Subject: Dyeing and Printing

Unit 2: Fabric preparatory process for dyeing and printing

Quadrant 1 – e-Text

Learning Objectives

The learning objectives of this unit are:

- Outline the Preparatory Process involved in Dyeing and Printing.
- Explain various operations in different departments in a processing house.
- Describe important pre-treatment process sequence for different types of fibers.

2.1 The Preparatory Process for Dyeing and Printing

This diagram shows the general preparatory process sequence carried out on grey cotton fabric.

2.2 Various Operations in Different Departments in a Processing House

2.2.1 Singeing
Singeing is the process of removing protruding fibers from the surface of the yarn or fabric by burning. Fuzzy and protruding fibres are removed by burning them off. It is important for the fabrics that are required a clear and smooth surface for printing.

Singeing is usually performed on both sides of the fabric. This is done in a singeing machine.

In a singeing machine, a fabric is passed over open flame at very high speed (200-400 mts/min) to prevent scorching. Then it is passed through water (or de-sizing bath) to extinguish any sparks. Uneven singeing may lead un-level dyeing. Therefore, the fabric is passed through singer flat, in open width and under slight tension. The gas burner should be properly controlled and maintained; otherwise streaky dyeing may occur.

2.2.2 Desizing

De-sizing removes starch from the fabric and makes the fabric more absorbent.

Rot steeping is the oldest and cheapest method, because no chemical is used in this treatment. The rot steeping process consists of three steps.
The fabric is first soaked in warm water (35 – 40°C) then passed through a padding mangle and squeezed. It is allowed to stand for 24 hrs. after that, it is hot washed. During storage, bacterial growth takes place, which helps effective removal starch materials.

These are the steps for Rot steeping.

![Diagram of Rot steeping process]

**Step 1:**
Wetting and Squeezing in a 3 bowl padding mangle.

**Step 2:**
Steeping of wet fabric in a storage tank.

**Step 3:**
Washing in a rope washing machine.

**Advantages and Disadvantages**
Rot stepping is the most economical and simplest process.

However, it is time consuming, can result in unevenness in desizing and there is no control over the process.

**The Acid Steeping Method**
In the Acid Steeping method, dilute Hydro Choleric Acid or Sulphuric Acid or a mixture of both are used to hydrolyze the starch from the sized fabric. The fabric is steeped in 0.25% to 0.5% (10 g/l) of the acid, passed through padding mangle and kept for 6 hrs.
The temperature rises to 50°C. The starch present in the fabric is liquefied and is easily removed by washing. Since, acid can attack cellulose care has to be taken to avoid damaging the cotton. The fabric should be washed with hot water after desizing.

**Advantages and Disadvantages**

The acid steeping process is less time consuming than the rot steeping process.

The main disadvantage is that there is no control over the process.

**Oxidative Desizing**

In this process starch is oxidized. The commonly used oxidative desizing agents are Hydrogen per Oxide Sodium Bromide. Ammonium Persulphate. Hydrogen peroxide of 1-2 volume concentration & caustic soda (7-15 gpl ) is prepared in padder. The cloth is first impregnated at room temperature and steamed for 3 minutes. During this process, some degree of bleaching also takes place.

**Advantages and Disadvantages**

In this process the time required for desizing is less and the process is continuous.

Water and energy consumption is less.

Combination with other preparatory process such as scouring and bleaching is possible.

Excellent and uniform removal of size.

The disadvantage are: there may be possibilities of penta-chloro phenol content in the de-sized fabric that may be harmful.

It is also an expensive process.

**Enzymatic Desizing**

It is the most effective and widely used method. Enzymes are bio-catalysts of organic origin which are produced by living organisms. Chemically, enzymes are proteins of high molecular weights. Amylases are the enzymes used in desizing. There are two categories namely α-amylase and β- amylases. These enzymes can be derived from sources like animal (pancreatic) and vegetable (malt and bacterial).

