Unit II

Mercerization – Theory process - Methods – Chemicals – effects. Bleaching – Hypo chlorites – Hydrogen peroxide – sodium chlorite. Equipments and chemicals for bleaching of cotton, viscose, cotton/ viscose Polyester/ cotton. Evaluation of bleached fabric – whiteness – absorbency – chemical damage - residues

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AIMS AND OBJECTIVES

We here discuss about in general instructions on mercerization and bleaching, its strategies and method. After going through the unit, it will be easy to

i. Know about the sequence of mercerization.
ii. Understand different steps in bleaching.
iii. Know about methods used in bleaching different fabrics.
iv. Describe the equipments used in processing.

MERCERISATION

The process of mercerization is a most satisfactory method for increasing luster on cotton materials and two particular advantages are that the process is a cheaper one and that the increased luster is prominent, so that it is unaffected by washing, drying and other methods of textile finishing.

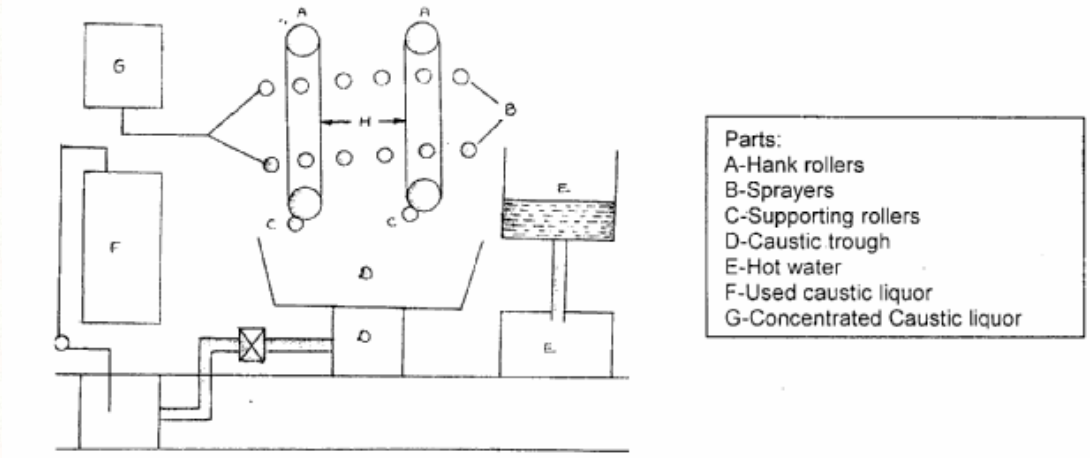
Mercerization after going through

1. Increase the shrinkage
2. Increase tensile strength,
3. Increase hygroscopocity
4. Increase affinity of dye
5. Increase the lustier.

Yarns are mercerized on yarn mercerizing machine. This is a batch wise process. Fabrics are mercerized on either chain or chainless mercerizing machine and the process is acontinuous.

YARN MERCERIZING MACHINE

Yarn mercerization can be done on grey yarn or on bleached yarn using the yarn mercerizing machine which contains two rollers, one of which is moveable and has a pointer which moves against on the graduated scale, which indicates the tension applied on the yarn. There is a rubber squeezer near the fixed roller.



18 to 22% of NaOH is taken in an over head tank which is the mercerizing liquor. The yarn is hank form is mounted on the two rollers and the tension is applied. The rubber

squeeze roller helps in removing the excess NaOH from the yarn, below the two rollers there is a two moveable trough or trays to collect the spent NaOH and wash water.

After mounting the yarn and applying the required tension the machine is started, when the movable roller connected to a motor starts moving. The mercerizing liquor NaOH is sprayed over the yarn with the help of perforated pipe, when the yarn gets wetted with NaOH, mercerizing takes place.

