

Chapter 3
DESIZING

3.1 Introduction

Desizing is the process in which the size applied to the warp yarn before weaving is removed to facilitate the penetration of dyes and chemicals in the subsequent wet processing operations. About 65% of the cotton used for textiles is made into woven fabric. The purpose of sizing is to form coating of sufficiently strong and elastic film around the cotton warp yarns so as to stand the tension during weaving and reduce the breakage. The surface coating of sizes are stiff, hard, smooth and less absorbant to water. Apart from film forming materials, the size recipe many a time also contains other additions such as humectants, binders and lubricants. Traditionally, starch-and tallow based lubricants (triglycerides) have been used as sizing components for cotton, being readily available, relatively cheap, and based on natural, sustainable materials. The removal of hydrophobic part of the sizes (the lubricants) is often especially problemetic. These are not removed during desizing, but are expected to be stabilised or emulsified in the alkaline scouring. The total material present in the cotton fibre is up to 20% of the fibre weight including that of 4-12% natural impurities. In the process of desizing, not only sizing agents, but also some natural impurities are eliminated from fibres.

About 75% of the sizing agents used throughout the world today consist of starch and its derivatives because of its low cost. Chemically starch is composed of amylose and amylopectin. Amylose molecule is in the form of helix with six glucose units per turn (Fig. 3-1). The low molecular weight of amylose is water soluble

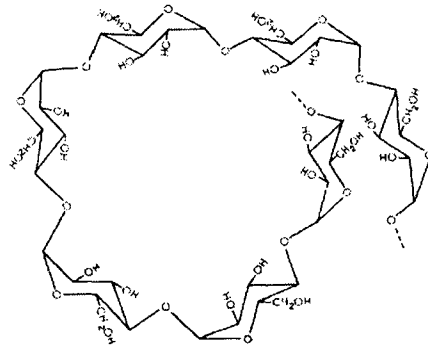


Figure 3-1. Helical structure of amylose [1].

straight chain polysaccharides of glucose whereas amylopectin (70-80%) being water insoluble is difficult to remove from cotton due to its higher molecular weight and branches chain (Fig. 3-2). Apart from starch, modified starches such as

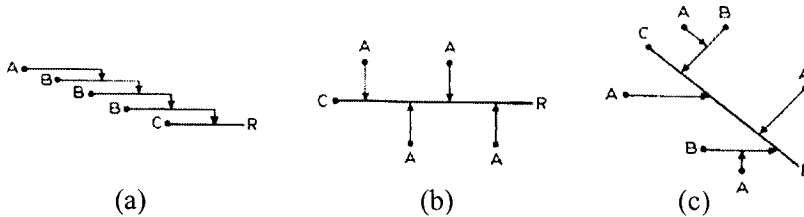


Figure 3-2. Schematic representations of amylopectin [2].

R = Reducing end.

A = Non-reducing end of singly connected chain.

B = Non-reducing end of multiply connected chain.

C = Non-reducing end of chain which carries a reducing end.

hydroxyethyl starch, carboxymethyl cellulose (CMC) and natural gums are also used. The other size ingredients particularly used in the case of regenerated cellulose fibres are protein based glue, gelatin etc.

In synthetic fibres the nature of sizes and sizing ingredients are different. Synthetic yarns are stronger and hence increasing strength by sizing is not the aim and adhesion of the sizing material to the yarn is also difficult. Starch sizing of man-made fibres possess many problems when yarns are slashed and fabrics are woven. Furthermore, with the introduction of textured synthetic fibre yarns, blended fibre fabrics, introduction of jet looms, system of dyeing and sizing together, permanent application of sizing, solvent sizing etc., change the pattern of sizing with conventional sizing ingredients. The demand for increasing the warp speed has also led to the development of special synthetic polymers and paraffin-based lubricants. The main synthetic sizes comprise of polyvinyl alcohol (PVA), polyacrylic acid, CMC, series of plasticised acidic vinyl acetate and acidic methyl acrylate polymers.

PVA is the oldest and best known group of synthetic sizes. PVA dries to form a tough to hard film of poor flexibility. The bars due to stoppages in sizing of pure cotton are dreaded and cause difficulties in dry splitting. The solubility of PVA can be impaired by heat applied during sizing, grey fabric heat-setting or singeing, an important point which influences desizing. The various grades of PVA can be differentiated depending on the degree of hydrolysis (of acetate groups of polyvi-

nyl acetate into hydroxy groups) and/ or the degree of polymerisation (viscosity).

There is a very wide variety of acrylic monomers that can be synthesised by various processes to yield products of different properties. They are derived from acrylic acid and from acrylic esters. The chemical structure thus decides the solubility of an acrylic sizes in water or whether it is so resistant to water that it is suitable for jet looms. Under high humidity conditions, many of the acrylic copolymer sizes absorb water and become tacky causing blocking on the beam, preventing the unwinding of the warp. Polyacrylates are compatible with other sizing agents like starch, CMC or PVA and sometimes give rise to synergistic effects. If acrylates are mixed with starch, good condition can be assured for effluent treatment. The adhesion of PVA can be controlled by CMC or acrylic sizing agents.

CMC and water dispensible polyester based size materials are also used for sizing of synthetic fibre materials. They are insoluble in acidic form and soluble in the presence of dilute alkali and can be removed from the fabric at about 60°C. They are, however, precipitated in presence of metal ions in the washing bath and hence the addition of chelating agent is recommended to nullify its effect. Synthetic detergents of either anionic or non-ionic type may be used to remove the polyester size from the fabric. The CMC can be reclaimed, recycled and reapplied from other size material.

In many cases efficiency of one type of size is inadequate and they must therefore be combined with other sizing agents to accommodate good adhesion, film flexibility, viscosity, compatibility with salts in hard water, abrasion resistance, washing out properties and possibilities of removal of the size and recycling the size from the effluent. By using synthetic polymers not only the quality of weaving is improved, but also reduce the amount of sizing additive, thus reducing the pollution and improvement in handle. Solvent soluble sizes are, however, a development for the future. Further, the easily removable sizing materials are preferred as the milder desizing and scouring treatments are required for synthetic fibres.

3.2 Methods of Desizing

Desizing of cotton fabric can be accomplished by physical, chemical or combination of physical and chemical mechanism, namely rot steeping, acid steeping, treatment with enzyme and oxidising agents. In desizing, the starches and polymers that are applied which are insoluble, are converted into water soluble com-

pound to ease their removal. This is accomplished by transferring the starch into their simple sugars or simple water soluble polymers. The synthetic sizes used for man-made fibres are generally water soluble and they are removed during the scouring operation.

3.2.1 Rot steeping

In this method grey cotton fabric is steeped in water in suitable box at a temperature of about 30-40°C. During the storage micro-organisms develop excreting enzymes which attack the starch. The swollen and hydrolysed starch is thus partially converted into soluble state which are then removed from the fabric by normal washing with water. The main problems in this method are low efficiency due to longer treatment time and degradation of cellulose due to cross-infections of mildew if the fermentation process is not properly controlled.

3.2.2 Acid desizing

In this method cotton fabric is treated with dilute sulphuric acid with a concentration of 5-10 g/l at a temperature of about 40°C for 3-4 h. Dilute acid attacks the polymer chain of starch and due to chain cleavage of starch molecule short water soluble or dispersible chain segments are formed. With sulphuric acid higher than 10 g/l and above 50°C there is always the possibility of weakening the cloth or causing holes [3,4]. The treated cloth must not be allowed to dry at all otherwise degradation of cotton will occur at the dried area. Rise in temperature increases the rate of reaction, but at the same time there is possibility of attacking the cellulose chain. Generally, the rate of reaction doubles for each 10°C rise in temperature. The acid-steeping method is particularly suitable for cotton varieties containing large metal contents as the mineral acid converts the metals to their corresponding sulphate which are water soluble. The degraded starch is removed from the fabric by normal washing treatment.

3.2.3 Enzymatic desizing

The word enzyme is from Greek words for 'in yeast' and was coined in 1876 by the German biochemist Willey Kuhne [5]. Enzymes are organic biocatalysts highly specific both in the reaction catalysed and their choice of reactants (substrate). Physically enzymes are colloidal nature and chemically they are of the nature of protein. Enzymes are complex and have high molecular weights [6]. Today enzymes are produced by biotechnological processes in great amount of constant quality, and are therefore applicable to large-scale processes. Advances in the field

of genetic engineering allow enzyme manufacturers to design specific enzymes for specific processes (with regard to temperature stability or an optimum pH, for example).

Enzymes can originate from animal or vegetable sources. Around 1900, the German Diamalt Co. of Munich introduced Diastafor, the commercial desizing compound, to the trade. Around 1912 enzymes extracted from slaughter house wastes became available. Generally, these contained four enzymes two of which reacted primarily with albumin and casein, one decomposed and reacted with starch. In 1919 bacterial diastase became available under the trade name Rapidase (Wallerstein & Co.), which rapidly liquified starch to dextrin. The main enzymatic development within starch desizing has so far been the introduction of amylase products (Diastafor) optimised to different temperature ranges. Malt amylases fall into two categories and are named the α (alpha) and β (beta) species which are found to be present in the ratio of 1.5 to 1.6. α -amylases are capable of hydrolysing starch molecules at random present in the sizing preparation, transform starch to dextrans, breaking them down to soluble sugars thus helping in eventual desizing. β -amylase attacks straight chains, cleaves the units and produces maltose, so that molecular chain of starch is shortened gradually. When an α -amylase is applied to a starch solution, it is found that viscosity of the solution decreases rapidly, but for β -amylase the viscosity drops slowly. Thus it is clear that the proportion of α and β -amylases in a desizing mixture determines the period (time) of effective desizing. It is also clear that the molecular structure of cotton is unaffected by amylases.

The other size ingredients namely glue, gelatin etc. being protein in nature can be hydrolysed using proteolytic enzymes such as Gelatase, Trypsin etc. The possibility of improving amylase desizing of woven cotton greige at medium/high temperatures with the help of a thermostable lipase is reported [7]. Starch and lubricants (glycerides) are known to form insoluble complexes and the lipase is expected to help break these complexes thus making the removal of starch much easier.

The enzyme process of desizing is very easy to use and is adaptable to any type of equipment. In actual practice the grey cloth is first passed through hot water to approximately 100% pick-up and then padded with the desizing mixture containing 0.5-2% malt extract and non-ionic wetting agent at 60-70°C. Wetting agent helps the enzyme to penetrate the size film. The optimum conditions required for

different enzyme desizing processes are compared with rot and acid-steeping in Table 3.1. The length of time for digestion will vary with the concentration of

TABLE 3.1.

Comparison of Process Conditions for Desizing [8].

Process	Concentration (g/l)	Time (hour)/pH	Temperature (°C)
Rot-steeping	—	10-16 h	30-40
H ₂ SO ₄ -steeping	5-10	3-4 h (pH)	40
Malt Diastase	3-20	4.5-5.5	50-60
Pancreatic Diastase	1-3	6.8-7.5	50-60
Bacterial Diastase	0.5-1	6.5-7.5	60-70

enzyme used, the temperature of the desizing bath, the types of goods being desized and by the methods depending on the batch or continuous process. Compared to pancreatic enzyme, the malt enzyme has a lower action even with the addition of more amount of enzyme. The use of greater amount of enzyme than the optimum will not itself convert the starch. When the goods are padded with desizing mixture, digestion of the starch is a matter of time and temperature. At lower temperature the desizing efficiency is also lower. Malt enzyme is more strongly dependent upon temperature than other enzymes. Even some enzymes are available which can now be worked at 100°C so that high temperature desizing is a reality. Enzymes are quite specific in their response to pH and require close control (Table

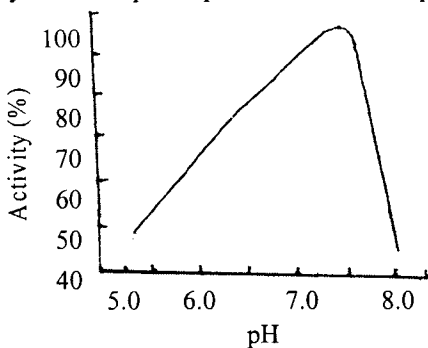


Figure 3-3. Effect of pH on enzyme activity (Courtesy of Graham Fisher, G.B. Fermentation Ind.).

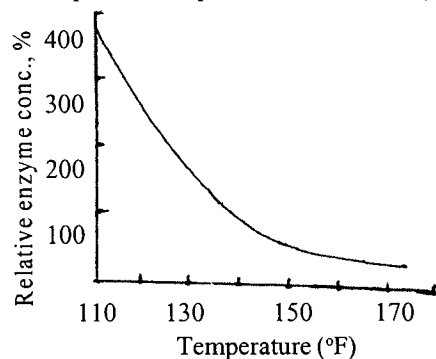


Figure 3-4. Effect of temperature on enzyme activity [8].

3.1). The pH of the desizing bath is maintained by adding acid or alkali. The effects of pH and temperature on enzyme activity are shown in Figs. 3-3 and 3-4 respectively. However storing the enzyme at a fixed temperature shows that the activity steadily decreases with time (Fig. 3-5). In general, changes in pH, tem-

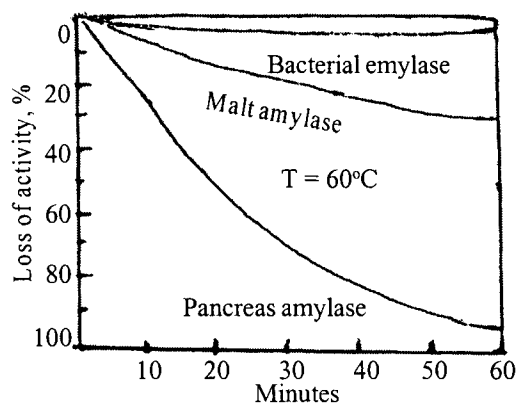


Figure 3-5. Decay of activity of various amylases [9] at 60°C.

perature and duration of storing alter both the activity and stability of enzymes very greatly.

Sometimes sodium or potassium chloride (0.18-1.0%) is added to the desizing bath for pancreatic enzymes to get its full activity. For malt α -amylase calcium ion is effective and sequestering agent must be avoided in the desize bath. These salts are particularly used for desize mixture by affording heat protection to enzyme, increased stability of the enzyme and efficiency. On the other hand, heavy metal ions such as copper, iron etc. may combine with enzyme and inhibit its activity [8]. Sometimes hydrocarbon solvents such as xylene (50 ml/l) along with suitable emulsifier (4 g/l) are also added to facilitate removal of waxy components of the size.

Following the digestion period, a hot water wash, with or without subsequent alkaline scour, is required for complete removal for the size that has been solubilised by the enzymes.

3.2.4 Desizing with oxidising agents

Though the use of oxidants for desizing of cotton fabric is widely accepted but their large scale industrial application is yet to be exploited. The most important aspects of oxidising agents are that they can be applicable to wide range of fabrics, the size content of which is often not known. Table 3.2 summarises the necessary conditions for desizing starch in presence of some important oxidising agents.