This table displays the enzymes and conditions for desizing.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Amylase Enzyme</th>
<th>Conc. gpl</th>
<th>Temp C</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Malt</td>
<td>5 – 20</td>
<td>50-60</td>
<td>6-7.5</td>
</tr>
<tr>
<td>2</td>
<td>Pancreatic</td>
<td>1 – 3</td>
<td>50-60</td>
<td>6.5-7.5</td>
</tr>
<tr>
<td>-----</td>
<td>------------</td>
<td>-------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>3</td>
<td>Bacterial</td>
<td>0.5 - 1</td>
<td>60-70</td>
<td>5.5-7.5</td>
</tr>
</tbody>
</table>

The fabric is passed slowly through a saturator where it is thoroughly impregnated with the desizing bath and then stored for 8-12 hrs usually in the rollers. The impregnating bath is prepared with the required amount of the enzyme, a wetting agent and a proper salt (Sodium Polyphosphate or NaCl). After batching, the fabric is thoroughly washed with hot water.

### 2.2.3 Scouring

Scouring is the process of removal of natural oil substances like waxes, fats and pectin's as well as added impurities like lubricating oil, dust, dirt and residual starch in the cotton materials.

**Reactions during Scouring**

During scouring:

- Oils, waxes and free fatty acids are emulsified by the soaps.
- Pectin's are converted into soluble salts.
- Proteins are degraded to simple soluble amino acids and mineral matter is dissolved.
- Dirt is removed and other added impurities are broken into soluble products.

**Kier**

A kier is a cylindrical vessel capable of holding 250 to 5000 kgs of fabric. It is provided with temperature, pressure gauge and safety valve.
**For kier boiling:**

A mixture of 5-10 g/l caustic soda solution, 1% sodium silicate, 1% soap along with wetting agent are used. The circulation of hot alkaline liquor through the fabric is carried out under pressure (at 25-30 psi and 130-135°C) for period of 6-12 hrs, depending on the type of fabric. In the atmospheric scouring process (open kiering) is at 95-98°C for a duration of 4-6 hours. This is followed by hot and cold washes to complete the process.

**J-Box Continuous Scouring**

In continuous machines, scouring can be carried out, through a series of J-Boxes for progressive desizing and scouring. The desized and washed fabric is padded with strong alkali solution (5-10 gm/lit NaOH or mixture of NaOH & sodium carbonate), emulsifying agent and wetting agent. After padding the saturated cloth, it enters in to J-Box where it remains for 40-60 mins in plaited form at a temperature of about 100°C. The cloth before entering J-Box is rapidly preheated by means of steam in U-shaped heating tube. The internal surface of the entire J-Box is very smooth to avoid any friction in the moving cloth.
2.2.4 Bleaching

Bleaching is done to remove the natural coloring matters and make the fabric in required whiteness with minimum damage to fibers, and within the shortest possible time. The main bleaching agents are Sodium Hypo Chlorite, Sodium Chlorite, Sodium Perborate and Sodium Percarbonate. Hydrogen peroxide. “Universal bleaching agent.” Almost all textile fibers like, cotton, silk, wool, polyester/cotton blends are bleached with hydrogen peroxide.

Types of Bleaching

**Full bleach** is done generally when highest degree of whiteness is required and going to be used as a white fabric for apparels or to be printed with white background. This is achieved by bleaching with hypochlorite followed by hydrogen peroxide bleach.

**Half bleach** is done for fabrics meant for dyeing and printing where more absorbency is required than the whiteness and fabrics going to be used during finishing. This is generally done using by bleaching with hypochlorite or hydrogen peroxide of adequate concentration.

**Sodium Hydrochlorite Bleaching**

The yarn or cloth after scouring is thoroughly washed before bleaching and is squeezed or hydro extracted to remove excess water as otherwise it would dilute the bleach liquor or “chemicking”.

In typical batch treatments of cotton fabrics with sodium hypochlorite in kiers, the bleaching bath is prepared as follows:
- Sodium hypochlorite 1-3 gm/lit of available chlorine
- Ph of the bath 11 – 11.5
Temperature Room temperature (30 – 40 c)
Time 45 min – 2 hrs

Since the bleaching is done in alkaline medium (pH 10-11) the alkali, which is present in the material has to be neutralized with dilute mineral acid after bleaching. It is referred to as “souring”.

