

26. Dry Finishing of Wool Fabrics

Mike Pailthorpe

Learning objectives

By the end of this lecture, you should be able to:

- Describe the various methods that are available for the drying of wool fabrics.
- Understand the need for conditioning wool fabrics after drying.
- Outline the methods used in the brushing of wool fabrics.
- Describe the process of shearing.
- Outline the principles involved in the decatizing of wool fabrics.
- Explain the need for the steaming of wool fabrics.

Key terms and concepts

Drying, conditioning, raising, shearing, singeing, pressing, decatizing, steaming, perching.

Introduction

The so called dry finishing processes for wool fabrics follow on after hydroextraction and scutching, beginning with drying. One of the objects in wool fabric finishing is to dry the fabric only once, thereby making substantial energy savings.

Drying is the process of removing water from wool textiles via the application of heat energy. The three methods of transferring heat energy from one object to another are conduction, convection and radiation. However, for a variety of reasons, convection dryers are preferred for wool fabrics, with the stenter being the most widely used drying machine. After drying the wool fabrics must be conditioned to a regain of 14-16% before further processing.

Depending upon the finish required, the wool fabrics may then either be shorn to remove surface fibres or brushed to create a pile of surface fibres. The brushed pile may be shorn to cut the pile fibres to a uniform height or to achieve a sculptured pattern.

The wool fabrics are then pressed using either flat, rotary or belt presses to achieve the desired appearance, lustre and handle characteristics. The effects of pressing are only temporary and hence the pressed fabric is then decatized to set the fabric. The set achieved in decatizing should last through tailoring. Pressure decatizing provides a longer lasting set in the wool fabrics.

The decatized wool fabrics are relaxed by steaming, thereby reducing relaxation shrinkage in use. Finally, the finished fabrics are inspected for faults in a process known as perching.

The general references for this lecture are (Rouette and Kitten, 1991), (Brady, 1997), (De Boos, 2003), (Shaw and White, 1984) and (Miles, 2003).

26.1 Drying

Drying is the finishing process that uses heat energy to remove both bound and liquid water from textiles. Heat energy may be applied to the wet fabric in three ways, being:

- Convection,
- Conduction, and,
- Radiation.

Convection drying employs hot air to carry the heat energy to the fabric, whereas conduction drying uses hot metal surfaces in contact with the fabric to transfer the heat energy. Heat transfer by conduction is a highly economic method of drying, and is usually achieved by bringing the fabric into contact with steam heated rollers. Drying by conduction methods is very common in the cotton industry. In the case of wool fabrics, however, drying in direct contact with metal surfaces may cause the fabric surface to become glazed, or shiny, and hence convection dryers are preferred for wool.

Energy can also be applied to wet fabric using electromagnetic radiation (EMR). Three EMR wavelength bands are used in the textile industry, being:

- Infra-red,
- Radio frequency, and,
- Microwaves.

The electromagnetic radiation is absorbed principally by the water molecules in the wet textile. The water molecules become excited and vibrate causing vibrational heating of the wet textile. Drying using radiation technology based dryers are not commonly used for the drying of wool fabrics.

Convection drying

The most common and most versatile convection drying machine employed for the drying of wool fabrics is the stenter (or tenter). Indeed, wool fabrics are usually dried using stenters for a variety of reasons, including the ability to control the finished dimensions of the fabric.

A stenter is a continuous open-width fabric-finishing machine. The fabric is held at each selvedge by endless travelling chains that control the width. The fabric selvages are held by either pins or clips attached to the endless chains.