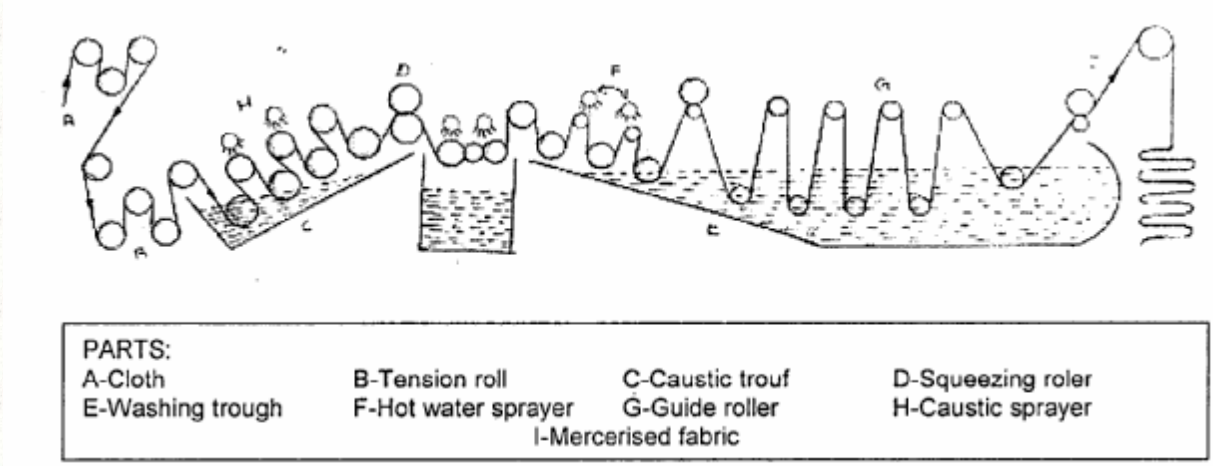
The mercerization treatment is carried out for 2 minutes, and the tray filled and hot water is a sprayed over the hank which removes 60% if NaOH held and the hands are given a cold wash and soured with hydrochloric acid or sulphuric acid to neutralize the alkali. For grey yarn 1% mercerizing auxiliary can be used which helps in better penetration of the caustic solution.

FABRIC MERCERIZATION

In this machine, both the chain and padding mangles are not found. In this machine, the fabric is not allowed to shrink, by applying the tension on the fabric during the whole process. The fabric is mercerized under tension, whereas in other method, the fabric is mercerized with shrinkage and stretching.

The machine consists of an impregnating section, washing section and squeezing mangles. The rollers of impregnating section are on inclined plane and those of washing section are on horizontal plane to assist the counter current system.

Before mercerizing, the cloth is passed over an expander to remove all creases and then over 4 curved, rubber covered expanding rollers. Two of which may be raised lowered thus the cloth enters the machine under tension and is held to its dimension by passing over a series of the rollers which make contact with each other during the mercerizing.



PARTS:

A-Cloth	B-Tension roll	C-Caustic trouf	D-Squeezing roler
E-Washing trough	F-Hot water sprayer	G-Guide roller	H-Caustic sprayer

I-Mercerised fabric

In the mercerizing section, there are two rows of bowls, one above the other and the cloth runs alternatively around the top and a bottom roller. The top bowls are covered with rubber and are carried by the bottom cast iron bowls. As the cloth passes with tension in the impregnating section, the cloth will not shrink, but the luster produced on the fabric is more.

The first two lower rollers carry the cloth through the sodium hydroxide solution in the trough. For better impregnation, the sodium hydroxide solution circulated through two pipes above the first two top bowls. After passing round the remaining bowls the fabric is squeezed by the squeezing mangle. It is then taken to a washing section, where the fabric is washed in hot water from the spurt pipes.

After series of spray and through washing, the fabric is squeezed by the second squeezing mangles and the passed to a washing compartment which are also arranged in the counter current system. The output is 10 to 25 m/min according to the type of cloth. Output may be increased by running two cloths at a time, either super imposed or side by side. When

two fabrics are run one on top of the other, the machine runs more slowly than the single running fabric to ensure even and regular treatment.

Mercerizing is a process of treating cotton material with concentrated solution of caustic soda to impart luster to it. If cotton yarn/cloth is steeped in a cold solution of caustic soda of 50 to 55○ TW (20 to 30%) strength for a few minutes and then thoroughly washed free from alkali; it shrinks considerably (up to 25 to 40 percentage of its length), increases in strength (up to 40 percentage) and increased capacity for absorption of dyestuff. The yarn or cloth is maintained in a stretched condition so that it cannot shrink when treated with caustic soda solution and washed free from alkali still in the stretched condition, then it develop a high degree of luster. This simple process is extensively used for production of mercerized cotton materials such as sewing threads, embroidery threads, handkerchiefs, Saree borders, dhoti's, muslins satins, shirting's, etc.

