PREPARATION OF FABRIC BEFORE DYEING

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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.

- Singeing
- Desizing
- Scouring
- Bleaching
- Mercerizing
- Dyeing

Pretreatment processes include desizing, scouring, and bleaching which make subsequent dyeing and softening processes easy. Uneven desizing, scouring, and bleaching in the pretreatment processes might cause drastic deterioration in the qualities of processsed products, such as uneven dyeing and decrease in fastness.
SINGEING

The verb ‘singe’ literally means ‘to burn superficially’. Technically, singeing refers to the burning-off of. Loose fibres not firmly bound into the yarn and/or fabric structure. Singeing is an important part of pretreatment. This is the burning off of protruding fiber ends from the surface of the fabric. If not done properly, unclear print patterns, mottled fabric surfaces, and pilling results.

- Loose yarns not firmly bound into the fabric structure;
- Protruding fibre ends sticking out of the textile yarns and/or fabrics.

Textiles materials are most commonly singed in woven or knitted fabric form or in yarn form.

OBJECTIVES & ADVANTAGES OF SINGEING

- Singeing of a fabric is done in order to obtain a clean fabric surface which allows the structure of the fabric to be clearly seen.
- Fabrics, which have been signed, soil less easily than un-singed fabrics.
- The risk of pilling, especially with synthetics and their blends, is reduced in case of singed fabrics.
- Singed fabrics allow printing of fine intricate patterns with high clarity and detail.
- The risk of skitterydyeings with singed articles dyed in dark shades is considerably reduced, as randomly protruding fibres are removed in singeing which could cause diffused reflection of light.
NECESSITY OF SINGEING IN TEXTILE

Singeing of textile materials is necessary for the following reasons:

- Cotton materials are valued for their smooth appearance. After the formation of fabric it has a fuzzy or hairy appearance due to projecting fibers, thus affecting the luster and smoothness cotton is known for.
- Unsigned fabrics are soiled easily
- The protruding fibers obstruct the subsequent dyeing and printing process
- Goods which are to be mercerized are signed to maximize the luster
- In fabrics of polyester and cellulosic fiber blends singeing is the best method to control pilling, sometimes double singeing is done to minimize the pilling.

SINGEING PROCESS

Singeing process is as follows:

- To produce a smooth surface finish on fabrics made from staple fibers first the fabric surfaces are brushed lightly to raise the unwanted fiber ends.
- Then the fabric is signed with or passed over heated copper plates or open gas flames. The fiber ends burn off.
- The fabric is moved very rapidly, and only the fiber ends are destroyed.
- As soon as the fabric leaves the singeing area, it enters a water bath or desizing bath. This stops any singeing afterglow or sparks that might damage the cloth.

PRECAUTION DURING SINGEING

Some of the precautions to be taken in considerations during singeing:

1. The fabric to be singed should be dry as wet fabric tends to scorch more readily than dry.
2. Uneven singeing may cause streaks on fabric or bubbles when the fabric is finished.
3. Improper singeing may lead to loss of 75% loss in tensile strength loss in warp direction.
4. The fabric should not contain any acid releasing salt, which may release acid on heating and tender the fabric.
5. Stopping the machines may cause bars on the fabrics.
6. Singeing may cause hardening of the size thus leading to difficulty in its removal.
7. Possibility of thermal damage to temperature sensitive fabrics.
8. The burning characteristics of fibers must be taken into account when this process is applied, as heat-sensitive fibers melt, forming tiny balls on the surface of the fabric. These balls interfere with dye absorption, so that, as a general rule, heat sensitive fibers would be singed after dyeing or printing.

**DESIZING**

Desizing is the process or removing the starch or size the covering the warp yarn using enzyme, Oxidizing agent, or other chemicals. There are three types of technique in desizing and four method of desizing that has been used in wet processing

**TECHNIQUE OF DESIZING**

There are three type of technique of desizing. Desizing technique are different depends on the kind of sizing agent to be removed. In desizing, bacteria are a conventional method depend by others method. During this process, the fabrics is wet out in water and allowed to lie damp for several hour. Other than that, the method is most popular that has been used in this wet processing is by using enzyme. This enzyme is named after the compound break down. Besides that, the other method is acid hydrolysis. This method can remove metal contamination at the fabrics, but it might affect the cellulosic since chemically starch and cellulose is very similar. Lastly, is oxidative desizing method. This method using hydrogen peroxide and persulphate that will degrade the starch with serious attack.
NATURAL SIZING AGENTS

Natural sizing agents are based on natural substances and their derivatives:

- Starch and starch derivatives; native starch, degradation starch and chemically modified starch products
- Cellulosic derivatives; carboxymethylcellulose (CMC), methylcellulose and oxyethylcellulose
- Protein-based starches; glue, gelatin, albumen

Synthetic sizing agents

- Polyaacrylates,
- Modified polyesters,
- Polyvinyl alcohols (PVA),
- Styrene/maleic acidcopolymers.

