Preparatory operations

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Wool and wool blends

Introduction

In the finishing of wool and wool blend fabrics, each type of fabric must be treated appropriately as far as its construction and composition are concerned. Any variation of either construction or composition will require a modification in procedure. The number of operations and degree of treatment must be decided after consideration of the following factors:

1. quality and type of raw material or materials employed to make the fabric
2. structure and colour of the yarns in the fabric
3. structure of the cloth
4. particular appearance and handle required in the finished fabric.

Dyed yarns have already undergone relaxation during the dyeing process, which has removed some of the stresses introduced during the spinning operation; therefore, some allowance must be made for this effect when finishing a piece-dyed fabric if it is to have the same handle and appearance as a yarn-dyed fabric. The structure of the weave will have an influence on the degree of contraction and shrinkage properties of a worsted cloth.

It is important to note that each type of cloth requires the particular treatment that gives the greatest enhancement of quality and, hence, the value of the cloth. A well finished cloth composed of say 20 micron wool will have a higher value than a poorly finished cloth composed of a finer 16 micron more expensive material.

Scouring

The successful removal of all the impurities from the fabric affects subsequent processes and the final result. It has been estimated that at least 70% of all faults in processing originate from inadequate preparation or scouring. Preparation processes have become more critical as the subsequent chemical and mechanical treatments of cloths have become more sophisticated. Typical impurities present in woollen and worsted fabrics are:

- spinning lubricant
- oils from the weaving or knitting machine
- floor dirt.

Modern spinning lubricants are more readily removed than the older style oily lubricants and are present on the fabric in levels of 1–2% for worsted fabrics and 7–10% for woollens. Machine oils from the weaving or knitting machine are normally mineral oil based and are more difficult to remove. Fabric that has been standing for some time may contain oxidised oils that pose special problems in the scouring operation. Very lightweight fabrics, where singles yarn has been used in the warp, may contain some sizes to aid in the weaving or the yarn may have been waxed to improve the weaving or knitting efficiency.

Three features are essential in scouring:

- saturation of the cloth with scouring liquor; wetting
- saponification or emulsification of the oils or grease in the fabric
- compression, to squeeze the liquor together with the impurities from the cloth.

Scouring is therefore both a mechanical and chemical process.

Efficient wetting of textile materials depends on the ability of the water to penetrate the spaces between the fibre bundles, particularly if the yarn is of high twist. This process is assisted by lowering the surface tension. Any wetting agent will perform the first step of detergency by penetrating through inter-fibre spaces, thus exposing the dirt and grease. The next stage is the detachment of grease and dirt from the fibre/fabric surface (usually referred to as the substrate) followed by the third step: maintaining the soil and grease particles in a suitable state to prevent re-deposition onto the substrate. This is accomplished either as a suspension or emulsion. The stability of the suspension or emulsion must be such that it will prevent re-deposition until the whole fabric is clean, when the grease and dirt-laden emulsion can be discharged down the drain. There are a large number of wetting agents that are incapable of detaching or removing grease and holding it in a suitable suspension or emulsion.

Soap is the simplest and oldest of all the detergents and can be represented by the general formula:

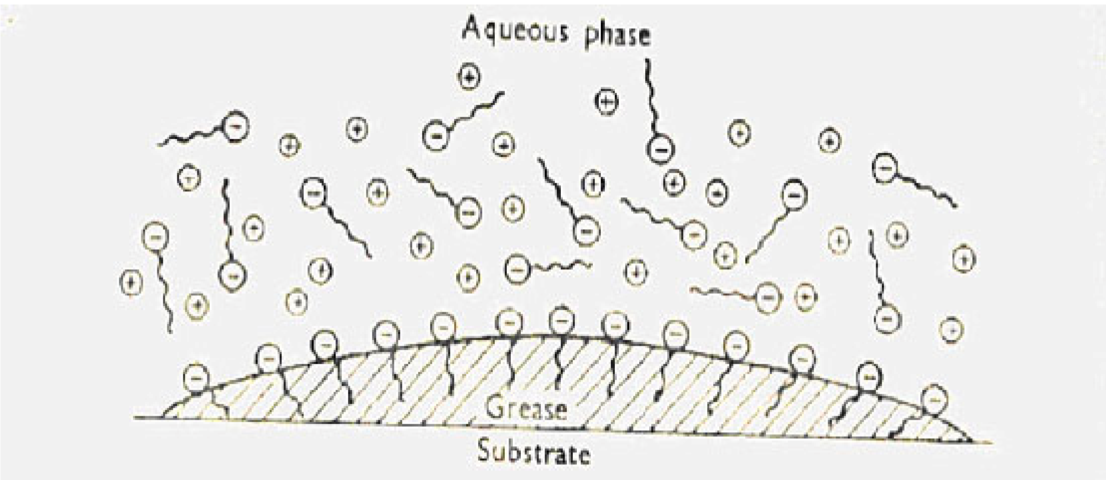
$R - COONa$, where R is a long chain hydrocarbon.

