

2.4 DYEING AND PRE-TREATMENTS RATIONALE

L -3 P- 4

A Textile Technology Diploma holder should know the various types of processes involved in converting a grey fabric into a dyed or a fully white fabric. This subject is included to provide requisite knowledge and skill about various processing of textile machineries used to convert grey fabric into dyed fabric.

COURSE OUTCOMES : After undergoing the subject, students will be able to:

CO1: Study about various textile wet treatments, singeing, desizing, scouring

CO2: Learn about scouring, bleaching and mercerization.

CO3: Summarize dyeing, various terms and cotton dyeing.

CO4: Describe about wool, silk and acrylic dyeing.

CO5: Carry out dyeing of polyester.

DETAILED CONTENTS

UNIT I

Introduction

Introduction to textile wet processing. Natural and added impurities in cotton, wool, silk. Singeing, Desizing and Scouring- principle and process. Degumming of silk, bleaching of silk with hydrogen peroxide. Bleaching of cotton with Sodium bleaching powder, hypochlorite and hydrogen peroxide. Scouring and carbonization of wool, bleaching of wool with sodium hypochlorite and hydrogen peroxide. Mercerization of cotton- Physical and chemical changes during process.

UNIT II

Scouring and bleaching, mercerization Scouring and bleaching of Polyamides, Polyester, Acrylic, Viscose rayon, Mercerization of cotton- Physical and chemical changes during process.

UNIT III

Introduction to Dyeing Classification of dyes, General terms used in dyeing, Principle of dyeing. Dyeing of cotton with- Direct dyes, Reactive dyes, Sulphur dyes, Vat dyes.

UNIT IV

Dyeing of wool, silk, acrylic Dyeing of wool with- Acid dyes, Metal complex dyes. Dyeing of silk with- Acid dyes, Basic dyes. Dyeing of acrylic with basic dyes.

UNIT V

Dyeing of polyester Dyeing of polyester with disperse dyes using- Carrier method, High temperature method Basic machinery used in dyeing- jigger, winch, padding mangle, fiber dyeing and hank dyeing, machine-principle and working.

PRACTICAL EXERCISES

1. Desizing of cotton with rot steep, acid steep and enzymes.
2. Scouring of cotton
3. Bleaching of cotton with suitable agent.
4. Bleaching of wool.
5. Bleaching of silk.
6. Scouring and bleaching of polyester.
7. Dyeing of cotton with Direct and Reactive dyes.
8. Dyeing of cotton with Sulphur and Vat dyes.
9. Dyeing of wool with Acid dyes.
10. Dyeing of wool with Metal complex dyes.
11. Dyeing of silk with Acid dyes.
12. Dyeing of silk with basic dyes.
13. Dyeing of polyester with disperse dyes.
14. Dyeing of acrylic with basic dyes.
15. Visit of dyeing unit for working of various dyeing machines i.e. jigger, winch and fibre dyeing machine.

RECOMMENDED BOOKS

1. Technology of Bleaching by Dr. V.A.Shanai,Sevak Publications Mumbai (1984)

2. Textile Bleaching by Rajesh Kalra, Abhishek Publications Chandigarh (2011)

3. Technology of Dyeing by Dr. V.A.Shanai, Sevak Publications Mumbai (1996)

4.

5.

6. Technology of Printing by Dr. V.A.Shanai, Sevak Publications Mumbai (1985) Technology of Finishing by Dr. V.A.ShanaiSevak Publications Mumbai Textile science by E.P.G. Gohl and L.D. Vilensky.

SUGGESTED WEBSITES 1. 2. <https://textilelearner.net/what-is-textile-basic-textiles/>
<https://textilestudycenter.com/pre-treatment-before-dyeing/>

Introduction to textile processing

Textile processing covers all the processes in which wet and dry are included which are carried out at a different stage for manufacturing of textiles. Singeing, desizing, scouring, bleaching, mercerization dyeing, printing and finishing all come in the category of textile processing. Some of these processes are essential and some are for special purpose.

