40 35 34 35 30 32 30 30 25 20 15 10 5 0 15 2 4.87 6 Single Jersey Viscose Before Bio-polishing WPI After Bio-polishing WPI 16.66 5 CVC Change WPI 6.66 2 Interlock Change WPI % Figure: 4.2 Column diagram shows the change of WPI The X-axis in the column diagram represents the Sample type, while the Y-axis represents the fabric WPI. The blue column represents the before bio-polishing WPI, the orange column represents the after bio-polishing WPI, the grey column represents the change in WPI, and the yellow column represents the percentage change in WPI. Before bio-polishing, the single jersey WPI is 41, and after bio-polishing, the single jersey WPI is 39, resulting in a change of 4.87%. The viscose fabric had a WPI of 40 before bio-polishing and a WPI of 34 after bio-polishing, resulting in a 15% change. The CVC fabric had a WPI of 30 before bio-polishing and 35 after bio- polishing, resulting in a 16.66% change. The Interlock fabric had a WPI of 30 before bio-polishing and 32 after bio-polishing, resulting in a 6.66% change. Here, we see the smallest percentage change in single jersey fabric. 4.2.2 Difference in WPI and CPI CPI- CPI stands for course per inch. The term "course per inch" (CPI) refers to the number of courses in an inch of knitted fabric. To calculate CPI, we took 1 inch square of sample and then count the wales lengthwise. By this way, we got before and after bio-polishing CPI for each sample. Then we compared the after bio- polishing CPI with the before CPI of the sample. The table (4.2) shows that the highest rate is 17.9% for Single jersey. The sample's CPI was 39 before bio-polishing and increased to 46 after bio-polishing. The minimum percentage of the interlock fabric is 4.34%. The CPI of the sample before bio-polishing was 46, and after bio- polishing, it decreased to 44. Viscose fabric's CPI is 38 before bio-polishing and 42 after bio- polishing, resulting in a change of 10.52%. Before bio-polishing, the CVC fabric's CPI is 37, and after bio-polishing, the CPI increases to 41, resulting in a change of 10.81%. 4.2.3 Change in CPI Before and After Bio-polishing After bio-polishing the change of CPI of different fabrics were recorded in the table (4.2). The change of CPI has been used here to drawn the following chart. Variation in CPI 50 46 46 45 42 44 40 39 38 37 41 35 30 25 20 15 10 5 0 17.9 10.52 7 4 Single Jersey Viscose Before Bio-polishing CPI After Bio-polishing CPI 10.81 4 CVC Change CPI 2 4.34 Interlock Change CPI % Figure: 4.3 Column diagram shows the change of CPI The X-axis of the column diagram represents the Sample type, while the Y-axis represents the fabric CPI. The blue column represents the before bio-polishing CPI, the orange column represents the after bio-polishing CPI, the grey column represents the CPI change, and the yellow column represents the CPI percentage change. Before bio-polishing, the single jersey CPI is 39, and after bio-polishing, it is 46, resulting in a 17.9% change. Before bio-polishing the viscose fabric CPI is 38 and after bio-polishing the CPI is 42 and their change% is 10.52. The CVC fabric had a CPI of 37 before bio-polishing and a CPI of 41 after bio-polishing, resulting in a change of 10.81%. Before bio-polishing, the Interlock fabric's CPI is 46, and after bio-polishing, it is 44, resulting in a change of 4.34%. Here, we observe the smallest percentage change in interlock fabric. 4.3 Spectrophotometer Data Table Fabric Sample Name Before Bio- polishing After Bio-polishing STD Batch-1 Single Jersey 79.71 81.68 Viscose 78.69 81.08 CVC 80.26 82.32 Interlock 69.71 70.24 Table 4.3- Difference in Reflection We measure the reflectance value of the bio-polish fabric using a spectrophotometer. At first we used a sample holder for fixing the fabric. The spectrophotometer measures the light intensity of a sample by transmitting a light beam through it. These tools are used for measuring color and ensuring color accuracy throughout production. 4.3.1 Change in reflection Before and After Bio-polishing After bio-polishing the change of reflection of different fabrics were recorded in the table (4.3). The change of reflection has been used here to drawn the following chart. 