TABLE 3.2.
Desizing Conditions with Oxidising Agents

Oxidising agent	Process	Additives (pad-bath)	pH	Time (min)	Temp. (°C)
Hydrogen peroxide	Pad-steam	1-2 vol. H ₂ O ₂ , 7-15 g/l NaOH.	8-9	1-5	90
Sodium bromite	Pad-batch (cold)	1-3 g/l active Br ₂ , 20-30 g/l Caustic soda, 5-10 g/l Wetting agent.	7.5-8.5	15	20-40
Persulphate	Pad-steam	3-6 g/l Na-persulphate 8-10 g/l Caustic soda, 5-10 g/l Wetting agent.	10-10.5	1-3	95-100
Persulphate + H ₂ O ₂	Cold-batch	40 ml/l H ₂ O ₂ (25%) 10 g/l Persulphate, 10 ml/l Water glass, 10 ml/l NaOH 5 g/l Stabiliser, 5 g/l Wetting agent.	10-10.5	6-20	20-40

The first oxidative desizing agent initially suggested is hydrogen peroxide [10]. For continuous desizing, first the cotton fabric is impregnated with a 0.8% solution of H₂O₂ at 90°C at near neutral pH; without intermediate rinsing, the fabric passes into the second bath which contains 0.5% caustic soda before final wash-off at minimum temperature of 70°C. Alternatively, the cloth may be desized by pad-steam system (Table 3.2) and longer steaming time will have some bleaching effect in addition to desizing.

Use of sodium hypochlorite, sodium chlorite and sodium bromite as desizing agents are reported [11]. Sodium chlorite, although an excellent bleaching agent, helps to 'fix' rather than remove size in single stage bleaching. Sodium bromite acts by the oxidation of starch in presence of cellulose. The sized cotton consumes bromite to a greater extent than that of unsized cotton [12]. Sodium bromite does not act as a bleaching agent. In continuous processes, bromite treatment can be carried out hot using a dwell time of 20 min. Hypochlorite and chlorite have the added advantage of some fabric whitening which gives a saving in the oxidant concentration in subsequent bleaching.

Alkaline peroxycompounds [13,14] have been found much more suitable for the effectiveness as desizing agent. Peroxymonosulphuric acid (H_2SO_5), sodium persulphate, peroxydisulphates [$\text{Na}_2\text{S}_2\text{O}_8$, $\text{K}_2\text{S}_2\text{O}_8$ and $(\text{NH}_4)_2\text{S}_2\text{O}_8$], acid hydrogen permonosulphates (KHSO_5 and NH_4HSO_5) and potassium peroxydiphosphate ($\text{K}_4\text{P}_2\text{O}_8$) have been shown to be effective for desizing [15-19]. Peroxymonosulphuric acid (2 g/l) is applied in a similar manner to that of mineral acid desizing. Persulphates are recommended for ambient temperature desizing containing 0.5% persulphate, 0.5% tetrasodium pyrophosphate and 0.5-3% caustic soda with 4-8 h treatment time. Perphosphate requires a higher temperature for activation than does persulphate, it is used more frequently in caustic saturator because of its stability at elevated temperatures. Perphosphate also exhibits a synergistic effect on the caustic treatment of the fabric as evidenced by the lower solvent extractibilities and the cleaner bottom. The inorganic persalts viz. sodium perborate ($\text{NaBO}_3 \cdot 4\text{H}_2\text{O}$) and sodium carbonate hydrogen peroxide ($2\text{Na}_2\text{CO}_3 \cdot 3\text{H}_2\text{O}_2$) have been shown to be effective in foam desizing and bleaching of yarn and dyed fabric.

The main limitations of oxidative desizing agents are increased pollution load, fibre damage and inability to recover and re-use water soluble sizes. Oxidative desizing agents require precise control on process parameters. Metals catalyse the action of oxidising agents and the desizing liquor should not be in contact with any metal fittings.

3.3 Desizing of Synthetic Fibre Fabrics and Their Blends with Cellulose

The most common sizing agents used for nylon are based upon PVA, gelatin, casein or variety of vegetable and mineral oils. Desizing of regenerated celluloses depends on nature of size that must be removed. Desizing is difficult as rayon swells in water to a great extent. This leads to poor penetration of enzyme.

When water soluble PVA is used as sizing agent in weaving, no desizing of synthetic fibre fabrics is necessary. Light scouring with non-ionic surfactant (3-5 g/l) at 95-100°C for 20-30 min is enough to remove the sizing material. However, high molecular weight PVA above 1,00,000 are found to be quite difficult to remove from the fabric during desizing and results in uneven desizing.

Polyester sizing agents are not removed by simple washing treatment. Suitable detergents for removing polyester size are the efficient anionic or non-ionic types

or blends containing both types. The grey fabric is treated with a solution containing non-ionic surfactant, 2-3 g/l; sodium hydroxide or soda-ash, 1-2 g/l at 80-95°C for 20-30 min. Alternatively, treatment with sodium tripolyphosphate (1-2g/l) in presence of soda-ash or sodium hydroxide (1-2 g/l) and non-ionic surfactant (2-3 g/l) at 80-90°C for 20-30 min can be used. It is recommended to use soft water during washing as metal ions may interfere with removal of size. Alternatively, suitable sequestering agents are added.

Polyacrylic is a water soluble salt of acrylic acid and are soluble in mildly acidic or alkaline solutions.

The desizing procedure of polyester/cotton blended fibre fabrics depends on the nature of the size to be removed. Acrylic copolymer is removed by simply mild alkaline scour, PVA and CMC are removed by hot water wash, a mixture of starch and emulsifying wax is removed by means of enzymatic desizing followed by alkaline scour. Acrylic copolymers are commonly added to starch sizes. Depending on their sodium carboxylate content they give a pH of about 9.95 and will tend to inactivate enzyme. In such cases fabric may be pre-acidified or acetic acid may be added to the desizing bath (pH \approx 8). Gelatin and dextrin are readily soluble in hot water. If casein or some other protein based products are used in substantial proportion along with starch, a proteolytic enzyme should be used in addition to starch liquifying enzymes in the same bath. PVA is difficult to be removed from blended fabrics which have been heat treated at temperatures above 135°C or when scouring temperature is below 75°C [20]. A desizing process using neutral hydrogen peroxide in presence of metal catalysts results in easier removal of PVA [21]. The desizing of diacetate/viscose fibres blended dress goods is carried out depending on the nature of size to be removed. Starch sizes are removed by treatment with malt extract or enzyme, to which has been added 1g/l of synthetic detergent, batching overnight, and then scouring at 70°C for 30-60 min containing a liquor of 1-1.5 g/l detergent and 2ml/l ammonia (sp. gr. 0.880). Large scale trials in which sizing and desizing carried out in solvents have also been described [22].

Recently a cold desizing process using sodium sulphide in a weakly alkaline solution is reported [23]. The rate of desizing is increased 5-fold compared with alkali alone. A mechanism involving a catalytic effect of the sodium sulphide in the hydrolysis of glucoside bonds in the polysaccharide is proposed.

3.4 Desizing Machineries

The desizing processes are very much dictated by economics in terms of the chemical or enzyme consumption, the equipment available and the end use requirements. With the introduction of J-Boxes and other continuous preparatory methods and equipment, desizing is gradually losing its identity as a separate process. Now-a-days desizing and scouring can be carried out in one operation and thus a substantial amount of time and energy can be saved. This has become possible mainly because of many mild oxidising agents can be added to conventional liquor to promote desizing, while the scouring is in progress. Simultaneous desizing and scouring can also be carried out in kiers by a judicious choice of chemicals. Desizing in the batch process can be carried out in a jig or winch or in a kier prior to boil-off. For small lots, for example of the order of 1000 m or less desizing can be carried out in jigs or rope washing machines. Comprehensive development of microprocessor technology enables jiggers (Fig. 3-6) to be connected to a personal computer. Ev-



Figure 3-6. Universal Jigger for pre-treatment processes
(Courtesy of Benninger AG, Uzwil).

ery stage of the process can be graphically displayed on the personal computer. The modern machine is supplied with batching up facilities, automatic selvedge shifting, automatic tension regulation and gentle handling of elasticised or ultra-delicate fabrics. The entire production data, from loading the fabric, desizing, washing and unloading etc. can be printed out. If enzyme treatment is carried out in winch or similar dyeing machine (Fig. 3-7) in form of rope, desizing may be carried out at 60-70°C for 30 min with reduced amount of enzyme. The modern

rope washing machines can be used for processing with any kind of fabric with reduced water consumption, chemicals and electrical energy. The fabric is pro-



Figure 3-7. Machine for desizing and washing in the rope form [Courtesy Cimi S.R.L., (Biella), Italy].

elled by a winch in conjunction with good milling effect. The fabric capacity of the machine is about 350 kg with maximum speed of about 600 m/min.

In the batch process (Fig. 3-8) long digestion time in the range of 6-16 h are

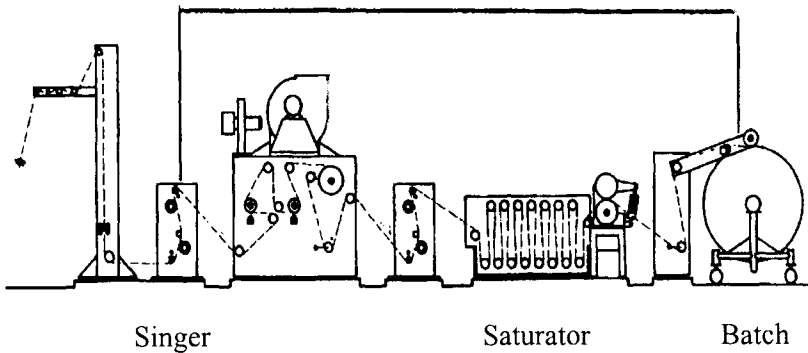


Figure 3-8. Schematic diagram of pad-batch system showing singer, desize saturator and padder. (Courtesy of Julien S.A, Belgium).

given because the material is unheated. After impregnation with the solution containing desizing agent, non-poisoning wetting agent and salt, the fabric in open width form is batched and covered with polythene sheet to prevent fabric being dried unevenly [24]. The saturator also works as a quench box in which all sparks are extinguished immediately after singeing the cloth.

In the semi-continuous process of desizing, the use of pad-roll installation is quite popular. Bacterial enzymes are widely used in pad-roll method [25] (Fig. 3-9). The cloth, in open width form is quickly pre-heated in a steam chamber or by infrared radiation immediately after impregnation with desizing agent containing other ingredients. The padded goods after steaming are batched in roll

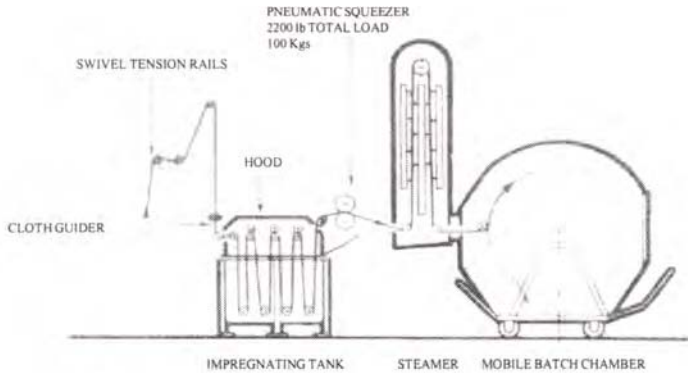


Figure 3-9. Pad-roll desizing unit (Courtesy of Farmer Norton).

form in moveable carriages and let lie for 8-12 h. Whilst in storage the material is rotated gently to prevent uneven desizing due to drainage and steam can be fed into the chamber slowly to maintain the required temperature.

When a continuous process is used, the padded fabrics are steamed for 20-60 sec at temperatures of 95-100°C using saturated steam (Fig. 3-10). A short open

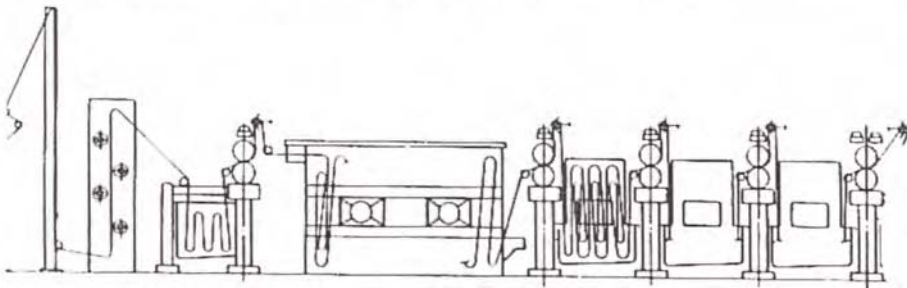


Figure 3-10. Schematic diagram of open width continuous desizing showing singer, saturator, padder steamer and enclosed washer (Courtesy of Morrison Machine Co.).

width steamer (Fig. 3-11) may be operated at temperatures of 95 to 100°C using

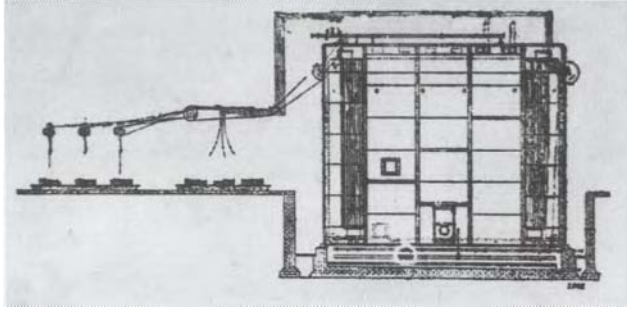


Figure 3-11. Continuous automatic steaming chamber.

saturated steam for 20-60 seconds. The bottom of the steaming chamber is provided with steam radiating pipes to obtain the necessary conditions of temperature and humidity. Alkaline peroxide is greatly used in continuous pad-steam processes [26] in which desizing, scouring and bleaching can be combined. When enzymes are applied to starch the enzyme sensitivity to heat is remarkably improved if the enzyme can be applied first and then steamed. After desizing is completed the fabric is washed in an open width washer (Fig. 3.12) to remove the short chain

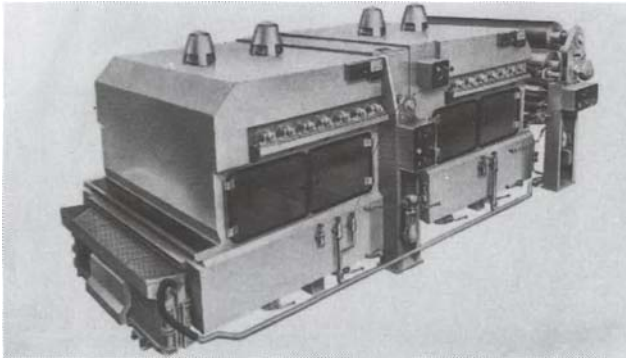


Figure 3-12. Open width washer (Courtesy of Farmer Norton).

sugars because these are water soluble. The washer is specifically designed to meet the current demand for greater energy saving and is totally enclosed and insulated. If J-Box (Fig. 3-13) is used for desizing of cotton fabric in continuous operation, a temperature range of 60-90°C for 15-20 min will suffice. The use of high pressure

continuous treatment machines such as Vaporloc and Benninger machines have necessitated the development of special amylase enzymes which are active at high

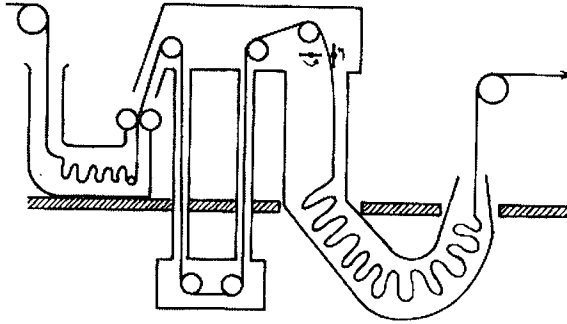
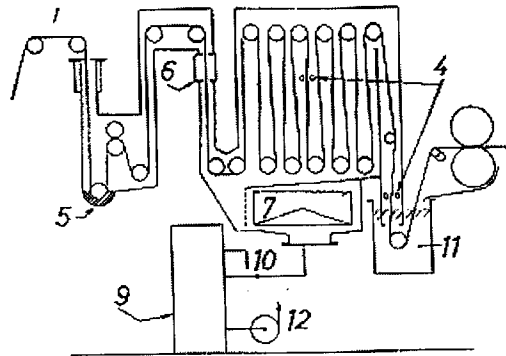


Figure 3-13. Continuous desizing in J-Box.

temperature of 100-110°C. Using these enzymes, high speed continuous desizing operations followed by continuous high pressure scouring and bleaching are being carried out.