DESIZING PROCESSES

Desizing, irrespective of what the desizing agent is, involves impregnation of the fabric with the desizing agent, allowing the desizing agent to degrade or solubilise the size material, and finally to wash out the degradation products. The major desizing processes are:

- Enzymatic desizing of starches on cotton fabrics
- Oxidative desizing
- Acid desizing
- Removal of water-soluble sizes

ENZYMATIC DESIZING

Enzymatic desizing is the classical desizing process of degrading starch size on cotton fabrics using enzymes. Enzymes are complex organic, soluble bio-catalysts, formed by living organisms, which catalyze chemical reaction in biological processes. Enzymes are quite specific in their action on a particular substance. A small quantity of enzyme is able to decompose a large quantity of the substance it acts upon. Enzymes are usually named by the kind of substance degraded in the reaction it catalyzes.
Amylases are the enzymes that hydrolyses and reduce the molecular weight of amyllose and amylopectin molecules in starch, rendering it water-soluble enough to be washed off the fabric.

Effective enzymatic desizing require strict control of pH, temperature, water hardness, electrolyte addition and choice of surfactant.

**OXIDATIVE DESIZING**

In oxidative desizing, the risk of damage to the cellulose fiber is very high, and its use for desizing is increasingly rare. Oxidative desizing uses potassium or sodium persulfate or sodium bromite as an oxidizing agent.

**ACID DESIZING**

Cold solutions of dilute sulphuric or hydrochloric acids are used to hydrolyze the starch, however, this has the disadvantage of also affecting the cellulose fiber in cotton fabrics.

**REMOVAL OF WATER-SOLUBLE SIZES**

Fabrics containing water-soluble sizes can be desized by washing using hot water, perhaps containing wetting agents (surfactants) and a mild alkali. The water replaces the size on the outer surface of the fiber, and absorbs within the fiber to remove any fabric residue.

**DESIZING CONDITIONS**

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Concentration (g/l)</th>
<th>Temperature (°C)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malt Extract</td>
<td>3-20</td>
<td>50-60</td>
<td>6-7.5</td>
</tr>
<tr>
<td>Pancreatic</td>
<td>1-3</td>
<td>50-60</td>
<td>6.5-7.5</td>
</tr>
<tr>
<td>Bacteria</td>
<td>0.5-1</td>
<td>60-70</td>
<td>5.5-7.5</td>
</tr>
</tbody>
</table>

Malt extract enzymes are obtained by the extraction of the freshly germinated malt. This acts on starches with greatest efficiency at conditions given in table. eg. Diastase, Maltostase etc.

The pancreatic enzymes are prepared from slaughterhouse wastes. The wastes are first extracted with water, concentrated under vacuum, followed by precipitation by adding alcohol (as enzymes are soluble in water but insoluble in alcohol). Eg. Viveral, Declrasan.
Growing pure cultures of certain microorganisms in sterilized wort produces the bacterial enzymes. E.g., Rapidose, Biolase. This method of desizing is considered to be the safest among other because it never results in the rendering of the cellulose of fabric and will only treat the starches present on sized fabric.

**SCOURING:**

The term ‘scouring’ applies to the removal of impurities such as oils, waxes, gums, soluble impurities and sold dirt commonly found in textile material and produce a hydrophilic and clean cloth.

**OBJECTIVES OF SCOURING:**

1. To remove natural as well as added impurities of essentially hydrophobic character as completely as possible
2. To increase absorbency of textile material
3. To leave the fabric in a highly hydrophilic condition without undergoing chemical or physical damage significantly.

**SCOURING PROCESS DEPENDS ON:**

1. The type of cotton
2. The color of cotton
3. The cleanliness of cotton
4. The twist and count of the yarn
5. The construction of the fabric.

**SCOURING PROCESS:**

There are two types of textile scouring processes –

1. **CONVENTIONAL SCOURING PROCESS:**
   
   - Kier boiling (discontinuous) scouring.
   - Scouring in J or L box (continuous).
   - Exhaust method
2. SPECIAL SCOURING PROCESS:

- Solvent scouring process.
- Vapor lock scouring process.

KIER BOILING (DISCONTINUOUS) SCOURING:
General recipe for scouring for Kier boiler process:

- Alkali (NaOH) - 2 to 5 gm per litre.
- Soda ash - x gm per litre to adjust pH (PH required for scouring is 10.5).
- Wetting agent - 1 gm per litre.
- Sequestering agent - 1 gm per litre.
- Detergent - 1 to 2 gm per litre.
- Temperature - 100 to 1250c.
- Time - 6 hours (close vessel) and 8 hours (open vessel)
- M : L - 1 : 10

N.B. : Water level should keep 6 to 8” above the fabric.
Machine capacity may be from 1 ton to 5 ton.