Only cotton material in the form of yarn or cloth is suitable for mercerizing. Mercerization is carried out mainly with a view to obtain (i) increased tensile strength (ii) increased luster and (iii) increased capacity for dyestuff absorption. The wetting agent used during mercerization should posses high wetting power and enable the alkali to rapidly swell the cotton; it should dispose well and it must be removed readily from the goods by washing. Mercerol, Inferol or Inferol M special etc., are some of the trade names of wetting agents used in mercerizing. Most modern mercerizing processes allow the material to shrink in the alkali in order to assist thorough penetration and then apply tension later either before or during the removal of caustic soda.

BLEACHING

Bleaching is a process by which the natural coloring matter and any other coloring matter are removed. During scouring of cotton all impurities are removed except the natural coloring matter leaving material satisfactorily absorbent. The natural coloring matter does not do any harm except it diminishes the whiteness. Hence for deep colors and dull shades the bleaching becomes essential.

After the removal of the waxes and other hydrophobic type of impurities from grey fabric by the desizing and scouring the fabric is now in a more absorbent state. But still have the pale appearance due to the presence of natural colouring materials like pigments etc. these pigments cannot be removed the only way to tackle these pigments is to decolourise them using suitable oxidising agents.

This will make the fabric in a super white form. This process of decolouration of natural pigments is called the **bleaching**. The process of bleaching gives a sparkling whiteness to the fabric and hence makes it suitable for further processing.

Bleaching agents can be broadly divided into two groups.

1. Oxidizing bleaching agents.
2. Reducing bleaching agents.

1. Oxidizing bleaching agents:

a) Chlorine (Cl)
b) Hypochlorus acid (HOCI)
c) Hydrogen Peroxide (H2 O2)
d) Potassium Permanganate (KMnO4)
e) Persulphates (K2S2O8)
f) Pen borates (K r O4)
g) Ozone (O3)

These agents use oxygen directly or indirectly for bleaching purpose. Nascent Oxygen decomposes coloring matter completely into simpler compounds which can be washed away with water during washing and which do not give any trouble at a later stage.

2. Reducing bleaching agents:
a) Sulphur di oxide (SO2)
b) Sulphurous acid (H2SO3)
c) Sulphite (Na2 SO2)
d) Bisulphate's (NaHSO3)
e) Hydrosulphites (Na2S2O4)

In most cases of reducing bleaching agents the nascent hydrogen combines with the coloring matter to produce a colorless compound, which remains in the fabric. This gradually gets oxidized back to the original coloring matter upon exposure to the air. Hence the whiteness produced by a reducing bleaching agent is not permanent.

Methods of Bleaching
The various chemicals employed to carry out bleaching process are:

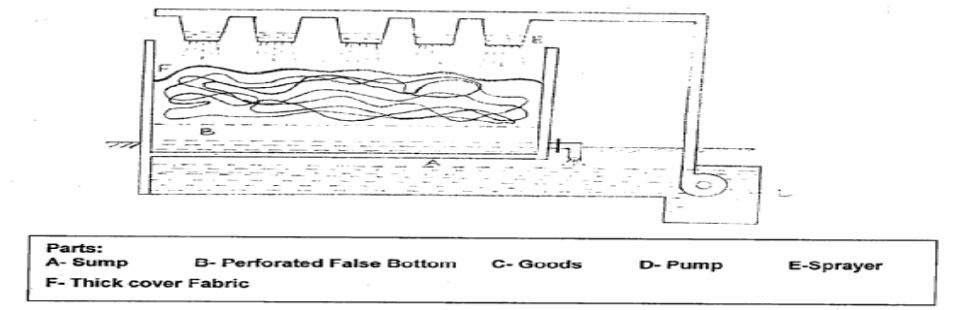
1. Dilute Sodium Hypochlorite (NaOCl)
2. Sodium Chlorite ($NaClO_3$) solution
3. Hydrogen Peroxide (H_2O_2) solution

The effect of different bleaching agents under various conditions of concentration, pH, temperature, time and activators.So that we can choose optimum conditions of bleaching with a particular bleaching agent.