Advantages and Disadvantages

Hydrochloride bleaching is a powerful and economical way of processing. It is free from the defects of bleaching powder. However, excessive chlorine may cause pollution. All protein impurities must be completely removed before bleaching, otherwise the fabric may turn yellowish. The residual chlorine must be removed.

To remove the residual chlorine, the fabric is to be washed with Sodium-thio-sulphate (chlorine destroyer) or hydrogen peroxide (weak solution). The chlorine will wash away. This treatment is called “antichlor”.

Hydrogen Peroxide Bleaching Process

Bleaching bath is prepared as:

- Hydrogen peroxide - 1.5 Volume
- Sodium silicate - 2 gpl
- Wetting agent or detergent - when needed
- pH - 10.2 – 10.8
- Temperature - 80º – 95º C

Bleaching is carried out near or above boiling temperature, under pressure, for 1 hour or more. After bleaching, the fabric is thoroughly rinsed with slight amount of basic solution to avoid formulation of insoluble silicates.

Advantages

Hydrogen per oxide is a universal and is used extensively for the bleaching of cotton materials. It:

- Can be employed for bleaching fibers like wool, silk, polyester and other man-made fibers also, under a wide range of application conditions.
- Requires less manipulation of fabric and hence less labour.
- Results in lesser loss in weight of fabric than that with Hypochlorite bleaching.
- Is more absorbent than hypochlorite bleached fabrics.
- Has no possibility of the fabric yellowing.
**Continuous Bleaching Process J-Box**

In this process desizing, scouring and bleaching are combined together. These are very attractive options since savings in time, energy, labor, etc., are possible. However, combined operations are not always sufficient for preparation of certain cotton fabrics for dyeing and finishing.

In this method, the fabric is padded with the enzyme bath and then passed into a wet steam chamber at 960°C - 1000°C, where the desizing takes place in less than a minute.

The fabric after desizing is impregnated a solution of 4-6% NaOH, 1-3 g/l wetting agent, and 1-3 g/l emulsifier at the period of 2-3 minutes.

The fabric after impregnation is taken out and piled into J-box at 980°C and allowed to remain there for two hours during which period the alkali reacts with the impurities.

The fabric is then rinsed and impregnated with 1% hydrogen peroxide at pH 10.5 using 1% sodium silicate as a stabilizer and wetting agent.

The cloth after impregnation is again heated to 90-95°C and stored for an hour in J-box.

It is then rinsed thoroughly.
2.2.5 Bio Polishing

Surface modification of cellulosic fabrics to improve their cleaner surface, cooler feel, brighter luminosity of color, softer feel, more resistance to pill using cellulase enzyme is called bio-polishing.

It can be applied to woven and knit cellulosic fabrics like cotton, linen, rayon and their blends. The elimination of micro fibrils of the cotton fibers is obtained by the controlled hydrolysis of cellulose.

Bio-polishing may be carried out at any time during wet processing, it is most conveniently performed after bleaching.

2.2.6 Optical Brighteners – Fluorescent Whitening Agents (FWA)

The purpose is to obtain extraordinary brilliant whiteness to cotton materials. Optical brighteners acts as fluorescent dyes and they are colorless. They absorb light near to ultraviolet region (below 400nm) and re-emit the light in the violet blue visible region.

Near white bleached cloth, possesses a yellowness caused by absorption in the blue region. When FWA is applied, the blue florescence complements the yellowness and adds a bluish hue to the fabrics, which the eye appreciates as brilliant white.

Application of Optical Brighteners

Optical brighteners are classified as direct, disperse and cationic types. The direct brightening agents are mainly used for the brightening of cotton, linen, viscose and nylon materials. The acid florescent brightening agents serve mainly for the brightening of silk and wool fabrics. The
Disperse florescent brightening agents are used primarily for polyester, acetate and acrylic materials.

2.2.7 Mercerization

Mercerization is defined as the treatment of cotton fabrics or yarns with a cold concentrated solution of Sodium Hydroxide solution for one minute or less is called mercerization. Cotton fibers swell, untwist and their bean shaped cross section changes into round form.

![Cotton cross sectional view and cotton longitudinal view](image)

These images here shows cotton cross sectional view and cotton longitudinal view.