84 82 81.68 80 79.71 78 76 74 72 70 68 66 64 62 Spectrophotometer Chart 82.32 81.08 80.26 78.69 69.71 70.24 Single jersey Viscose CVC Interlock Before Bio-polishing After Bio-polishing Figure: 4.4- Column diagram shows the reflection The X-axis in the column diagram represents fabric type, while the Y-axis shows the rating of spectrometer data range. The blue bar indicates the reflectance of the fabric before bio-polishing, while the orange bar indicates the reflectance after bio-polishing. The single jersey standard reflectance is 79.71, and after bio-polishing, it increases to 81.68. The reflectance of the viscose fabric is 78.69, which increases to 81.08 after bio-polishing. The reflectance of the CVC fabric standard is 80.26, which increases to 82.32 after bio-polishing. The reflectance of the interlock fabric is 69.71, and it increased to 70.24 after bio-polishing. 4.4 Difference in Strength test Fabric Sample Name Before Bio-polishing After Bio-polishing Force N Force N Single Jersey 387.04 420.99 Viscose 257.85 235.73 CVC 187.74 267.63 Interlock 393.03 256.73 Table: 4.4- Difference in Strength test After testing, we observed significant differences in the bio-polishing strength before and after. We use four different types of samples: single jersey, viscose, CVC, and interlock. We have created four graphs representing four different fabrics to show the difference in strength before and after bio-polishing. 4.4.1 Test: Single Jersey Before Bio-polishing After bio-polishing the change of strength of different fabrics were recorded in the table (4.4). The change of reflection has been used here to drawn the following chart. Figure: 4.5- Single Jersey Before Bio-polishing 4.4.2 Test: Single Jersey After Bio-polishing Figure: 4.6- Single Jersey After Bio-polishing 4.4.3 Test: Viscose Before Bio-polishing Figure: 4.7- Viscose Before Bio-polishing 4.4.4 Test: Viscose After Bio-polishing Figure: 4.8- Viscose After Bio-polishing 4.4.5 Test: CVC Before Bio-polishing Figure: 4.9- CVC Before Bio-polishing 4.4.6 Test: CVC After Bio-polishing Figure: 4.10- CVC After Bio-polishing Figure: 4.11- Interlock Before Bio-polishing Figure: 4.12- Interlock After Bio-polishing The single jersey fabric's strength was tested at 387.04 N before bio-polishing and 420.99 N after bio-polishing. The viscose fabric's strength was 257.85 N before bio-polishing and 235.73 N after bio-polishing. The force for CVC fabric was 187.74 N before bio-polishing and 267.63 N after bio-polishing. Before bio-polishing, the interlock fabric showed a force of 393.03 N and 256.37 N after the bio-polishing process. CHAPTER- 5 CONCLUSION The study indicates that bio-polishing has a significant impact on textile materials and is considered a sustainable and environmentally friendly finishing procedure. The study aimed to analyze the basic physical characteristics of fabric samples before and after bio-polishing, with a specific focus on parameters such as weight loss, WPI (Wales per Inch) and CPI (Courses per Inch), reflectivity, and strength. The study observed that reducing protruding fibers decreased the weight of the fabrics, resulting to changes in the WPI and CPI depending on the kind of fabric. Bio-polishing improves fabric qualities by decreasing hairiness, improving handling and shine, and strengthening sewing ability, demonstrating its potential advantages across various textile types. This study will be advantageous for our upcoming projects. ? In weight loss table we see the maximum change% is 2.75% which is interlock and the minimum change% is 1.90% which is single jersey fabric. ? In WPI data table we see the maximum change% is 15 which is viscose and the minimum change% is 4.87 which is single jersey. ? In CPI data table we see the maximum change% is 17.9 which is single jersey and the minimum change% is 4.34 which is interlock. ? In light reflection data table we see the maximum reflection is 82.32 which is cvc and the minimum reflection is 70.24 which is interlock. ? In brusting data table we see the maximum load which is 420.99 of single jersey and the minimum load which is 235.73 of viscose. REFERENCE 1. https://textilelearner.net/bio-polishing-on-cotton-knit-goods/ 2. https://textilelearner.net/biopolishing-in-textile-process-advantages/ 3. https://www.textileflowchart.com/2015/08/flow-chart-of-bio-polishing-process.html 4. https://www.slideshare.net/MdRafsanJany/bio-processing-of-textiles-rafsan-6th- 39515183 5. https://diutestudents.blogspot.com/2016/09/bio-polishing-of-100-cotton-knitted.html?m=1 6. https://www.htfine-chem.com/list-of-chemicals-used-in-textile-industry/biopolishing- enzymes.html 4.4.7 Test: Interlock Before Bio-polishing 4.4.8 Test: Interlock After Bio-polishing