1. **Sodium Hypochlorite Bleaching:**
   - It is done by using sodium hypochlorite (NaOCl) as a bleaching agent. This process is also known as **chemicking**.
   - NaOCl is a highly unstable compound at normal conditions of temperature and pH.
   - It doesn't exist as solid form. As it is highly unstable so it undergoes self-decomposition by the following reactions:

The **bleaching mechanism** of sodium hypochlorite consists of the following reaction:
NaOClNaCl + (O) ⟶

When cotton goods are to be bleached they are scoured or kier-boiled and then packed into a cylindrical or rectangular vessel which may be wood, stone cement lining or stainless steel. The vessel has a perforated false bottom with an outlet to a tank below which has an equal capacity. The liquor in the tank is made unto the desired concentration of available chlorine with bleaching power or sodium hypochlorite solution. It is then pumped up and spread, through which it percolates to find its way ultimately into the tank again. The concentration of available chlorine required in the bleach liquor varies between 1 to 3 grams per liter, but for most purposes good results can be obtained with 1.5 g per liter.



The bleaching action of sodium hypochlorite depends on **several factors**

- The most important of which is the **pH**. The pH of solution highly influences the action of bleaching agent.

- In the pH region above 8.5 (in between 9 to 11) very little changes occur in cellulose i.e it is the normal working range for hypochloride solution. Thus the suitable pH range for sodium hypochloride bleaching is the 10-11.

➢ The other factor which affects the efficient bleaching after pH is the **concentration**.
- Generally the concentration of NaOCl which give 2-3 g/l available chlorine is enough.

➢ The other important factor considered for efficient bleaching is the **temperature**.
- The NaOCl bleaching should always be carried out at room temperature. Also the variation of rate of oxidation with temperature is more prominent at higher concentration of NaOCl.

➢ The other important factor considered for efficient bleaching is the **time.**
- Longer the treatment time larger is the oxidation of material and our aim to achieve good whiteness with minimum damage to material.
- Generally a solution containing 2g/l available chlorine requires 2 hours for good whiteness; the same effect can be obtained in 80-90 mins by using solution of 4g/l available chlorine.

General Recipe:

Concentration	-	2-3 gpl available chlorine
pH	-	10-11
Temperature	-	Room temperature (RT)
Treatment time	-	2 hours

Disadvantages:

The bleaching process carried out by NaOCl is known as Half bleach because the whiteness obtained is temporary not permanent. So, the hypochlorite bleaching should followed by another bleaching treatment.

2. Hydrogen Peroxide (H_2O_2) Bleaching:

Bleaching with H_2O_2 called as full bleach because the whiteness obtained is permanent.

Properties of H_2O_2

- It is a colourless syrupy liquid
- It is absolutely stable under acidic conditions
- It is sensitive to sunlight.
- It decompose if allow to react with heavy metals.
- It is highly unstable to alkali like NaOH, Na_2CO_3, rapidly decomposition takes place.

However, at higher pH (above 10.8) the liberation of HO_2^- ion is so rapid that it becomes unstable with the formation of oxygen gas which has no bleaching property. If the rate of decomposition is very high, the unutilized HO_2^- may damage the fibre.

General Recipe of H2O2 Bleaching:

H2O2 Concentration	-	2-4%
Sodium silicate	-	0.5-1%
NaOH/Na2CO3	-	0.5-1%
Sequestering agent	-	0.1-0.3%
pH	-	9.5-10.5
Temperature	-	80-85°C

Time - 90 mins

For bleaching of woven goods, the system consists of a series of washers, padding mangles (Saturators) and J-boxes operated in line and synchronized. The fabric may be handled either in the open width or in rope form. Various types are available in which the process may be of one stage or two stages. Essentially, four unit operations are involved in process. They are the following:

1. Wetting out and saturating the fabric with peroxide solution.
2. Heating the chemically saturated fabric to 93ºC to 100ºC by applying steam.
3. Storing the heated cloth for sufficient period to allow the chemical reactions to take place.
4. Washing the heated cloth to remove the products of decomposition and untreated chemicals.

ONE STAGE PROCESS: (Continuous bleaching process)

Grey cloth is first singed, desized and washed. It is squeezed to about 20% expression and fed into the saturator, where it is impregnated with 3 and 4% hydrogen peroxide. The saturator has a set of squeeze rollers on the exit and to remove the excess chemicals and to ensure proper degree of saturation of the cloth. Then the cloth is processed in the heater tube. It is an integral part of J-Box. The heating assembly is built in the form of 'U' with reels at the top and bottom of the enclosed unit so that the cloth can freely travel through the heater; Dry saturated steam at atmospheric pressure is then admitted to the heater tube.