DESCRIPTION AND WORKING PRINCIPLE OF SCOURING PROCESS:
Kier boiler is a long mild steel or cast iron cylindrical vessel provided with two perforated tube sheets (disc with a number of holes). One is placed at the bottom and another is top. These discs are connected by a number of tunnels which carry the liquor from the bottom compartment to the upper one. In the middle compartment steam is passed. Thus the tubes carrying the liquor are surrounded by steam which heats them.

The hot liquor from the multitublar heater is sprayed over the cloth, packed in the kier, through a hollow perforated ring. The liquid passes slowly over the packed cloth, collects below the false bottom, from where it is pumped into the auxiliary heater by a centrifugal pump and the cycle repeats.

PRECAUTION:

1. Kier boiler should be cleaned.
2. Material should be packed evenly.
4. After boiling the liquor should be removed in absence of water.
5. Before starting all the joining parts should be checked.
6. Fabric should always keep under scouring solution.

**SCOURING IN THE J BOX:**
In continuous process J-box is used for cotton scouring. It looks like English letter j. so it is called J-box. In J-box cotton is scoured open width and rope form.
General recipe of scouring in J-box:

- Alkali : 4 to 6 g/l
- Wetting agent : 4 to 5 g/l
- Impregnation temperature : 70 to 800c.
- Impregnation time : 40 to 90 second.
- Pick up : 90 to 100%
- Storing time in J box : 1 to 2 hours.
- Temperature in J box : 98 to 1020c.

Rinsing with water and finally hot wash (not less than 800c) and cold wash is done.

**DESCRIPTION AND WORKING PRINCIPLE:**
The scouring process in J-box can be divided into four units. They are
a) Impregnation box
b) Pre-heater.
c) J-box.
d) Washing unit.

**A) IMPREGNATION BOX:**
Fabric is passed into impregnation box in open width form and through the guide rollers and padded by caustic soda and wetting agent. The temperature for impregnation should be maintained at 70 to 800c for about 40 to 90 seconds. Then the fabric is squeezed and passed on to the next unit.

**B) PRE HEATER:**
In this unit the material is passed to the thermostatic controlling system at temperature of about 90 to 1000°C for about 30 seconds. Then the material is passed to the J-box.

C) J-BOX:
The capacity of normal J-box is about 12000 to 15000 pounds. The material from the J-box is passed to the washing unit passing through squeeze roller.

D) WASHING UNIT:
The water soluble impurities or products that were left on the material are removed by washing. First of all the materials are washed in hot water at the temperature above 800°C, then it is cold washed and finally dried.

ADVANTAGE:
1. The process is a continuous process. So consumes less time.
2. The process is economical.

DISADVANTAGE:
1. The result of scouring is not good as compared with kier boiler.
2. The process is not hydrophilic as kier boiler.

ESTIMATION OR SCOURING EFFECT:
The scouring effect can be estimated by carrying out one of the following tests-

2. Test of (absorbency) Immersion test.
3. Drop test.
4. Wicking or column test.

ASSESSMENT OF SCOURING:/ABSORBENCY TEST: DROP/SPOT TEST:
In a pipette a solution of 0.1% direct red or Congo red is taken and droplet of solution put on the different places of the fabric. Then the absorption time of the fabric is observed. The standard time for the absorption of one drop of solution is 0.5-0.8 sec up to 1 sec.
DIFFERENCE BETWEEN SCOURING AND SOURING:

<table>
<thead>
<tr>
<th>Scouring</th>
<th>Souring</th>
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<tbody>
<tr>
<td>To remove oil, waxes gum</td>
<td>Not to remove any soluble impurities, only for alkali neutralization</td>
</tr>
<tr>
<td>Scouring is done in alkali</td>
<td>Sourcing is done dilute solution. HCl or H₂SO₄</td>
</tr>
<tr>
<td>Required heat to boiling</td>
<td>No need of heat.</td>
</tr>
<tr>
<td>Need of definite time</td>
<td>No need of definite time.</td>
</tr>
</tbody>
</table>

TYPES OF SCOURING TREATMENTS

1. Scouring By Chemicals Means
2. Bio scouring or scouring with Enzymes

SCOURING OF COTTON:

In the scouring process the cotton cellulose material is treated with a solution containing alkali (soda ash and caustic soda), an anionic and/or nonionic detergent, a wetting agent, a complexing and sequestering for the removal of metal ions and polyacrylates or polyphosphonates as special surfactant free dispersing agents, at high temperature. The scouring operation was conventionally done in kier machines and hence the process was called kier boiling, but now a days the scouring is done mostly in the dyeing machines itself as a part of combined or single operation such as scouring and bleaching.

1. Saponification of fats into water soluble soap and water miscible glycerin under alkaline conditions.
2. Hydrolysis of proteins into water soluble degradation products.
3. Dissolution of amino compounds.
4. Solubilising of pectose and pectins by converting into soluble salts.
5. Dissolution and extraction of mineral matter.
7. 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.