Bacterial enzymes are used in the very elegant Markal method [27] (Fig. 3-14).



- | | |
|---|---------------------------------|
| 1 Application unit | 7 Condenser |
| 2 Transfer duct | 8 To water wash tanks |
| 3 Solvent recovery/chemical reaction vessel | 9 Water separator and hold tank |
| 4 Steam jets | 10 Water to drain |
| 5 Chemical addition | 11 Water seal |
| 6 Seal unit | 12 Recovered solvent to storage |

Figure 3-14. Continuous solvent desizing process
(Courtesy of ICI Mond Division, England).

The ICI Markal process is used for desizing and scouring by using suspension of enzyme in trichloroethylene and surfactant solution. The fabric is padded through the solvent formulation, steamed to remove the solvent and to activate the enzyme. A wash-off with water completes the process. The Markal processes are suitable for polyester/cotton, polyester/rayon and other blends as well as for cotton.

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SCOURING

4.1 Introduction

The loom state cotton fabric contains about 8-12% natural impurities of total weight of the fibre. These impurities mainly consists of waxes, proteins, pectic substances and mineral matters. In addition to this, the mechanically held impurities called ‘motes’ are present containing seed-coat fragments, aborted seeds and leaves etc. that cling to the fibre. Apart from these, the loom-state fabric is also contaminated with adventitious oils such as machine oils, tars, greases etc.

Scouring is a purifying treatment of textiles. The objective of scouring is to reduce the amount of impurities sufficiently to obtain level and reproducible results in dyeing and finishing operations. Scouring agents can be generally classified into different groups (Fig. 4-1). The appropriate type of scouring agent gener-

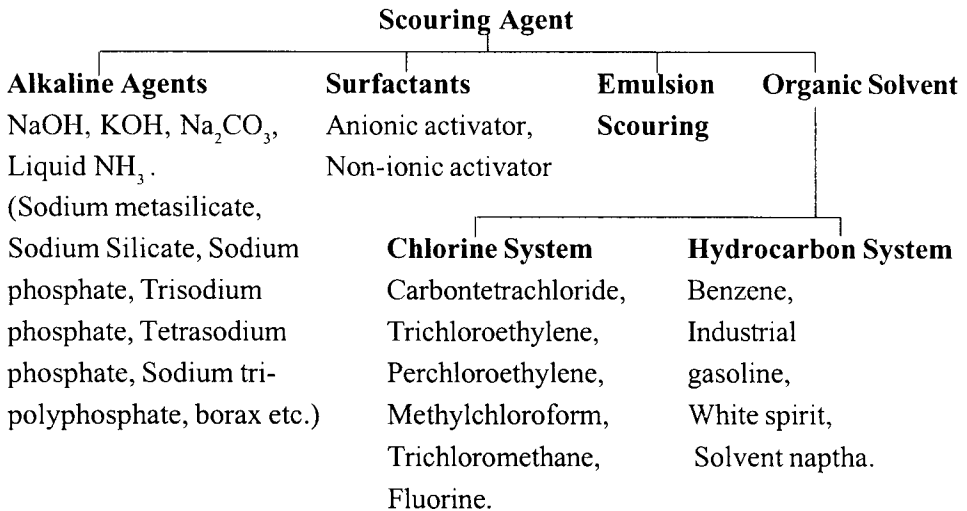


Figure 4-1. Classification of textile scouring agent.

ally depends on the kind of fibre ; fabric type i.e. woven or knitted, thick or thin ; texturised or non-texturised and the extent of impurities present in the fibre. The selection of alkali is most important as free alkali can have a deleterious effect on certain fibres. For example, wool and silk are dissolved by alkali, whereas acetate and triacetate are converted back to their original cellulose form. Cotton fibre ab-

sorbs alkali. Alkali neutralises the carboxyl group in cellulose and in pectin. The hydroxyl groups on the glucose units in cellulose are also weakly acidic. Owing to this preferential sorption, the concentration of alkali in the fibre is increased and thus attacks the impurities more intensively.

4.2 Mechanism of Removal of Impurities

The action of alkaline scouring agent is to saponify any residual oils, to neutralise carboxylic acids, to solubilise any sizing materials and to cause dispersion of naturally occurring impurities in natural fibres. Table 4.1 summarises the removal process involved during scouring.

TABLE 4.1.

Techniques for Removing Natural Impurities of Cotton During Scouring [1]

Impurities	Method of removal
Fats and waxes	Levels are reduced to acceptable limits by the action of alkali and surface active products, in extreme cases the use of solvent and surfactant mixtures may be necessary.
Pectins and related substances	Solubilised by the action of alkali, usually caustic soda, which also acts as a swelling agent to facilitate removal.
Minerals and heavy metals	(a) By producing more soluble salts e.g. acid demineralisation (b) By use of sequestering agents.
Amino acids or proteins	Solubilised by producing corresponding sodium salt.
Lubricants/Knitting oils	Modern mineral oil formulation usually contain their own self-emulsification system.

Natural fats, oils and lubricants (tallow) are mostly esters usually in the form of triglycerides. Being triglycerides, the lubricants can be almost hydrolysed by lipases, yielding glycerol, fatty acids and mono- and diglycerides as the reaction product. Glycerol is completely water soluble, fatty acid is removed during scouring and mono and diglycerides are known to be efficient surfactants or emulsifiers. Thus, a lipase treatment improve not only desizing but also the scouring processes. The esters react with sodium hydroxide to form soap and glycerine. The soap thus

form can serve as an effective detergent and promote scouring. The unsaponifiable oils are emulsified by the soaps formed during hydrolysis of the saponifiable matter and are easily removed.

Wax is difficult to remove. If wax is not removed, non-uniform absorption of dyes and finishing agents will take place. In fact it is the distribution of residual wax after scouring that determines the water absorbancy.

Pectic acid is insoluble in water but soluble in alkaline solution. Proteins are situated in the central cavity of the fibre and are therefore relatively inaccessible to chemical attack. The proteins and nitrogenous materials are hydrolysed by alkali into soluble amino acids or ammonia.

The alkali earth elements represents a major variable in cotton fibre (Table 4.2) and mainly comes from cotton seed husks. Further the use of hard water can precipitate alkali earth metal phosphates on the fibre instead of eliminating them [2]. The reason for reddish shade after bleaching with peroxide is the high content of manganese, $Mn^{2+} \rightarrow$ colourless but $Mn^{7+} \rightarrow$ violet. The contents of Fe, Mn, Ca and Mg varies depending upon the origin of cotton (Table 4.2). With the demineralisation

TABLE 4.2.

Metal Content in Cotton Fibre

Country of origin	Content in p.p.m. (mg/Kg)			
	Iron	Manganese	Calcium	Magnesium
Brazil	100-250	10-30	1500-2500	800-1500
Russia	50-150	3-7	800-1500	500-1000
USA	30-50	< 1	500-800	300-600
Peru	10-30	< 1	500-800	300-600

treatment the mineral content of cellulosic substrates can be reduced substantially and thereby diminishing the negative influence of earth alkali and heavy metal ions in subsequent process operation. Complexion of earth alkali salts (Ca and Mg) is possible in the acid medium and heavy metals (Fe and Mn) is possible in alkaline medium. The advantages and benefits of the demineralisation are : better levelness and more brilliance in the dyeing process, lower peroxide consumption, reduction in the ash content, increase in degree of whiteness, regular decomposition of peroxide, no catalytic damage of the fibres (holes) and possibility of replacement of

hypochlorite bleach. Generally good pre-treated materials should have 100-300 p.p.m. of Ca and Mg and 4-8 p.p.m. iron.

Sodium hydroxide reacts with 'motes' (cellulose of low crystallinity). Motes are swollen in alkali to form sodium celluloses which tend to become water soluble. If any 'motes' still remain in the fibre after scouring, subsequent bleaching operation destroys them completely.

4.3 Scouring of Cotton in Alkaline Agents

The complex nature of natural impurities present in the cotton substrate and its effect by treatment with alkaline solution is already highlighted. The various types of alkalies and other additives used for scouring of cotton are given below.

4.3.1 The lime-soda boil

In this process the fabric is boiled with milk of lime which convert the fatty acid into insoluble lime soaps. The lime soap is then converted into free acids on acidification and calcium is washed away as calcium chloride. The deposited free acid is then converted to soluble soaps on subsequent boiling with sodium carbonate. This method is tedious and not economical as two boils are required to remove the natural impurities.

4.3.2 The caustic soda boil

In this process cotton fabric is boiled with a solution of 10 to 20 g/l (3 to 6% o.w.f.) caustic soda in a kier with a liquor ratio of 3 : 1. In continuous scouring about 30 g/l of caustic soda is added in the pad-bath with a liquor pick-up of about 100%. In batch process the piece goods are treated in 4-6% sodium hydroxide for 8 h at 130°C (30 lb/in²). Loose cotton for bandage and sanitary cotton, where absorbency is the prime importance, are boiled at 80 lb/in². In continuous processes, it is possible to decrease the time of post impregnation steaming to about 2 min at a temperature of 130-135°C with sodium hydroxide solution of 40-60 g/l. The rate of saponification of waxes increases considerably as the temperature (pressure) of boiling increases. Generally, the rate of chemical reaction is doubled with each 10°C rise in temperature and saponification of oil is increased sixteen times from 60 to 100°C [3]. However, with increase in temperature oxycellulose formation is also increased. Cotton is not degraded by boiling with sodium hydroxide solution up to a concentration of 20 g/l in the absence of air.

4.3.3 The soda-ash boil

The type of alkali used for scouring of cotton depends on the quality of goods. For example, if coloured yarns present in the fabric, sodium carbonate is ideally suited because of its low pH. Cotton yarns to be dyed in dark shade should be scoured with 1-2% sodium carbonate solution for 30 min in presence of wetting agent.

4.3.4 The mixture of caustic-soda and soda-ash boil

A combination of 2 parts of caustic soda and 1 part of sodium carbonate is often used in single stage boiling. Soda-ash softens the water while interacting with Ca and Mg salts (if such are present) ; it creates an active reaction of the medium which is most favourable for the formation of stable emulsions and suspensions ; increases fibre swelling, thus contributing to the release of impurities from the fibre ; neutralises fatty acids contained in the fabric by soap formation ; obviates soap hydrolysis in the presence of wool ; reduces the adherence of detergents to wool in the alkaline medium conditions.

4.3.5 The soap/detergent – soda-ash boil

This combination is comparably milder combination than that of caustic soda and hence ideally suitable for more delicate cloths and colour woven goods compensating for the slower action of the milder alkali by the addition of a detergent. Anionic products like sodium alkyl sulphates and alkyl aromatic sulphonates and non-ionics like polyethoxylated compounds are used as detergent. Sometimes mixtures of anionic and non-ionic products are used. It is possible to obtain a synergistic effect between a detergent and alkali, so that the two agents when combined increase their total activities rather than inhibit each other. Fig. 4-2 shows the syn-

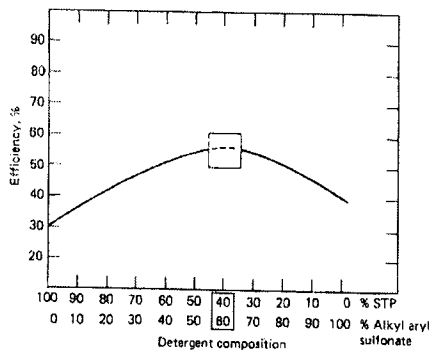


Figure 4-2. Effect of sodium tripolyphosphate (STP) on detergency [4].

ergistic effect when phosphates are combined with alkyl aryl sulphonates and are used as scouring agents in processing water. After scouring, washing is carried out by hot progressive rinsing while gradually decreasing the temperature in order to avoid break down of the emulsion and precipitation of the impurities onto the cotton. Washing is completed by treating the fabric in an acid solution to neutralise any alkali retained by the fabric.

4.3.6. Sequestering agents

Sequestering agents or chelating agents are negatively charged and are capable of forming strong ring structures (Fig. 4-3) with the metal ions present in hard

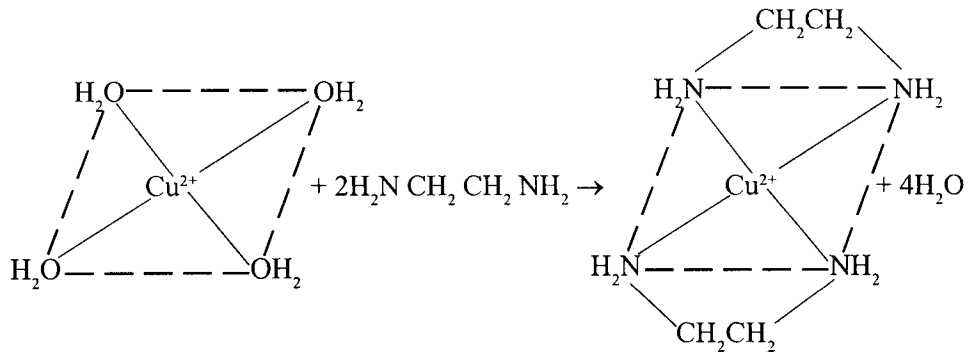


Figure 4-3. A typical chelate structure (Courtesy of Dow Chemical Co.).

water and in pectins of cotton. The positively charged metal ions, particularly Fe^{3+} and Ca^{2+} are readily available for reaction with any negatively charged anion such as OH^- or CO_3^{2-} and insolubilise soap in the fibre which may disturb subsequent operation. This problem is much more acute when scouring is carried out in continuous process involving padding bath where liquor ratio is much lower than the batch process [5]. Thus, the functions of the chelating agents in the soap and detergent formulations are for the prevention of –

- i) film and scum formation,
- ii) precipitation of hard water,
- iii) calcium and magnesium inhibition of foaming properties,
- iv) clogging of liquid dispersions,
- v) haze turbidity in liquid solutions, and
- vi) rancidity and oxidation that cause discolouration of formulation.