After the cloth is heated, it falls into the J-Box. It is a large stainless steel chute provided with a cloth piling device and is large enough to hold the heaviest cloth to be processed atthe highest speed for an hour.The heated cloth is taken out from the J-box and fed into the washer where it is thoroughlywashed.

TWO STAGE METHOD: (Continuous scoring and bleaching)

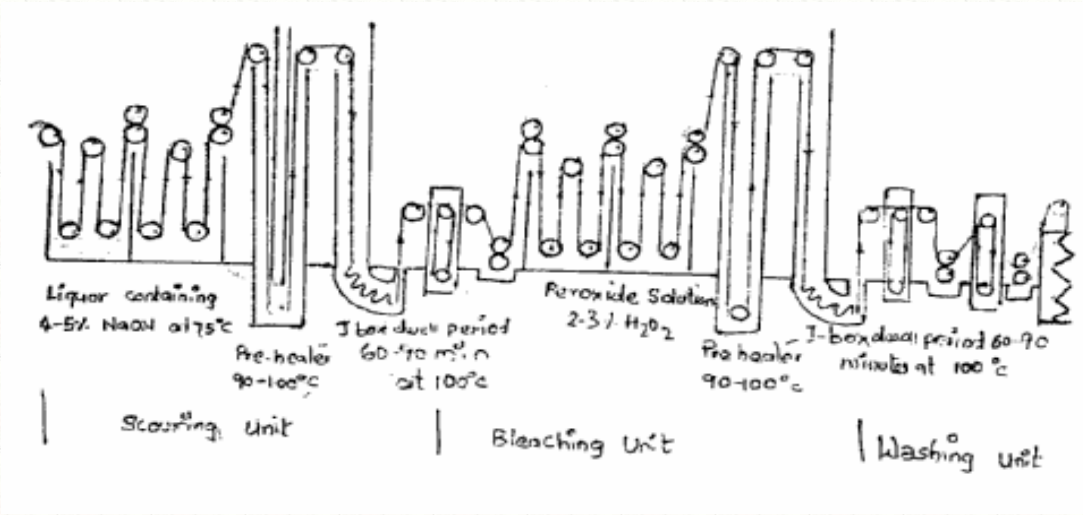
Continuous peroxide bleaching is done in two stages. Caustic scouring and peroxidebleaching.

Caustic Saturator:

The first stage is carried out in caustic saturator. It contains caustic liquor; here the clothdips into the caustic liquor 6 to 8 times. The concentration of NaOH in the saturator can bemaintained at 4%. Before entering into the saturator, the cloth is squeezed to about 85 to90 % expression.

The saturator consists of rollers, giving the cloth more dips in the trough and even wetting of the cloth. When the cloth leaves the saturator, is should contain 100 to 110 % of caustic solution.

The caustic treated goods are steamed in a J-box for an hour at about 100ºC. It is a large stainless steel chute provided with a cloth piling-in device and is large enough to hold the cloth for an hour. Before enters into the peroxide saturator it is necessary to remove NaOH solution. If NaOH is retained in the cloth the pH of the peroxide solution increased and the peroxide solution becomes unstable. Hence bleaching efficiency will be lowered. The washing efficiency of machine determines the speed of the range. Peroxide



Peroxide Saturator:

After washing, the cloth enters the peroxide saturator where it is impregnated with thebleaching liquor. The bath generally contains hydrogen peroxide sodium silicate and a small amount of NaOH. The concentration of H2 O2 depends on the cloth construction,weight of fabric, quality of cotton etc. More closely constructed fabric requires higherconcentration of peroxide. Sodium silicate fixes the pH value of the bleach liquor andproduces good peroxide stability for efficient bleaching. NaOH is added to avoid thesurface of the J-Box to become rough due to the precipitation of silicon residues fromsodium silicate when it is used alone.The cloth saturated with the bleaching solution is sent to the peroxide J-Box where it issteamed for an hour at atmospheric pressure at 100ºC, for uniform bleaching the cloth.

