Faculty of Engineering
Department of Textile Engineering

Project (Thesis) on

EFFECTS OF TIME ON THE BIO-SCOURING PROCESS OF COTTON KNITTED FABRICS

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Bachelor of Science in Textile Engineering

Advance in Wet Processing Technology

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DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Sumon Mozumder** 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.

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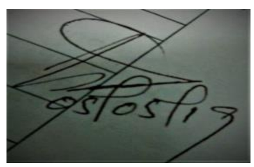
LETTER OF APPROVAL

This project report prepared by Md. Mohay Menul Hasan (ID: 162-23-4768), Md. Majedul Islam Kazi (ID: 162-23-6771) and Mahamudul Islam Prince (ID: 162-23-4740) is approved in Partial Fulfillment of the Requirement for the Degree of BACHELOR OF SCIENCE IN TEXTILE ENGINEERING. The said students have completed their project work under my supervision. During the research period I found them sincere, hardworking and enthusiastic.



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

DEDICATION

This internship report is dedicated to

our beloved parents and honorable

Abstract

This study pretend to assess the eco-friendly Bio-scouring process on cotton fabrics. Living organisms and their components are being used to remove natural and added impurities from cotton fabric in Enzymatic scouring or Bio-scouring application. This project is mainly focused on, effects of different periods of time (5mins, 10mins, 15mins, 20mins and 25mins) on the Bio-scouring process of cotton knitted fabrics and aim of the work was to measure fabric characteristics (CPI, WPI, SL, GSM), absorbency test (Immersion test, Drop test, Wicking test) as well as PH test. For doing the project we took three types of fabric like Single Jersey, (1*1) Rib and Plain Interlock. We studied Bio-scouring process of cotton by using pectinase enzyme. Here for doing Bio-scouring we changed the time (5 mins, 10 mins, 15 mins, 20 mins, 25 mins). We took pectinase, emulsion and wetting agent. After we had done the process, we test the fabric like absorbency test, wicking test and drop test. Stich length, WPI, CPI, GSM and weight loss of fabric test also. After done the research we found that Single Jersey, (1*1) Rib and Plain Interlock were showing higher% of change in CPI, WPI, SL, GSM, Weight Loss and good Absorbency in 25mins of Bio-scouring process.

TABLE OF CONTENTS

Contents **Page No.**

List of Figures

List of Tables

CHAPTER 01

INTRODUCTION

CHAPTER 01

INTRODUCTION

Cotton yarn or fabric, before dyeing or printing it passes through number of process in textile processing. Scouring is a very important process. Non-cellulose elements are completely or incompletely removed by this process. For doing scouring fabrics get high and even wet ability. In this process highly alkaline chemicals as like as caustic soda are used. Which is not only removing the non-cellulose from the cotton, but also the cellulose governance to risk chemical result in high COD (Chemical Oxygen Demand) BOD (Bio-chemical Oxygen Demand) and TDS in the waste water. So, it is not friendly for environment.

In this era, consumers are conscious about the clothes they buy are of high-quality material and are well made. Additionally they are concerned about the clothes in which excessive number of chemicals are used. They are aware of the environmental friendly process of the manufacturing clothes. The most efficient way to reduce impurities (natural/additive) from the clothes are enzymatic scouring or Bio-scouring. Pectinase is used in Bio-scouring process as a chemical. In this process living organisms and their components are used to remove the impurities. So Bio-scouring will have a large impact in future in many industrial sectors as it an eco-friendly process.

Bio-scouring process is an inexpensive process than the other scouring processes because of the use of the low temperature, little energy and less water. The pectinase breakdown the formation of the epidermis, hydrolyzing the pectin and killing the links with wax and protein and remaining the fiber structure. Even when fabric remain 30% of the remaining pectins after a residence stage, a wash at 80 ºC-90 ºC eliminates the solubilized waxes. In Bio-scouring process, here need less amount of dyes, chemicals and water so after treatment when we release the waste water in the environment it will more friendly for environment then conventional scouring process. [1,10]

1.1 Objective of the study

The broad objective of the research is to established a basic structure for effects of time on the bio-scouring process of cotton knitted fabrics.

The **specific objectives** of this research are mainly –

- ✓ To know about enzyme which is mainly used in Bio-scouring process and also know about a modern technology which is used in scouring process.
- ✓ To assess the Bio-scouring effect with various test as like drop test, Immersion test, wicking test.
- ✓ To assess the SL (Stich Length), GSM (Gram Per Square Meter), CPI (Course Per Inch) and WPI (Wales Per Inch) of fabric before and after Bio-scouring process.
- ✓ To know the weight loss percentage of the fabric by measuring the weight before and after Bio-scouring process.
- ✓ To know the effect of fabric before and after Bio-scouring process.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Cotton

Cotton is a cellulosic natural fiber. It is one of the oldest fibers in this world which is most useable for various purpose and familiar to human beings. With cellulose non-cellulosic material such as sugars, starch, protein and some inorganic matters will be present in cotton fiber. Without this matters lignin also found in the cotton fiber which is a complex organic compound. It works a safety sale which is stay around on the fabric. [10]

2.1.1 Chemistry of Cotton

Cotton is an insoluble substance. In some specific solvent it will soluble. In cotton fiber cellulose percentage is higher then other fiber. It is one kind of vegetable fiber. Mainly cotton fiber composed from polysaccharide which holds a chain of glucose monomers.

Which cotton we get from nature it is highly crystalline then other fiber and rigid molecular structure. Main building block of cotton cellulose chain are β-1, 4-D. Free rotation of the anhydrogluco-pyranose C-O-C link is stopped by steric effect. Because of present of hydroxyl groups and the chain conformation there also many bonds produce. Some bonds increase the rigid by increasing the rigidity of the structure of cotton fiber. [8,10]

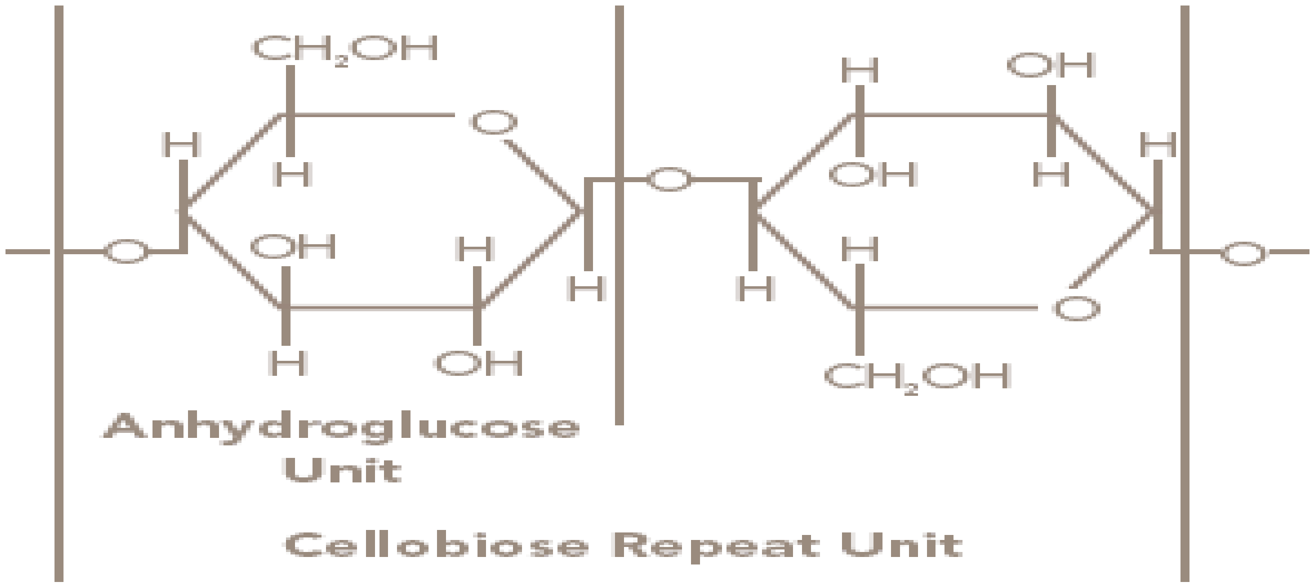


Figure 2.1 Structure of cotton cellulose.

2.1.2 Chemical Structure of Cotton

Cotton is a natural cellulose. As it have common element of a vegetable cell. Proteins, oil and wax, pectose and pectins, mineral matters and natural coloring matters are the contents of natural fiber. Cotton fiber also contains impurities. The percentage of impurities depends on the type of cotton and fiber maturity. Immature cotton produce more impurities the mature cotton fiber. For a dry cotton fiber, the approximate formation is shown in Table 2.1. [3,8,10]

Table 2.1 Chemical components of cotton

Chemical	Formation (%)
Cellulose	88.0-97.0
Protein	1.0-2.0
Oil and wax	0.4-1.5
Pectins	0.4-1.5
Minerals	0.7-1.6
Others	0.5-8.0

a) Cellulose

In cotton maximum amount of components we get cellulose. Naturally cellulose is composed of glucose molecule which is prepared in stearic method. The molecular weight is 2 million approximately of the cellulose present in cotton.

b) Protein

Cotton is a protein fiber. As usual protein produced from polypeptides and amino acids. Those are mainly present in primary cell wall and lumen of fabric. The various amount between cell wall and lumen is1-2%.

c) Oil and Wax

Oil and wax are basically hydrophobic substance. It works as a protective coating on fiber surface. They are from of high molecular weight of glycerides and fatty acid present in free from. Waxes will be melted in various value. The approximate value is 68 ºC-80 ºC. After treatment (scouring) wax removed from fiber. Waste wax used to produce soap during treatment in alkaline solution.

d) Pectin

About 0.4-1.5% pectins present in cotton fiber. Mainly these are from calcium, magnesium and iron pectates with some free pectic acid and methyl pectate. It’s calcium and magnesium salt are not soluble in water and the free acid also but in alkali hydroxides or soda ash they will be converted into soluble product. So, during alkali boiling or scouring these can be removed from the cotton fiber or materials.

e) Minerals

About 0.7-1.6% minerals present in cotton fibers. These minerals removed from cotton as ash after burnt. Minerals matters added on cotton fiber as a outer surface. Minerals contains chlorides, carbonates and sulphates of potassium, calcium and magnesium. Minerals are removed or reduce from cotton fiber by boiling. [8,10]

2.2 Knitting

Knitting is a process of manufacturing knit fabric. On other hand it is a process of knit fabric construction by forming loops into yarn. Manufacturing fabric yarn maybe single yarn or set or group of yarn.

In another word knitting is method by manipulated yarn to produce Textile. Knitting produce multiple loops of yarn, which is called stitch. Stitching is done in a line. Stitch creates a line in warp and also in weft direction.