In aqueous solution it dissociates:

$R - COONa$? $R - COO^{-} + Na^{+}$

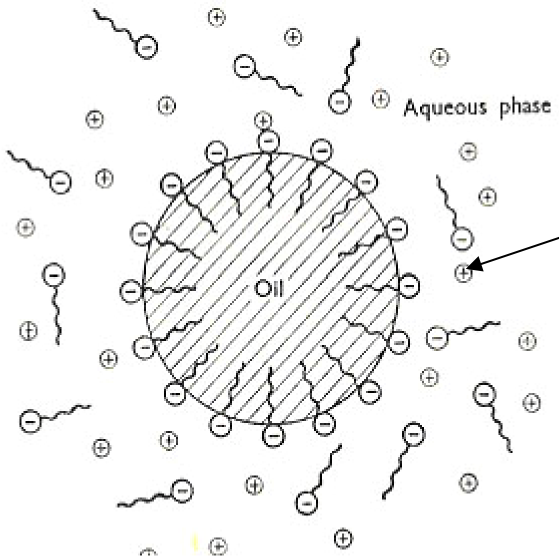
giving a large anion consisting of a mainly long hydrophobic or oleophilic hydrocarbon chain terminated by an ionised carboxyl group sufficiently hydrophilic to bring the entire ion into solution. Soaps with a saturated hydrocarbon chain of more than 20 carbon atoms are only sparingly soluble in water.

The long chain ions orient themselves along the oil-water interface, the carboxyl ion in the aqueous phase and the oleophilic portion in the grease phase as in the diagram:



(Source: Practical Textile Chemistry – J.W. Bell.)

As the grease is removed from the fabric it is stabilised in an emulsion as small droplets. The removal of the grease depends on the formation of micelles. The formation of micelles commences when the carbon chain is about seven atoms long.



The diagram illustrates the formation of a single micelle. Large numbers of micelles are formed, resulting is an emulsion.

Efficient detergency does not arise until the length of the chain has increased to about 11 carbon atoms. The same rules apply to synthetic detergents, which differ from soaps chiefly by containing instead of an ionised carboxyl group, a hydrophilic radical sulphonate group that is less sensitive to acids and hard water. The oleophilic portion is still a long chain, commonly a hydrocarbon that must be capable of micelle formation. Otherwise, the substance would have no detergent properties, though it may have excellent wetting properties. Sodium sulphosuccinate has excellent wetting properties but no detergent properties.

The influence of water on scouring efficiency

Water plays a most important part in the scouring process. Impurities present in the water, such as calcium, magnesium salts and suspended solids, may be responsible for creating defects that develop in later processes. These defects may not be noticeable in the scouring process and may only appear after dyeing. For scouring purposes water from 0 to 3° of hardness is desirable. Hard water is inefficient and consequently expensive for scouring. Calcium and magnesium salts can be removed by chemical treatment using a base exchange resin system such as Zeolite. Suspended solids are removed by filtration and settling using an appropriate flocculation treatment. Aluminium sulphate ($Al_2(SO_4)_3$) is often used as the cheapest flocculating chemical. If an appropriate base exchange softening plant is not available, the addition of a suitable sequestering agent to the scouring liquor will minimise the problems associated with poor quality water. Typical sequestering agents that may be used are sodium hexa meta-phosphate or organophosphates such as methyl phosphonate. Compounds such as methyl phosphonate have excellent sequestering properties for heavy metals as well as calcium and magnesium, and are effective over a wide pH range. More recently, proprietary products based on low molecular weight polyacrylates have been successfully used in both scouring and dyeing to overcome some of the problems associated with poor water quality.

Chemicals used in the scouring of woollen and worsted fabrics vary widely. In earlier times the most common chemicals used were soap and soda ash (sodium carbonate). To a large extent, soap has been replaced with specialised non-ionic detergents, sulphated fatty alcohols and blends of non-ionic with anionic detergents. The detergent and emulsifying properties of pure non-ionics is extremely high and therefore economic in use. Unlike soap, they are unaffected by the presence of calcium and magnesium salts that may be present in the water; however, they do not have any lubricating properties that may be required to prevent the formation of creases. Many non-ionic detergents are not biodegradable and this can be a problem in effluent treatment. Sulphated fatty alcohols, on the other hand, are biodegradable and have some lubricating properties that can be an advantage with certain types of fabrics when batch scouring in rope form.

The concentration of chemicals used should be sufficient to remove the impurities effectively, without injury to the colour or quality of the material. Excessive use of chemicals will create problems in their removal and may cause difficulties in later processes such as dyeing.