Finally, the cloth is washed in an open washing machine with soap and hot water and then cold water. Now the cloth will be in white condition and will be very absorbent. The bleaching liquor consists of

1. Hydrogen peroxide (35% by wt) = 2 to 8%
2. Sodium silicate = 3 %
3. Soda Ash = 0.8% to 1%
4. NaoH = 0.4% to 0.6%
5. Initial PH = 10.3 to 13.8%

Full bleaching (Yarn whitening):- The yarn which is bleached as described above is called half-bleached yarn and the white produced is sufficient for dyeing even light shades. For very dark shades and black, even scoured yarn may be good enough for dyeing. For some purpose, a bright, white yarn is required. To achieve this, the half-bleached yarn (obtained by hypochlorite or per-oxide bleaching) is treated with a solution containing an Optical whitening agent.

Comparison of hypochlorite and Peroxide bleaching:

H_2O_2 Bleaching	**Sodium Hypochlorite Bleaching**
Peroxide is universal bleaching agent can be employed to wool, silk as well as cotton.	It is mainly used for cellulosic fibres not for protein fibres like wool, silk.
Peroxide is milder agent so degrading effect on cellulose is less.	Hypochlorite is having degrading effect on cellulose.
Peroxide also gives mild scouring action so simultaneous scouring and bleaching is possible in continuous process.	It doesn't give any scouring action.
It doesn't affect the coloured material so it can be used for coloured materials.	It can't be used over coloured material.
With H_2O_2 there is no need of danger of equipment corrosion and no unpleasant odours.	There is a problem of corrosion and unpleasant odours.
Only rinsing after bleaching is sufficient	Hypochlorite bleaching needs an antichlor treatment.
Bleaching with peroxide is a costlier than hypochlorite.	Relatively it is less costly.
Hydrogen peroxide bleaching requires stabilization usually with silicates which have problem of stains on subsequent dyeing.	No such need of stabilizers in hypochlorite bleaching.

Bleaching for other fabrics.

a) Viscose:

- Filament viscose rayon may not require bleaching since this is normally carried out during manufacture. However, viscose in staple form requires bleaching as it may not necessarily include a bleaching treatment during its manufacture.
- The same reagents as those used for bleaching linen and cotton fabrics are useful for these fibres.
- For very good whiteness, rayon may be bleached on a jigger with alkaline hypochlorite or combined scour and bleach using hydrogen peroxide (up to 1 vol. strength) containing sodium silicate and alkaline detergents-at a temperature of about 70°C.

b) Polyester/Cellulosic Blends:

- Polyester fibre in blends with cellulosic fibres in the ratios of 65/35 and 50/50 are common construction.
- When cellulose portion is rayon, the blends rarely require bleaching, but when cotton is present bleaching is usually necessary.
- Bleaching treatments of such blends are normally required to remove the natural colours of cotton, sighting colours and if the polyester portion is turned yellow at the time of heat-setting operation.
- Chlorine bleaching, peroxide bleaching and chlorite bleaching are employed widely. If the polyester portion requires bleaching, then chlorite bleaching is used, as this bleaching agent bleaches both polyester and cellulose. If the polyester portion does not need bleaching, then peroxide bleaching is more convenient. Alkaline hydrogen peroxide bleaching is the most preferred system for polyester/cotton blends.

c) Nylon/Cellulosic Blends:

- Blends of nylon and cellulosic fibres may be bleached with either H_2O_2 or $NaClO_2$.
- H_2O_2 does not bleach nylon and normal methods of bleaching degrade nylon. Blends containing 30% or less of nylon may be bleached by the continuous H_2O_2 method, and in such cases cotton will absorb the peroxide preferentially and so protect the nylon from damage.
- The goods are entered into a bath containing 2-3 volume H_2O_2, 1 g/1 sodium hydroxide flake, 0.2 g/1 peroxide stabilizer, 0.25 g/1 sequestering agent at 40°C the temperature is raised to 85°C and then the treatment continued for 1 h.
- The treated goods are then cooled and rinsed thoroughly. Hypochlorite does not damage nylon but it has got no bleaching action on it. Sodium chlorite causes no degradation of either cellulosic or polyamide and is a better bleaching agent the fabric is treated with a solution containing sodium chlorite (2-5 g/l) at pH 3 to 4 at 90°C for $1^{1/2}$ to 2 h.
- This is followed by a treatment in a 2 g/1 solution of sodium carbonate at 40-50°C and finally hot and cold rinses are given in water.