Loops are made by using needle. Fineness of the fabric given by the number of stitch/needles per inch in a machine. If the gauge number is higher per inch then the fabric is finer and if the gauge number is less high per inch then the fabric will be less fine.

The size of the loop of the yarn determine of course and wales. Fabric length determines the number of courses in fabric and width of fabric determines the number of wales in the fabric. [3,11]

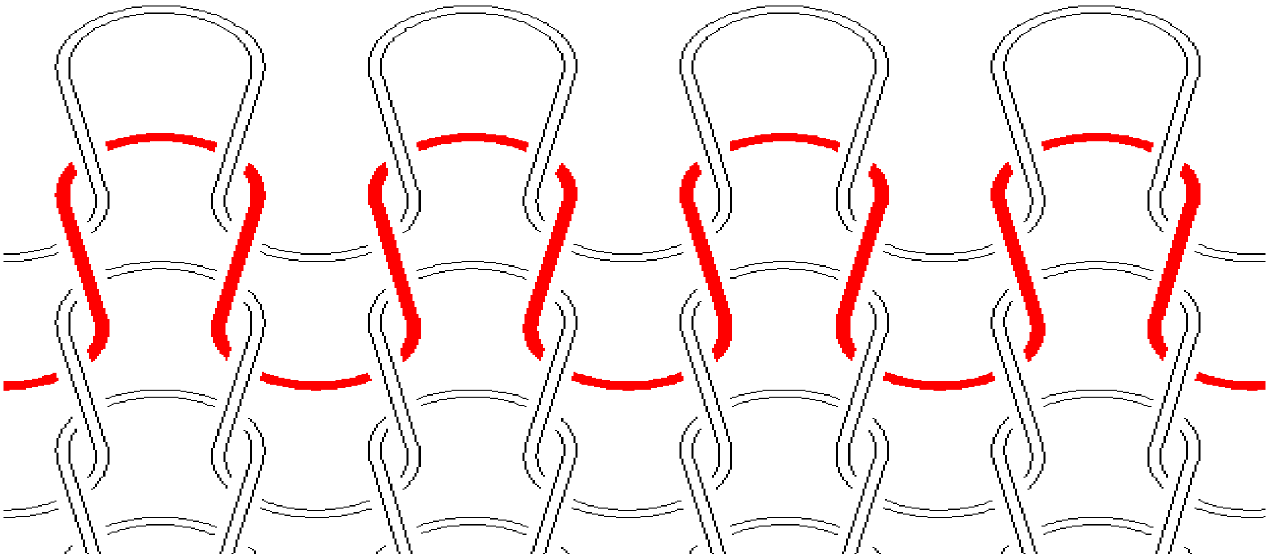


Figure: 2.2 Knitting structure

Basically there are two types of knitting:

1.Warp Knitting

2.Weft knitting

- **Warp knitting:** It is a fabric manufacturing process by producing loops warp wise. In this process loops are produced two or sets of yarn. Here loops are formed vertically. Usually warp knitted fabric is done in flat or open form.
- **Weft knitting:** It is a fabric manufacturing process by producing loops weft wise. In this process loops are produced a single yarn. These loops are formed horizontally. Usually weft knitted fabric is done in tubular form. [11]

2.2.1 Basis Structure in Knitting

1.**Single Jersey:** Single jersey fabric is a weft knitted fabric. Here one set on needles are used. From structural view front side and back side of single jersey fabric are different.

2.**Rib Fabric:** In rib fabric produce, each course has one face loop and one back loop. In this fabric front and back both sides are same.

3.**Interlock:** Although interlock is derived from 1*1 rib structure, the fabric properties are not same. [3]

2.3 Scouring

Scouring is a process by using to remove natural and added impurities from the cotton fabric. The natural impurities are oil, waxes, fat etc. And added impurities are gear oil, grease etc. Dirt and dust also remove by scouring process.

Scouring will be continuous or discontinuous system. For scouring impurities removed from the fabric as well as it increases the absorbency of the fabric.

When scouring process in run we should concern about temperature, processing time, pH, liquor ratio, fabric types etc. Complete Scouring helpful for the next process. On the other hand, incomplete scouring originates bad affect for next process such as dyeing and printing process due to poor affinity of dyes of the material.

Types of Scouring Processes are:

a) Conventional Scouring process. (Scouring by chemicals means) and

b) Bio-Scouring or Enzymatic Scouring Process.

Conventional Scouring Process: It is a traditional process to remove impurities from the fabric. In this process high amount of water required and time also. So, this process cost is higher than Bio-scouring process. Here need high amount of water and dyes and chemical also. So here waste water amount also higher than other scouring process. As here the amount of waste water is higher so the rate of contamination is also high. Over all this is a costly process but the cost of the machineries is cheap. [6]

Bio-Scouring or Enzymatic Scouring process: This is an updated scouring process to remove the impurities from the fabric. Here need less water and time than other scouring process. This process is cheaper the conventional scouring process but machineries cost is higher than conventional process. [2]

2.3.1 Scouring of Cotton

At high temperature, the cotton cellulose material is treated with a solution containing alkali, soda ash and caustic soda, an anionic and/or nonionic detergent a wetting gent a complexing and sequestering (which is used for the removal of metal ions) and polyacrylates or polyphosphonates (as special surfactant free dispersing agent) in the scouring process. Now a days the scouring is done mostly in the dyeing machines. Scouring is done as a part of combined or single operation such as scouring and bleaching. Conventionally the scouring operation was done in kier machine for which the process was called kier boiling.

i. Saponification of fats into water soluble soap and water miscible glycerin under alkaline condition.
ii. Hydrolysis of proteins into water soluble degradation products.
iii. Dissolution of amino compounds.
iv. Solubilizing of pectose and pectins by converting into soluble salts.
v. Dissolution and extraction of mineral matter.
vi. Emulsification and solubilization of natural oils and waxes.
vii. Removal and dispersion of dirt particles and kitty by the action of alkali and detergent.

The material after scouring is more absorbent, free from natural impurities and coloring matter. This treatment can be carried out on filaments, yarns and fabrics. [6,15]

2.4 Enzymes

Enzymes are protein catalysts that accelerate the rate of chemical reactions. From protein all enzymes are made with having three dimensional specific shape. For different enzymes the shapes are different. The enzymes which are used for one reaction those are not used for the further reactions i.e. amylase speeds up the breakdown of starch into the sugar maltose. Catalase speed up the breakdown of hydrogen peroxide. The reason for this is that the substrate fits into a special region of the enzyme called the active site. When in the active site the enzyme can catalase the reaction.

Due to the advantages of enzyme being non-toxic, biodegradable and environmentally friendly the uses of enzyme in textile processes has gained increased. In textile wet processing like desizing, scouring, bleaching, dyeing and finishing enzyme can be safely used while traditional chemicals can cause many problems including pollution of effluents when disposed into the environment. Advances in enzyme technology use in the textile industry have made it possible to explore the potential of single enzymes or enzyme mixtures for specific applications. For fabric preparation and finishing hydrolases (e.g. amylases, cellulose, pectinases, proteases) have been employed.

Enzyme are large high-molecular weight protein structure with highly specific active sites within the molecule that perform the catalytic reaction. Replacing enzymes with simpler compounds that mimic the behavior of these biocatalysts could significantly increase the reaction rate, facilities the enzymatic process and decrease costs.

Enzymes can work at atmospheric pressure and in mild conditions with respect to temperature and acidity (pH). Most enzymes function optimally at a temperature of 30ºC-70ºC and at pH values, which are near the neutral point (pH 7). Enzyme processes are potentially energy saving and save investing in special equipment resistant to heat, pressure or corrosion. [5,12]

2.4.1 Advantages of Using Enzymes in The Textile

Usage of enzymes has the following advantages in the textile industry:-

- Enzymatic process is environment friendly.
- Speed up the chemical process.
- It is non-toxic process.
- It may improve the product quality.
- Less water is required.
- Less energy is required.
- Less time is required.[14]

a) Environment Friendly

For the textile processes many toxic hazardous chemicals had been used before the replacement of using enzymes. Using enzymes in the textile process have reduced the percentage of pollution and helped to treat the waste water easily with minimum cost.

b) Enzyme speed up the process

As catalysts, enzymes remain the same after the reaction. By lowering the activation energy of reaction and increasing the rate of particular reaction, enzymes speed up the reaction.

c) Enzyme Act on a Individual Substrate

Enzymes catalyze only on some specific substrate. It works in milder conditions. For each specific enzyme there is a specific temperature and pH value in which they perform there best in speeding the chemical reaction. Otherwise if the temperature or pH beyond the specific one would degrade the enzymes performance.

d) Easy to Control

Easy controlling means the less chances of having any problem therefore better results. As each enzyme has a specific condition under which they perform, it reduces the chance of attacking the fiber structure which gives a better material and it also reduces the weight loss of fiber.

- Save water
- Very sensitive
- Enzyme can be reduce easily
- Enzymes can measure very tiny concentrations of substances.
- Reusability of enzymes
- Limited usage of water (one of the most useful and scare resource). Water usage is reduced by almost 19000 liters per ton of textile bleaches.

The only disadvantage of enzymes is that they are expensive and if the enzymes are not sued up in reaction then separation form product is time consuming and expensive. [2,12]

2.5 Enzymatic Scouring (Bio-scouring)

The process by which the living organisms and their components remove the natural and added impurities from fabric is called enzymatic scouring or Bio-scouring. Bio-scouring is an important technology that will have a large impact on many industrial sectors in future. Bio-scouring process mainly rely on inexpensive substrates for biosynthesis. In Bio-scouring process the function operates at low temperature and also consume little energy and water as well. Enzymatic removal of impurities also reduces the total chemicals consumptions and possibilities of accident. [2]

2.5.1 Bio-scouring of Cotton Fabrics

Scouring is removal of non-cellulosic material present on the surface of the cotton. About 90% of cellulose are contained in raw cotton and various non-cellulosic such as waxes, fats, pectins, proteins, lignin-containing impurities and coloring matter. Grey or untreated cotton contains various non-cellulosic impurities such as pectins, waxes, hemicelluloses and mineral salts, present in the cuticle and primary cell wall of the fiber. The goal of the cotton preparatory process is the remove the hydrophobic and non- cellulosic components and produce highly absorbent fibers that can be dyed and finishing uniformly. These are responsible for the hydrophobic properties of raw cotton and interfere with aqueous chemical processes on cotton, like dyeing and finishing therefore before cotton yarn or fabric can be dyed, it needs to be pretreated to remove materials that inhibit dye binding. This step, named scouring, improves the wet ability of the fabric and normally uses alkalis, such as sodium hydroxide. However, these chemicals also attack the cellulose, leading to reduction in strength and loss of fabric weight. Furthermore, the resulting wastewater has a high COD (Chemical Oxygen Demand), BOD (Biological Oxygen Demand) and salt content. Enzymatic or Bio-scouring, leaves the cellulose structure almost intact, preventing cellulose weight and strength loss.