The Effect of Mercerization

![Effect of Mercerization](image)

This image shows the effect of mercerization.
1: A cross section before mercerization
2 – 5: The swelling process in 18% NaOh
6: Rinsing process after swelling
7: Final state

Mercerization improves the following properties. It modifies the internal reorientation of cellulose structure. It increases the strength is increased by 15-25%. Improves elasticity and dimensional stability. It enhances luster and feel. Improves absorbency of water, dyes and other finishing chemicals. Increases the uniformity of dyeing. Improvises the color yield by increasing the dye affinity, resulting in enhanced colour fastness and saving in cost of dyestuffs.
The Mercerization Process

The fabric is padded with about 20-25% NaOH solution containing a wetting agent. It is then passed over several cans to allow a doweling time of approximately one minute. During this time, NaOH will penetrate the fibers and react with them. At this stage, the tension is applied lengthwise. The fabric is then placed on a stenter frame and is pulled to its desired dimensions (Tension is applied in both the warp and filling direction). While on the stenter frame, the fabric is washed by spraying water until the concentration of Sodium Hydroxide is reduced to less percent. The fabric is then washed by passing through several washers, one of which contains a diluted Sulphuric acid or Acetic acid.

2.3 Wool Preparatory Process

2.3.1 Preparation of Wool

Impurities present in wool are animal fat, suint (dried perspiration), dirt, mineral and vegetable matter. Animal fat is a wax which can be removed by the formation of emulsion with alkali. Suint is soluble in water. The dirt and sand in the wool are removed during scouring by mechanical agitation.

2.3.2 Cleaning of Wool

Wool Scouring

The technique consists of passing wool fibres through a series of four long narrow bowls containing soap or non-ionic synthetic detergents and sodium carbonate at a temperature of 40-550°C.

This table displays the details for the wool scouring process.

<table>
<thead>
<tr>
<th></th>
<th>Detergent</th>
<th>Soda ash</th>
<th>pH</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – bowl</td>
<td>0.25%</td>
<td>0.25%</td>
<td>9-10</td>
<td>48-52°C</td>
</tr>
<tr>
<td>2 – bowl</td>
<td>0.2%</td>
<td>------</td>
<td>10</td>
<td>46-50°C</td>
</tr>
<tr>
<td>3 – bowl</td>
<td>0.1%</td>
<td>------</td>
<td>------</td>
<td>43-46°C</td>
</tr>
</tbody>
</table>
Raw wool scouring machine contains four bowls. Each bowl consists of a long trough provided with a false bottom. Soap and alkali are added to the first bowl. Detergent is added to the 2nd & 3rd bowls and only water in the 4th bowl.

Carbonizing
Cellulose material such as leaves, grass, seeds, and vegetable fibers are removed. The wool is treated with a diluted solution of H2SO4, then dried, and cured. Cellulose materials decompose to form a very fine black powder, which can be easily dusted out.

**Wool Bleaching**

Two methods of bleaching are commonly used. The **oxidation method** using hydrogen peroxide. The reduction method employing sulphur dioxide, sodium bisulphate or sodium hydrosulphite. Sometimes, the wool is bleached with peroxide followed by bleaching with sulphur dioxide.

This is a method of **peroxide bleaching under acidic conditions**. The bath is made up of 4 volume of H2O2 containing 0.25% formic acid and adjusted to pH 3 to 3.5 at room temperature. The scoured material is impregnated with the peroxide solution on a padding mangle, and allowed to stand overnight, it is then washed.

**2.3.3 Silk Preparatory Process**

Silk is a protein fibre made up of fibre forming protein called fibroin. This fibre forming protein is coated heavily with a gum protein called sericin, which gives it a harsh and stiff feel and hides the rich luster and whiteness of the silk filament. This sericin gum has to be removed as the first preparatory process of silk before dyeing. A typical silk filament is composed of Fibroin- 75-80% and Sericin- 20-25%.

![Micrograph of silk filament showing fibroin and sericin layers](image-url)
2.3.4 Cleaning of Silk  
**Degumming with Synthetic Detergents**

Synthetic detergents are now being increasingly used in place of soap. Their main advantage is that they permit continues processing of piece goods and the time of treatment is shorter (40 minutes).