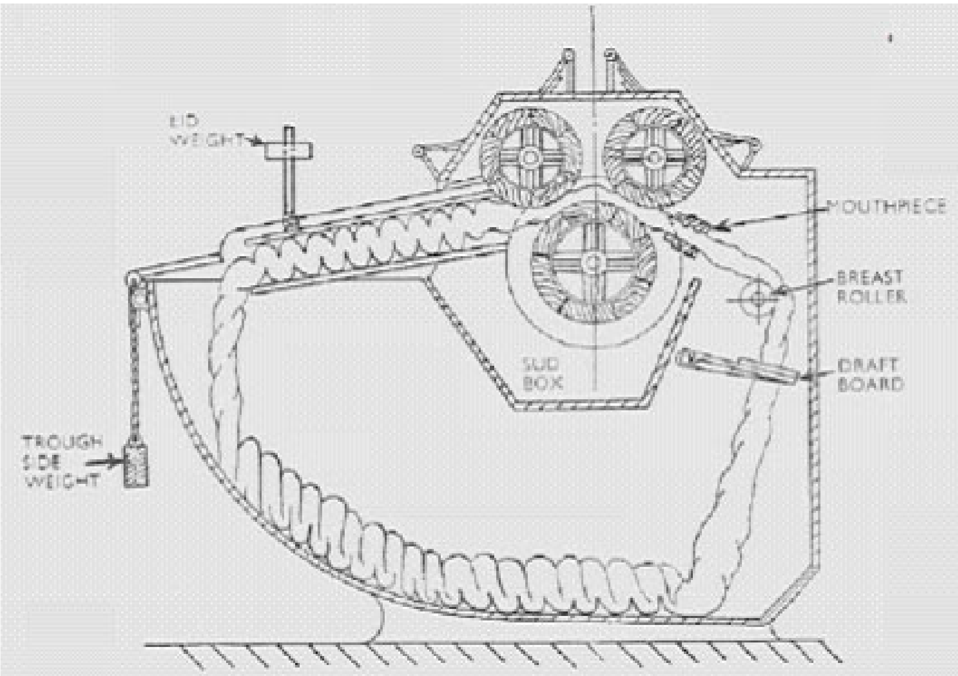
When choosing non-ionic surfactants it is important to choose one with the correct HLB (hydrophilic/lypophyillic balance); for example, a non-ionic surfactant such as nonylphenol with five moles of ethylene oxide will have a low HLB value and would have poor wetting properties, but would be suitable as an effective emulsifying agent. One with 8–10 moles of ethylene oxide in the molecule would have excellent wetting power, with good scouring properties for the removal of soil. Chemical manufacturers often produce mixtures of surfactants in order to optimise their properties.

Nonylphenol surfactants have poor biodegradability and are now being replaced with more environmentally friendly materials. In Europe nonylphenol surfactants are slowly being replaced due to environmental pressures. Many European companies are now specifying that surfactants based on nonylphenol must not be used in the manufacture of textile fabrics destined for sale in the EU.

Scouring temperatures vary widely. Too high a temperature, particularly for coloured pieces, may cause bleeding or reduction in depth of shade, which would be detrimental to the quality of the fabric. Temperatures in the order of 40–60°C are used, depending on the fabric type.

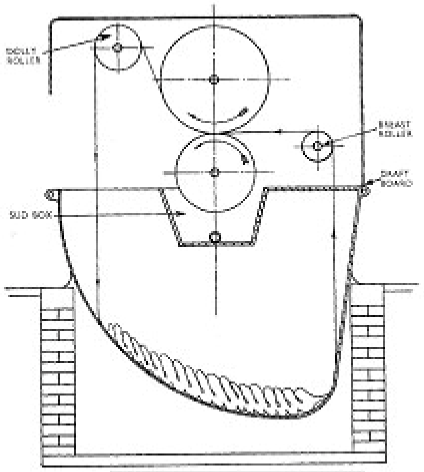
Batch scouring

Rope scouring machine – Rope scouring was, until recently, the most common processing medium. Rope scouring does pose special problems, particularly the formation of rope marks; however, where a slightly felted effect is required this machine is still effective and economic. The combined scouring and milling machine, particularly for woollen fabrics, reduces handling and water consumption and gives a slight surface cover to the fabric.



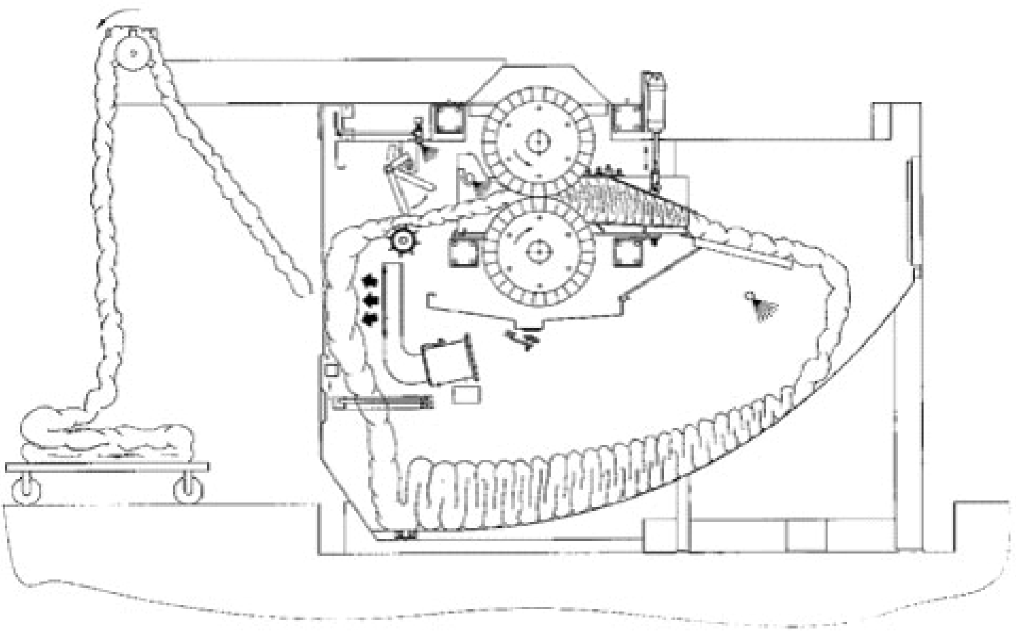
Combined Process Scouring and Milling Machine.