Bio-scouring has a number of potential advantages over traditional scouring. It is lower BOD, COD, TDS (Total Dissolved Solids), performed at neutral pH, which total water consumption reduce, the treated yarn/fabrics retain their strength properties, the weight loss is reduced or limited compared with processing in traditional ways.

It increases cotton fiber softness. Several types of enzyme, including pectin cellulose proteases and lipases, alone or combined have been studied for cotton bio-scouring, with pectinases being the most effective.

Compare to harsh feel in alkaline scouring process hand feel is very soft in enzymatic scouring process. To effectively scour fabric without negatively affecting the fiber or the environment enzymatic scouring can be used. As operators are not exposed to aggressive chemicals, it minimizes the health risks. Bio-scouring process provides many advantages:-

- Bio-scouring process has reduced water and waste water cost.
- It has reduced treatment time.
- This process has lowered energy consumption. (Because of lower treatment temperature, the optimal temperature is form 40-60ºC)

- It has reduced the weight loss in fabric.
- Because of this process the fabric quality is improved with a superior hand.
- Bio-scouring process has reduced strength loss.

The technical advantages that the enzyme scouring commercially appealing, are a higher quality of the fibers (soft to the touch and better strength), less waste waters, economy of energy and compatibility with other products, equipment and materials pectinase, as the name suggests, hydrolysis pectins the are present in cotton as a non-cellulosic impurity. The best kinds of pectinase are those, which can function under slightly alkaline conditions even in the presence of chelating agents. Such enzymes are called “alkaline pectinases”. Most conventional pectinases are usually inactive under these commercially useful conditions, their optimum activity lying in the slightly acidic region. During the pectinase treatment the pectin content of cotton fiber can be decreased by about 30%. The bio-scouring process results in textile being softer than those scouring in the conventional sodium hydroxide process. [2,4]

2.5.2 Bio-scouring Systems and Advantages of Bio-scouring

Water saving: In conventional process a minimum of 5 baths are used before the actual dyeing, whereas in bio-scouring process only one bath is used. This leads to a total 4 bath saving. Considering an MLR of 1:7, the total amount of water that will be saved about 28 litters for per Kg. processed. For a unit doing a 30 Mt. of bleaching every day, the amount of water that will be saved is 840,000 litter per day. On annual basis the amounts come to be 3066,00,000 liters of water.

Temperature Saving: At a temperature of 55ºC as against 98ºC, the entire process takes place. The temperature difference is about 43ºC. The specific heat of water is 4.186 Joule/gram K. It requires 4.186 joules of energy to heat 1 gm of water by 1 K. Assuming an MLR of 1:7, for every kg of cotton, 7 litters of water is used during the bleaching process.

Smoother Surface Profile: The binding agent named pectin prevents the hairiness of the cotton that gets generated due to abrasion with processing equipment’s. Pectin also itself acts as a softener for the cotton. So the application of final softener can be reduced from 25-40%. Smoother profile will also help in improving the loom running efficiency by 4% at least.

Time Saving: The bio-scouring process takes place about 50 minutes for completion whereas the conventional scouring process takes place about 2 hours 50 min. So, for every batch dyed we are saving 2 hours per batch. Using bio-scouring dyeing can be completed in 5 hours where it takes 7 hours to complete the dyeing process in conventional method. The percentage of time saving will be 29%. Thus any process house can raise its production by 29% approximately by using the bio-scouring process.

Environmental Benefits: Reduce effluent treatment cost, as avoiding caustic soda, which in turn reduces TDS. During conventional scouring if we consider TDS to be 100% the scourenz ABE liquid process has only 20-40% TDS.

Lesser Weight Loss: In bio-scouring process weight loss of fabric is not more than 1.5%. The weight loss in conventional process is close to 4%. The total saving in the weight loss can be close to 2.5%. In this world, where the cotton prices have shown a steady inflation, this will be a considerable advantage to the process owner. [1,2]

2.6 Differences Conventional VS Bio-souring Process

Conventional Scouring	**Bio-scouring**
In conventional system process carried out at high temperature for 4-6 hrs.	In Bio-scouring system process carried out at ambient temperature.
In this process high pressure required.	Low pressure required.
High energy process.	Low energy process.
Not Eco-friendly.	Eco-friendly.
In this process high water consumption.	In this process low water consumption.
Process cost high.	Process cost low.

[1,2,5,6,7]

2.7 Estimation of Scouring Effects

2.7.1 Absorbency Test

a. Immersion Test

The absorbency of a fabric increased when scouring is done. First we need to cut a sample by (1x1) cm2. Then we put the sample on the water surface and time taken by it to be immersed is noted. The standard time is 5s. If it is up to 10s then we can say that the sample is well scoured. If it higher than 10s then the scouring has not taken place properly.

b. Column Test/ Wicking length

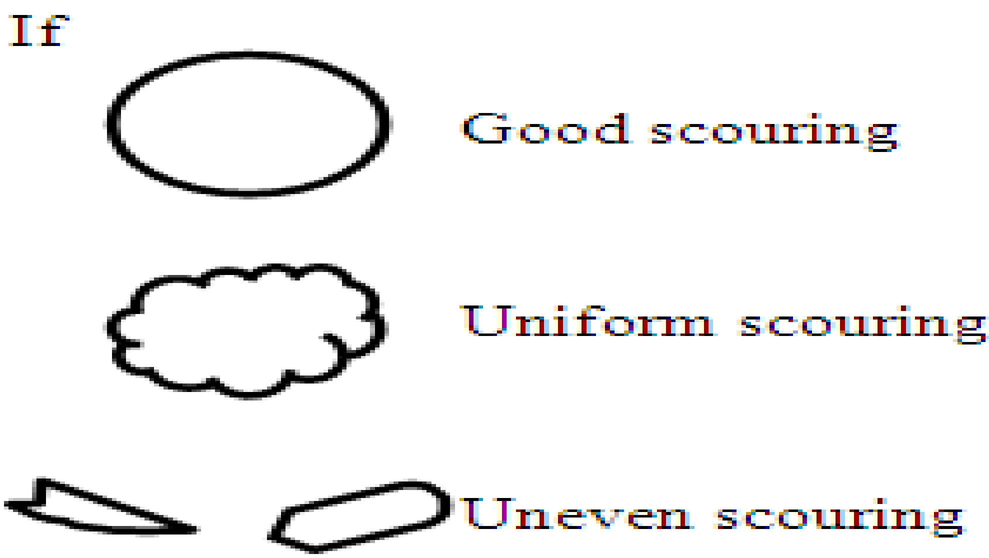
First, we need to cut a sample from scoured fabric which is 18cm x 5cm. In a beaker we have taken 0.1% direct dye red. Above from the bottom a marker is drawn about 1cm. From a wood stick the sample is hung. Then 1cm portion of fabric is immersed in the dye liquor for 5 min. Then about 1cm mark of distance traveled by the colored solution is noted. Where acceptable range is 30-50mm.

c. Drop Test/ Spot Test

In this test, 0.1% direct dye red colored solution is used. Then the solution dropped on the sample by pipet and its absorbency estimated visually. The drop may have various shape when absorbed.

Two things can be measured:

1. The time is taken in s to absorb one drop of solution. Standard time is 0.5-0.8 s, up to 1s is allowed.
2. In a pipette a solution of 0.1% direct dye red is taken and droplet of solution put on the different place of the fabric. Then the shape of the absorption area on the fabric is observed.



From sample spot uniform scouring can be said.

2.7.2 Determination of Weight Loss Percentage

At the same moisture content, the weight loss of un-scoured and scoured sample is taken and the weight loss% is calculated. The weight of scoured sample is less than un-scoured sample. Standard weight loss% is 4-8%.

CHAPTER - 3

EXPERIMENTAL DETAILS

CHAPTER 3

EXPERIMENTAL DETAILS

3.1 Materials

For this research we took 3 grey fabric samples. Specification of these samples is mentioned in Table 3.1

Table 3.1: Sample specification.

Sample No	Sample Name	Fabric GSM	CPI	WPI	SL (mm)
1	100% Cotton Single Jersey	0.105	53	33	27 mm
2	100% Cotton 1*1 Rib	0.167	47	52	3.09 mm
3	100% Cotton Interlock	0.139	92	70	3.25 mm

For this research we have been following chemical used. About details of the chemicals used are mentioned in the Table 3.2.

Table 3.2: Types of chemicals used in the research.

Name of the Chemical	Purpose of Use
Pectinase Enzyme	To remove oil, waxes, protein, pectin
Emulsion	For fiber softens
Sequestering Agent	To reduce water Hardness

3.2 Methods

3.2.1 Methods of bio-scouring

Firstly, we described the collected samples into 3 baths in where three samples treated separately with the addition of Wetting agent, pectinase enzyme and emulsion for 5 min, 10 min, 15 min, 20 min and 25 min respectively. The amounts of chemicals were taken in the weight of the sample with the help of liquor ratio.

However, we maintained particular time, temperature and pH during bio-scouring of fabric samples. The above parameters mention in the Table 3.3.

Table 3.3: Bio-scouring Recipe.

Particular	Recipe
Pectinase Enzyme% (OWF)	(1% owf) (Stock Solution-1%)
Wetting Agent (g/l)	1 gm/l (Stock Solution-1%)
Emulsifier (g/l)	2 gm/l (Stock Solution-2%)
Temperature (ºC)	70ºC
Time (min)	5, 10, 15, 20 and 25 min
pH	6
M: L	1:30
Sample weight (gm)	15 gm
Total liquor (ml)	450 ml

In our investigation used the apparatus mentioned in the Table 3.4.