Need for preparation/ pretreatment: The main objective of textile wet processing is removal of added or natural impurities present in textile fibres to improve the absorbency. Processes used to remove impurities from fibres to make it dye able or printable. Natural fibers and synthetic fibers contain primary impurities that are contained naturally, and secondary impurities that are added during spinning, knitting and weaving processes. Textile pretreatment is the series of cleaning operations. All impurities which causes adverse effect during dyeing and printing is removed in pretreatment process. This prepares the textile material for downstream processes like dyeing, printing, finishing etc.

In case of silk, degumming improves luster but reduces absorbency. The nature and amount of natural impurities present depends on the fibre type (generally high in natural fibres). In general, synthetic fibres do not have any natural impurity. Added impurities are the additives or chemicals which are added to facilitate certain processes like weaving (sizing) or prevention of static (lubrication/anti-static treatment during melt spinning).

Natural impurities: These impurities come from nature dirt, dust, protein, natural colouring matters come in this category.

Added impurities: These impurities are added during spinning, weaving and sizing. They mainly contain oil, starch, grease etc.

1. Mainly sizing matter (protective coating for warp yarns)
2. Machine oils , lubricants, grease etc
3. Coning oil (In knitting)

Oil, grease, starch etc. is to be removed to get uniform absorbency in further wet processes like bleaching, dyeing, mercerization and printing. Natural colouring matter is removed to get whiteness.

Impurities in wool: All contains 20 to 70% impurities. These are three type of impurities in wool.

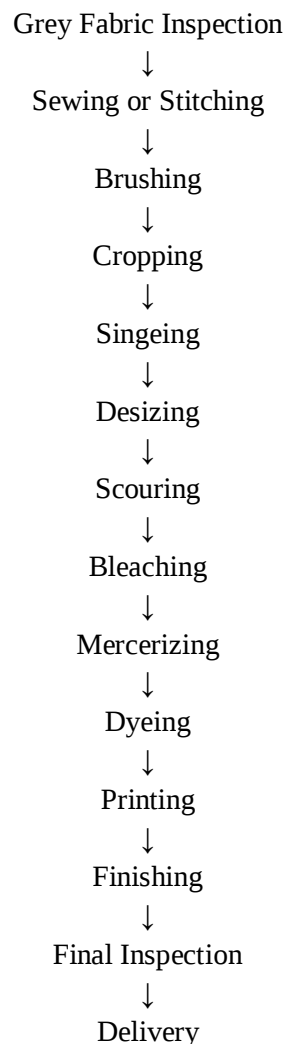
1. Wool Fat: It is wool fat or grease it is nothing but wax and it is removed in emulsion scouring.

2. Shunt: Water soluble impurity and is removed by simple washing after washing this solution of cement is used for scoring of wool and method is called suint scouring.

3. Dirt, sand and vegetable matter: These are picked up by sheep and goat. The dirt and sand are removed by mechanical agitation during scouring and vegetable matter is removed by carbonization. Most of impurities are removed in scouring.

Impurities in silk: Silk fibre contains glue or gum like substance called "Sericin" which makes silk harsh and stiff feel. It also hides the lustre and whiteness of silk. This is the only impurity in silk except this some dirt and dust is also present which is added from atmosphere. All these impurities of silk are removed in degumming of silk.

Process Flow Chart of Textile Wet Processing



Where stages after scouring are optional.

Logic for above sequence of operations in cotton pretreatment processing. Having separate processing steps for removal of size (added impurity), wax, protein and pectin matter (scouring) and natural coloring

matter (bleaching) is a necessity as these impurities respond to different kind of treatment which need different types of chemical and process conditions. Although combining of a couple of these processes has been practiced, it generally is not feasible to combine all stages without compromising on some properties.

Singeing is the first step because: In singeing, protruding loose fibres are removed by destroying them through action of heat or direct flame. Hence singeing requires a dry fabric. Therefore, it can always be done on a loom state grey fabric. If it were to be carried out after say desizing, scouring or bleaching, the fabric would need to be dried before singeing.

Secondly, since there is always a possibility of a live spark existing in the singed fabric which can lead to a potential fire, the fabric needs to be quenched in an aqueous medium immediately after singeing to kill the sparks. So it is logical to singe the fabric first and then quench it in a desizing liquor. This saves one drying step. Afterwards, all wet treatment steps can occur in sequence.