Non-ionic detergents, together with a small quantity of soda ash (sodium carbonate), would be the preferred chemicals for use in this type of machine.



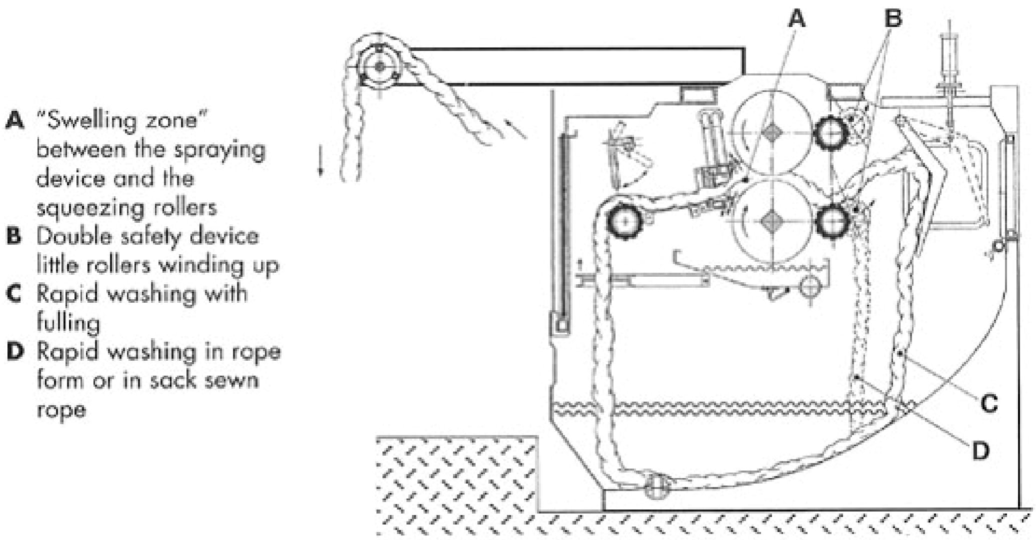
Dolly Scouring Machine

Zonco has developed a combined scouring and milling machine that uses an air blower to open the fabric folds, thus preventing creasing. The Flexicom machine uses an advanced digital electronic control that presets water levels and maintains accurate temperature control of both the scouring and milling processes. The machine can also be supplied with a patented electronic device for continuous measurement of the milling process in length and in each channel, thus giving more efficient process control.



Flexicom machine – Zonco.

High-speed rope scouring



The development of modern high-speed scouring machines that operate at speeds up to 600 metres per minute has greatly increased the efficiency of the scouring operation. Many of these machines have provision to give increased mechanical action to the fabric by throwing the fabric against a baffle at the back of the machine, which will give some fabric development or light milling, as in the Flexirapid 600 machine from Zonco (illustrated).

Batch open-width scouring

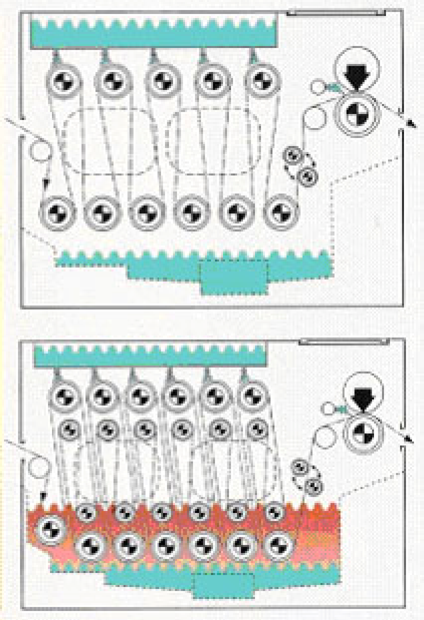
In open-width scouring, the fabric is circulated as an endless loop in a batch machine. The advantage of this method is that permanent creasing of the fabric can be avoided. The general principle of this type of machine is that the scour liquor is sprayed onto the fabric while it lies in plaited form on a belt or an inclined trough. The fabric is then immersed briefly in the liquor in a separate treatment bath before being passed through squeeze rollers. A complex guidance system is required to keep the fabric in open width and centred in the machine. Unfortunately, fabric development is not sufficient for many end uses, so some machines incorporate devices for compressing the fabric in a stuffer box, similar to that used in a milling machine.

Continuous scouring

Increasing numbers of finishers are now using continuous scouring ranges. These machines are particularly appropriate for worsted fabrics that are prone to running marks, moiré and creasing. These machines arose from developments in open-width preparation of cotton and synthetic fibre fabrics. The finisher obtains improvements in scouring efficiency, water consumption, space utilisation and process control compared to conventional batch type processing machinery. It has been estimated that for wool these ranges can achieve 20–30% savings in chemicals and energy with a reduction in water consumption from as much as 150 l/kg to 15–20 l/kg. The majority of continuous scouring ranges process the fabric in open-width. As open-width scouring does not always give width and length consolidation, a number of machinery manufacturers have attempted to increase the degree of mechanical action in their ranges. The Roto-jet system introduced by Küsters increased fabric consolidation and improved washing efficiency by having a series of cascade jets as the fabric travels around two large-diameter cylinders in each of the scouring and washing-off compartments.