Table 3.4: Apparatus used in the research

SL. No.	Name of the Apparatus
1	Gas burner

2	pH meter
3	Electronic balance
4	Beaker
5	Thermometer
6	Scissor
7	Glass rod
8	Tri-pod stand
9	Measuring cylinder

3.2.2 Bio-scouring process

Recipe of bio-scouring process

The weight of 15 gm fabric from three samples (each sample contains 5 gm) have taken for bio-scouring by using the following recipe:

Pectinase Enzyme: 1% (OWF) (Stock Solution-1%)

Emulsifiers: 2 gm/l (S.Solution-2%)

Wetting agent: 1 gm/l (S. Solution -1%)

Temperature: 70ºC

Time: 5, 10, 15, 20 and 25 mis.

pH: 6

Fabric weight: 15 gm

M:L : 1:30

Calculation

Fabric weight = 15 gm

M:L = 1:30

Total liquor = (30×15)

= 450 ml

Pectinase= (15×1%)÷ (1%)

=15 ml

Wetting Agent = (450×1×100)÷(1×1000)

=45 ml

Emulsion= (450×2×100)÷(2×1000)

=45 ml

Required water= 450−(15+45+45)

=350 ml

Process Curve

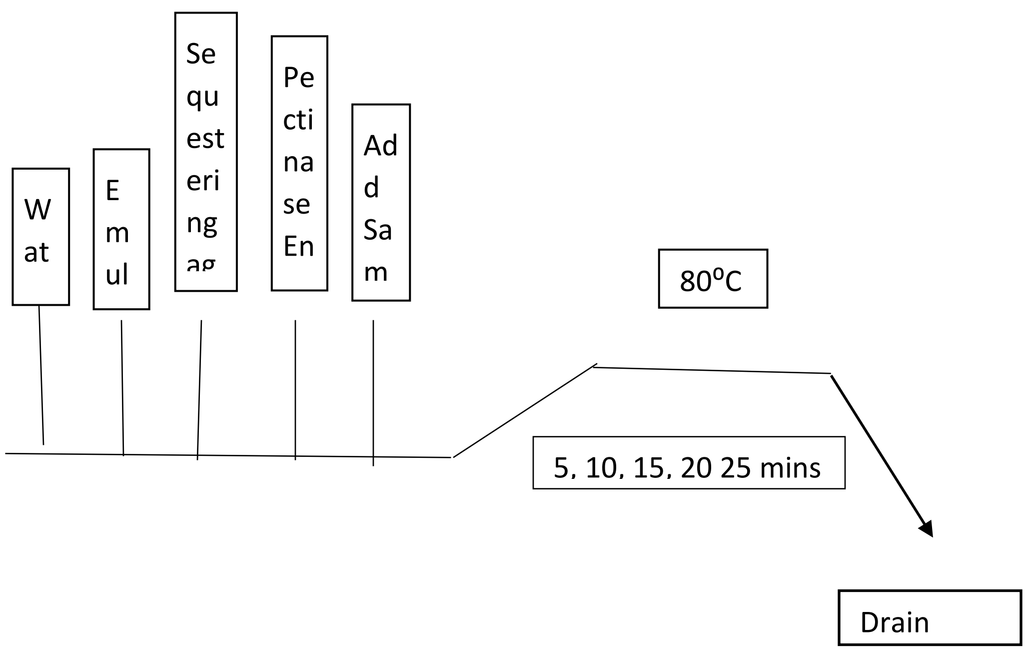


Figure: 3.1 Process curve for bio-scouring

Procedure

- ✓ At first we took sample and calculate chemicals amount from recipe.
- ✓ Then we prepared three baths for three types of sample
- ✓ Then we samples and chemicals were taken in the bath at room temperature.
- ✓ After raised the temperature at 60ºC, we kept the samples in the bath for 5, 10, 15, 20 and 25 mins.
- ✓ Then we took the sample from the bath and washed with water which is normal temperature.
- ✓ Then the samples were dried.

3.3 Method of Evaluation

3.3.1 Determination of fabric weight loss%

During Bio-scouring, fabrics loss a remarkable amount of oil, waxes, fat. For remove impurities from textile goods, thus goods loss some weight. The Bio-scouring effect cab be evaluated based on this weight loss of fiber. This weight loss calculated from difference of treated and untreated sample weight. Then it converted into percentage. We took the weight of unscoured sample scoured sample. Then the weight loss% determined.

3.3.2 WPI

The meaning of WPI is wales per inch. It is very much important parameter for knitted fabric. To determine WPI, we took the sample and marked it 1 inch according to wales wise. Then we counted WPI of fabric with magnifying counting glass and determined the percentage in WPI.

3.3.3 GSM

The meaning of GSM is Gram per Square Meter. It is very much important parameters for knitted fabric. To determine GSM, we took the sample and Cut it with GSM cutter and measure it with electric balance. Then we determined the percentage in GSM.

3.3.4 CPI

The meaning of CPI is Course per inch. It is very much important parameters for knitted fabric. To determine CPI, we took the sample and marked it 1 inch according to course wise. Then we counted CPI of fabric magnifying counting glass and determined the percentage in CPI.

3.3.5 SL

The meaning of SL is Stitch Length. It is very much important parameters for knitted fabric. It is the length of yarn in knitted loop. To determine SL, we took the sample and marked it 1 inch according to course and wales wise. After that we took 1 course from 1 inch sample and measured that course by measuring scale and then determined no. of wales in one inch of sample. Then we got the stitch length by using the formula and the formula is length of the one course is divided by total no. of wales in one inch of sample.

3.4 Absorbency test

- Immersion Test
- Drop Test
- Wicking Test

3.4.1 Immersion Test

For done this test, first we took (1×1) cm scoured (Bio-scouring) sample and put the sample gently on the surface of the water. Then we recorded the time in seconds by the stopwatch for submerging sample into water.

3.4.2 Drop Test

For this test, First we take scoured sample. Then we prepared 0.1% direct dye red solution. After that we fall a drop on the fabric. At that time, we record the time, whenever the drop totally absorbed.

3.4.3 Wicking Test

For this test we took a scoured sample which was (18×5) cm to immerse into a beaker of 0.1% direct dye red solution in which 1 inch bottom portion is immersed for 5 minutes. After 5 minutes we measured the dipped length. Between 30-50 mm is a standard dipped length.

SAMPLE ATTACHMENT

SAMPLE ATTACHMENT

Sample before and after bio-scouring

Single Jersey Fabric					
Before bio-scouring	**After 5 minutes of bio-scouring**	**After 10 minutes of bio-scouring**	**After 15 minutes of bio-scouring**	**After 20 minutes of bio-scouring**	**After 25 minutes of bio-scouring**

(1×1) Rib Fabric					
Before bio-scouring	**After 5 minutes of bio-scouring**	**After 10 minutes of bio-scouring**	**After 15 minutes of bio-scouring**	**After 20 minutes of bio-scouring**	**After 25 minutes of bio-scouring**

Interlock Fabric					
Before bio-scouring	**After 5 minutes of bio-scouring**	**After 10 minutes of bio-scouring**	**After 15 minutes of bio-scouring**	**After 20 minutes of bio-scouring**	**After 25 minutes of bio-scouring**

Samples for drop test

Single Jersey Fabric					
Before bio-scouring	**After 5 minutes of bio-scouring**	**After 10 minutes of bio-scouring**	**After 15 minutes of bio-scouring**	**After 20 minutes of bio-scouring**	**After 25 minutes of bio-scouring**

(1×1) Rib Fabric					
Before bio-scouring	**After 5 minutes of bio-scouring**	**After 10 minutes of bio-scouring**	**After 15 minutes of bio-scouring**	**After 20 minutes of bio-scouring**	**After 25 minutes of bio-scouring**

Interlock Fabric					
Before bio-scouring	**After 5 minutes of bio-scouring**	**After 10 minutes of bio-scouring**	**After 15 minutes of bio-scouring**	**After 20 minutes of bio-scouring**	**After 25 minutes of bio-scouring**

Samples for wicking length test

Single Jersey Fabric					
Before bio-scouring	After 5 minutes of bio-scouring	After 10 minutes of bio-scouring	After 15 minutes of bio-scouring	After 20 minutes of bio-scouring	After 25 minutes of bio-scouring

(1×1) Rib Fabric

Before bio-scouring	After 5 minutes of bio-scouring	After 10 minutes of bio-scouring	After 15 minutes of bio-scouring	After 20 minutes of bio-scouring	After 25 minutes of bio-scouring

Interlock Fabric					
Before bio-scouring	After 5 minutes of bio-scouring	After 10 minutes of bio-scouring	After 15 minutes of bio-scouring	After 20 minutes of bio-scouring	After 25 minutes of bio-scouring

CHAPTER 4

DISCUSSION OF RESULTS

CHAPTER 4

DISCUSSION OF RESULTS

4.1 Change in WPI of fabric after bio-scouring process

The change in WPI of fabric after bio-scouring process, different time value is recorded in the Appendix-A1. After bio-scouring process change in WPI of fabric in different time has been used to draw the following Figure 4.1.

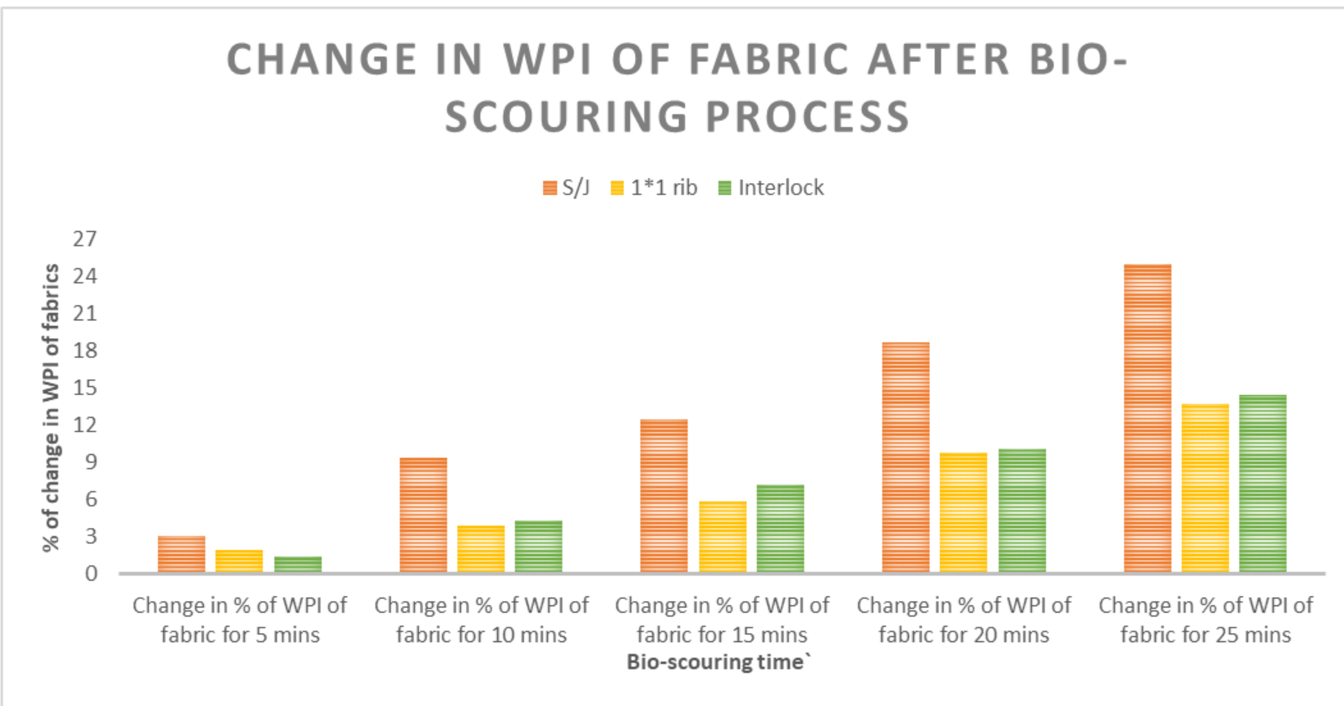


Figure 4.1: Column diagram represents the changes in WPI of fabrics

The diagram has been drawn for the % of change in WPI of fabric under different stages of time. In this diagram, % of changing value of WPI is indicated in vertically which is along the Y axis and different stages of time value is indicated in horizontally which is along in X axis. For different stages of time, the % in WPI value of fabric also changes. If we increase the time then WPI of fabric also increase. Because dust, dirt, oil removed from fabric after bio-scouring.