**SAPONIFICATION:**
When a grey cotton fabric is dipped in water the oil present in the size will not allow the water to spread on the fibre, i.e, the oil resists the wetting of the fabric by water. For further processes such as bleaching, dyeing, printing etc. to be effective, it is essential for the fabric to wet easily when treated with solutions of chemicals and dyestuffs. In other words, the cloth should be highly absorbent towards water. To achieve this objective, the oil has to be removed from the fabric. Also China clay (of the size) is firmly fixed on the grey cloth with the help of oils and waxes which act as binding agent for the clay particles. Thus it is necessary to remove the oils and waxes for removing the China clay from the fabric.

**SCOURING OF SILK:**
The scouring of pure silk is a degumming process used to remove sericin (silk gum) from fibroin floss. Sericin is the gummy element which keeps together the fibroin floss and gives the silk a hard hand and dull appearance. It is carried out on yarn, on dyed yarn, piece-dyed fabric or on products ready for printing. The treatment, which causes a loss of weight ranging between 24 and 28%, gives the degummed silk a lustrous appearance and a soft hand; the treatment is carried out with soapy solutions or with buffer dissolving agents. It is also possible to use enzymes (protease), which hydrolyses sericin

**SCOURING OF WOOL:**
On wool, the scouring process removes oils and contaminants accumulated during upstream processing steps and can be carried out on slivers, yarns and fabrics with solutions containing sodium carbonate with soap or ammonia, or anionic and non-ionic surfactants, which carry out a softer washing to avoid any damage to the fibers.

**SCOURING OF SYNTHETICS:**
The scouring process applied to synthetic fibres removes oils, lubricants and anti-static substances, dust, contaminants and can be carried out on yarns and fabrics (when warp yarns have been bonded, the treatment is called deboning). It is carried out by means of surfactants, detergents and emulsifying agents.
SCOURING OF COLORED WOVEN GOODS:
In certain type of fabrics, dyed yarns are used for warp and weft along with white yarns to produce colored woven designs. Thus colored borders of saris and dhotis, colored check effects, shirting’s etc. are woven using white and dyed yarns. These are known as colored woven goods and the dyed yarns are known as colored effect threads. Since the woven cloth has to undergo rigorous conditions of scouring and bleaching, a restriction is imposed on the selection of dyes for dyeing these yarns. For example, if direct dyes are used for the purpose, bleeding of the dye from the yarns takes place during scouring with the consequent staining of the white yarns present in the fabric being scoured. When the scoured fabric is subsequently bleached with sodium hypochlorite solutions, most of the direct dyes are destroyed by the bleaching agent. If sulphur dyes or reactive dyes are dyed for producing such colored threads, sodium hypochlorite destroys most of these dyes. Therefore, these classes of byes are not suitable for the purpose. Generally, vat and azoic colors are dyed on such yarns. Vat dyes re superior to azoics in this respect. These liquor, neither are they destroyed by the subsequent bleaching.

BIO-SCOURING:
Bio-scouring with pectinases(enzyme) have shown promise in replacing the traditional alkaline scouring treatment. Some auxiliaries’ suppliers have introduced an enzymatic process to remove hydrophobic and other non-cellulosic components form cotton. The new bio-scouring process operates at mils pH conditions over a broad temperature range and can be applied using equipment such as jet machines. It is claimed that, due to a better bleach ability of enzyme-scoured textiles, bleaching can be carried out with reduced amounts of bleaching chemicals and auxiliaries. Bio-scouring enzymes actually make the substrate more hydrophilic (which could explain better bleach ability), but they are not able to destroy wax and seeds which are therefore removed in the subsequent bleaching process. There is no need for the use of caustic soda in enzymatic scouring. So this process reduced pollution loads, high TDS, BOD and COD in the effluent.

BLEACHING
Bleaching operation is carried out to improve the whiteness of fabric. This is achieved by the process known as bleaching. During bleaching the natural colouring matters present in cotton
are decomposed to colourless substances. The removal of these colouring matters helps to improve the whiteness of cotton fabric.

PURPOSE OF BLEACHING:

1. To produce white fabric by destroying colouring matter with minimum fibre degradation.
2. To improve brightness of colour after dyeing or printing
3. Further improvement of whiteness by treatment with optical brightening agents when the fabric is to be marketed as white

BLEACHING AGENTS

The chemicals used for improving the whiteness of fabric are known as bleaching agents. Although several bleaching agents are available, hydrogen peroxide is most popular for bleaching of cotton.

PROPERTIES OF HYDROGEN PEROXIDE

The important properties of hydrogen peroxide are summarized below

- Colourless liquid
- Corrosive to skin, dangerous to eyes
- Stable under acid pH
- Activated under alkaline conditions. Chemicals like sodium hydroxide, sodium carbonate, trisodium phosphate alone or in combination may used as alkali for activation.
- Decomposition in presence of alkali alone is very rapid resulting in uneven bleaching. Hence the use of stabilizer along with alkali is essential during bleaching.