Desizing is followed after singeing - The size layer is the outer- most layer on a warp yarn so it is only natural to remove it first. Removing it ensures that the natural impurities on cotton are exposed and can be removed later with better efficiency.

Scouring - After desizing, fabric still retains natural impurities and has poor absorbency. These impurities are removed by action of hot alkaline aqueous solution in presence of suitable surfactants.

Bleaching - Bleaching is the last pretreatment step. Many times, it is combined with scouring. Both bleaching and mercerization are optional stages but desizing and scouring are a must for almost all cotton fabrics.

Mercerization - Since mercerization is a short treatment (1-2 min) performed at relatively low temperatures (15-20°C), having good absorbency ensures uniform and better treatment. However, mercerization has been known to be performed at grey stage also. Since it does not remove any impurity, it can be fitted in the sequence in a more flexible manner.

Shearing and cropping: This is a preparatory process for singing. Cropping machines have blades to cut long protruded fibre. Fabric is passed at very high speed.

Singeing

Singing is not a wet processes, singing is the process of removal of loose hairy protruding fibres from the surface of cloth giving it a smooth and even cleaning look. Protruding fibres are burnt by passing the fabric through hot surface. Singing is essential for all textile fabrics. The protruding fibres on the surface of a fabric manufactured with spun yarns may be desirable in that they impart a little softness to the fabric, but nonetheless they are seen as a nuisance. These protruding fibres:

1. Create a fuzz which might obscure sharpness of a print or a coloured strip on the garment.
2. Can attract soil.
3. May lead to pilling.

Many cotton materials are valued for their smooth appearance e.g. lustrous sateen and satin weaves. Hence, in general, it is desirable to remove these surface fibres. One of the most common methods to do this is just burn off these fibres. This is known as **Singeing**.

Objective- To remove or burn off protruding fibers from the surface of a yarn or fabric.

Advantages of singeing -

1. Improved end use and wearing properties.
2. Clean Surface.
3. Reduced fogginess.
4. Reduced pilling.
5. Reduced Soiling.

Objectives of Singeing:

1. To remove the short fibers from the textile materials (yarn and fabric).
2. To make the textile materials smooth, even and clean looking.
3. To develop maximum luster in the textile materials.
4. To make the textile materials suitable for subsequent next process.

Types of machine used in the singeing process:

1. Plate singeing M/C.
2. Roller singeing M/C.
3. Gas Flame singeing M/C

Precaution takes before singeing:

1. The singeing fabric should be dry as wet fabric tends to scorch faster than dry. Upon completion of the fabric, uneven singeing may cause streaks on the fabric or bubbles.
2. Incorrect singeing can result in a loss of 75 percent in tensile strength loss in the direction of the warp.
3. The fabric should not contain any acid releasing salt that may release acid when heated and make the fabric tender. It should be avoided to stop the machines.

4. The temperature should be properly controlled otherwise thermal damage to sensitive fabrics may occur. Consideration must be given to the burning characteristics of fibers when applying this process as heat-sensitive fibers melt, forming small balls on the fabric surface.
5. These balls interfere with the absorption of dye so that after dyeing or printing, heat-sensitive fibers are generally singed.

Singeing machines: There are three types of singeing machines

1. **Plate singeing machine:** It consists of two copper plates which are heated copper by a furnace below or some other heating arrangement. Fabric in open width form is passed over and in contact with these hot plates at a speed of 135 to 225 meters per minutes and protruding fibres are burnt during these passage.