The Aqua machine manufactured by Zonco of Italy incorporates a continuous crabbing section after the scouring range. Within the crabbing section the temperature is maintained as close as possible to 99°C, thus ensuring a more rapid and even setting effect.

The trend towards open-width scouring has been facilitated by the use of mineral-based lubricants that are applied at lower concentrations and are easier to remove compared to natural-based products. Open-width scouring does demand improved wetting and scouring systems, which have been developed by a number of suppliers and are based on anionic/non-ionic blends of detergents.



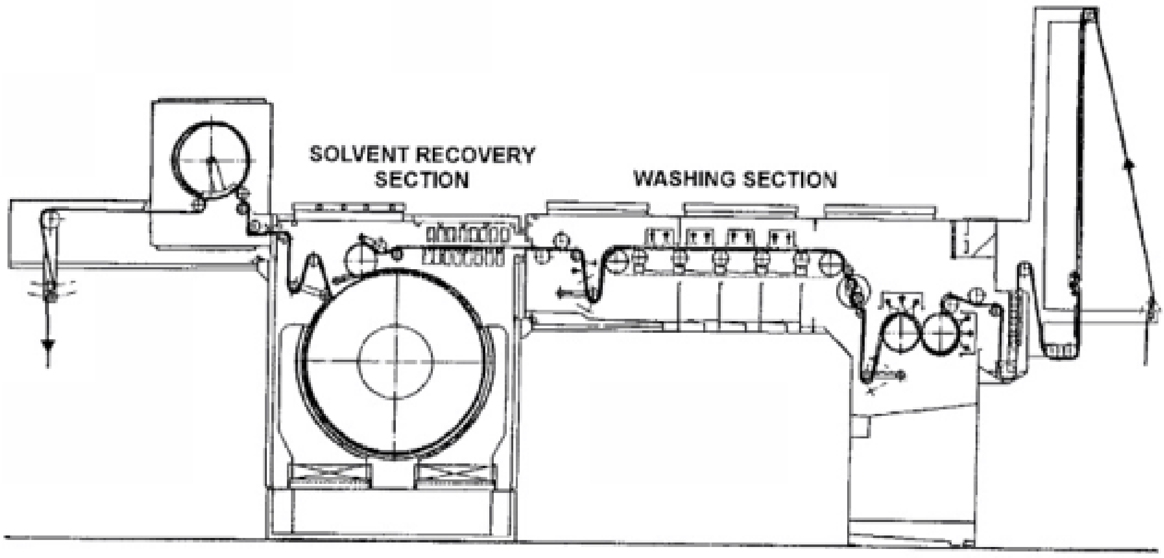
The Zonco Aqua machine, a continuous open-width scouring and crabbing machine, incorporates special tension controls, continuous liquor recirculation and filtration in each section.

Within the crabbing section, the temperature can be maintained at a constant 99°C, to ensure a more rapid and even crabbing effect.

Illustration of fabric transport through the Zonco Aqua: the top picture, ***Scouring*** *section, the bottom picture,* ***Crabbing*** *section.*

Solvent scouring

In the early 1970s, organic solvents were frequently claimed to be the processing media of the future. High production rates, reduced energy requirements and minimum pollution were generally cited as the principal advantages of the new technology. However, developments in aqueous processing, principally in continuous open-width ranges, together with some limitations of solvent scouring, have resulted in only a slow introduction of solvent plants. Manufacturers include Boewe (Contisol ranges), Bruckner (Solvo-knit and Duplosolv), Jawatex (Permosol F) and Spirotto Rimar (Nova).



A Nova (Spirotto Rimar) solvent scouring machine

The machines are offered in a variety of widths and processing speeds, with some specifically designed to process knitted fabrics in a tensionless state. Scouring wool containing fabrics in solvent is claimed by some processors to be not completely satisfactory; even with the addition of specific detergents, all water-soluble impurities are not completely removed. As a result, water-soluble contaminants must be removed in other operations such as crabbing or pre-scouring prior to dyeing. The principal solvent used is perchloroethylene, and continuous distillation of the solvent often creates problems. Solvent costs are high compared to water, and it is necessary for the solvent recovery plant to operate at maximum efficiency for the plant to be economical. Concentrated residues from the distillation must be disposed of at an economical cost.

Processing polyester wool blends

Since polyester wool blended fabrics are normally dyed at 120°C it is necessary to preset by heat setting the polyester in the fabric prior to dyeing. Heat setting griege fabric is not recommended due to the presence of oils and dirt that would be difficult to remove in subsequent scouring. Solvent scoured fabrics can be heat set directly. However, if no solvent scouring system is available, the fabrics should be scoured in open-width to relax the tensions introduced into the fabric during weaving. Drying and heat setting can then follow immediately.