In this method, the material is treated with 2.5 to 5 g/l detergent (Sandopan SRS liq. of Sandoz) at pH 11.2 to 11.5 for 30 to 60 minutes at boiling temperature.

Finally, it is rinsed thoroughly first with hot and then cold water. The disadvantage of this method is that the soft feel is not always obtained.

Treatment with some protein enzymes like trypsin or papain may dissolve the sericin gum. The treatment is time consuming and involves a three-step process. This treatment is longer than that with synthetic detergents.

2.3.5 Degumming with Enyzmes - The three step process:

In the first step, the material is first treated with 0.5 g/l soda ash; 0.5 g/l Glauber’s salt; 3 g/l penetrating agent like Imerol XN liq. (Sandoz); at boil for about 1 hour.

In the second step, it is then treated with 1-5 gpl sericin dissolving enzyme(trypsin or papain), 1gpl soda ash, 2gpl Glauber’s salt at 450C.

Finally, in the last step, the above material is treated in the 3rd bath with 0.5gpl Soda ash, 2gpl Sodium Silicate, 2gpl Penetrating agent and 0.5gpl Glauber’s salt at boil for one hour.

2.3.6 Bleaching of Silk

The process of bleaching silk, consists of boiling the material with, 1-2 volumes of Hydrogen Peroxide concentration (0.3-0.6%) and 2gpl sodium silicate for 2hrs, which is followed by a hot wash. As an alternate method, the amount of silicate can be reduced using a small portion of ammonia to bring the pH to 10.

Here the mixture of 0.8gpl ammonia and 1.5gpl sodium silicate, the temperature is kept at 70-750C & time 5-6 hrs.

The silk is then soaped at 80-850C, and washed in hot and cold water.

2.4 Polyester Preparatory Process

2.4.1 Pre-treatment for Polyester
Fabrics made for 100% polyester containing size material, spin finishes, coning oil and tinting colors as major impurities, and do not have any natural impurities.

**De-sizing**
Polyester fabric consists of only water soluble size materials such as polyvinyl alcohol etc., which can be removed by a treatment with a mild alkali such as polyvinyl carbonate (up to 4 gpl detergent a 70-80°C for one hour. The fabric is then washed hot and cold.

**Scouring**
100% polyester fabric can be scoured using 1-5gpl sodium carbonate and 1-5 gpl detergent at a temperature 60-700C for 60-90min using a jet dyeing machine or any other dyeing machine.

**Bleaching**
For full white fabrics, Polyester can be treated with 1-5 gpl sodium chlorite, 1-2 gpl sodium nitrate and 1-2 gpl formic acid (85%) (pH 4.5) at boil for 60-90 minutes. The goods are then washed hot and cold.

### 2.4.2 Heat-setting of Synthetic Fabrics

Heat setting or thermosetting is a heat treatment applied to fabrics made of thermoplastic fibers such as polyester or nylon to impart dimensional stability. Heat – setting temperatures are well above the glass transition temperature (T°g) of the fiber, heat is applied by means of hot air, heated cans, or steam.

The treated fabric acquires dimensional stability, i.e. a memory to the shape it was during the heat setting.

It will resist shrinkage and creasing, and will have the ability to maintain pleats present in the garment during the heat-setting treatment. In a typical heat-setting of polyester, the fabric is placed on a stenter frame set to the desired final width. Temperature chosen in the range of 190 - 215°C for 30 to 90 seconds.

Heat-setting affects the dye ability of the fiber. Usually it decreases its dye-ability, and therefore when performed before dyeing it is extremely important to apply the heat-setting uniformly. Uneven temperature in the oven may cause difference in the fabric from the selvedge-to-selvedge and/ or from selvedge to center, which will show later as uneven dyeing.

### 2.5 Conclusion

To summarize, in this unit, you have learnt about the preparatory process involved in dyeing and printing. You have also reviewed the operations in different departments in a processing house – Cotton preparatory process, Wool preparatory process, silk preparatory process and the polyester preparatory process. Finally, you have also examined the important pre-treatment process sequence for different type of fibers.