Sequestering power is influenced by pH of the scouring bath. At a given pH,

different amount of chelating agents are required to chelate a given amount of metal. Organic sequestering agents that find commercial uses (Fig. 4-4) are stable

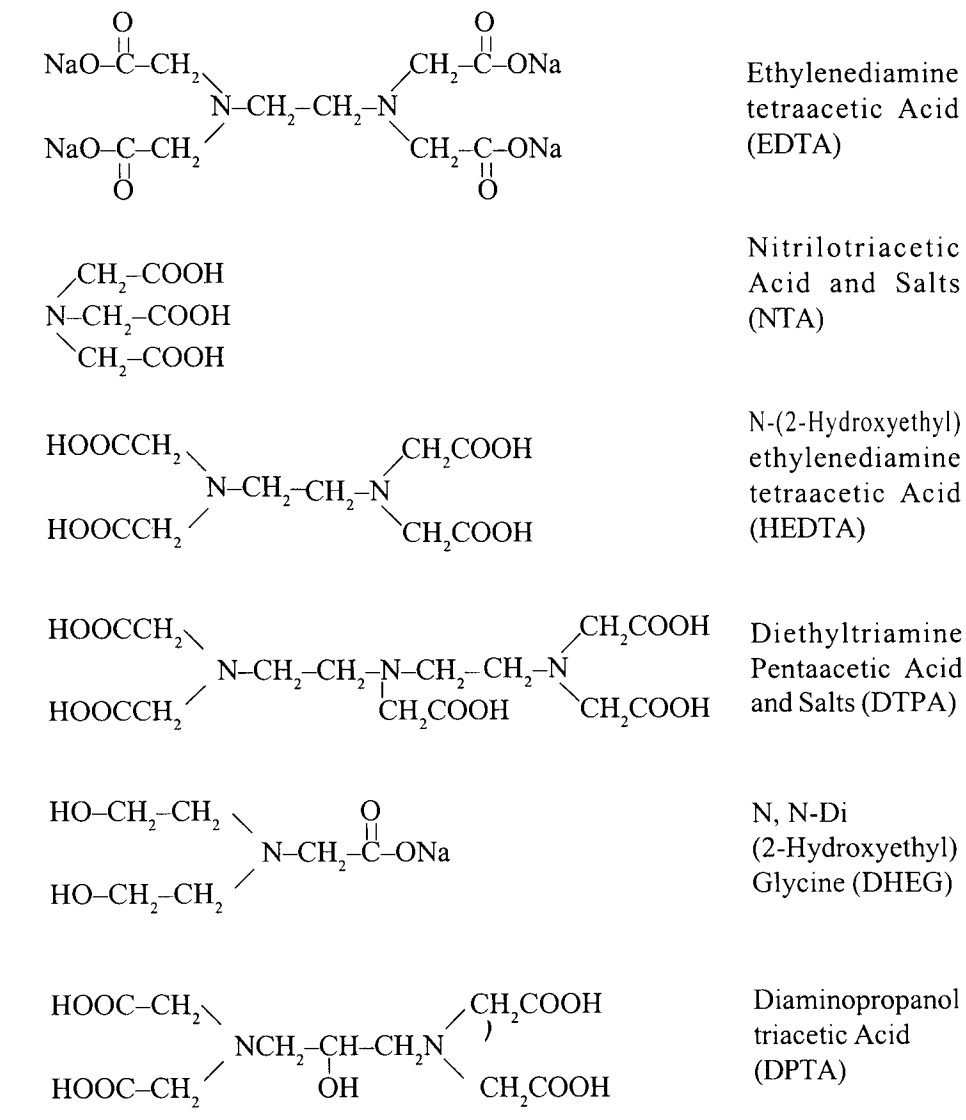


Figure 4-4. Aminocarboxylates and hydroxy carboxylates as organic sequestering agents.

to hot alkaline scouring solutions. There are some organophosphonates (Fig. 4-5)

4.3.8. Fibre protecting reducing agents

Sodium hydroxide solution during kier boiling of cotton at high temperature can form oxycellulose in presence of oxygen. Generally, oxygen is removed from the kier before scouring starts, but even a small quantity of air entrapped in the fabric layers may cause problems and tendering of cloth takes place. Thus, a small quantity of mild reducing agent such as sodium bisulphite or even hydrosulphite is added to the kier liquor to prevent oxidation of cellulose during scouring operation.

4.3.9 Mild oxidising agents

Sometimes, woven fabric contains a vat or azoic dyed coloured yarn to have a stripe effect. When such fabrics are scoured in a pressure kier under alkaline condition, there is always a risk of staining the adjacent white ground by bleeding of dyes from the coloured thread. Azoic dyes may be mechanically transferred while the vat dyes may be reduced to its soluble leuco state in presence of alkali and impurities removed from the cloth. For such types of fabrics mild oxidising agents like Ludigol, Resist Salt L etc. may be added to the scouring bath to resist the reducing properties of dyes. Chemically, these products are sodium salt of nitrobenzene sulphonic acid. Alternatively, such fabrics containing coloured threads can be scoured in open kier, on winch machine, jigger or continuous machine with boiling soda-ash liquor (2.5% o.w.f.) instead of caustic soda to reduce the mark-off to a minimum.

4.3.10 Water insoluble solvents

For the purpose of accelerating the scouring process, wetting agents are sometimes used in conjunction with high boiling solvents (cyclohexanol, methylcyclohexanol, tetrahydronaphthalene, decahydronaphthalene etc.). The function of the solvent is to dissolve more insoluble fats and waxes and that of the detergent to emulsify the solvent and waxes.

4.4 Surfactants

A surfactant may be defined as a substance which, when applied in low concentration, markedly reduces the surface tension of a solvent. A good surfactant, for example, will reduce the surface tension of water from 72 dynes/cm to 30 dynes/cm at a concentration of less than 0.1%. The concentration at which no further reduction in surface tension occurs is known as 'critical micelle concentration'. Generally, surface tension between textile fibres, particularly synthetic fibres and

water is high, and hence wetting of the fibre surface does not take place thoroughly and quickly. Surfactants reduce the interfacial tension and thereby bring about quick wetting of the fibre surface. Surfactants are widely used in scouring of synthetic fibres which do not contain naturally occurring impurities like cotton. Surfactants are also used in wool scouring and also assist in the milling and development of woollen fabric.

A high quality synthetic detergent provides a good balance with wetting, cleaning, emulsifying, dispersing and foaming properties, thus providing it a good cleaning ability. Chemically, the surfactants are long chain organic compounds containing both a hydrophobic and a hydrophilic component. The hydrophobic character in the surfactant molecule is associated with the hydrocarbon chain, usually quite long in its length. Although lowering of surface tension is an essential requirement of a good surfactant, the compound should have proper hydrophobic lyophilic balance (HLB) to have balanced water solubility and water insolubility. Surfactants may be classified into four groups, viz. anionic, cationic, non-ionic and amphoteric surfactants. However, the non-ionic and anionic detergents and blends, solvent assisted detergent blends, soaps and pH buffered 'built products' are mainly used for scouring in textile industry.

4.4.1 Anionic surfactants

Anionic surfactants are those which bear a negative charge and migrate toward the anode or positive charge in solution. This class of salt like compounds include the soaps and many of the popular synthetics (Fig. 4-6). When fats are hydrolysed

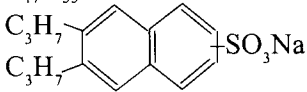
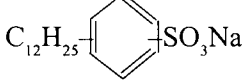
Anionic detergent	Chemical structure
Sodium stearate (soap)	$C_{17}H_{35}COONa$
Dipropyle naphthelene sulphonates	
Alkyl benzene sulphonates	
Alkyl sulphates	$CH_3-(CH_2)_{16}-CH_2OSO_3Na$
Alkane sulphonates	$C_{17}H_{33}COOCH_2SO_3Na$ Igepon A
	$C_{17}H_{33}CO-N(CH_3)-C_2H_4SO_3Na$ Igepon T
Phosphate esters	$R-O-(C_2H_4O)_x-PO_3Na_2$ R = Octyl or nonyl phenol or fatty alcohol

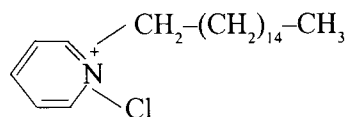
Figure 4-6. Typical examples of anionic detergents.

in presence of alkali fatty acid is formed which on neutralisation with caustic soda form a sodium salt of fatty acid, known as soap. The most important factor which determines the properties of soap is the number of carbon atoms in the aliphatic soap. Soap with high molecular weight (C_{12} to C_{18}) is only suitable for use when scouring can be carried out at or near the boiling point of the solution. The instability of soap in acid solutions is the main drawback. Synthetic detergents are surfactants developed to overcome the drawbacks of soaps. They are salts of strong acids and when pure they are practically neutral. In contrast to soap they are less liable to hard water precipitation and are readily rinsable.

In the late 1920's long chain fatty alcohols were sulphonated and sold as neutralised sodium salts. In 1930's long chain alkyl aryl sulphonates with benzene as aromatic nucleus and alkyl portion made from kerosine portion appeared on the market in U.S.A. Both the alcohol sulphates and trialkylaryl sulphonates were sold as such as cleaning materials but did not make much headway on the total market. In 1940's, dodecyl benzene, formed by the reaction of propylene tetramer with benzene, was available in plenty and dodecyl benzene sulphonate dominated the synthetic detergent market. Late in 1950's, higher molecular weight materials with an average of 13 carbon atoms instead of 12 as in dodecylbenzene was found to have better detergency. In the early 60's, it was found that the branched chain structure of dodecylbenzene sulphonates are not biodegradable and thus linear alkyl benzene sulphonate has replaced propylene tetramer. Anionic surfactants with phosphate esters are finding more and more uses in industry and are obtained by treating non-ionic surfactants with phosphorous pentoxide.

4.4.2 Cationic surfactants

Chemically they are just opposite to the anionic surfactant and hence are unsuitable for use as detergents or wetting agents. The hydrophobic part of the molecule of the cationic surfactant is the organic ammonium or pyridinium compound containing one or more hydrophobic residues as shown below :



Cetyl pyridinium chloride

Cationic surfactants are rarely used in preparation unless applied as a lubricant

or antistat at the end of the scour cycle on goods that are to be dyed but not bleached. A small quantity of cationic surfactant is also recommended as an aid in weight reduction in caustic treatment of polyester. Cationic surfactants are mainly used as softeners, levelling agents, retardants in dyeing, water repellents, bacteria growth inhibitors and emulsifiers.

4.4.3 Non-ionic surfactants

Non-ionics are second major surfactant class used in preparation and are manufactured in different forms. Non-ionic surfactants do not contain an ionisable group and have no electrical charge (Table 4.2). The most important non-ionic detergents

TABLE 4.2

Non-ionic Surfactants that Bear an Electrically Neutral Charge

EO-PO Ethers	Sorbitan ester-EO
EO-PO Esters	Sorbitol esters
Fatty esters	Sorbitol ester-EO
Amphoteric (at isoelectric point)	EO fatty acid
Thioethers	PO fatty acid
Sorbitan esters	Fatty alkanol amides

are those obtained by condensation of ethylene oxide or propylene oxide. Ethylene oxide can be reacted with fatty acids, alcohols and alkyl phenol, fatty amide etc. to give polyoxyethylene compound of ether, ester and amide known as ethylene oxide condensation product (Fig. 4-7). The non-ionics are rendered water soluble by

Non-ionic detergent	Chemical structure
Ethoxylated primary alcohol	$R-O-(C_2H_4O)_nOH$
Ethoxylated nonyl phenol	$C_9H_{19} \left[\text{C}_6\text{H}_4 \right] O(C_2H_4O)_nH$
Ethoxylated thio-ethers	$CH_3-S-C_2H_4-(C_2H_4O)_nH$
Ethoxylated fatty acids	$R-\overset{O}{\parallel}C-(C_2H_4O)_n-OH$
Ethoxylated fatty amide	$R-CONH-(C_2H_4O)_nH$

Figure 4-7. Some typical examples of non-ionics.

the solvation of oxygen in the ether and the solubility is proportional to the number of such oxygen atoms in the molecule. A primary hydrate is formed in which further water molecules participate, resulting in the formation of voluminous hydrate sheath with 20 to 30 water molecules to each oxygen atom. Some typical examples of non-ionic surfactants are given in Fig. 4-7.

Non-ionics are characterised by its cloud point. It is the temperature at which 1.0% solution of non-ionic surfactants, become cloudy or insoluble. The larger the number of ethylene oxide molecules in the product, higher is the cloud point. The exception to this rule is a non-ionic that is co-reacted or capped, with propylene oxide. Another method of overcoming the problem of cloud point is to blend the non-ionic with an anionic such as a soap, a sulphonate or a phosphate. The cloud point of non-ionic surfactant solution can be depressed by the addition of an electrolyte like common salt, Glauber's salt etc.

Non-ionic surfactants are free from precipitation and redeposition onto the fabric and can be safely used which also permit the caustic to act as a lime-soap detergent. Its advantages are excellent compatibility with all classes of surfactants, good wetters and rewetters, good emulsifiers, excellent oil solubility and good components of oil emulsifier.

4.4.4 Amphoteric surfactants

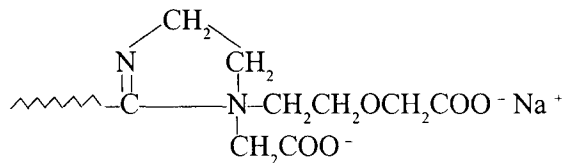
Amphoteric surfactants may be cationic, anionic or non-ionic depending upon the pH of the aqueous solution (Table 4.3). A typical amphoteric surfactant can be

TABLE 4.3.

Effect of pH on Ionic Nature of Amphoteric

Structure	pH	Ionic charge
$\overset{(-)}{\text{Cl}} \text{R} \overset{(+)}{\text{NH}_2} \text{CH}_2 \text{CH}_2 \text{COOH}$	Acidic	Cationic
$\overset{(+)}{\text{R}} \overset{(-)}{\text{NH}_2} \text{CH}_2 \text{CH}_2 \text{COO}^-$	Isoelectric range	Non-ionic
$\text{R} \overset{(-)}{\text{NH}} \text{CH}_2 \text{CH}_2 \overset{(+)}{\text{COO}} \text{Na}^+$	Alkaline	Anionic

represented by the following formula :



Amphoteric surfactants offer an excellent degree of lubrication, corrosion inhibitor, and wetting action and provide a protective colloid for silk and wool processing. The major uses of amphoteric are in the scouring and dyeing of protein fibres to prevent chafing, crack marks and crow's feet. Amphoteric are comparatively expensive and some of them are not heat stable and hence cannot be used at elevated temperature.

4.4.5 Blends of surfactants

Blended surfactants are commonly used in preparation auxiliaries as they are found to be more efficient than the single component. When natural waxes, and sizes are to be removed from cotton, anionics-or non-ionics built with anionics – appear to be the better choice. Anionics, whether sulphate or phosphate derived, when neutralized with amines or alkanolamines become solvent and oil soluble and may be used in conjunction with low-mole ethoxylates. A blend of propylene oxide-capped non-ionics or thioether ethoxylates, coupled with low-mole phosphate ester of dinonyl phenol ethoxylates that has been neutralised with alkanolamine, is commonly used to emulsify a high boiling mineral spirit type solvent. This combination product provides good detergency and satisfactorily accomplishes the removal of processing oils, greases and sizes. A simple blend of short-chain ethoxylates and long-chain ethoxylates of same hydrophobe that provides a balanced HLB can sometimes be the best choice. On many occasions, it is necessary to incorporate a solvent processing aids and a complex mixture of ethylene oxide and fatty acid derivatives produced with inorganic compounds to provide optimum processing efficiency.

4.4.6 Surfactant as wetting agent

Generally interfacial tension between the textile fibre and the liquor is high, and hence wetting of the fibre surface does not take place quickly. This is particularly true in the case of grey cotton fabric and hydrophobic fibres. One of the main function of the surfactants is to reduce the surface tension and thereby bring about wetting of the surface.

Water has an uncommonly high surface tension of 72 dynes/cm. The most important feature about high surface tension of water is its structure. A lone oxygen atom in the water molecules contains a pair of electrons, which is balanced by a correspondingly large positive charge in the hydrogen atoms. This structure gives

water a great dipole moment, and also the molecules 'stick' to one another when water is in its liquid phase. It is a mixture of clusters of tetrahedrally linked water molecules and a single molecule, with single molecule occupying spaces between the clusters. The water molecules in the clusters and molecular aggregates are held together by strong bonds. The energy of a hydrogen bond is even greater than that of any other molecular interaction. All these factors either alone or together make the wetting of textiles difficult.