Bleaching of polyester / cotton:

Usually many mills adopt full bleaching of polyester cotton after scouring. Many manufacturers suggest for full bleaching of both components and suggest sodium chlorite (NaCl2) bleaching of polyester and hydrogen peroxide (H2O2) for cotton. Many mills are not having the necessary equipment to adopt sodium chlorite bleaching of polyester for which non corrosive metal such as glass, porcelain, earthenware, resistance plastic or special steel of the continuous or semi continuous range.

The scope of bleaching for 100% synthetic fabric is to remove the yellowing caused by the heat treatment process.

For scouring synthetic and its blends the machine like jigger, winch and pad roll machines are used.

Chemicals used for Bleaching Polyester:
1. Sodium Chlorite - 1gm/liter
2. Nitric Acid to adjust the PH to 2-3
3. Temperature - Boil
4. Time - 30 minutes.

Chemicals used for bleaching polyester viscose:
1. Hydrogen Peroxide -20
2. Sodium Silicate - 14
3. Temperature - 60ºC
4. Bath ratio - 1:30

Chemicals used for bleaching polyester cotton:
1. Hydrogen Peroxide - 1-2%
2. Sodium Silicate - 5-10%
3. Temperature - 80ºC
4. Time - 10-20 minutes

Evaluate the bleaching Efficiency:

i. Absorbency Test: Method I

- ✓ The simple test of measuring the absorbency of sample consists of allowing a drop of water to fall from a fixed height (2.5 cm) on to the conditioned fabric sample, which is mounted on an embroidery frame of about 6 inches diameter.
- ✓ A stop watch is started as soon as the drop falls on the fabric and stopped as the water drop is completely absorbed by the fabric.
- ✓ This complete absorption of drop is ensure by appearance of a dull spot on fabric i.e. the reflected light disappear from the edge of drop. This time is termed as the absorbency time.
- ✓ Yet **another method (Method II)** for absorbency test is the measurement of the time required for the sample of about 1 inch size to sink in water, termed as sinking time.
- ✓ Drop absorbency or sinking time of about **5 sec** is generally considered satisfactory for well-prepared fabric.
- ✓ In case of **synthetic fabrics** or their blends the above test methods are not applicable and for such materials strip test is used. In this we measure the height of water raised by capillary action in the fabric.
- ✓ In his test method a 5cm wide strip is cut across the filling direction. Then numbers of these strips are immersed 1mm deep in 1% aqueous solution.
- ✓ Direct Blue 86 for 2 sec and then immediately placed on wire screen. After drying, the capillary rise of dye solution is measured.

ii. Whiteness:

Whiteness is related to the luminosity as well freedom from yellowness. It is measured by measuring the reflectance of the specimen against a standard white (magnesium oxide/ ceramic) tile which represents a whiteness value of 100.

iii. Cuprammonium Fluidity:

- ✓ This test indirectly measures the chemical degradation of cotton cellulose during pre-treatment process.
- ✓ In this test, the conditioned cotton sample is exactly weighted and dissolved in cuprammonium hydroxide solution. The flow time of this solution between two fixed mars on a calibrated viscometer (fluidity tube) is measured at a specific temperature.
- ✓ The fluidity value, F is calculated from F= C/t, where "C" is viscometer constant and "t" is flow time. The results are expressed as Rhes ($poise^{-1}$), which is reciprocal of unit of viscosity.
- ✓ Fluidity value of 5-8 is considered satisfactory for normal bleached cotton fabric.

POINTS TO REMEMBER:

- The process of mercerization is a most satisfactory method for increasing luster on cotton materials and two particular advantages are that the process is a cheaper one and that the increased luster is prominent, so that it is unaffected by washing, drying and other methods of textile finishing.
- Bleaching is a process by which the natural coloring matter and any other coloring matter are removed. During scouring of cotton all impurities are removed except the natural coloring matter leaving material satisfactorily absorbent. The natural coloring matter does not do any harm except it diminishes the whiteness.

EXPECTED QUESTIONS:

Section A

1.Bleaching is a process of improve the …….. of fabric.

2. Blends of nylon and cellulosic fibres may be bleached with either ……..

Section B

I.What is mercerization?
2. Explain about bleaching?

Section C

1.Explain the methods of mercerization.

2. Explain the hydrogen peroxide bleaching.