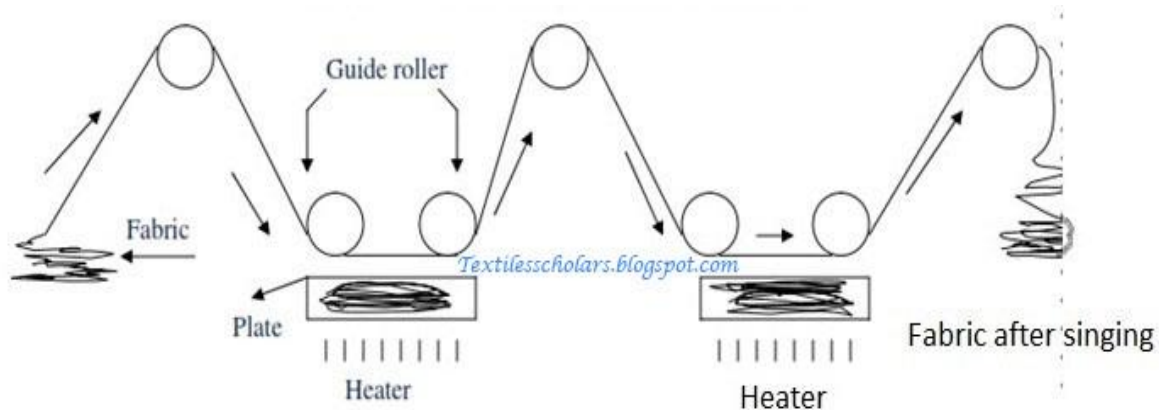


Plate Singeing machine process diagram

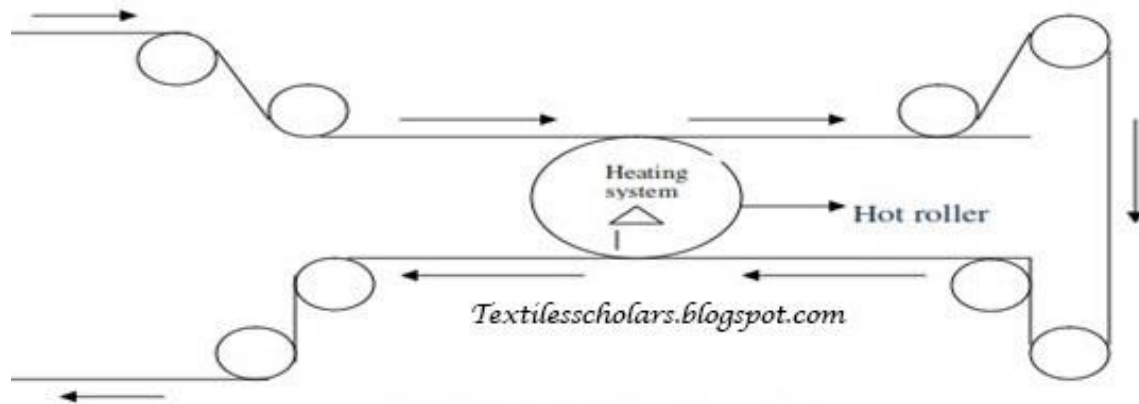
Advantages:

- Hot plate singeing machine is suitable for back filling finishing process as the fiber ends in the interstices are not removed.
- Lusture of fabric is improved.

Disadvantages:

- Fiber ends in the interstices of warp and weft are not singed.
- Produces an undesirable fabric luster due to the frictional contact with the hot plate.
- Causes uneven singeing due to difficulty in maintaining uniform plate temperature.

2. **Roller Singeing Machine:** In this machine a rotating cylinder which is electrically heated is used as singing surface. The rotation of cylinder is in opposite direction to the movement of surface of fabric. The cloth moves through and into contact with a heated cylindrical cylinder made of copper or cast iron with this kind of singeing machine. With internal firing, the rotary cylinders turn slowly, and a cool surface of the roller constantly comes into contact with the cloth. The cylinder rotating direction is contrary to the fabric direction so that the fibers or nap outstanding in the fabric can be lifted. This type of machine is especially suitable for velvet and other pile fabrics to be singed. Uniform singing takes place but fibre in interest tricks of warp and weft are not singed.



Roller Singeing machine diagram

Advantages:

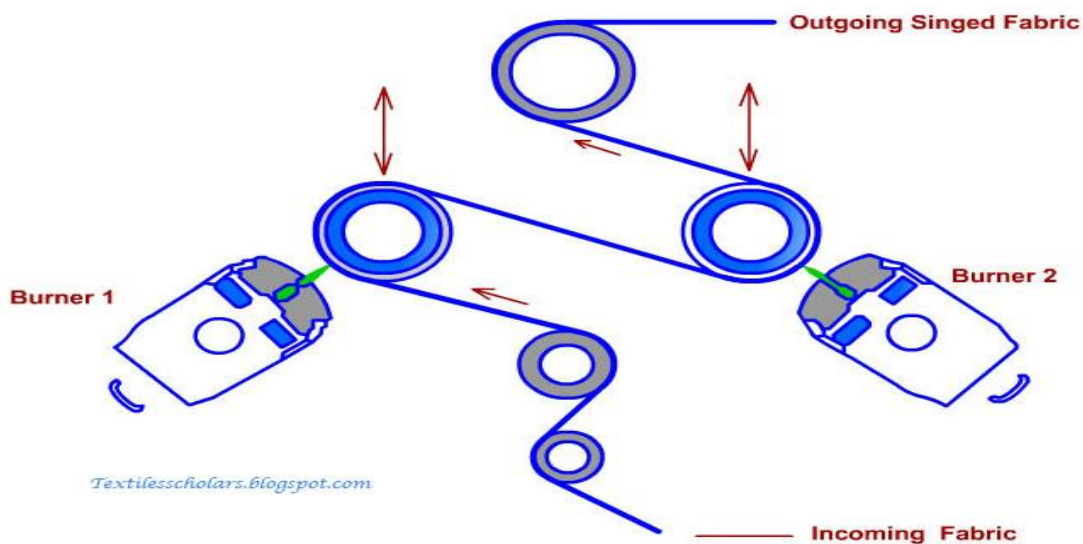
1. Fiber ends in the interstices of warp and weft are not removed.
2. The uneven singeing takes place to a lesser extent in roller singeing.

Disadvantages:

1. Fiber ends in the interstices of warp and weft are not singed.
2. Produces an undesirable fabric luster due to the frictional contact with the hot plate.
3. Causes uneven singeing due to difficulty in maintaining uniform plate temperature.

3. Gas Singeing Machine: This machine consists of one or more burner giving continuous flame. Fabric is drawn over flame at it is a very high speed and protruding fibres are burnt without damage to cloth. A suitable mixture of gas and air under pressure is used as the source of heat in gas singeing. This mixture is fed into a combustion slot burner. It is possible to use coal gas, petrol gas or butane gas as fuel.

The burner width can be adjusted to suit different widths of the fabric. For different fabrics, the flame height and consequently the heat intensity can be varied by changing the mixture pressure or the mixture gas and air ratio.



Gas singeing process diagram

The flame temperature may reach 1300 ° C when combusted.

Before singeing, it is important to preheat the cloth to reduce its moisture content as a dry cloth is better than a cold fabric. The heat energy can convert the moisture in the fabric into steam that can impede **the singeing process**.

The cloth may be lifted in an aqueous bath immediately after the singeing to quench any similar spark to prevent a potential fire.

Advantage:

1. Uniform singeing takes place.
2. Fibres and in interstices of warp and weft are burnt.
3. It is a fast process.
4. Both sides of the cloth are singeing simultaneously.
5. There is no question of unwanted cloth sheen as there is no contact with any metal surface as in the case of the other singeing machines such as the roller and hot plate singeing machine. Fibers in the interstices between the warp and weft threads are also burn effectively.
6. This is not entirely possible in the case of other singeing machines.
7. Different varieties of fabric can be singed.

Disadvantages:

1. The major disadvantage of gas-singeing is obviously that there is a great risk of fire, if proper care is not taken on this count. However, any risk of fire can be avoided completely if,
2. The flame is adjusted to be at its optimum size.
3. Careful monitoring of the singeing process is carried out.
4. The necessary fire-fighting equipment is available close at hand.
5. The operators at the machine are properly trained to run the singeing machine and to use the fire-fighting equipment in an emergency.

The difference between Plate, Roller, and Gas singeing Processes: The difference between Plate, Roller, and Gas singeing Processes is given below;

Singeing is the first pre-treatment process of textile wet processing technology. It helps to remove short loose fiber from the fabric and yarn. This is a **mechanical process of reducing pilling and short fiber**. It has plenty number of advantages as well as disadvantages.