It is possible to bring down the surface tension of water from 72 dynes/cm to 28 dynes/cm by dissolving soap in water. When a surfactant (soap) is dissolved in water the hydrocarbon chain (hydrophobic part tail, \equiv) tries to get away from the

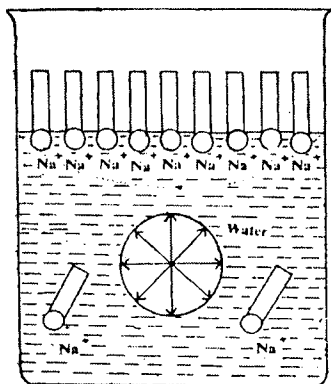
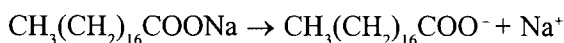


Figure 4-8. Surface activity and orientation of soap molecules.

water medium due to its hydrophobicity (Fig. 4-8) and concentrate at the surface. The hydrophilic grouping (carboxyl head, O) just dip in the water at the surface and the sodium cation is in the vicinity of negatively charged carboxyl head. Thus this compound, sodium stearate (soap), distort the structure of water and decrease the free energy of the system.

However, there is another means of minimising free energy of these systems. The distortion of the solvent structure can also take place by aggregation of the surfactant molecules into clusters (micelles) with their hydrophobic groupings directed toward the interior of the cluster and their hydrophilic groups directed towards the solvent. Micellisation is therefore a mechanism alternative to adsorption at the interfaces for removing lyophobic groups from the contact with water, thereby reducing the free energy of the system.

The wetting agent not only facilitates the wetting of the fibre by water but also results in the displacement of air from the micropores of cotton by the water. Thus the wetting of a surface involves the reduction of interfacial tension, so that liquid spreads as a continuous film instead of remaining as drops (Fig. 4-9). When the

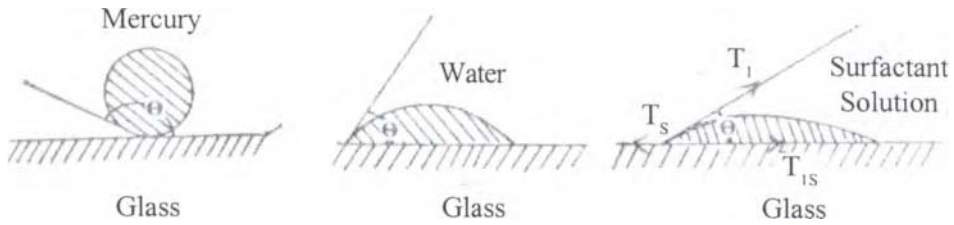


Figure 4-9. Angle of contact, θ .

interfacial tension is large, the angle of contact is also large. Surfactants can reduce the angle of contact, since they facilitate wetting (spreading) of the liquid on the surface. The relationship between the various forces can be written as :

$$\cos\theta = \frac{T_s - T_{1s}}{T_1}$$

For perfect wetting of the fibre, θ must be zero, so that,

$$\frac{T_s - T_{1s}}{T_1} = \cos 0^\circ = 1$$

$$\text{or, } T_s - T_{1s} = T_1$$

This means that if θ is less than 90° , the oil will tend to spread over the fibre and adhere to it. But if θ is greater than 90° , the oil will tend to form globules which are easily detached from the fibre. The effect of adding surfactant to water is that the surfactant molecules will congregate at the oil/fibre (T_s) and even more at oil/water (T_{1s}) interfaces, thus reducing the values of $\cos \theta$.

4.4.7 Surfactant as detergent (scouring agent)

The function of the detergent is to remove the dirt and dust particles and other constituents of the size such as china clay from the cotton fabric. The detergent keeps the soils in dispersed or suspended form in scouring solution and prevents redeposition on the fabric. Fig. 4-10 illustrates the sequence of events of soil removal. Adventitious dirt adhere to the fabric because the oil acts as an adhesive towards it. The fabric/soil/water interfaces not soluble in water is shown in

Fig. 4-10 (A). When detergent is added [Fig. 4-10 (B)], the soil hydrophobe either dissolves into the soil or orient along the fibre surface. The largest concentration of detergent is present along the edge of the soil. Because of the hydrophile, the edges tend to associate with water and thus the removal of soil from the fabric starts. Ultimately, the oil disperses as droplets [Fig. 4-10 (C)] and the dirt is held in suspension within the droplets [8]. The suspended soil particles with its sheath of

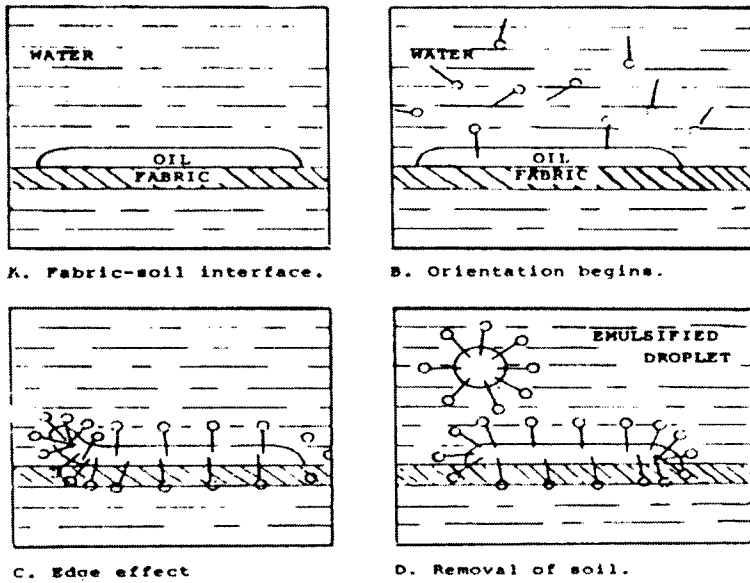


Figure 4-10. Schematic diagram of events causing detergency [7].

oriented soap molecules assumes a net negative charge similar to the globular micelle of soap. Cotton fibres also take up a negative charge when immersed in water. The electrostatic repulsions between the particles and the fibre play a major role in preventing redeposition. The addition of carboxymethyl cellulose (CMC) and/or polyvinyl pyrrolidone (PVP) (Fig. 4-11) can act as anti-redeposition agents.

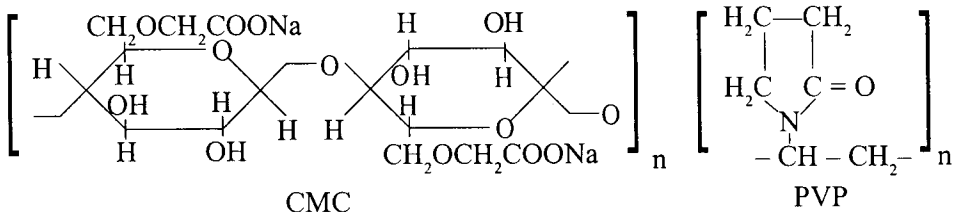


Figure 4-11. Chemical structure of CMC and PVP.

CMC is used primarily in surfactants and PVP is used as bath additive. Further, CMC also forms a protective colloid with the soil and thus prevents soil redeposition on the cloth. The emulsion of oil and dirt should be stable, otherwise there will be redeposition. Ordinary soap and detergent is a good emulsifying agent.

The most important consideration in scouring is the critical micelle concentration (CMC) of the surfactant. A reservoir is established at the CMC and several factors become evident (Fig. 4-12). The detergency is at its maximum while the

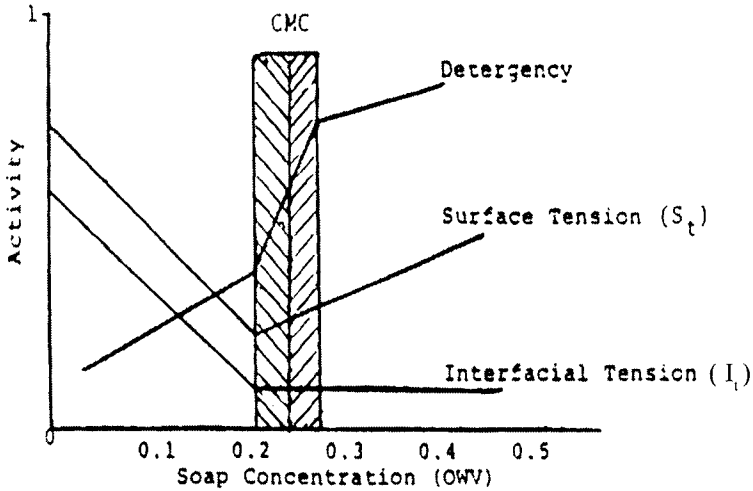


Figure 4-12. Relationship between detergency, surface tension, interfacial tension and CMC [9].

surface tension and interfacial tension are at their minimum. The CMC is different for different molecular structure of surfactants, and it varies with temperature, agglomeration number and average number of molecules per micelle.

4.4.8 Emulsion scouring

The knitting yarn in cotton weft knitted fabrics contains lubricants which replace the size on woven fabrics. Lubricants are widely used in worsted and woollen sectors of the wool industry, primarily to aid processes such as carding, combing and spinning. At the final stages of manufacturing of synthetic fibres, they are subjected to oiling to improve their physical and mechanical properties and to finishing with anti-static agents to reduce their ability to be electrified [10,11]. Stabilised bulked-polyester yarns for weft knitting are heavily oiled.

The term 'yarn lubricants' (or coning oil) is defined as all lubricants applied by textile mill or processors subsequent to application of spin finish. Increasingly sophisticated spin finishes are used and long group of compounds are known to serve as fibre lubricants, mineral oils being used since long. Straight chain esters such as methyl, ethyl or butyl of fatty acids with functional groups C_6 to C_{18} are the largest groups having excellent lubricity. Polyglycols or their fatty acid esters and fatty glycerides, more complex chemicals such as esters of dibasic acids, pentacrythritol, neopentylene glycol, and polycerols as well as aryl, alkyl, alkyl aryl phosphates, silicones, silicate esters, fluoroesters and polyphenyl ethers have been used for greater stability. Lubricants have been modified by ester interchange, ethoylation or acetylation in order to influence the degree of lubricity and other properties. The main lubricants, however, used are saponifiable, water emulsifiable (ester based), water dispersible and water soluble (surfactant based). Out of these ester based and water soluble types are more popular because of their technical performance and ease of removal. Table 4.8 shows a range of typical application levels used for the main

TABLE 4.8.
Main Types of Lubricants Used on the Woollen System [12]

Yarn end use	Lubricant	Apply (o.w.f.)
Fabrics	Saponifiable	
	Emulsifiable	5 - 7%
Hosiery	Emulsifiable	4 - 11 %
Carpets	Emulsifiable	
	Dispersible	1 - 5 %
	Water soluble	

types of lubricants on the woollen system. Most oils have lower refractive indices than drawn polyester fibres, so that the presence of oil on the surface of the fibre reduces the scattering of incident light; impair level dyeing properties and the fastness to washing and rubbing; and modify the structure of polyester fibres on storage and thermal treatment. A proper selection of lubricants is necessary so that scouring must be thorough.

Non-scourable oils are difficult to remove from cotton giving rise to unlevel dyeings [13]. The oil, grease and tar stains are generally removed by spotting on

stained portion with stain remover comprising emulsified solvents in the liquid form. The stains are spotted with stain remover and rubbed and left for short time and then washed. The process may be repeated to remove stains completely. The treated areas however should not dry before they are washed as otherwise ring marks are likely to be formed. Emulsified solvents (Table 4.9) are used in the

TABLE 4.9.

Type of Emulsified Solvents

Type	Surfactants (emulsifier)	Solvents
Anionics	Sulphated oil, alkyl aryl sulphonates.	Carbon tetrachloride, and trichloroethylene.
Non-ionics	Ethylene oxide condensate with alkyl phenols, fatty alcohols and fatty acids.	Perchloroethylene, isopropylalcohol, oxycyclohexane, chlorobenzene, benzyl alcohol.

formulation of stain removers. They are usually organic solvents containing emulsifier dissolved in them and hence become self-emulsifiable. The solvent must be capable of dissolving the hydrocarbon impurity and the detergent must be capable of emulsifying both the hydrocarbon and the solvent. Solvents blended with surfactants are claimed to have superior environmental behaviour along with excellent grease removal [14].

Other alternative methods are that the powerful stain removers may be applied from the bath along with wetting agents cum detergents at high temperature and solvent scour. One such formulation which has been widely used for polyester/cotton blended fabrics for removing unsaponifiable waxes from cotton portion apart from lubricants and conning oils from the yarn is given in Table 4.10. The left over

Emulsion Scouring Recipe

Ingredients	Proportion by weight
Essential Oil	40-50 parts
Perchloroethylene	20-10 parts
Emulsifier (e.g. nonyl phenol, HLB = 13-15)	40 parts
	Total 100 parts

solution as well as the wash water are removed. Rust stains are best removed by oxalic acid up to 10 g/l at about 60-70°C followed by washing.

The mechanism by which emulsion scouring occurs is attributed to the hydrophobic portion of the micelle being saturated with the solvent. The micelle, when loaded with solvent, is more effective in solubilising oily impurities from the fabric than is the detergent alone, provided both solvent and emulsifier are properly selected and used. The critical feature of such a solvent is its KB Value, which is a measure of its solvency for a particular oily soil.

4.5 Solvent Scouring

Solvent scouring appears to be alternative to aqueous scouring and particularly suitable for polyester and woollen goods. This process not only permits scouring, but also simultaneous scouring and desizing or even partial bleaching in one step [15,16]. Solvent scouring is also useful for the removal of lubricating oils from knitted polyester, oligomer from polyester and bulking of knitted goods. Wool felts less in solvent media and is particularly useful in wool milling and application of shrink-resist resins to wool [17]. Solvent processing has been established due to reduced water pollution, reduced energy cost and consumption apart from effective removal of impurities. Solvent preparation gives excellent results in terms of uniformity, reproducibility and high absorbancy [18].

Basically solvent scouring is a refinement of dry-cleaning and is carried out either batchwise or continuously (Chapter 5). Solvents intended for use in textile processing should ideally be inexpensive, readily obtainable, non-toxic, non-flammable, stable to repeated recovery, inert to textiles and non-corrosive. The most suitable solvents for textile processing are the chlorinated hydrocarbons, e.g. tetrachloroethylene (perchloroethylene), trichloroethylene and 1,1,1-trichloroethane. Perchloroethylene is widely used in drum machine [19]. Trichloroethylene is best avoided because of its stripping action of dyed polyester materials if the temperature should rise above 30°C. One important factor for solvent processing is the stability of solvents to recovery by distillation or by adsorption process. The recovery of stabiliser in the solvents is also equally important. The stabilisers recommended for different solvents are shown in Table 4.11. In certain processes 'booster solvents' are added to perchloroethylene. They are generally dipolar aprotic solvents [27,28]. Soil removal in chlorinated hydrocarbons can be improved by the addition of solvent detergents, e.g. monoethanolamine, alkylbenzene sulphonate,

TABLE 4.11
Solvents and Stabilisers for Textile Scouring

Solvent	Stabilisers	Ref.
Trichloroethylene	Substituted diamines	20
	or	
Perchloroethylene	Crotonaldehydedialkyl hydrazones.	21
1, 1, 1 – trichloroethane	Mixtures of acetonitrile and nitromethane	22
	or	
	Dimethoxyethane and 1, 4 – dioxan.	23
Helogenated hydrocarbons (general)	Triethyleorthoformate,	24
	Phosphoric acid,	25
	Benzotriazoic.	26

alkyl poly (glycol ether) and alkyl pyridine chloride [29]. Such products are usually mixtures, e.g. dodecylbenzene sulphonate (13%), nonyl phenol along with 5 ethylene oxide units (5%), isopropylalcohol (5%), water (7%) and chlorinated hydrocarbon (70%). Chlorinated hydrocarbons containing such products are capable of dissolving water and hence enhances detergency.