HYDROGEN PEROXIDE STABILIZER
Compounds which control the rate of decomposition of hydrogen peroxide under alkaline conditions are known as peroxide stabilizer. Sodium silicate is the most common and economical stabilizer. Commercially silicate and non-silicate based products are also available.

TYPICAL BLEACHING EQUIPMENT

EQUIPMENT

- **Kier**: On small scale kier can be used for bleaching of cotton with hydrogen peroxide. The most important precaution to be taken during bleaching in kier is that the inside walls of the kier must be thoroughly cemented so that the peroxide solution does not come in contact with iron from which the kier might have been constructed. If this precaution is not taken the iron walls of kier would act as catalyst for the rapid decomposition of hydrogen peroxide even in presence of stabilizer. This would result in uneven bleaching and also fabric degradation. Ideally a stainless steel kier must be used for peroxide bleaching.

- **In kier** the bleaching process is carried out while the fabric is in rope form. Therefore the liquor circulation must be efficient to get uniform bleaching.

- **Jigger**: This is most suitable equipment as the commercial jiggers are made of stainless steel. Therefore there is no danger of rapid decomposition of hydrogen peroxide and fabric degradation. The other advantage of jigger is that the fabric is processed in open width form. Therefore the treatment is more uniform.

<table>
<thead>
<tr>
<th>Typical bleaching recipe</th>
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<tbody>
<tr>
<td>Hydrogen peroxide (35 %)</td>
<td>3-5% owf</td>
</tr>
<tr>
<td>Wetting agent</td>
<td>0.1-0.5% owf</td>
</tr>
<tr>
<td>Sodium hydroxide (NaOH)</td>
<td>0.3-0.8% owf</td>
</tr>
<tr>
<td>Sodium silicate</td>
<td>2-3% owf</td>
</tr>
<tr>
<td>Magnesium sulphate (Epsom salt)</td>
<td>0.5% owf</td>
</tr>
</tbody>
</table>

- Maintain the temperature between 80oC and 100oC for the process: 60-120 minutes

- After the process is complete, drain the water; and, then rinse with hot and cold water

**BLEACHING EFFICIENCY**
Whiteness of bleached fabric: The bleaching efficiency can be tested by expressing the whiteness of bleached fabric in terms of whiteness index (or percentage reflectance). The whiteness index of 70% and above can be considered as acceptable whiteness.

For measurement of whiteness, spectrophotometer equipment is essential.

If a standard white fabric is available then whiteness of the bleached fabric can be compared with the standard white fabric visually. This test can be done in the absence of equipment. However, the test being visual it can be subjective. Therefore, instrumental test is recommended to avoid any discrepancy.

Strength measurement: The strength measurement (Tensile or tear strength) does not give idea about the whiteness, but it gives an idea whether the bleaching operation is carried out without fabric degradation. The loss in strength up to 10% compared to scoured fabric normally is acceptable. If Strength loss is beyond 10%, then bleaching recipe and conditions must be reviewed.

OPTICAL BRIGHTENING TREATMENT

The whiteness of cotton fabric achieved during hydrogen peroxide bleaching is adequate if the fabric is subsequently dyed or printed. However, it is not adequate if the fabric is to be sold or marketed as white. For this purpose there is a need for further improvement of bleached fabric whiteness. This can be achieved by treating the bleached fabric with

1. Bluing agent or
2. Tinting dyes or
3. Optical brightening agent

It must be remembered that the treatment with above agents is given only when the fabric is to be sold as white. If the fabric is to be dyed or printed then above treatment is not essential.

The improvement of whiteness of cotton fabric during H$_2$O$_2$ bleaching is a chemical process due to conversion of colouring matter into colourless water soluble products and their subsequent removal from the fabric.
On the other hand, the improvement of whiteness due to bluing agent, tinting agent or optical brightening agent is a physical process.

**MERCERIZING**

Mercerization, in textiles, a chemical treatment applied to cotton fibres or fabrics to permanently impart a greater affinity for dyes and various chemical finishes. Mercerizing also gives cotton cloth increased tensile strength, greater absorptive properties, and, usually, a high degree of lustre, depending on the method used.

The treatment consists of immersing the yarn or fibre in a solution of sodium hydroxide (caustic soda) for short periods of time, usually less than four minutes. The material is then treated with water or acid to neutralize the sodium hydroxide. If the material is held under tension during this stage, it is kept from shrinking appreciably; if no tension is applied, the material may shrink by as much as one-fourth. Higher-quality cotton goods are usually mercerized; cloths so treated take brighter, longer-lasting colours from less dye. The effect of caustic soda on cotton was discovered in 1844 by John Mercer, an English calico printer, who received a patent for it in 1850.