From this diagram we can see that for single jersey fabric, after 5 minutes of bio-scouring % if change in WPI of fabric is very little, after 10 minutes of bio-scouring % of WPI increase a little more, after 15 minutes % of WPI increase again little more and in 20 minutes WPI also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in WPI.

From this diagram we can see that for 1*1 rib fabric, after 5 minutes of bio-scouring % of change in WPI is very little, after 10 minutes of bio-scouring WPI increase a little more, after 15 minutes WPI increase little more and in 20 minutes WPI also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in WPI.

From this diagram we can see that for Interlock fabric, after 5 minutes of bio-scouring % of change in WPI is very little, after 10 minutes of bio-scouring WPI increase a little more, after 15 minutes WPI increase little more and in 20 minutes WPI also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in WPI.

Finally, from the diagram we can see that, % of change in WPI of fabrics after 25 minutes of bio-scouring is higher than other time stages and at this stage Single jersey fabric % of change in WPI increases higher than other fabrics.

4.2 Change in CPI of fabric after bio-scouring process

The change in CPI of fabric after bio-scouring process, different time value is recorded in the Appendix-A2. After bio-scouring process change in CPI of fabric in different time has been used to draw the following Figure 4.2.

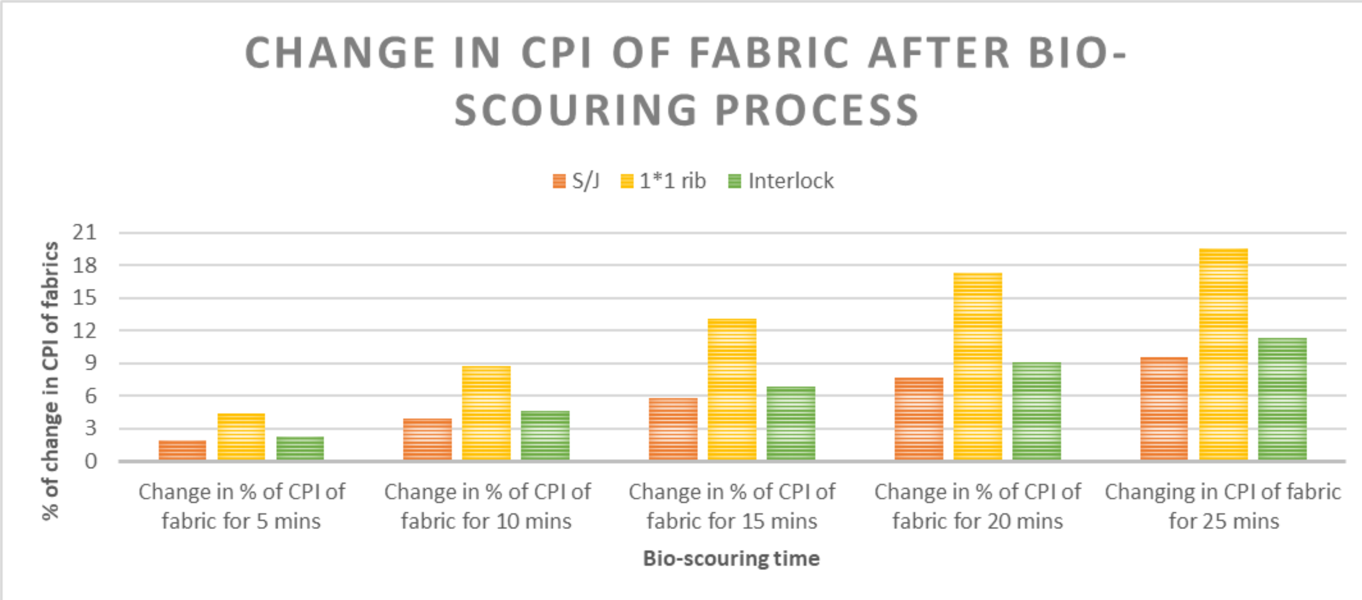


Figure 4.2: Column diagram represents the changes in CPI of fabrics

The diagram has been drawn for the % of change in CPI of fabric under different stages of time. In this diagram, % of changing value of CPI is indicated in vertically which is along the Y axis and different stages of time value is indicated in horizontally which is along in X axis. For different stages of time, the % in CPI value of fabric also changes. If we increase the time then CPI of fabric also increase. Because dust, dirt, oil removed from fabric after bio-scouring.

From this diagram we can see that for single jersey fabric, after 5 minutes of bio-scouring % if change in CPI of fabric is very little, after 10 minutes of bio-scouring % of CPI increase a little more, after 15 minutes % of CPI increase again little more and in 20 minutes CPI also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in CPI.

From this diagram we can see that for 1*1 rib fabric, after 5 minutes of bio-scouring % of change in CPI is very little, after 10 minutes of bio-scouring CPI increase a little more, after 15 minutes CPI increase little more and in 20 minutes CPI also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in CPI.

From this diagram we can see that for Interlock fabric, after 5 minutes of bio-scouring % of change in CPI is very little, after 10 minutes of bio-scouring CPI increase a little more, after 15 minutes CPI increase little more and in 20 minutes CPI also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in CPI.

Finally, from the diagram we can see that, % of change in CPI of fabrics after 25 minutes of bio-scouring is higher than other time stages and at this stage 1*1 rib fabric % of change in CPI increases higher than other fabrics and single jersey fabric % of change in CPI is lower than other stages of time.

4.3 Change in GSM of fabric after bio-scouring process

The change in GSM of fabric after bio-scouring process, different time value is recorded in the Appendix-A3. After bio-scouring process change in GSM of fabric in different time has been used to draw the following Figure 4.3.

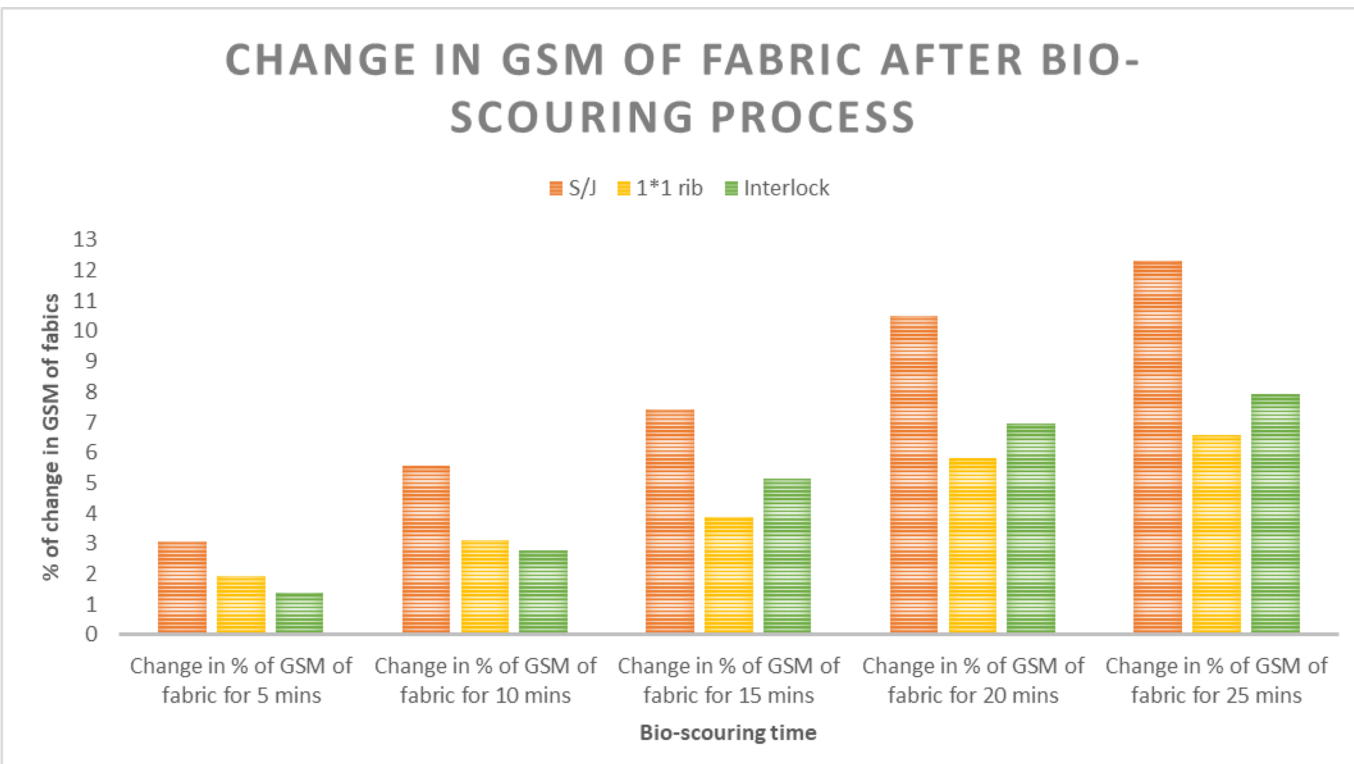


Figure 4.3: Column diagram represents the changes in GSM of fabrics

The diagram has been drawn for the % of change in GSM of fabric under different stages of time. In this diagram, % of changing value of GSM is indicated in vertically which is along the Y axis and different stages of time value is indicated in horizontally which is along in X axis. For different stages of time, the % in GSM value of fabric also changes. If we increase the time then GSM of fabric also increase. Because dust, dirt, oil removed from fabric after bio-scouring.

From this diagram we can see that for single jersey fabric, after 5 minutes of bio-scouring % if change in GSM of fabric is very little, after 10 minutes of bio-scouring % of GSM increase a little more, after 15 minutes % of GSM increase again little more and in 20 minutes GSM also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in GSM.

From this diagram we can see that for 1*1 rib fabric, after 5 minutes of bio-scouring % of change in GSM is very little, after 10 minutes of bio-scouring GSM increase a little more, after 15 minutes GSM increase little more and in 20 minutes GSM also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in GSM.

From this diagram we can see that for Interlock fabric, after 5 minutes of bio-scouring % of change in GSM is very little, after 10 minutes of bio-scouring GSM increase a little more, after 15 minutes GSM increase little more and in 20 minutes GSM also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in GSM.

Finally, from the diagram we can see that, % of change in GSM of fabrics after 25 minutes of bio-scouring is higher than other time stages and at this stage single jersey fabric % of change in GSM increases higher than other fabrics and other fabrics % of change in GSM is lower than single jersey.