The main difficulties of solvent scouring are the need for systems to recover the solvent from fabrics after processing. Apart from this, solvent can remove binders from bowl fillings and adhesives from laminated bowl covers and rapidly attacks conventional rubber coverings with expensive effect. At high temperatures adsorption of solvent into the fibre web increases and the degreasing action in subsequent steaming operation can have embarrassing side effects. However, the growing problems associated with the increasing demand for raw water in some countries and disposal of effluent in general have given an impetus to the solvent scouring system.

4.6 Scouring of Raw Wool

Raw wool is difficult to spin because of the natural grease/wax (yolk), large perspiration salts termed suint, acquired impurities like vegetable matters, dirt, proteinaceous contaminant layers (PCL) and wool burrs which contain hemi-cellulose

and lignin. Finer varieties of wool may contain fats and suint as much as 50% of the weight of raw wool. The optimal residual wax content after scouring should be of the order of 0.5 to 0.75% only because amounts in excess of this are liable to cause trouble in carding, doffing and in subsequent dyeing processes. On the contrary, too low a wax content impairs the handle of wool as well as spinning properties. To achieve satisfactory residual grease content on wool various scouring procedures have been used [30].

4.6.1 Emulsion scouring

Scouring of raw wool is carried out in tanks filled with detergents or oleate soap (2-4%) and sodium carbonate (2%) at 50-55°C for 10 to 15 min. The pH of the liquor is about 10. In practice the raw wool is propelled gently through the scouring tank, then squeezed between rollers and then passed through another or more tanks in this way, until eventually it is rinsed in clean water. Such a multi-stage scouring environment is needed to remove dirt from the wool.

The levels of wool wax and dirt (ash) remaining after conventional scouring are considerably higher on the top than base (Table 4.12). The hard to remove wool wax is principally oxidised wool whose emulsion stability is considerably higher

TABLE 4.12.

Levels of Residual Contaminants on Portion of a Wool Fibre

Portion of fibre	Wool wax	Ash
Base	0.46	0.42
Top	1.18	4.73

and in multistage scouring system more effective contact time is available for solubilisation rather than rolling-up mechanism [31, 32]. Thus, in the final stage of scouring in presence of detergent, the hard to remove wool wax is solubilised by the detergent to form a fairly dispersed micelles, whereas the strongly adhering dirt (inorganic or organic) is displaced by the adsorption on non-ionic detergent at the fibre/solution interface [33]. In the surfactant solution there are four stages in the removal mechanism [34] :

- i) an initial swelling of the proteinaceous contaminants ;
- ii) formation of grease globules within or on, the swollen PCL ;
- iii) removal of the swollen PCL with attached globules; and
- iv) breaking up of the swollen PCL/grease complex into spherical or irregularly shaped particles in solution.

4.6.2 Suint scouring

In this process the dusted raw wool is steeped in water at 16°C and then the liquor is withdrawn and clarified by sedimentation or centrifuging [35]. The pH of the suint liquor is between 5.5 to 8.8. For removal of wax the suint liquor should be heated at 60°C, when wax is emulsified. The material is then rinsed, washed with soap and finally rinsed in the subsequent bowl.

4.6.3 Solvent extraction scouring

About 90% of the wool wax can be removed by this system. The recommended solvents are benzene, carbontetrachloride, solvent naphtha, white spirit, trichloroethane etc. In one method solvent is applied under high pressure jet on the material placed on a permeable conveyer and dislodges much of the dirt and suint apart from removal of wax from the fibre [36]. The solvent content on the treated wool is reduced to about 45% by passing through the rollers and is further reduced to about 10% by centrifuging. Finally, the residual solvent is removed from the fibre by blowing hot air [37].

4.6.4 Refrigeration process

In this method raw wool is first exposed to low temperature environment of about -30°C which freezes the wax and vegetable matter and thus becomes hard and brittle. In the second stage these impurities are removed from the fibre by some mechanical means [38].

4.7 Scouring of Wool Yarn and Fabric

The scouring of loose wool is a common practice, although further scouring of wool yarn or piece is often carried out to remove the added impurities i.e. combing and spinning oil. However, before scouring treatments of wool yarns and fabrics, particularly all worsteds and wool/cotton union are given other pre-treatment processes like crabbing and potting.

4.7.1 Setting and scouring of wool yarn

Certain yarns such as those from cross-bred wools are wet set before scouring to prevent cockling occurring in the pieces. Setting of yarn is carried out by stretching the hanks in a suitable frame and the stretched hanks are immersed in boiling water for 30 min. The hanks are allowed to cool under tension before removing from the frame.

Woollen yarns are normally spun with a saponifiable oil, such as oleine based

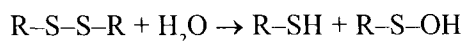
lubricants (70% FFA /30% mineral oil). Scouring can be carried out by saponification system using soda-ash only and forming the necessary soap by reaction with the oleic acid content of the lubricant. Soap will exert a strong emulsifying action to remove grease and dirt from wool yarn. Worsted yarns are generally spun with up to 3% of emulsifiable oil (blends of mineral oil and emulsifiers). This is removed by soap added to the scouring bath together with alkali as a soap builder or by alkaline solutions of synthetic detergents. Surfactant types of lubricants are mainly used on worsted and semiworsted systems, and the low levels applied are often removed in the dyebath. Polyglycol type of lubricants used for carpet yarn spinning can be readily removed using non-ionic detergents in neutral conditions.

4.7.2 Crabbing (setting) of woollen fabrics

Crabbing is merely a relaxation process conducted under controlled conditions before scouring to prevent distortion during subsequent processing. Relaxation removes the latent strain introduced into the yarn before being woven. In the batch process the cloth is passed open width under guide rollers through boiling water in the first trough and is then tightly wound on the lower roller of the two large rollers in such a way that half of the rotating roller of cloth is immersed in the hot water. This treatment takes about 5 minutes. The process is repeated by passing the cloth to the second unit. In this way the outer layer of the cloth in the first treatment becomes the inner layer during the second and thus uniform treatment is possible.

4.7.3 Potting of woollen fabric

Crabbing is frequently followed by steaming or blowing with steam and the wool fabrics are given surface stability without losing their shaping capacity in the making up process. The bonds that stabilise wool fibres in a particular configuration are disulphide cross-links, hydrogen bonds, electrostatic bonding between anionic and cationic side chains and hydrophobic side chains in the protein molecules (Table 4.13). In the setting process, the stresses are relaxed within the fibre by mobilizing one or more various cross-linking bonds and thereby allowing them to rearrange into new, unstressed position. The action of steam on strained wool fibre is two-fold [40]. The first stage consists of breaking the existing bonds :



The second stage consists of a formation of new bonds :

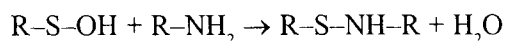


TABLE 4.13.

The Cross-links in Wool and Reagents Capable of Mobilizing Each Type and Bringing About Stress-relaxation or Setting [39].

Cross-link	Mobilizing agents
<p>Disulphide links</p> $\begin{array}{c} \text{C} = \text{O} \\ \\ \text{HC} - \text{CH}_2 - \text{S} - \text{S} - \text{CH}_2 - \text{CH} \\ \qquad \qquad \qquad \\ \text{NH} \qquad \qquad \qquad \text{HN} \\ \qquad \qquad \qquad \end{array}$	Thioglycolic acid, reducing agents, alkalis, steam at high pressure or steam at atmospheric pressure for long periods of time.
<p>Hydrogen bonds</p> $\begin{array}{c} \text{C} = \text{O} \cdots \cdots \cdots \text{HN} \\ \qquad \qquad \qquad \\ \text{NH} \qquad \qquad \qquad \text{NH} \\ \qquad \qquad \qquad \end{array}$	Water, steam or hydrogen bond breaking agents such as urea and DMF.
<p>Electrostatic bonds</p> $\begin{array}{c} \text{C} = \text{O} \\ \\ \text{HC} - \text{R}_1 - \text{COO}^- \cdots \cdots \text{NH}_3 - \text{R}_2 - \text{CH} \\ \qquad \qquad \qquad \\ \text{NH} \qquad \qquad \qquad \text{HN} \\ \qquad \qquad \qquad \\ \text{R}_1 \text{ \& R}_2 = \text{hydrocarbon units} \end{array}$	Water or steam.
<p>Hydrophobic bonds</p> $\begin{array}{c} \text{C} = \text{O} \\ \\ \text{HC} - \text{R}_3 \cdots \cdots \cdots \text{R}_4 - \text{CH} \\ \qquad \qquad \qquad \\ \text{NH} \qquad \qquad \qquad \text{NH} \\ \qquad \qquad \qquad \\ \text{R}_3 \text{ \& R}_4 = \text{hydrocarbon side chains} \end{array}$	Organic solvents e.g., alcohols, DMF etc.

The redistribution of H-bonds is an accepted theory. Temperature, pressure, moisture and time are the parameters which introduce physical and chemical processes in kier decatizing. The optimum pH for crabbing has been shown to be around 6 [41].

The so-called "disulphide exchange" reaction is also accepted today. Wool is constructed of a matrix and microfibrils. The crystalline substance of the microfibrils is embedded in the matrix, the amorphous substance. The two morphological components, differ distinctly in sulphur content. During the kier decatizing, it is assumed that this disulphide exchange, the splitting of disulphide bridges, takes place

first in the matrix by means of water as a kind of preliminary stage. The so-called microfibril component is plastically deformable, i.e. these microfibrils are particularly stabilized by hydrogen bridges. Steam can actually only now attack these hydrogen bridges, which were previously masked by a complicated system of disulphide bridges. The important step therefore is that the microfibrils are deformed : then by cooling, oxidation and the blowing through of air, this set microfibril condition is re-locked by the reorganised disulphide bridges in the matrix. Fig. 4-13 shows how after the disulphide interchange an initially tense molecular structure goes into relaxed (stabilised) state in a new, geometric structure.

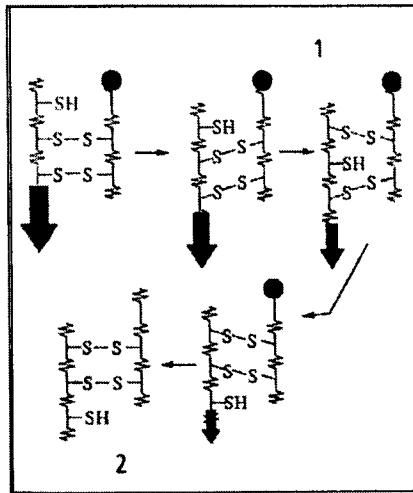


Figure 4-13. Exchange of sulphide and relaxation of the tensions [42]
1, internal exchange at the progressive relaxation of the tension and
2, final stage without tension.

In actual practice the fabric is wound on a perforated roller or cylinder covered with cotton cloth to prevent the perforation marking. Between each layer of wool fabric there is a similar thickness of interleaving fabric. The steam is blown through the inside of the metal roller under pressure of 40-50 lb for 10 to 15 min whilst the cylinder rotates. Then the absorbed steam is removed from the cloth by blowing compressed air through the fabric in much the same way as the steam was blown through it. The air also produces some cooling on the fabric. The cloth is then wound on a second steaming cylinder so that outer layer of the cloth forms the inner layer of the roll and is steamed as before. The cloth is then cooled or passed

through cold water in open width or squeezed. Potting also gives soft handle and bright finish. The main disadvantage is that steaming at high temperatures tends to yellow the wool.

4.7.4 Scouring of wool fabric

Woollen fabrics are still mostly lubricated with olein-based products or mineral wool oils. Worsted may be lubricated as in former times, with natural oils of vegetable or animal origin, or with polyalkylene glycol based lubricants with or without mineral oil additions. Woollen fabrics are generally scoured using scouring liquors similar to those used in yarn scouring. Use of soap and soda is mainly used as scouring agent. This system has certain advantages in promoting bulking and good handling.

4.8 Carbonising of Wool

Carbonising is done to remove the cellulosic impurities from wool by treatment with acid or acid producing salts. Carbonising may be carried out in loose wool or on piece goods after scouring. However, it is common practice to carbonise worsted piece goods as well as woollens.

The conventional carbonising process comprises five main stages : scouring, acidizing, drying and baking, burr crushing and dedusting and neutralising [43-46]. Wool piece goods are treated with sulphuric acid (6-8° Tw) containing acid stable wetting agent and hydroextracted. The treated wool substance is dried at low temperature (60-70°C) very quickly to minimise degradation by sulphuric acid of intermediate critical concentration [47]. The dried wool is then heated at 110°C for a short time. The goods are then neutralised immediately or run dry through a dolly or milling machine to remove the charred vegetable matter and then neutralised. Neutralisation of wool fabric can also be carried out in open-width scouring machine. Neutralisation with ammonia or ammonia/ammonium acetate mixtures removes acid from the fabric far more rapidly than either sodium carbonate and sodium acetate.

In a rapid carbonising process [48] wool is treated in up to 8% (w/v) sulphuric acid solution for 30 sec and time delay of about 10-15 min is introduced before drying. The locally damaged areas can greatly weaken the fibre if surface acid is not evenly distributed [49] during drying. However, in the rapid carbonising method with a delay of 10-15 min, the distribution of sulphuric acid between surface acid

and total acid inside the wool changes [50]. Free surface acid penetrate into the wool fibres and bonds to wool. Thus the amount of concentrated acid formed during drying and baking is minimised and as a consequence, less chemical attack occurs to wool in rapid carbonising.

Magnesium chloride, aluminium chloride (8-10⁰ Tw) or gaseous hydrochloric acid may also be used for carbonising of wool. Rags are carbonised to remove cotton stitchings prior to use in shaddy by the 'dry carbonising' process by exposing to hydrochloric acid gas in an enclosed chamber. Metal acid salts liberate hydrochloric acid at high temperature and attack the cellulose in wool. But owing to their high cost and higher temperatures required which cause injury to dry wool, are rarely used.

The wool burrs contain hemi-cellulose and lignin apart from cellulose. The lignin is not effected by carbonising process on acid hydrolysis, but can be split oxidatively. Salt of persulphuric acid accelerates degradation of wool burrs which enable shortening the time of reaction [51].

Natural soiling of wool and vegetable matter and skin flakes, can also be enzymatically modified [52]. The replacement of carbonisation by the use of enzymes, such as cellulases, ligninases, hydrolases, lyases, oxidoredulases etc. are reported [53]. The main advantages of enzymatic carbonising are reduced wool fibre damage, effluent load and energy consumption.

Carbonised wool are more porous than scoured wool and hence the dye uptake is higher. Uneven dyeing may result due to faulty carbonising [54].