**MERCERIZING PROCESS**

Mercerizing is the process to improve the luster, hand and other properties of cotton by using strong caustic alkaline solution. In this process, it can be divided into three uses that are dyeing printing, finishing and it also has been used in final appearance in general. Besides that, in this process has some type of mercerizing. Slack mercerizing is the example of type of mercerizing
THE EFFECTS OF MERCERIZATION

- Improved luster
- Increased ability to absorb dye
- Improved reactions with a variety of chemicals
- Improved stability of form
- Improved strength/elongation
- Improved smoothness
- Improved hand

Appearance is improved through increased luster, a deepening of the color and the production of a transparent look, the feel of the fabric is improved through a resulting soft hand and improved smoothness, and strength and elongation are also improved, along with the addition of good stretching ability. The treatment and handling can be adjusted to fit different requirements, thus allowing for the best application of the results of different processing.

TYPES OF MERCERIZATION

Mercerization is widely used, and in the mercerization of different kinds of cellulose products, including blended products, the machine used and the treatment conditions must be selected in accordance with the type of fiber, the form that it is in and its properties, and also in accordance with the aims and the timing of the mercerization.

The wide range of treatment methods can approximately be broken down into the following divisions. Parentheses denote established terminology.
1. CLASSIFICATION ACCORDING TO THE FORM OF THE PRODUCT

A) YARN MERCERIZATION

BATCH :

- Hank mercerization
- Cheese mercerization

CONTINUOUS :

- Single end mercerization
- Tow mercerization
- Warp mercerization

B) KNIT MERCERIZATION

- Open mercerization
- Closed mercerization (Round mercerization, tubular knit mercerization)

C) CLOTH MERCERIZATION

- Chainless mercerization (Roller mercerization)
- Chain mercerization (Stenter mercerization)
- Batch-up mercerization

2. CLASSIFICATION ACCORDING TO THE MERCERIZING CONDITIONS

A) WATER CONTENT

- Dry mercerization
- Wet mercerization

B) TENSION

- Fixed-length mercerization
- Tension mercerization
- Tensionless mercerization
C) ALKALINE CONCENTRATION

- Low-concentration alkaline mercerization
- High-concentration alkaline mercerization
- Two-step mercerization

D) TEMPERATURE

- Ambient-temperature mercerization
- High-temperature mercerization
- Low-temperature mercerization

3. CLASSIFICATION ACCORDING TO TIMING

- Gray mercerization
- Pre-dyeing mercerization
- Post-dyeing mercerization

4. CLASSIFICATION ACCORDING TO THE NUMBER OF TREATMENTS

- Single mercerization
- Double mercerization

5. CLASSIFICATION ACCORDING TO THE TYPE OF ALKALI USED

- Caustic soda mercerization
- Ammonia mercerization

6. OTHER

- Alkali pad-dry method
- Alkali pad-steam method

While other variations are also used, mercerization in industry is generally implemented according to a combination of the basic factors as listed above.
WASHING IN TEXTILE

Rinsing and washing are the operations carried out most frequently during a complete textile finishing cycle. They are almost always connected to key treatments and aimed at removing from the fabric insoluble matters, matters already in solution or an emulsion of other impurities. During the fabric preparation process, for example, washing is carried out after desizing, boiling and other bleaching and mercerising processes; in dyeing, the washing stage is necessary to complete the dyeing process itself or to eliminate the dyestuff which has not been fixed; during the printing stage, washing performs a finishing action. When using vat dyes or disperse dyes, the washing process aims at removing insoluble pigment substances from the fibre surface by means of wetting or dissolving agents.

This could therefore be considered a crucial treatment in the whole textile process, because of the frequent use and strong economic impact. Manufacturers increasingly focus their attention on reducing water consumption, which leads to subsequent energy and hot water saving as well as a reduction in wastewater. Together with traditional washing systems with vats equipped with "vertical cylinders" the market offers horizontal washing units, which reduce the liquor ratio and the energy and water consumption for each kilogram of washed material.

Washing includes a chemical-physical process, which removes the dirt from the substrate, and a series of physical operations aiming at improving the "feedback action".

THE SEQUENCE OF THE VARIOUS WASHING STEPS IS THE FOLLOWING:

a. Formation of the detergent liquor (transfer of matter + energy by mixing);

b. Reaching of the process temperature and wetting (transfer of the liquor to the material);

c. Separation of impurities and emulsification (transfer of matter from one step to the other);

d. Removal of the liquor from the fibre (transfer of macroscopic matter);

e. Drying (interstage transfer of heat and matter).

Often these steps occur simultaneously. The use of surfactants (detergents) during the washing stage is extremely important to speed up the wetting of the textile material, to facilitate the removal of dirt from the substrate, thus keeping the emulsion inside the liquor and preventing the particles laying down again on the fibre.
Crucial factors are water (which must be quite soft to avoid precipitation of Ca and Mg salts which could give a rough and coarse hand to the textile) and chemical products to be used (emulsifying agents, softening agents and surfactants).