Heat setting is usually carried out on a stenter, often with a pre-drier installed prior to the heat setting section of the stenter. Fabric width is controlled during both the pre-drying and heat setting operation. The objective of the pre-drier is to increase productivity of the operation, particularly if only a three or four-bay stenter is available.

Permanent set of wool

One hundred per cent wool worsted fabrics, particularly those of high loom sett, must be set prior to wet treatments. The process for the setting of worsted fabric is called ‘crabbing’. Fabrics that have yarns of high twist and high loom sett are prone to creasing during wet processing, particularly in rope scouring and dyeing. Fabrics that are solvent scoured do not require setting prior to the scouring process, but must be set (crabbed) prior to dyeing. Woollen fabrics, due to the lower twist in the yarns and generally lower loom sett, are not normally set prior to scouring and dyeing.

True permanent set requires the prolonged action of steam or boiling water. It is now becoming common to refer to the set which is permanent to cold water as temporary set.

It has been shown that the process of wool setting takes place in two stages:

1. breakdown of cross-linkages

2. re-building.

When wool is stretched, the long peptide chains uncoil and certain cross-linkages of the grid are put under stress. When steamed in this stage hydrolytic breakdown of the cross-linkages takes place, so, if the tension is removed, super-contraction occurs. As the steaming is continued with the wool in the stretched state, the broken cross-linkages reform in new and unstressed positions and inhibit, to a considerable extent, the normal contractive force of stretched wool.

Maximum setting properties of wool fibre is developed at about pH9.2.

Processes for imparting permanent set

Crabbing

Crabbing is a setting process that imparts a definite position to the fibres constituting the warp and the weft. Crabbing is used to obviate any distortions in yarn and cloth that may arise during subsequent wet processing due to release of latent strains in the wool. The conditions for crabbing are determined to some extent by the subsequent processes through which the pieces have to pass.

The objective is to reduce uneven fibre movement in the subsequent processes. Some woven fabrics may be described as a mass of unbalanced strains, due to the considerable variation in diameter, length, strength and elasticity of the fibres constituting the yarns. Unless these stresses are brought into equilibrium there is a tendency for the fibres and thus the yarns to move or shrink irregularly and create in the fabric a streaky or cockled appearance.

Tension and pressure on the fabric are important factors during the crabbing process. Excessive tension leads to an adverse handle. Excessive pressure can lead to watermarking, which would not be noticeable until subsequent dyeing. When crabbing loom state fabric it is advisable to add a small quantity of detergent to the crabbing liquor in order to improve subsequent scouring.

Methods of setting include:

- blowing with steam
- boiling
- pressure decatising
- treatment in hot liquor on a jigger
- continuous crabbing machines.

Blowing with steam

The fabric is wound under tension onto a perforated roller with end cloths sewn at each end. Steam is then passed through the fabric until it completely penetrates the fabric. The time of steaming will vary with different fabric structures and weights. When the steaming is complete, the steam is turned off and the roll subjected to a vacuum to cool the role. The fabric is then rolled onto another cylinder and the process repeated to achieve uniform setting throughout the piece.

Boiling

Boiling is an alternative to steaming, and is effected by winding the fabric under tension through hot or boiling water containing a small amount of wetting agent onto a metal beam or roller. The beam is then immersed in the boiling water for about 10 minutes. The fabric is then wound onto another beam and the operation repeated. The temperature must be constant and the pH should be maintained at pH7.

Pressure decatising

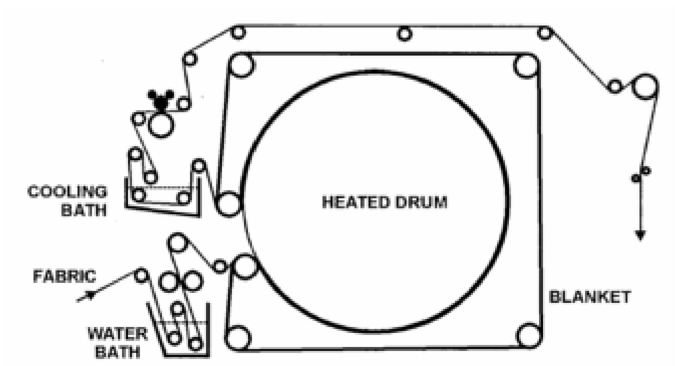
In pressure decatising the fabric is first wound under controlled conditions onto a perforated beam. The beam is then transported to a pressure vessel where a vacuum/steaming cycle is carried out. The fabric is then transported to a cooling and winding station. Continuous pressure decatising is the most advanced method of setting all wool fabrics. These machines consist of a reaction chamber with a special seal to allow the fabric to enter and leave the pressurised chamber. The fabric is given a wet treatment for one minute at up to 140°C. The Mather and Platt Vaporloc is a typical machine for continuous pressure decatising.

Treatment on a jigger

This process has the same effect as boiling the fabric. Some fabrics may require this more severe treatment in order that a more permanent sett is obtained. Fine 100% worsted fabrics of specific fabric construction high loom sett and high twist yarns require more severe treatment particularly if they are to be piece dyed. Usually four to six ends on a jigger dyeing machine at 95°C in the presence of a suitable wetting agent will give sufficient sett to the fabric so it will withstand the dyeing process.