4.9 Degumming of Silk

Degumming or boiling-off is the process employed to remove the silk gum (sericin) enveloping the two raw silk threads (fibrion) (Fig. 4-14). During the

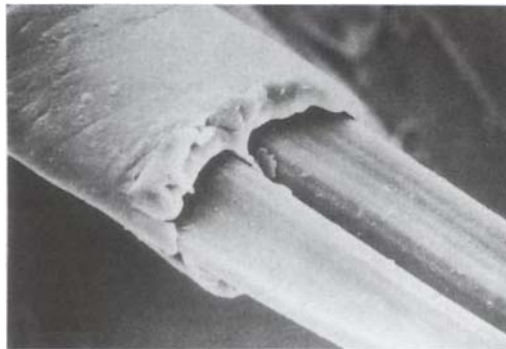


Figure 4-14. The microphotograph of raw silk [55].

spinoning process of silk by silkworms the two filaments are made into one by means of proteinous gummy substance called sericin. The gum content of silk varies according to quality and origin. *Bombyx mori* or Mulberry silks have about 20-30% gum and Tussah 5-15%. The gum is not completely removed in every case. The extent of degumming gives rise to different varieties of silk [56]. 'Ecrú silk' (crude, bast silk) is rarely degummed, quite hard and without lustre. The degumming loss is maximum 4%, since mostly only grease, wax and resin substances are removed. This type of silk is mainly used as warp threads. 'Half-boiled silk' (souple, soft, matt silk) is partially degummed. The degumming loss is approximately 6-12%. In order to make the gum on the fibre to soften and remain in that condition, a treatment of 3-4% of tartar ematic is advisable. 'Cuite silk' (lustre silk) with nearly 18-30% gum loss can be classified as a completely degummed variety with a soft handle and high lustre.

Apart from sericin, other impurities present in silk are lubricants and softeners added during throwing or in preparation for weaving or knitting, dirt and oils picked up incidentally during processing and undesirable natural colours. The component of fats and oils is around 0.5-1% and that of natural pigments 1.0-1.4%. During the degumming process, soil, stain, oil and fats sticking to the material will also be removed. Thus degumming is synonymous with the scouring process normally used for the purification of cotton and wool.

Silk warp is not subjected to sizing before weaving like cotton. However, grey silk fabric and its blended fabrics are subjected to singeing prior to degumming. Degumming can be carried out by physical or chemical means on silk in the form of hank and also on fabrics which are subsequently taken for dyeing. The choice of degumming conditions depends on the type of silk product (yarn, twist, fabrics of different densities). Wild silk fabric is more difficult to degum than Mulberry silk. Tussah silk contains higher quantities of calcium salt. Loss in weight of silk by degumming process is also accompanied by a loss in strength of approximately 20%. The loss of weight and volume can be completely or partially compensated by the subsequent weighting process.

Degumming is effected by careful treatment of silk with high pressure water, acids, alkalies, soaps and synthetic detergents. Chemical dissolution of sericin is obtained partly by hydrolysis and partly by dispersion, independent of the method used. Soap works mainly by dispersion whilst alkalies have a strong hydrolytic effect [57].

4.9.1 Degumming of silk in water [58]

Cultivated varieties of silk can be degummed by extraction with water at 120°C for about 2 h and repeating the process three to four times. In this case degradation of silk is minimum, but use of pressure equipment is essential. However, some modification of the protein molecule does take place.

4.9.2 Degumming of silk with alkali [59] and acid [60]

Silk degumming in aqueous solutions of acids and alkalies is greatly influenced by pH and temperature. An alkaline reaction at a pH > 9 and acid reaction at pH < 2.5 ensure a rapid elimination of sericin completely after 30 min of treatment. The temperature should not exceed 95°C to avoid weakening of the fibre. The degree of hydrolysis of fibrin also depends on pH of the bath.

4.9.3 Degumming of silk with soap [61]

Degumming is effected by careful boiling-off in soap baths which should be slightly alkaline. The fibre is treated with soap solution to give a pH around 10.0 at 90-95°C for 1.5-2 h. In order to avoid lien soap deposits and resulting stains, the water should be properly softened. Sequestering agent may be added in the bath to correct the hardness of water. In case of white and delicate varieties a two bath method may be employed. The second degumming bath will consist of 50% quantity of soap taken for the first degumming bath and the duration of treatment may be divided equally between 40-45 min for each bath.

Neutral soap like Merseille soap or olive oil soap have no degumming property as the free alkali present in them are very negligible. However, Merseille soap (8 g/l) can be used in presence of non-ionic tenside (fatty alcohol polyglycol ether) (1-3 g/l), polyphosphate (1-3 g/l) (for softening the water) and soda (1 g/l) at 95°C for 1-2 h with a material to liquor ratio of 1:30. Here also a two bath method can be resorted to. Non-ionic tenside accelerates the degumming process and facilitates rinsing out the soap. Tussah silk is usually prewetted with boiling water before degumming and then degummed in strong alkaline bath [62].

4.9.4 Degumming of silk with synthetic detergents

Degumming with synthetic detergent is increasingly replacing soap. The main drawbacks are soap is expensive, great quantity of soap is required and longer treatment time. A large number of synthetic detergents are available in the market and their selection is very important particularly on the requirement of soft feel as

that achieved with soap. Non-ionic product like nonyl phenol ethoxylated compound in the pH range of 11.2-11.5 for a treatment time of 40 min at 95°C is found to remove the gum and maintain the strength of the yarn.

4.9.5 Enzymatic degumming of silk

Enzyme which can hydrolyse the sericin is classified as proteolytic enzymes [63-65]. The proteolytic enzymes cleave the peptide/amide linkages and convert them into amino acid. Mainly there are three types of proteolytic enzymes such as zinc protease (e.g. carboxy peptidase A), serine protease (Chymotrypsin, Trypsin, Thrombin) and thiol protease (acts as cystine residue in the protein). The function of proteolytic enzymes in their degree of degumming depends on the pH of the bath and the optimum activity is found to be different at different pH for different enzymes.

Usually enzymatic desizing of silk is a two stage process. In pre-degumming stage, the cloth is treated with a solution containing soda-ash (1 g/l) at 95°C for 20 min at a liquor ratio of 30. In the second stage, further degumming is carried out by treatment in a solution containing protein enzyme (0.06-0.1 g/l), non-ionic detergent (1 g/l) for 30 min at 55 to 60°C. It is usually impossible to achieve full degumming of silk by enzymes. A short-time treatment in a third bath containing soda-ash or soap may be given for the removal of the remaining sericin.

4.9.6 Foam degumming

The degumming of silk can also be carried out by foam method. The silk skiens are subjected to the action of foam from a boiling soap bath. Skiens are actually hung above the soap solution and the foam action has a tendency to dissolve and eliminate sericin. This method, however, is not popularly adopted.

4.9.7 Partial degumming of silk

Before partial degumming the silk is degreased in moderately warm (30-40°C) and slightly alkaline soap baths. The actual degumming is then taken place in a bath containing acid salts or acids. The sericin is not released as much in an acid medium as it is in a neutral or alkaline bath, thus only partial degumming results. Acid degumming has also a positive effect on the strength and handle. The actual degumming bath can have various compositions :

- Sulphuric acid and magnesium sulphate,
- Sulphuric acid and soap,
- Sulphuric acid and tartar,
- 4% strength soap solution,
- NaHSO₃ solution.

Depending on the nature of silk, it is treated for 1-3 h at boiling temperature. The weight loss with half boiled silk lies in the range of 6-12% on the original raw weight.

4.9.8 Washing of degummed silk

After boiling-off, the silk is thoroughly washed with lot of water at 50-60°C containing 1ml/l ammonia for 15-20 min. This is then followed by 1 to 2 cold rinsing baths. Half-boiled silk should not be subjected to hot soap baths and alkaline liquors over 30°C because this would act on the silk gum still present.

Following washing and drying silk is given further mechanical treatment in the form of stretching, beating or glossing. Scroop is imparted to the silk fabric by treatment with 2-5 g/l of 30% acetic acid at room temperature for 15-30 min. When silk is delivered in dyed condition, scrooping is done after dyeing.

Both degumming and partial degumming are only suitable for reeled silk (greige). These finishing processes are insignificant where schappe and bourette silks are concerned, since these are freed from their gum in the early stages of preparation before spinning [66].

4.10 Degumming of Remie

Degumming of remie is a long and complex procedure. Different degumming technologies [67-72] use different auxiliaries. Besides boiling-off, other treatments such as scuthing, washing in acid solution and water etc. directly effect the sheen and gum content of the mass of cleaned fibre.

In chemical degumming of remie, hot caustic soda solution of about 10% (o.w.f.) is used to dissolve pectic substances. Apart from this, sodium phosphate, sodium pyrophosphate, sodium metasilicate, sodium sulphite can also be used for degumming of remie.

Sodium pyrophosphate is better than sodium phosphate in washing and total cleaning [73]. Although sodium pyrophosphate is very permeable, diffusible and can scour as well in presence of metal ions, it is expensive. Sodium metasilicate shows good washing, total cleaning and emulsifying properties and it is inexpensive. Sodium sulphite, not only has a bleaching function, but also protects the physical properties of the fibres. The degumming efficiencies of these three auxiliaries was studied by using quadratic orthogonal rotation experimental design [74]. The concentration of auxiliaries and time of second boiling-off are the most important

factors in degumming. Sodium pyrophosphate can be replaced and replenished by sodium metasilicate over a definite range, so also decrease the manufacturing cost. The optimum conditions of sodium sulphite degumming are 1% and second boiling-off time, 3-3.5 h, the concentrations of sodium metasilicate and pyrophosphate are 2.5-3% and 0.7-1.0% respectively.

4.11 Scouring of Linen

The scouring of linen is associated with number of problems such as weight loss, release of cations from salts into solution and loss in strength. If the released cation is iron, this can lead to cationic tendering during bleaching. This problem can be minimised by adding suitable chelating agents in the scouring bath and thus sequesters any cations released from the proteins.

Traditionally, long slow processes are carried out to obtain correct balance between the required properties of whiteness, absorbancy etc. in one hand and chemical damage on the other. The traditional process usually consists of chlorination, extraction of the chlorinated lignin by scouring in soda-ash and then bleaching preferably with alternate chlorite and peroxide stages or even hypochlorite bleach. Process details of conventional method are shown in Table 4.14. Lime boil is

TABLE 4.14
Conventional Process Details for the Scouring of Flax

Kier boil	Lime	10-12% (o.w.f.), 8 h at 60°C
Cistern sour		
Kier boil	Soda-ash	12.5 g/l, 18 h at 60°C
Cistern chemic	Available Cl ₂	1.7 g/l, 2 h at pH 4.3
Kier boil	Soda-ash	6.5 g/l, 18 h at 60°C
Chemic bleach	Available Cl ₂	0.6 g/l, cold pad-batch over-night
	Soda-ash	2.0 g/l

followed by hydrochloric acid sour, alkaline (soda-ash) boils, acid chemic (hypochlorite at pH 4 to 5), a further alkaline boil with soda-ash which removes the chlorinated sprit (remnants of the woody core of the flax stem), and finally a hypochlorite bleach (pH 9-10). This complicated process sequence has been streamlined over the years. The lime boil has been replaced by a caustic-soda-ash boil.

4.12 Scouring of Jute

Although jute is a natural fibre like cotton, it differs in chemical composition. Unlike cotton jute contains a high percentage of non-cellulosic matter (about 40%) and the pre-treatment processes of jute are somewhat different from that of cotton. Scouring of jute with caustic soda under pressure cannot be carried out like cotton because of removal of hemi-cellulose which results in high losses of tensile strength (10-15%) and weight (6-8%).

Apart from natural impurities, jute yarns or fabrics contain mineral oil/jute batching oil (JBO), which is added to facilitate spinning of jute fibre. The JBO has a delustering effect and also contributes additional yellowing on exposure to light.

Despite golden brown colour of jute and presence of mineral oils it is directly taken for bleaching after a hot and cold rinse or an acid steeping or a neutral/mild scouring. Treatment with dilute solution of sodium hydroxide and soap at elevated temperature results in softer feel and pliability which may be attributed to the action of alkalinity in the soap and deposition of fatty materials on the fibre surface. An effective method of removal of JBO or mineral oil together with adhering/extreme dirt/impurities is to treat the grey material with an emulsified solvent for 15-20 min at 70-80°C, to which soda-ash may optionally be added. The advantage of the process is that the strength of jute is not affected much.

4.13 Scouring of Synthetic-polymer Fibres

Synthetic fibres generally do not contain naturally occurring impurities like natural fibres i.e. cotton and wool. However, spin finishes, processing and coning oils and antistatic agents are added to improve the physical and mechanical properties during spinning, weaving and knitting. Other impurities are dirt and sighting colours (to distinguish one kind of fibre from the other). The objective of scouring synthetic fibre fabrics is to remove the dirt, size, processing lubricants and sighting colours, achievement of relaxation in the case of texturised and knitted fabrics and production of special effects.

4.13.1 Scouring of polyester

Loose stock, slubbing and some types of polyester yarns may be simply rinsed with water or even be placed directly in the dyebath. The scouring of polyester fabric mainly depends on the type of sizing agents used on the yarn. Flat polyester-filament fabrics are commonly scoured to remove sizes and lubricants, after spotting (if necessary) to assist the removal of loom stains. The preferable condition for scouring of polyester in alkaline reagents (caustic soda, soda-ash, ammonium hydroxide) is about 2 g/l with a treatment time of 30-60 min at a temperature of 75-80°C. Alternatively, scouring can be carried out with anion active detergents in an amount 1-2 g/l at 80-95°C for 20-30 min.

Special precaution is necessary when polyester is scoured with strong alkali at higher temperatures and care has to be taken not to hydrolyse the fibre. Fig. 4-15 shows the reduction in weight of polyester on treatment with caustic soda at 100°C.

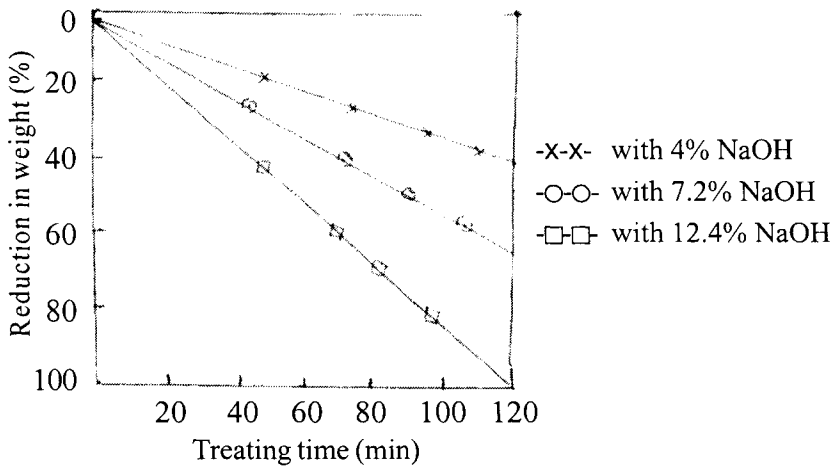


Figure 4-15. Loss in weight of polyester on treatment with caustic soda at 100°C.

4.13.2 Scouring of nylon

Nylons are scoured before dyeing to remove the added impurities and sighting colours. Synthetic detergents along with mild alkali are generally suitable for scouring nylons. Generally, non-ionic detergents are used in scouring of nylons as the anionic preparations are absorbed by the same sites of the fibre similar to that of anionic dyes and consequently reduce the exhaustion of the dyebath. Recipes for the scouring of nylon by batch and continuous processes are given in Table 4.15. Soft water should be used in the scouring bath to minimise the retention of heavy metals by the free carboxyl end groups of nylons. Emulsified organic solvent will

TABLE 4.15
Recipes for the Scouring of Nylons

Scouring chemical	Batch process	Continuous process
Non-ionic detergent (g/l)	2-3	2-3
Anionic detergent (g/l)	1-2	1-2
Soda-ash (g/l)	1-3	–
Sodium pyrophosphate (g/l)	–	3-6
Temperature (°C)	70	90
Time (min)	20-30	10-20

be of assistance if oil stain is also be removed from the fibre. The temperature of scouring depends on whether the material has been heat-set or not. For unset fabric the preferable temperature range is 70-80°C and for the set fabric it is 95-100°C. Unset fabrics have creasing problem if scouring is carried out in rope form above 60°C. After scouring the fabric is washed first at room temperature and then raised to the required temperature. An acidic wash-off is necessary when cationic finish is to be removed from the fabric.