4.4 Change in SL of fabric after bio-scouring process

The change in SL of fabric after bio-scouring process, different time value is recorded in the Appendix-A4. After bio-scouring process change in SL of fabric in different time has been used to draw the following Figure 4.4.

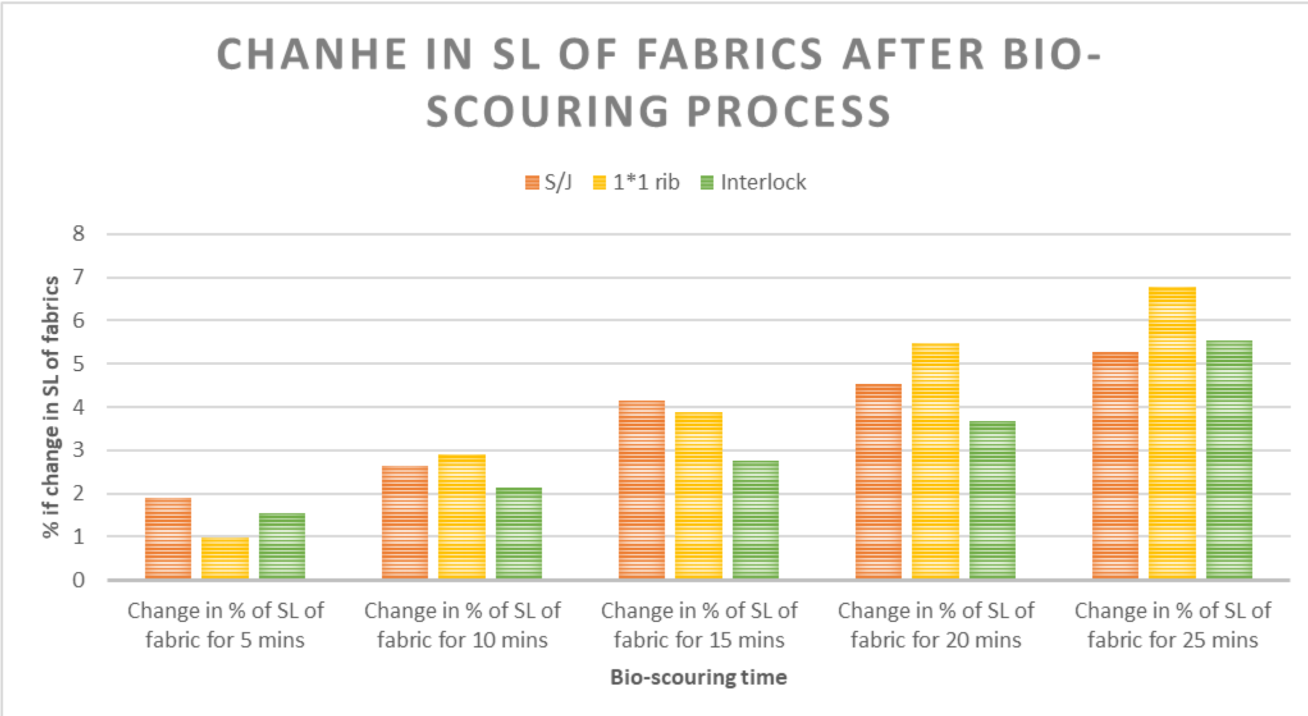


Figure 4.4: Column diagram represents the changes in SL of fabrics

The diagram has been drawn for the % of change in SL of fabric under different stages of time. In this diagram, % of changing value of SL is indicated in vertically which is along the Y axis and different stages of time value is indicated in horizontally which is along in X axis. For different stages of time, the % in SL value of fabric also changes. If we increase the time then SL also increase. Because dust, dirt, oil removed from fabric after bio-scouring.

From this diagram we can see that for single jersey fabric, after 5 minutes of bio-scouring % if change in SL of fabric is very little, after 10 minutes of bio-scouring % of SL increase a little more, after 15 minutes % of SL increase again little more and in 20 minutes SL also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in SL.

From this diagram we can see that for 1*1 rib fabric, after 5 minutes of bio-scouring % of change in SL is very little, after 10 minutes of bio-scouring SL increase a little more, after 15 minutes

SL increase little more and in 20 minutes SL also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in SL.

From this diagram we can see that for Interlock fabric, after 5 minutes of bio-scouring % of change in SL is very little, after 10 minutes of bio-scouring SL increase a little more, after 15 minutes SL increase little more and in 20 minutes SL also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in SL.

Finally, from the diagram we can see that, % of change in SL of fabrics after 25 minutes of bio-scouring is higher than other time stages and at this stage 1*1 rib fabric % of change in SL increases higher than other fabrics and other fabrics % of change in SL is lower than 1*1 rib fabric.

4.5 Change in Weight loss % of fabric after bio-scouring process

The change in weight loss % of fabric after bio-scouring process, different time value is recorded in the Appendix-A5. After bio-scouring process change in weight loss % of fabric in different time has been used to draw the following Figure 4.5.

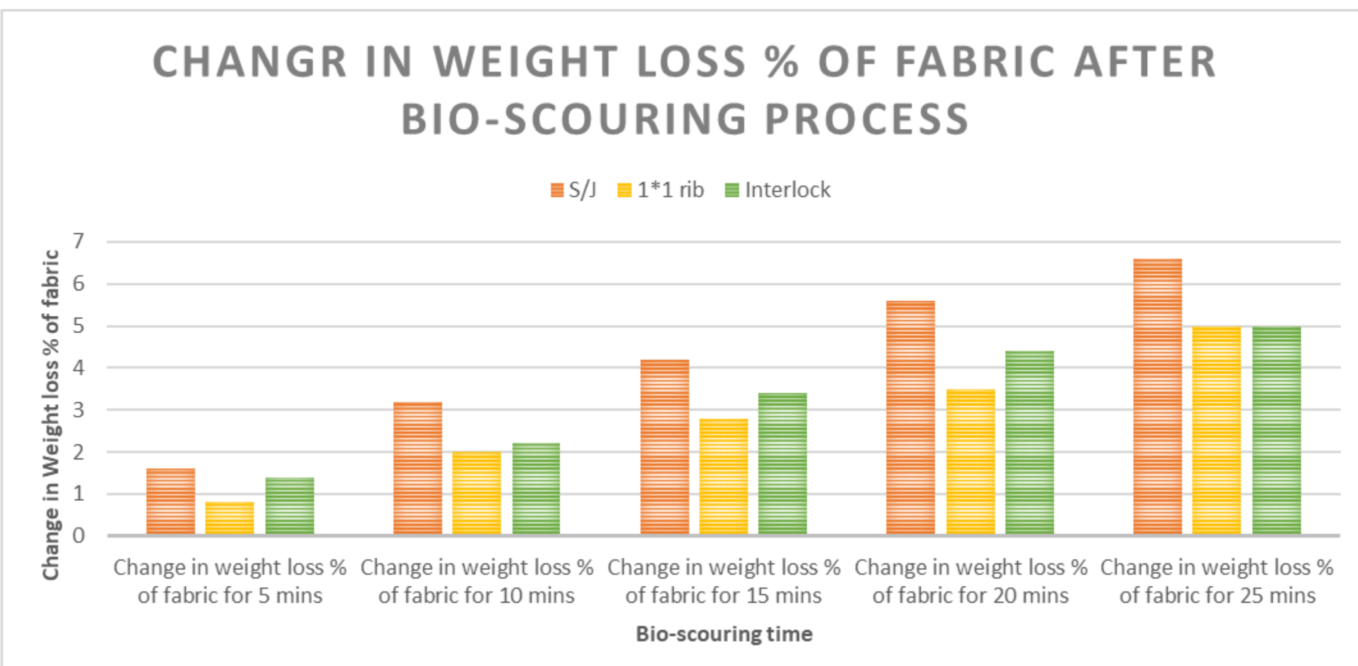


Figure 4.5: Column diagram represents the changes in weight loss % of fabrics

The diagram has been drawn for the change in weight loss % of fabric under different stages of time. In this diagram, % of changing value of weight loss is indicated in vertically which is along the Y axis and different stages of time value is indicated in horizontally which is along in X axis. For different stages of time, the % in weight loss value of fabric also changes. If we increase the time then weight loss also increases. Because dust, dirt, oil removed from fabric after bio-scouring.

From this diagram we can see that for single jersey fabric, after 5 minutes of bio-scouring % if change in weight loss of fabric is very little, after 10 minutes of bio-scouring % of weight loss increase a little more, after 15 minutes % of weight loss increase again little more and in 20 minutes weight loss also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in weight loss.

From this diagram we can see that for 1*1 rib fabric, after 5 minutes of bio-scouring % of change in weight loss is very little, after 10 minutes of bio-scouring weight loss increase a little more, after 15 minutes weight loss increases little more and in 20 minutes weight loss also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in weight loss.

From this diagram we can see that for Interlock fabric, after 5 minutes of bio-scouring % of change in weight loss is very little, after 10 minutes of bio-scouring weight loss increase a little more, after 15 minutes weight loss increases little more and in 20 minutes weight loss also increase little more. But after 25 minutes of bio-scouring there is a further slight increase in % of change in weight loss.

Finally, from the diagram we can see that, % of change in weight loss of fabrics after 25 minutes of bio-scouring is higher than other time stages and at this stage Single Jersey fabric % of change in weight loss increases higher than other fabrics and other fabrics % of change in weight loss is lower than Single Jersey fabric.

4.6 Change in Immersion time of fabric after bio-scouring process

The change in immersion time of fabric after bio-scouring process, different time value is recorded in the Appendix-A6. After bio-scouring process change in immersion time of fabric in different time has been used to draw the following Figure 4.6.