Continuous crabbing machines

The continuous crabbing machine does not yield the same degree of permanent set as batch crabbing either by decatising or boiling; however, these machines are highly productive. The fabric is first immersed in a bath of hot water approximately 95°C. It is then held in contact with a heated drum by an impervious blanket. The fabric passes round the drum with a contact time of between one and two minutes.



Continuous crabbing machine
(Finishing and Wool Fabric Properties – CSIRO).

A suitable chemical setting agent such as sodium monoethanolamine sulphite to the initial hot water bath can be added to increase the degree and speed of setting.

Carbonising

Vegetable materials of cellulosic origin get caught in wool fibres before shearing of sheep as burrs and fodder remains (leaves, grass etc.). A greater part of these materials is removed during the various mechanical treatments to which wool is subjected. The residual impurities find their way into the final fabric before finishing and must be removed to ensure a fabric of the highest quality.

Woollen fabrics made from shoddy (reclaimed fibre) may contain cotton or viscose rayon, which if not removed would reduce the quality of the fabric.

Carbonising relies on the principle that if a cellulosic material is treated with a mineral acid such as sulphuric acid and subjected to elevated temperatures, cellulose is chemically degraded into brittle hydrocellulose, which can subsequently be removed. Wool is fairly stable to mineral acids under controlled conditions of concentration and temperature.

Carbonisation is carried out by:

1. impregnation of the fabric with a solution of sulphuric or hydrochloric acid
2. squeezing the excess liquor from the fabric to the required pick-up
3. drying the fabric to remove excess moisture
4. heating the fabric to bring about hydrocellulose formation
5. dry milling the fabric to remove the hydrocellulose char.

Other acid donating chemicals such as sodium bisulphate, aluminium chloride and magnesium chloride can also be used in the process. Optimum temperature ranges of these acids and acid liberators are given in the following table.

Optimum temperatures for carbonising

Carbonising agent	Optimum temperature range
1. Sulphuric acid	110°–170°C
2. Hydrochloric acid	125°–130°C
3. Sodium bisulphate	125°–130°C
4. Aluminium chloride	125°–150°C
5. Magnesium chloride	125°–150°C

Optimum temperatures for carbonising

In the carbonising of woollen fabric the quality of the process is determined by:

- concentration of the acid
- condition of the fabric after impregnation with the acid solution
- temperature and duration of heating.

As the cellulosic material is well imbedded in the fabric it is important that the acid solution thoroughly wets and penetrates the cloth. To ensure uniform carbonisation an acid stable wetting agent such as a *polyethylene glycol ether* is used in the carbonising liquor. If woollen fabric is carbonised in the griege state and a nonionic wetting agent is used, it is likely to remove the oils that protect the wool and expose certain sites to the action of the acid. This will produce frosty dyeing due to the decreased affinity of the exposed wool to acid dyes. The severity of this depends on the concentration of acid, temperature and time.

$$\text{Wool} - NH_2 + H_2SO_4 \rightarrow \text{Wool} - \overset{\displaystyle H \atop |}{NH_2} - SO_4$$

$$\Downarrow \text{Heat}$$

$$\text{Wool} - NH - S0_3H^+$$

The amino group is attacked by the sulphuric acid and converted into amino sulphonic acid which has less affinity for acid dyes compared to the amino group. The methylene blue test is often used to determine the effect of uneven carbonising when uneven dyeing occurs, particularly in piece dyeing.

Non-shrink and non-felting wool

Wool felting and shrinkage during repeated washing is due to the presence of the cuticle scales that interlock during mechanical treatment. At the same time, the natural elasticity of wool serves to increase the degree of interlocking of the scales by drawing the fibres closer together during any mechanical treatment. Treatment of the fibre can be undertaken both in top or piece form, the former being the most common.

It is therefore possible to prevent wool felting and shrinking by treatments that reduce the elasticity of the fibre and or the interlocking effect of the scales. Two main treatments are used:

- modification of the surface scale structure of the cuticle to reduce the differential frictional effect
- reduction of the fibre elasticity by internal cross-linking and/or reduction of the fibre movement by adhesion at their points of contact.

Modification of the fibre surface may be accomplished by treatment with chlorine, which attacks the scale surface, resulting in a smoother fibre. Treatment of moist wool top using chlorine gas in a sealed chamber has proved to be very effective (KROY PROCESS). The wet treatment of wool acidified with dilute hydrochloric acid at 20°C, rinsing, then slowly adding sodium hypochlorite solution in a fresh bath, the acid retained in the wool reacts with the hypochlorite liberating chlorine. Very careful control of the processes is required to ensure that the wool is uniformly treated. If the treatment is not uniform, level dyeing can be a problem.

Since the chlorination process removes the scales, dyestuff adsorption is more rapid and dyes of good migration properties that have good levelling characteristics are more easily desorbed from the fibre during washing.

The most common wet chlorination method uses the sodium salt of dichloroisocyanuric acid (Basolan DC™ BASF). This process partly overcomes the problems of even chlorination. This system uses a constant pH of 4.5–5.0 with increasing temperature that gives a controlled release of chlorine.

Other processes used for destroying the scales are known. These include treatment with permonosulphuric acid. This process may increase in importance as concern for pollution with organochlorine compounds increases.