4.13.3 Scouring of polyacrylonitrile fibres

Scouring is particularly necessary for yarns which are to be dyed in pale and medium shades as grey patches may appear due to soiling and lubricant present in the fibre.

Before scouring high bulk acrylic yarns on cones are relaxed in saturated steam at about 100°C for 20 min or in hot water. The hanks may be relaxed during dyeing also. Fabrics may be given dry heat treatment to impart some stability against creasing and to relax the material.

Alkaline solutions or soaps are not used for scouring of polyacrylonitrile fibres as they discolour the fibre. Scouring is carried out in a solution containing 1-2 g/l non-ionic detergent and 1 g/l trisodium phosphate at boil for 30 min. Anionic detergent should be avoided. 1 ml/l solvent-based detergent may be added in the bath for removal of oil and grease from the fibre. After scouring the bath is cooled to 60°C and rinsed at this temperature thoroughly to remove detergents as its presence affect the handle of the fibre.

Generally, scouring of modacrylic fibres is not always necessary. However, scouring and desizing may be carried out in a similar manner to that regular acrylic

fibres with non-ionic detergents at 50-60°C for 30 min under either weakly acid (acetic acid) or alkaline (trisodium phosphate) conditions followed by thorough rinsing.

4.13.4 Scouring of acetate fibres

The scouring of acetate fibres can be carried out in a solution containing 3 g/l soap and 1 g/l of a 25% solution of ammonia for 30-35 min at 70°C. Diacetate can be saponified under certain conditions of alkaline scouring and therefore careful control is necessary to avoid surface modification. Delustering of normally bright acetate fibres can be combined with scouring. Triacetate is not delustered by boiling or soap solutions. For triacetate higher temperature of wet treatment can be given than for diacetate.

4.13.5 Scouring of regenerated cellulose

Viscose and cuprammonium rayons do not contain natural impurities and scouring is done only to remove added impurities. Rayon can be cleaned by treatment at a temperature of 80-90°C with soap solution (0.3 - 0.5%) to which mild alkali like soda-ash or trisodium phosphate may be added. Rayon fabrics may be desized, scoured and bleached by treatment with a solution containing hydrogen peroxide (0.67 vol), caustic soda (5 g/l), together with sodium silicate (5 g/l) and wetting agent (1.5 g/l) by pad-steam method. The treated fabric is steamed for 2 min. After boiling-off, the fabric is washed with warm and cold water. The strength of hydrated cellulose is considerably reduced in wet condition and hence scouring should be carried out in a tensionless condition.

4.13.6 Scouring of texturised fabric

The filament yarn has an established superiority over spun yarns due to its high strength and lustre. However, fabrics made from filament yarn do not possess a soft feel and appear to be papery. To remove this drawback and to achieve suppleness in the fabric, the filament yarn is given what is called a ‘‘Crimping’’. The process of making crimp yarn is known as ‘texturising’. Texturising is possible for synthetic fibre because of its thermoplastic nature. Texturising improves the elasticity, bulkiness, resiliency, crease resistance etc. of the fabric. False twist processes are widely used for the production of bulked polyester and nylon yarns for a variety of end uses in the woven and knitted goods, including socks, gloves, knitted underwear, mufflers, sweaters, bathing suits and many other products.

The textured woven and knitted goods possess latent heat of torque which is already set during texturing process. The warp yarn is applied with a large amount of sizing and oiling agent and thus the grey fabric loses its crimp by mechanical tension, becoming in a flat state. Therefore, it is necessary to restore the crimp of the yarn by relaxing treatment in water under tensionless condition. Relaxing can be carried out by water, steam and dry heat and it can be seen (Fig. 4-16) that hot

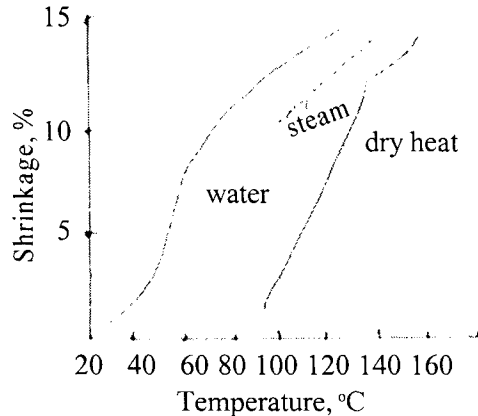


Figure 4-16. Effect of heating medium on relaxation of textured fabric.

water is better than steam or hot air for obtaining the fabric relaxation to develop stretch. The resultant shrinkage is about 15-20%.

The textured fabrics are relaxed in water at 80-95°C in the absence of tension for 20-30 min. For high twist yarn and fabric a longer time is required. A gradual elevation of temperature is more favourable to relaxation. A high temperature relaxing without tension may cause wrinkling, so that a little tension of the order of 1-2 mg/d is favourable. The force existing between yarns and in the textured woven fabric restrain the relaxation so that it is necessary to reduce the restraint by some mechanical impact in the form of bending, pressing, vibrating and rubbing action that can be utilised by making use of various machines.

Spin finishes of textured polyester yarns and knitted fabric normally contain oiling agent of self-emulsified type, and can therefore be readily removed by rinsing at 50-60°C without any addition of detergent. Spin finishes that do not contain emulsifying agent are removed by washing with 1-2 g/l a combination of non-ionic and anionic detergent at 60-70°C. The temperature of the bath should not be raised more than 2°C/min to avoid production creases.

In most cases scouring is carried out in conjunction with the relaxing process on a tensionless machine. In paddle scouring, circular knitted nylon fabrics or garments are loosely packed into polyester mesh bags and scoured/relaxed in overhead or side-paddle machines using 1 g/l non-ionic or anionic detergent, 0.5 g/l sodium hexametaphosphate and 1 g/l solvent scouring agent at 60°C for 30 min. The liquor is cooled, fabric is rinsed, hydroextracted and dried without tension at 60-80°C.

The goods may be solvent scoured in rotary drum machine, restricting the load to 50% of the machine maximum capacity and the centrifuging time to 1 min to avoid the formation of pressure creases. Warp knitted fabrics are, in general, more stable to tension than weft knitted fabrics.

4.14 Scouring of Blended Fibre Fabrics

The wide range of natural and man-made fibres provides many combinations to create new effects with desirable properties. Strength, wearability and crease recovery are the main properties responsible for synthetic fibres becoming established for blends with cotton, viscose and wool. The acrylics are also in much demand for such blends, while polyamide fibres and triacetates are of secondary importance.

4.14.1 Scouring of polyester/cotton blends

Scouring is mainly designed to remove the natural oils and waxes from the cotton portion and the finish oils which manufacturer add to polyester fibres when extruded. Blends of polyester/cotton can be scoured with alkaline scouring agents as per conditions shown in Table 4.16. Trisodium phosphate can also be used as an

TABLE 4.16

Alkaline Scouring Conditions for Polyester/Cotton Blends

Equipment	Scouring agent and conditions
Jigger	Caustic soda (3%) at 70°C for 90 min or at 100°C for 15 min.
Jigger	Soda-ash (5-10 g/l) and detergent (2-5 g/l) at boil, or NaOH (2-5 g/l) and detergent (2-5 g/l) at 75°C.
Winch	NaOH (1-2 g/l) or Na ₂ CO ₃ (2-5 g/l) at 75°C.
Pad-steam	Soda-ash (5-10 g/l) and detergent (2-5 g/l), 100% pick-up, steaming at 100°C for 30-60 min.

alkali. The use of emulsifiable solvent scouring agents are useful. Combined scouring and bleaching process using alkaline hydrogen peroxide is also preferred for the reason of economy. Fabrics containing polyester fibre should not be kier-boiled. In such blends, milder conditions of alkalinity and temperature are used to avoid detrimental effects on the polyester portion.

4.14.2 Scouring of polyester/wool blends

Polyester/wool blends are very popular, the most common blend ratios are 55:45 and 70:30 polyester : wool. Polyester rich blends are normally constructed from a texturised polyester fibre warp and 55:45 polyester : wool weft yarns. The 20:80 polyester/wool is woven from 55:45 warp and a pure weft yarn. Worsted polyester/wool blend yarns may contain 2.5 – 3% solvent extractable oil, compared with 3.5 – 5% for similar all wool yarns. The oils have much greater affinity for polyester fibre than wool and after normal piece scouring, the blends contain residual oil content of 0.6 – 1.2% compared with 0.3% for wool. Oxidation of combing oil is influenced by exposure to light which should be avoided before scouring. Addition of surfactant to combing oil improves the scourability of the blend fabric [75].

The object of scouring polyester/wool blended fabric is not only to remove spin finishes, lubricating oils, sizes and contamination of all types, it also helps in fabric relaxation and parting the necessary compactness. Blended fabrics may also be pressed and flattened by any of the usual methods employed with all-wool cloth before scouring.

Scouring can be carried out either in rope form in Dolly washing machine for wool rich blends or open width form for polyester rich blends. The spin finishes are removed by 0.5-1% non-ionic alkyl phenol polyglycol ether type of detergent and 0.25-0.5 ml/l NH_3 (25%) or 0.2-0.4 g/l soda-ash at pH 8 to 9 for 20-30 min at 40-50°C. Synthetic detergent solution at pH 5 to 6 can be used to minimise degradation. The presence of man-made fibre in a blend with wool (greater than 20%) may inhibit milling. In general, the greater the percentage of wool in the cloth the greater is the shrinkage. The fabric is finally washed-off at 35-40°C for 45 min, and then cooled gradually. A typical procedure for a soft finish for polyester/wool knitted goods is to scour in tubular form (face inside) at 30-35°C for 25 min in 4° Tw Na_2CO_3 (1.9% solution) and 4% soap (o.w.f.). After washing-off in water at 35°C for 15 min, the fabric is dried on either tubular drier or stenter, is cropped

closely on the face side, open steamed for full relaxation and finally decatized.

In case of solvent scouring it is claimed that trichloroethylene at the boil provides a satisfactory method in a continuous open width plant of special design.

4.14.3 Scouring of polyester/acrylic blends

Scouring of polyester/acrylic fibre blended fabrics can be carried out in either a weakly acid or alkaline bath using a combination of 0.5-1 g/l non-ionic and anionic detergents. The pH of the bath is adjusted to 5-6 with acetic acid or 8-7 with ammonia or soda-ash and the treatment is done for 20-30 min at 60°C (for acidic pH) and 40-50°C (for alkaline pH). The amount of detergent used depend on the degree of soiling. After washing, rinsing proceeds until the cloth is free of alkali. It is an advantage to sour the last rinsing with a little acetic acid.

4.14.4 Scouring of acrylic/wool blends

Wool/acrylic fibre blend yarns are prepared on the woollen or worsted systems of spinning. Generally, fatty acid type of lubricants applied in woollen processing should be avoided to prevent discolouration of the acrylic fibres. High bulk acrylic fibres are also used in the wool industry. Blend yarns containing unrelaxed high-bulk acrylic fibre should be completely relaxed before being dyed, either by steaming in an autoclave at 107°C for 10 min after preliminary evacuation of the steamer, or by immersion in boiling water for 5 min.

For worsted yarns, scouring can be conducted at a maximum temperature of 60°C for 30 min with 1 g/l non-ionic detergent and 0.5 ml/l acetic acid (80%). Woollen spun yarns lubricated with oleine are scoured at 30°C with soap or synthetic detergent and sodium carbonate. The addition of solvent is sometimes advantageous for the removal of oils. Tape scouring machines are generally used for the scouring of hanks.

Acrylic/wool blended fibre fabrics may be prepared according to established practice for wool, except that precautions are taken to allow for the thermoplastic properties for the acrylic fibres. Relaxation is done to remove the inherent strain. Worsted fabrics are crabbed and then scoured in either a Dolly at temperature not exceeding 40°C or in winch.

4.14.5 Scouring of acrylic/cellulosics blends

Blended yarns of acrylic/cellulosic fibres are prepared on the woollen system. Yarns prepared in the cotton system of spinning may be scoured at 60°C (30°C for

unrelaxed bulked yarns) for 30 min in a liquor containing 1 g/l non-ionic detergent and 0.5 ml/l acetic acid (80%). Fabrics should be desized and scoured to remove sizes, spinning assistants and other impurities. Scouring can be carried out with 1 g/l non-ionic detergent, 1 g/l trisodium phosphate at 60°C for 30 min followed by rinsing well with sufficient water.

4.14.6 Scouring of acetate/wool blends

Diacetate and triacetate are both used in blends with wool. Scouring and milling can be conducted with the minimum quantity of alkali at temperatures not exceeding 50°C and care should be taken to avoid excessive mechanical friction on the fabric. Fabrics made from triacetate/wool blends should be given a crabbing treatment before dyeing.

4.14.7 Scouring of blends containing viscose

Standard viscose and polynosic rayons are blended with cotton for improved physico-chemical properties of the blended fabric. The increase in tensile strength brought about by blending wool with viscose is well-known. Fabrics containing around 65% triacetate with viscose may be given durable pleats. Bulked or textured nylon is sometimes used with viscose rayon for fabrics. Table 4.17 shows

TABLE 4.17

Scouring Conditions for Blends Containing Viscose

Blend	Treatment conditions
Viscose/Cotton	0.1% soap ; 0.1% NaOH ; 1 h at boil.
Viscose/Wool	3% non-ionic detergent ; 1 ml/l NH ₃ (0.88 sp. gr.); 15-20 min at 40-45°C.
Viscose/Acetate	0.2% soap, 0.2% ammonium hydroxide (sp. gr. 0.88) ; 30 min at 90°C. Temperature should not exceed for bright acetate.
Viscose/Acrylic	0.25% synthetic detergent ; 0.5% sodium acetate or acetic acid, adjusted to pH 5.5-6 ; 30 min at 90°C.
Viscose/Nylon	2-5% (o.w.f.) soap or synthetic detergent ; 2-5% trisodium phosphate ; 30 min at 40-70°C.
Viscose/Regenerated protein	Solution is same as for viscose/acrylic blend ; 30 min at 50°C.

some representative scouring treatments that are suitable for specific blends containing viscose fibres but in practice the precise conditions vary also with the procedure and machineries used.

4.14.8 Scouring of polyester/silk blends

Blends of natural silk and polyester fibres (35:65) are sometimes used for dress goods, blouse fabrics and men's fashion wear. Sizing agents and soils are removed by washing with a minimum tension in open soaper containing 1 g/l non-ionic detergent and 1 ml/l NH_3 (25%) at 50°C.

4.14.9 Scouring of blends containing casein fibres

Casein/cellulosic fibre blended fabric is first desized under mildly acidic conditions at 60-70°C for 30-60 min and then scouring is carried out in a fresh bath at pH 6 with 3-4 g/l non-ionic detergent at 50-60°C for 30 min, and rinsed well, first in warm and then in cold water.

Blends containing casein/wool can be scoured with 1 g/l non-ionic detergent, 1 g/l sodium hydrosulphite and 1 ml/l NH_3 (sp. gr. 0.88) for 30 min at 50°C. The grey fabric is scoured in the Dolly or winch with minimum mechanical action. Strong alkalis and prolonged wet processing temperatures above 80°C are not advisable. Apart from certain limitations in scouring, most other woollen and worsted preparation and finishing operations can be carried out without major changes, they include carbonising, crabbing, blowing, decatising and pressing.

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