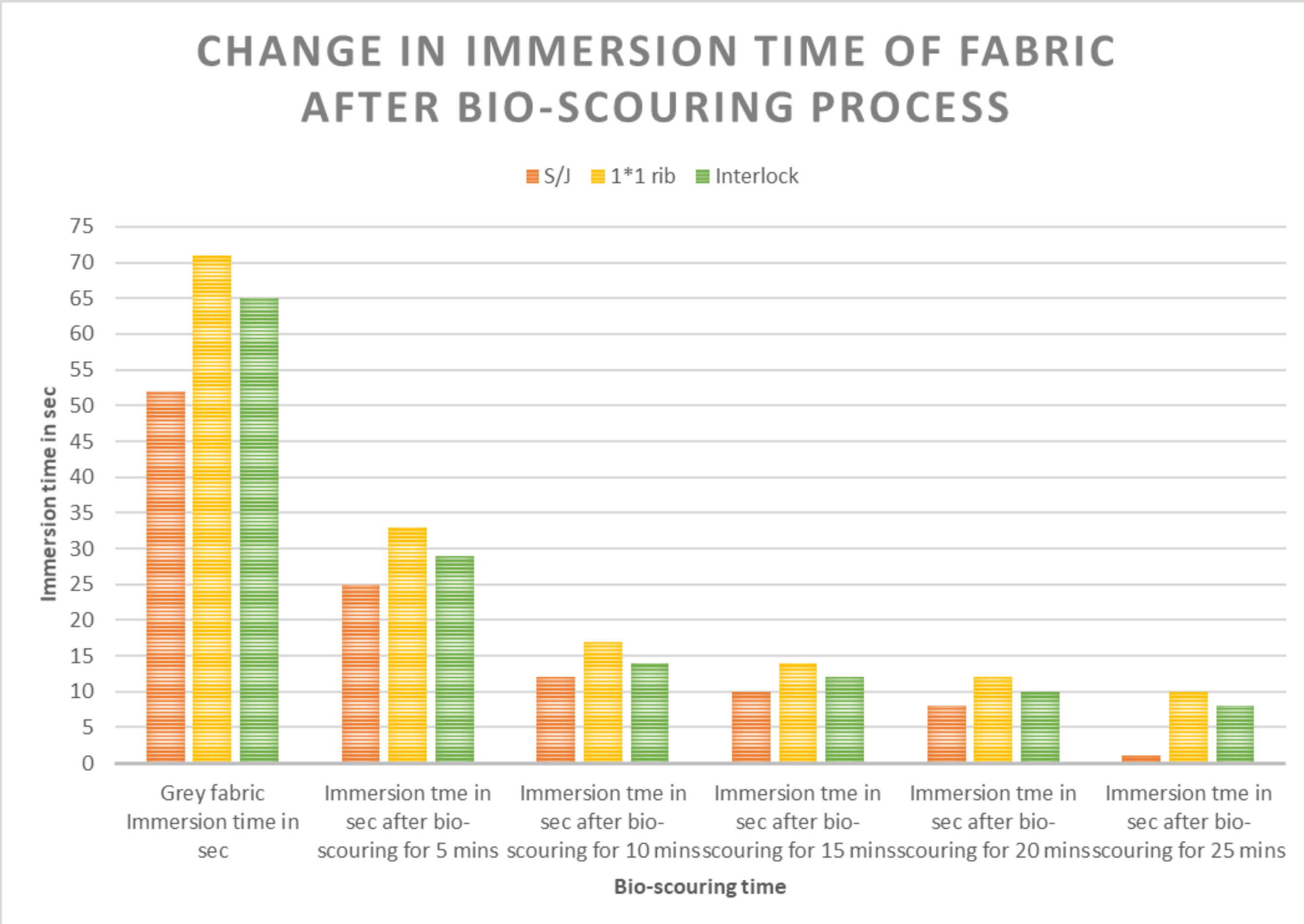


Figure 4.6: Column diagram represents the changes in immersion time of fabrics

The diagram has been drawn for the change in immersion time of fabric under different stages of time. In this diagram, immersion time is indicated in vertically which is along the Y axis and different stages of time value is indicated in horizontally which is along in X axis. For different stages of time, the immersion time value of fabric also changes. If we increase the time of bio-scouring then immersion time also increase. Because dust, dirt, oil removed from fabric after bio-scouring.

From this diagram we can see that from 5 to 25 minutes, the immersion time decreases gradually than the grey fabric. We see here the same result for all fabrics.

Finally, from the column diagram we can see that after 25 minutes of bio-scouring, change the immersion time of fabric has decreased most. In case of single jersey fabric, immersion time is less than other fabrics.

4.7 Change in wicking length of fabric after bio-scouring process

The change in wicking length of fabric after bio-scouring process, different time value is recorded in the Appendix-A7. After bio-scouring process change in wicking length of fabric in different time has been used to draw the following Figure 4.7.

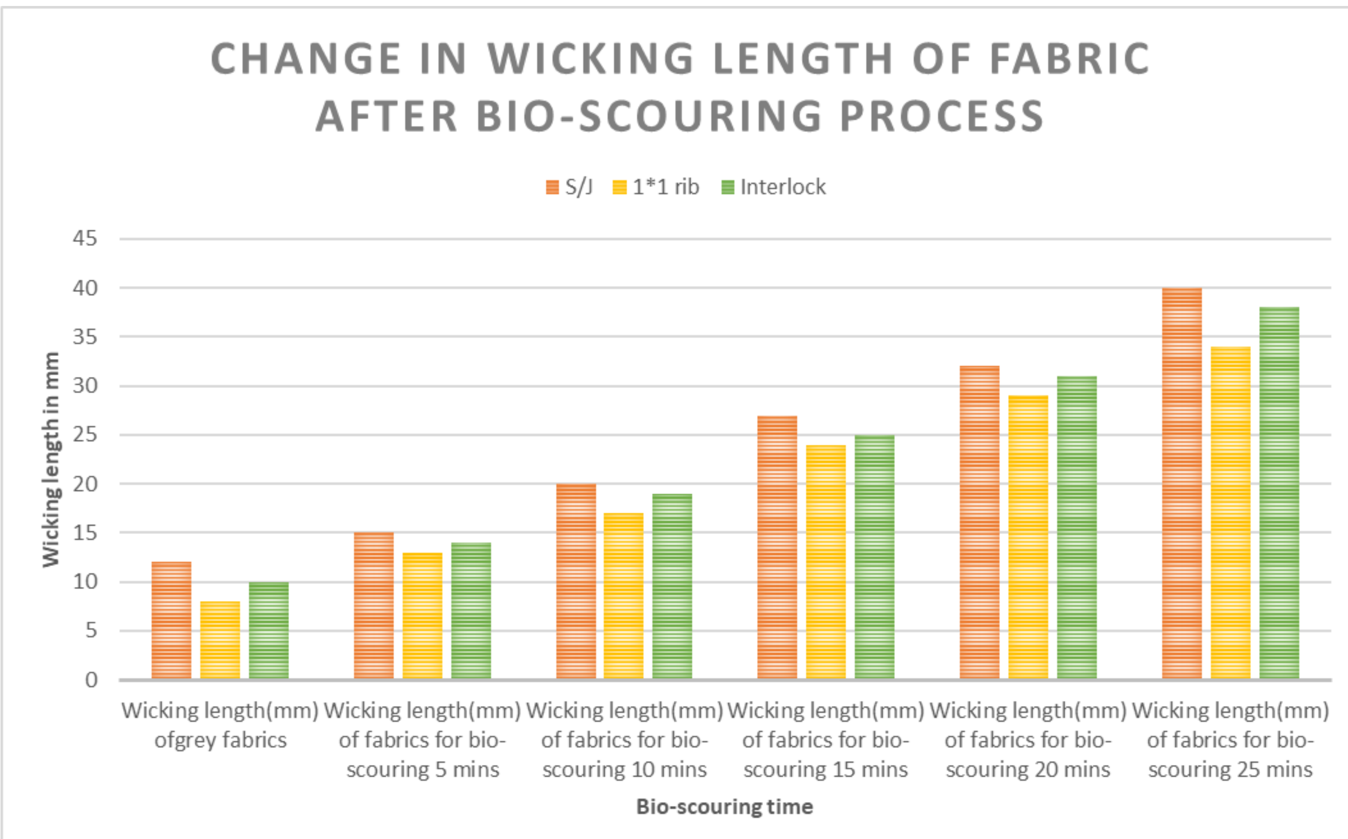


Figure 4.7: Column diagram represents the changes in wicking length of fabrics

The diagram has been drawn for the change in wicking length of fabric under different stages of time. In this diagram, wicking length is indicated in vertically which is along the Y axis and different stages of time value is indicated in horizontally which is along in X axis. For different stages of time, wicking length value of fabric also changes. If we increase the time of bio-scouring then wicking length also increase. Because dust, dirt, oil removed from fabric after bio-scouring.

From this diagram we can see that from 5 to 25 minutes, wicking length decreases gradually than the grey fabric. We see here the same result for all fabrics.

Finally, from the column diagram we can see that after 25 minutes of bio-scouring, change the wicking length of fabric has decreased most. In case of single jersey fabric, wicking length is higher than other fabrics.

4.8 Change in Drop test time of fabric after bio-scouring process

The change in drop test time of fabric after bio-scouring process, different time value is recorded in the Appendix-A8. After bio-scouring process change in drop test time of fabric in different time has been used to draw the following Figure 4.8.