Plate Singeing Process	Roller Singeing Process	Gas Singeing Process
One side of fabric can be singed.	One side of fabric can be singed	Both side of fabric can be singed
Uniform temperature cannot be maintained.	Uniform temperature cannot be maintained	Uniform temperature can be maintained
Extra luster is produced due to friction between fabric and surface.	Extra luster is produced due to friction between fabric and surface.	No Extra luster is produced
Not suitable for dyeing and printing.	Not suitable for dyeing and printing.	Very suitable for dyeing and printing.
The brush is not used for proper singeing.	The brush is not used for proper singeing.	The brush is used for proper singeing.

Desizing

Desizing is the process of removal of size material applied on warp threads of a fabric to facilitate the process of weaving. Size forms a stiff, hard and smooth coating on warp yarns to enable them to withstand the cyclic tensions during weaving and reduce breakage. Size contains starch, wax and tallow. Wax and tallow are removed in the scouring. Desizing is the process of removal of starch to improve water absorbency of material. It is also called destarching. In case the size is not soluble, it is removed by either hydrolysis or oxidation. Hydrolysis or oxidation results in lowering of molecular weight of starch, which results in improved solubility of degraded starch.

Method of desizing

1. **Rot Steep method-** Fabric is past throw a padding mangle having warm water at 40 degree Celsius temperature squeezing to 100% expression and then allowed to stand for 24 hours. Microorganism present in water solublise the starch present in the fabric. Fabric is then washed

with water and most of starch is removed. But it is a slow process and space requirement is very high and a lot of labour is also required.

1. Steeping in water at 30-40°C, starch swells
2. Swollen starch is attacked by enzymes secreted by microorganisms in environment
3. Hydrolyzed starch is removed by normal washing
4. Low capital investment
5. Slow, low reproducibility, risk of cellulose being attacked

2. Acid Steep method- Fabric is treated with a solution of dilute HCl at room temperature. Acid hydrolysis the starch which is then removed by washing. Two bowl or 3 bowl padding mangle is used. Duration of process is reduced to 8-12 hours. Disadvantage of this process is that weight loss of fabric is more. It is also not a eco-friendly process because acid is drained.

- H₂SO₄/HCl- (5-10 gpl) is needed at 40°C for 3-4 hours.
- Above 40°C & 10 gpl acid concentration, degradation of cotton cellulose itself may occur.
- The fabric is padded with acid solution and stored (batched).
- Action of acid will result in gradual degradation of starch. But not all starch is degraded to the extent where it all becomes water soluble.
- Hence the action of acid will result in fabric having a range of starch molecular weights. Some with high water solubility, some with medium and some with poor or no solubility.
- Hence desizing should always be followed with hot water washing to remove maximum amount of starch.

3. Enzymatic Desizing- In Greek enzyme means - in yeast. Enzymes also liquify the starch. Fabric is first passed through hot water and then through malt extract solution kept at 60-70 degree Celsius. Malt extract is most effective at 60-70 degree Celsius, so temperature should be maintained properly. The pH of solution should also be maintained at 7. Liquefied starch is removed by washing.

Enzyme Sources For Desizing : Vegetable, bacterial, Animal (Diastase, Rapidase, Amylase etc.)

Malt Amylase has two components: α & β - Amylase (Ratio 1:5 to 1:6)

α - Amylase attacks the chain at random

β -Amylase attacks the chain end & produces maltose.

Since enzymes act optimally at specific conditions of temperature and pH, it is important to maintain narrow range of conditions for best results.

4. Bromite Desizing- It is an oxidative method. Sodium Bromite has powerful oxidizing action on starch. Fabric is padded with a liquor containing

0.3% - Sodium Bromite (desizing agent)

0.1 % - Sodium Carbonate Na_2CO_3 (pH stabilizer)