**TYPES OF WASHING:**

Washing can be performed on fabrics either in open-width or in rope form. Rope washing is more effective than open-width washing thanks to a stronger mechanic action, which favors the cleansing, and the relaxation of the fabric structure; for delicate fabrics an open-width washing must be preferred to avoid marks and creases. Open-width washing is also the best choice for processing huge lots.

**ROPE WASHING**

Substantially, batch piece washing machines are made up of a couple of squeezing cylinders, which make the fabric swell (the fabric is previously sewn on top and bottom and takes the shape of a continuous ring); these cylinders are assembled inside a vessel, whose lower part contains the detergent liquor. It is possible to wash a fabric inside this vessel, by feeding it into restricted area without laying it stretched out.

![Rope washing machine](image.png)

The efficiency of this operation is enhanced by the mechanic action, which facilitates both detergency and tension relaxation. This operation is highly cost-efficient because open-width washing allows only one working position and therefore only limited loads can be processed (max. 180 kg) while a rope washing machine can include from one to eight ropes, with an
overall weight exceeding 600 kg. Furthermore rope washing machines grant reduced operating times thanks to a more effective mechanic action.

**OPEN-WIDTH WASHING**

An open-width washing machine is usually a system featuring a vertical path washing with driven cycle of multiple action baths, with a resulting 30/40% water and steam saving. This operating unit is manufactured in several versions (10-15-30 meters) and can be used for every kind of preparation and finishing treatment. Four different washing actions alternate inside this machine:

1) Washing on rising paths;

2) Washing on sloping-down paths, carried out by means of spray nozzles, which atomise on both face and back of fabrics, performing a strong penetration action;

3) "Vibraplus" effect washing, which removes from the fabric the threadlike elements (fibrils) that do not dissolve in water;

4) Extraction washing by means of vessel intermediate squeezing. The longitudinal tension of the fabric remains perfectly unchanged on the whole path; it can be adjusted between 5 and 20 kg by means of upper cylinders equipped with self-adjusting control system which generates a sliding motion crease-and-fold proof also on extremely delicate fabrics. Plush fibrils are removed from the vessel with no need for brushes or liquor dilutions.

![Open-width washing machine](image)
Another type of machine divides the washing process into single steps, which are systematically repeated. In this way the whole process can be not only constantly monitored but also accurately calculated.

EQUIPMENTS AND NEW METHODS OF DYEING

METHODS OF DYEING

Colour is applied to fabric by different methods of dyeing for different types of fiber and at different stages of the textile production process. Dyeing can be done during any stage in the textile manufacturing process. Textiles may be dyed as fibre, as yarn, as fabric, as garments, depending upon the type of the fabric or garment being produced.

THESE METHODS INCLUDE:

1. Direct dyeing;
2. Stock dyeing;
3. Top dyeing;
4. Yarn dyeing;
5. Piece dyeing;
6. Garment dyeing
7. Solution pigmenting or dope dyeing etc.

Of these Direct dyeing and Yarn Dyeing methods are the most popular ones.

1. DIRECT DYEING

When a dye is applied directly to the fabric without the aid of an affixing agent, it is called direct dyeing. In this method the dyestuff is either fermented (for natural dye) or chemically reduced (for synthetic vat and sulfur dyes) before being applied. The direct dyes, which are largely used for dyeing cotton, are water soluble and can be applied directly to the fiber from an aqueous solution. Most other classes of synthetic dye, other than vat and sulfur dyes, are also applied in this way.

2. STOCK DYEING

Stock dyeing refers to the dyeing of the fibers, or stock, before it is spun into yarn. It is done by putting loose, unspun fibres in to large vats containing the dye bath, which is then heated to the appropriate temperature required for the dye application and dyeing process.
Stock dyeing is usually suitable for woolen materials when heather like color effects are desired. Wool fibre dyed black, for example, might be blended and spun with un-dyed (white) wool fibre to produce soft heather like shade of grey yarn. Tweed fabrics with heather like color effects such as Harris Tweed are examples of stock dyed material. Other examples include heather like colours in covert and woolen cheviot.

3. TOP DYEING

Top dyeing is also the dyeing of the fibre before it is spun into yarn and serves the same purpose as stock dyeing – that is, to produce soft, heather like color effects. The term top refers to the fibres of wool from which the short fibres have been removed. Top is thus selecting long fibres that are used to spin worsted yarn. The top in the form of sliver is dyed and then blended with other colors of dyed top to produce desired heather shades.

4. YARN DYEING

Yarn dyeing is the dyeing of the yarns before they have been woven or knitted into fabrics. Yarn dyeing is used to create interesting checks, stripes and plaids with different-colored yarns in the weaving process. In yarn dyeing, dyestuff penetrates the fibers in the core of the yarn.