Currently, the most common and successful treatment to give permanent anti-shrink properties combines the chlorination and treatment with a cationic polymer to the surface of the fibre. The Hercosett^{tm} method for wool tops is a continuous process. An antichlor treatment with sodium bisulphite is given to remove residual chlorine prior to resin deposition. The polymer is applied from aqueous solution and is substantive to the anionic wool fibre.

The dyeing properties of Hercosett wool are different to those of normal and chlorinated wool. Under neutral and weakly acid conditions the polymer treated fibre has a distinct cationic charge. As a consequence, the anionic acid dyes have higher affinity for the treated wool and, therefore, higher rates of initial adsorption because of the attraction of the cationic polymer. As a consequence, level dyeing can be a problem. The washing fastness of most acid dyes is decreased with the exception of fibre reactive dyes that covalently bond to the fibre.

Apart from difficulties with level dyeing the chlorination treatment, if not carefully controlled, can result in considerable yellowing of the wool fibre. This yellowing can cause problems with shade matching, particularly bright blues and pinks, when different batches of material are processed together.

Piece chlorination of wool fabrics, both knitted and woven, must be controlled carefully to avoid uneven dyeing. Woven fabrics can successfully be given the chlorination treatment in open width on the jigger. Knitted fabrics, however, are more difficult to process, showing unevenness in dyeing and or printing if the chlorination treatment is not uniform, particularly when the treatment has been carried out in rope form. In this respect, successful results on knitted fabrics have been obtained by carrying out the chlorination treatment on a beam dyeing machine.

Preparation of yarn for dyeing

If wool yarn is to be dyed successfully, careful consideration must be given to the preparation of the packages. Whittaker (JSDC 77 (1961) 690) recognised that the packages should have a uniform package density. Control of package density can be obtained by adjusting the yarn tension and the winding speed during the winding process.

A wide range of centres for winding packages is now available. Both metal and plastic materials can be used. Metal formers are more robust and have a longer life, whereas plastic centres are less expensive and have a shorter life, but are more easily stained by certain dyes.

Parallel sided packages are better due to the improved liquor flow characteristics. Soft wound packages should be avoided as dye liquor channelling can occur due to package distortion. Stable, high density packages are preferred, since they can be used without the need for rewinding.

J. Park (*A Practical Introduction to Yarn Dyeing* – SDC 1981) has suggested the following specification for staple fibre yarns:

- Package weight 1.5 kg
- Package diameter 220 mm
- Package centre diameter 69–72 mm
- Package traverse 190 mm
- Angle of traverse wind 12°
- Package density 200 g/l
- Spindle density of packages after press-packing on column 260 g/l.

Given that wool yarns are usually steam set prior to dyeing, the above specification would be suitable. Yarns that have not been steam set will shrink during the dyeing process, causing uneven dyeing such as inside to outside variations, due to changes in package density.

Carpet yarns can be successfully dyed on packages, but the bulk of the yarn will be reduced.

Packing on to the dye spindles is initially carried out by hand until the spindle is full. More packages are loaded using a mechanical press to give a package compression of 25–40%. This method gives increased material weights, reduces package density variations, minimises liquor channelling and contributes to more level dyeing.

Illustration of unlevelness due to channelling during package dyeing.

Hank-dyed yarns

It is rare to dye a worsted spun wool yarn in hank form, so this process is usually restricted to woollen spun yarns. Dyeing in hank form results in a bulkier yarn compared with package dyeing. Woollen yarns are normally spun using a larger amount of oil, 5–15% on the weight of the fibre. The removal of this spinning lubricant usually takes place prior to dyeing. Special continuous scouring ranges, tape scouring machines, are used for this process.

In a tape scouring machine the hanks are laid on a belt of tapes. The tapes transport the hanks through the scouring liquor and then through a squeeze roller where excess moisture is removed. The system consists of a series of tanks and squeeze rollers that ensure thorough rinsing prior to dyeing. Residual detergent in the yarn when carried over into the dyeing may cause the hanks to float, particularly in single-stick Husong machines, resulting in severe unlevelness.

Dyeing auxiliaries

There are two types of dyeing auxiliary used in wool dyeing:

- fibre sensitive
- dyestuff sensitive.

The simplest of all the fibre reactive levelling agents is sodium or potassium sulphate. Sodium sulphate competes with the dye for the reactive site, that is, the amino group. As the temperature rises, the activation energy of the dye increases and the sulphate ions are displaced from the reactive site.

Sodium dinaphthyl methane sulphonate behaves in a similar manner in that it competes with the dye for the reactive site. It exhibits a stronger retarding action than sodium sulphate. Sodium dinaphthyl methane sulphonate is more effective as a levelling agent than sodium sulphate when applying premetallised dyes.

Many of the proprietary levelling agents currently on the market are based on amphoteric surfactants such as amine ethoxylates. These materials form weak cationic complexes with the dye, so as the temperature rises the complex breaks down releasing the dye in a controlled manner. These chemicals have a strong retarding action and if used to excess will reduce the final exhaustion of the dye. In some cases they may well increase the final exhaustion due to their mildly cationic nature under weakly acid conditions. Amine ethoxylates can be successfully used to reduce the depth of shade by stripping some of the dye from the fibre.

References

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