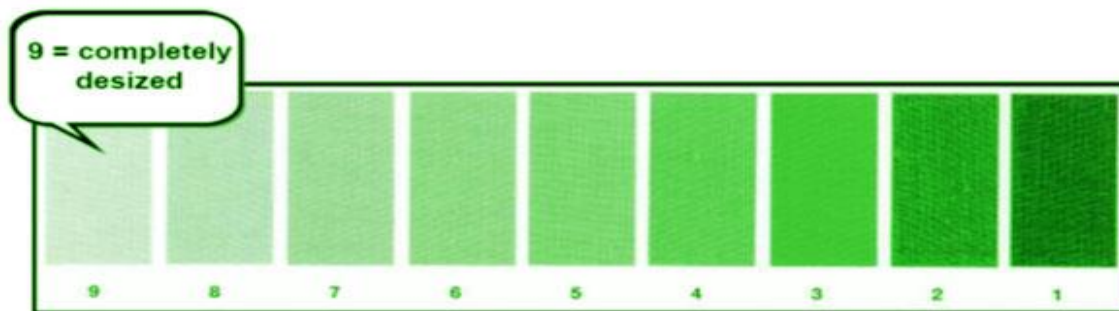
At room temperature for 6-20 minutes. Fabric is then washed and treated with hot caustic soda solution to remove converted starch. Best Desizing is obtained at pH 10 and temperature below 30 degree Celsius.

Assessment of desizing efficiency: Industrially, the assessment of desizing process efficiency is done by rating the process on a TEGEWA violet scale.

The TEGEWA Association comprises of manufacturers of the following: Textile, paper, leather and fur auxiliaries and colourants, surfactants, complexing agents, antimicrobial agents, polymeric flocculants, cosmetic raw materials, pharmaceutical excipients and allied products.

Reagent preparation: Put potassium iodide [10g of KI (100%)] in 100 ml of water; then add 0.6358 g of iodine (100%); stir well until iodine is completely dissolved in the KI solution. After this, add 800 ml of ethanol. Then by adding water the volume should be raised to 1000 ml.

Method of Testing: Put one or two drops of the above solution on a fabric. Rub it gently and then assess the colour change as per the Tegewa scale. Before testing, the fabric should be cold and there should not be any residual alkalinity in it.



TEGEWA violet scale (1-9 from left to right)

Scouring

After desizing fabric still contains fat and wax due to which water absorbency of fabric is adversely affected. Which cause improper dyeing, printing, bleaching and finishing. All these impurities are removed in scouring process which is also called kiering or kier boiling. Hot alkaline solution are circulated under pressure regularly packed size fabric for 8-24 hours. The temperature and pressure duration of boiling depends on nature of goods to be scoured. The main object of scouring cotton is to remove natural and added impurities, which are of hydrophobic nature and to make fabric highly absorptive.

Main processes which occurs during scouring

1. Saponifiable oils are converted into soap
2. Protein is hydrolyzed into soluble degradation product
3. Emulsification of unsaponifiable oil and waxes
4. Removal of dust particles.

Process of scouring of cotton- In cotton scouring wax and fat are removed by treating with alkali in presence of some surfactants at elevated temperature. Sodium Hydroxide is main active ingredients and it saponifies the impurities. Efficiency of caustic soda is improved by adding surfactants. Soap has power of detergent as well as emulsifying properties. Solution containing sodium hydroxide, sodium carbonate and detergent is circulated under pressure through desized fabric in kier machine at boiling temperature.

Bleaching

Bleaching of cotton:

Objects of bleaching-

1. Scoring removes all impurities except natural colouring matter and this natural colouring matter is removed by bleaching.
2. Bleaching also gives extra brightness.
3. Permanent bleaching is obtained by using oxidizing bleaching agents.

The main oxidizing bleaching agents are -

1. Bleaching powder

2. Sodium Hypochlorite NaOCl

3. Hydrogen peroxide H_2O_2

4. Sodium chlorate NaClO_3

Bleaching powder it is a traditional oxidizing bleaching agent. It is prepared by spreading lime on the floor of a chamber and then chlorine gas is passed through the chamber.

Properties of bleaching powder -

1. It is a white powder having smell of chlorine.

2. In contact with air it is damaged

3. When mixed with water it tends to form cake.

4. Bleaching powder solution is alkaline in nature.

Method of bleaching cotton with bleaching powder- After scouring cotton material is kept in some vessel having perforated bottom and a circulation pump. Bleaching liquor contain bleaching powder is pumped up into a vessel and circulated through the cotton material. The process is repeated still required whiteness is achieved. Material is then washed with hot and cold water then it is dried.

Disadvantage of bleaching powder -

1. Bleaching powder sledge is a problem.

2. Fabric feel is very Harsh.

- 3 bleaching time is more due to poor diffusibility.