![Yarn dyeing](image)

**THERE ARE MANY FORMS OF YARN DYEING:**

- Skein (Hank) Dyeing,
- Package Dyeing,
- Warp-beam Dyeing, and
- Space Dyeing.
A. SKEIN (HANK) DYEING
Skein dyeing consists of immersing large, loosely wound hanks (skeins) of yarn into dye vats that are especially designed for this purpose. Soft, lofty yarns, such as hand knitted yarns are usually skein dyed. Skein dyeing is the most costly yarn-dye method.

B. PACKAGE DYEING
In package dyeing the yarn is wound on a small perforated spool or tube called a package. Many spools fit into the dyeing machine in which the flow of the dye bath alternates from the center to the outside, and then from the outside to the center of the package. Package dyed yarns do not retain the softness and loftiness that skein-dyed yarns do. They are however satisfactory and very widely used for most types of yarns that are found in knitted and woven fabrics.

C. WARP BEAM DYEING
Beam dyeing is the much larger version of package dyeing. An entire warp beam is wound on to a perforated cylinder, which is then placed in the beam dyeing machine, where the flow of the dye bath alternate as in the package dyeing. Beam dyeing is more economical than skein or package dyeing, but it is only used in the manufacture of woven fabrics where an entire warp beam is dyed. Knitted fabrics, which are mostly produced from the cones of the yarn, are not adaptable to beam dyeing.

5. PIECE DYEING
The dyeing of cloth after it is being woven or knitted is known as piece dyeing. It is the most common method of dyeing used. The various methods used for this type of dyeing include jet dyeing, Jig dyeing, pad dyeing and beam dyeing.

6. GARMENT DYEING
Garment dyeing is the dyeing of the completed garments. The types of apparel that can be dyed are mostly non-tailored and simpler forms, such as sweaters, sweatshirts, T-shirts, hosiery, and pantyhose. The effect on sizing, thread, zippers, trims and snaps must be considered. Tailored items, such as suits or dresses, cannot be dyed as garments because the difference in shrinkage of the various components and linings disorder and misshape the article.
Garment dyeing is done by placing a suitable number of garments (usually about 24 sweaters or the equivalent, depending on the weight) into large nylon net bag. The garments are loosely
packed. From 10 to 50 of the bags are placed in large tubs containing the dye bath and kept agitated by a motor–driven paddle in the dye tub. The machine is appropriately called a paddle dryer.

MODERN MACHINERY USED IN DYEING PROCESS:

Modern dyeing machines are made from stainless steels. Steels containing up to 4% molybdenum are favored to withstand the acid conditions that are common. A dyeing machine consists essentially of a vessel to contain the dye liquor, provided with equipment for heating, cooling and circulating the liquor into and around the goods to be dyed or moving the goods through the dye liquor. The kind of machine employed depends on the nature of the goods to be dyed. Labor and energy costs are high in relation to total dyeing costs: the dyers aim is to shorten dyeing times to save steam and electrical power and to avoid spoilage of goods.

Modern dyeing machine

The conical-pan loose-stock machine is a widely used machine. Fibers are held in an inner truncated conical vessel while the hot dye liquor is mechanically pumped through. The fiber mass tends to become compressed in the upper narrow half of the cone, assisting efficient circulation. Leveling problems are less important as uniformity may be achieved by blending the dyed fibers prior to spinning.

The Hussong machine is the traditional apparatus. It has a long, square-ended tank as a dye bath into which a framework of poles carrying hanks can be lowered. The dye liquor is circulated by an impeller and moves through a perforated false bottom that also houses the open steam pipe for heating. In modern machines, circulation is improved at the points of
contact between hank and pole. This leads to better leveling and elimination of irregularities caused by uneven cooling. In package-dyeing machines dye color may be pumped in rather two directions:

1. Through the perforated central spindle and outward through the package or
2. By the reverse path into the outer layers of the package and out of the spindle. In either case levelness is important.

Some package-dyeing machines are capable of working under pressure at temperatures up to 130°C.

The winch is the oldest piece of dyeing machine and takes its name from the slated roller that moves an endless rope of cloth or endless belt of cloth at full width through the dye liquor. Pressurized-winch machines have been developed in the U.S.

In an entirely new concept, the Gaston County jet machine circulates fabric in rope form through a pipe by means of a high-pressure jet of dye color. The jet machine is increasingly important in high-temperature dyeing of synthetic fibers, especially polyester fabrics. Another machine is the jig. It has a V-shaped trough holding the dye color and guide rollers to carry the cloth at full width between two external, powered rollers, the cloth is wound onto each roller alternately, that is, the cloth is first moved forward, then backward through the dye color until dyeing is complete. Modern machines, automatically controlled and programmed, can be built to work under pressure.