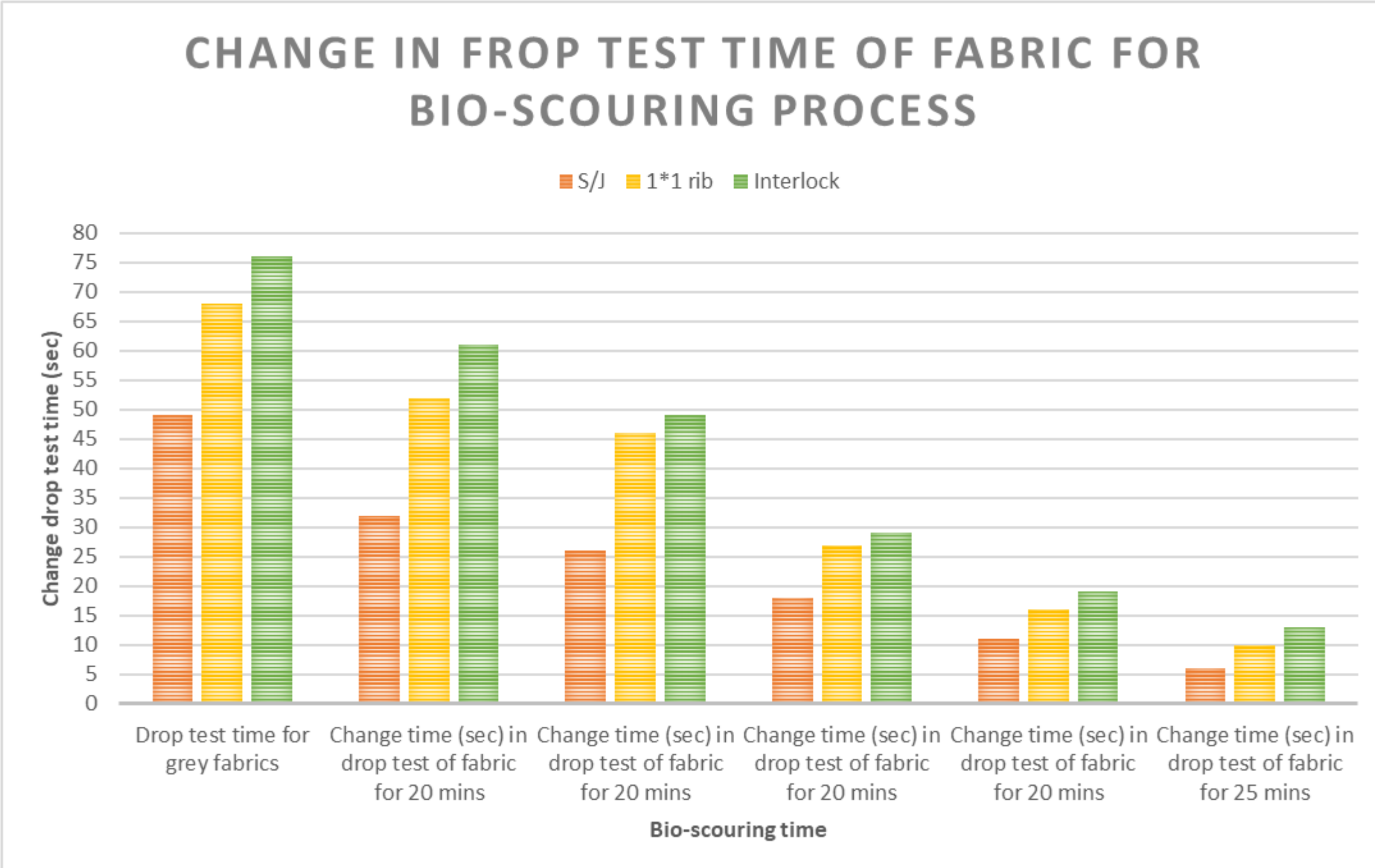


Figure 4.8: Column diagram represents the changes in drop test time of fabrics

Thee diagram has been drawn for the change in drop test time of fabric under different stages of time. In this diagram, drop test time is indicated in vertically which is along the Y axis and different stages of time value is indicated in horizontally which is along in X axis. For different stages of time, drop test time value of fabric also changes. If we increase the time of bio-scouring then drop test time also increase. Because dust, dirt, oil removed from fabric after bio-scouring.

From this diagram we can see that from 5 to 25 minutes, drop test time decreases gradually than the grey fabric. We see here the same result for all fabrics.

Finally, from the column diagram we can see that after 25 minutes of bio-scouring, change the drop test time of fabric has decreased most. In case of single jersey fabric, drop test time is higher than other fabrics.

CHAPTER 5

CONCLUSION

CONCLUSION

In this project we studied, the effect on various types of knitted fabrics by changing time. Different periods of time show different effects on the knitted fabrics. For that we tried to scoured the knitted fabrics in different periods of time to compare the effect on knitted fabrics. Then we tried to find out the various effect from the scoured fabric by using various testing method like absorbency test, immersion test, drop test, wicking test and also measured WPI, CPI, GSM, SL and also measured weight loss% after bio-scouring. After test we got different result from the different test. After that we analyzed all data and made a decision that, how many change the fabric by changing the various period of time in bio-scouring process.

After completing the hole research on "Effects of time on the bio-scouring process of cotton fabrics" we reached at the end with following outcomes-

- After 25 mins of bio-scouring, % of change in WPI was higher than other period of time and in single jersey fabric % of change in WPI increase highly and 1*1 rib fabric % of change in WPI was lowest.
- After 25 mins of bio-scouring, % of change in was CPI higher than other period of time and in single 1*1 rib fabric % of change in CPI increase highly and single jersey fabric % of change in CPI was lowest.
- After 25 mins of bio-scouring, % of change in GSM was higher than other period of time and in single jersey fabric % of change in GSM increase highly and (1*1) Rib fabric % of change in GSM was lowest.
- After 25 mins of bio-scouring, % of change in SL was higher than other period of time and in interlock fabric % of change in SL increase highly and single jersey fabric % of change in SL was lowest.
- After 25 mins of bio-scouring, change the weight loss% of fabric was higher than other period of time and in single jersey fabric % of change weight loss was higher and in (1*1) rib and interlock both fabrics % of change weight loss was same.
- After 25 mins of bio-scouring, change in immersion time of fabric was decreased highly than other period of time. In case of 1*1 rib fabric immersed time was higher and single jersey fabric immersed time was lowest.
- After 25 mins of bio-scouring, change in wicking length of fabric was increased highly than other period of time. In case of single jersey fabric wicking length was high and (1*1) rib fabrics wicking length was less.
- After 25 mins of bio-scouring, change in drop test time of fabric was decreased highly than other period of time. In case of interlock fabric immersed time was higher and single jersey fabric immersed time was lowest.
- Completing this research, we found that Single jersey, (1*1) Rib and Interlock fabrics were showing higher % of change in WPI, CPI, GSM, SL, Weight loss% and good absorbency after 25 minutes bio-scouring.

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Appendix

Table A1. Change in WPI of fabric after bio-scouring process

Sample no	Sample name	WPI in grey fabric before bio-scouring	WPI in fabric after bio-scouring for 5 mins	% of Change in WPI of fabric after 5 mins	WPI in fabric after bio-scouring for 10 mins	% of Change in WPI of fabric after 10 mins	WPI in fabric after bio-scouring for 15 mins	% of Change in WPI of fabric after 15 mins	WPI in fabric after bio-scouring for 20 mins	% of Change in WPI of fabric after 20 mins	WPI in fabric after bio-scouring for 25 mins	% of Change in WPI of fabric after 25 mins
1	Single Jersey	32	33	3.13	35	9.38	36	12.5	38	18.75	40	25
2	(1*1) Rib	51	52	1.96	53	3.92	54	5.9	56	9.80	58	13.72
3	Interlock	69	70	1.45	72	4.35	74	7.24	76	10.14	79	14.49

Table A2. Change in CPI of fabric after bio-scouring process

Sample no	Sample name	CPI in grey fabric before bio-scouring	CPI in fabric after bio-scouring for 5 mins	% of Change in CPI of fabric after 5 mins	CPI in fabric after bio-scouring for 10 mins	% of Change in CPI of fabric after 10 mins	CPI in fabric after bio-scouring for 15 mins	% of Change in CPI of fabric after 15 mins	CPI in fabric after bio-scouring for 20 mins	% of Change in CPI of fabric after 20 mins	CPI in fabric after bio-scouring for 25 mins	% of Change in CPI of fabric after 25 mins
1	Single Jersey	52	53	1.92	54	3.85	55	5.76	56	7.69	57	9.61
2	(1*1) Rib	46	48	4.35	50	8.69	52	13.04	54	17.39	55	19.56

3	Interlock	88	90	2.27	92	4.55	94	6.81	96	9.09	98	11.36

Table A3. Change in GSM of fabric after bio-scouring process

Sample no	Sample name	GSM in grey fabric before bio-scouring	GSM in fabric after bio-scouring for 5 mins	% of Change in GSM of fabric after 5 mins	GSM in fabric after bio-scouring for 10 mins	% of Change in GSM of fabric after 10 mins	GSM in fabric after bio-scouring for 15 mins	% of Change in GSM of fabric after 15 mins	GSM in fabric after bio-scouring for 20 mins	% of Change in GSM of fabric after 20 mins	GSM in fabric after bio-scouring for 25 mins	% of Change in GSM of fabric after 25 mins
1	Single Jersey	162	167	3.09	171	5.55	174	7.41	179	10.49	182	12.34
2	(1*1) Rib	258	263	1.93	266	3.10	268	3.88	273	5.81	275	6.59
3	Interlock	215	218	1.39	221	2.79	226	5.12	230	6.97	232	7.91

Table A4. Change in SL of fabric after bio-scouring process

Sample no	Sample name	SL in grey fabric before bio-scouring	SL in fabric after bio-scouring for 5 mins	% of Change in SL of fabric after 5 mins	SL in fabric after bio-scouring for 10 mins	% of Change in SL of fabric after 10 mins	SL in fabric after bio-scouring for 15 mins	% of Change in SL of fabric after 15 mins	SL in fabric after bio-scouring for 20 mins	% of Change in SL of fabric after 20 mins	SL in fabric after bio-scouring for 25 mins	% of Change in SL of fabric after 25 mins
1	Single Jersey	2.65	2.60	1.89	2.58	2.64	2.54	4.15	2.53	4.52	2.51	5.28
2	(1*1) Rib	3.10	3.07	0.97	3.01	2.90	2.98	3.87	2.93	5.48	2.89	6.77
3	Interlock	3.25	3.20	1.54	3.18	2.15	3.16	2.77	3.13	3.69	3.07	5.54

Table A5. Change in Weight loss% of fabric after bio-scouring process

Sample no	Sample name	Grey fabric Weight in gm.	Change in Weight loss after bio-scouring for 5 mins	% of Change in Weight loss of fabric after 5 mins	Change in Weight loss after bio-scouring for 10 mins	% of Change in Weight loss of fabric after 10 mins	Change in Weight loss after bio-scouring for 15 mins	% of Change in Weight loss of fabric after 15 mins	Change in Weight loss after bio-scouring for 20 mins	% of Change in Weight loss of fabric after 20 mins	Change in Weight loss after bio-scouring for 25 mins	% of Change in Weight loss of fabric after 25 mins
1	Single Jersey	5	4.92	1.6	4.84	3.2	4.79	4.2	4.72	5.6	4.67	6.6
2	(1*1) Rib	5	4.96	0.8	4.90	2.0	4.86	2.8	4.81	3.8	4.75	5.0
3	Interlock	5	4.93	1.4	4.89	2.2	4.83	3.4	4.78	4.4	4.72	5.6

Table A6. Change in immersion time of fabric after bio-scouring process

Sample no	Sample name	Grey fabric immersion test time (in sec)	Immersion time (in sec) after bio-scouring for 5	Immersion time (in sec) after bio-scouring for 10	Immersion time (in sec) after bio-scouring for 15	Immersion time (in sec) after bio-scouring for 20	Immersion time (in sec) after bio-scouring for 25
1	Single Jersey	52	25	12	10	8	7
2	(1*1) Rib	71	33	17	14	12	10
3	Interlock	65	29	14	12	10	8

Table A7. Change in wicking length of fabric after bio-scouring process

Sample no	Sample name	Wicking length (in mm) of grey fabric	Wicking length (in mm) of grey fabric after bio-	Wicking length (in mm) of grey fabric after bio-	Wicking length (in mm) of grey fabric after bio-	Wicking length (in mm) of grey fabric after bio-	Wicking length (in mm) of grey fabric after bio-
1	Single Jersey	12	15	20	27	32	40
2	(1*1) Rib	08	13	17	24	29	34
3	Interlock	10	14	29	25	31	38

Table A8. Change in drop absorbency (drop test) time of fabric after bio-scouring process

Sample no	Sample name	Grey fabric absorption [drop test] time (in sec)	Absorption time (in sec) after bio-scouring for 5	Absorption time (in sec) after bio-scouring for 10	Absorption time (in sec) after bio-scouring for 15	Absorption time (in sec) after bio-scouring for 20	Absorption time (in sec) after bio-scouring for 25
1	Single Jersey	49	32	26	18	11	6
2	(1*1) Rib	68	52	46	27	16	10
3	Interlock	76	61	49	29	19	13