Stenters are used for

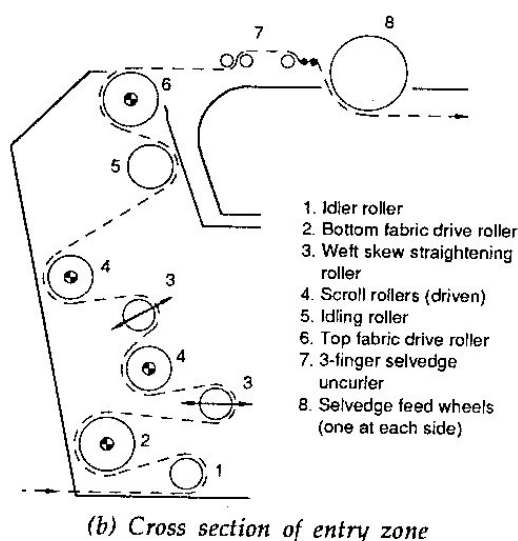
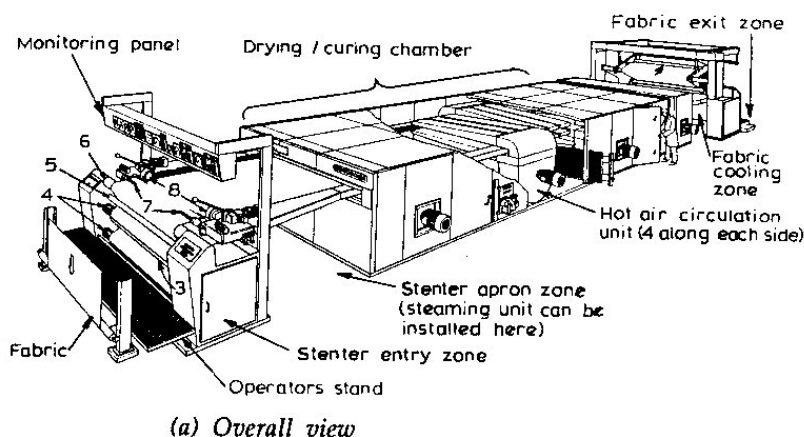
1. Drying piece-dyed or piece-scoured fabric.
2. Steaming and straightening the courses or grain of yarn-dyed knitted fabric that hasn't been wet processed. Stenters may also be used for weft straightening.
3. Heat-setting thermoplastic fabric both before and after dyeing. Before dyeing, it prevents creasing (pre-setting) and after dyeing, it is a final finishing treatment (post-setting).
4. Pre-setting and winding fabric onto the perforated cylinder for beam dyeing.
5. Fixing or curing chemical finishes that are applied by continuous add-on means.
6. Fixing dyes (thermosol process) that have been applied to fabric by continuous means.
7. Overfeeding, steaming, and width correction of fabric after dry-finishing processes such as raising and sanding.

Figure 26-1 shows the general layout of a 4-bay stenter, with the entry zone shown in cross section.

Fabric from a trolley, a batched roll, or from chemical add-on equipment passes over elevated rollers, and then descends to pass under the operator's platform.

The selvedge feed wheels are each fitted with a disc brush to push the fabric edges onto the pins. The disc brush is guided by a photoelectric cell. More disc brushes in the apron zone push the fabric edge onto the pins.

Figure 26.1 A 4-bay stinter. Source: Pailthorpe, 2006.



A stenter allows the finisher to control the final dimensions of the fabric. The length dimensions of the fabric can be controlled by adjusting the relative speeds of the fabric feed rollers and the pin-track chains. Three variants are possible, being:

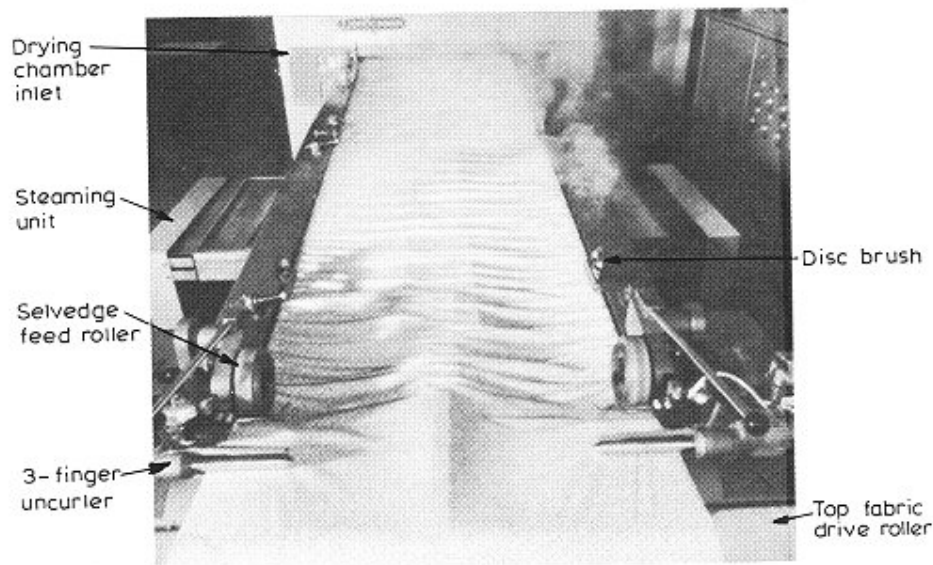
- Underfeed (pin-tracks running faster than the feed rollers, causing stretching),
- At par (pin-tracks running at the same speed as the feed rollers), and,
- Overfeed (pin-tracks running slower than the feed rollers, allowing shrinkage).

Figure 26-2 shows a knitted fabric being overfed into the stenter drying chamber.

The rails that the pin chains run on have joints at the beginning of each bay and at the fabric exit, each with independent width adjustments. This is shown in Figure 26-3 for a 3-bay stenter. Using these adjustments, the fabric can be shrunk, or stretched, in the weft direction as needed.

Each bay has a separate temperature control so that gradual heating occurs through the drying/curing chamber. Stenters can be heated by electricity, steam, hot oil, or gas flame. The choice depends on cost efficiency, fumes, and ease of cleaning. Double layer stenters are available for where space is limited.

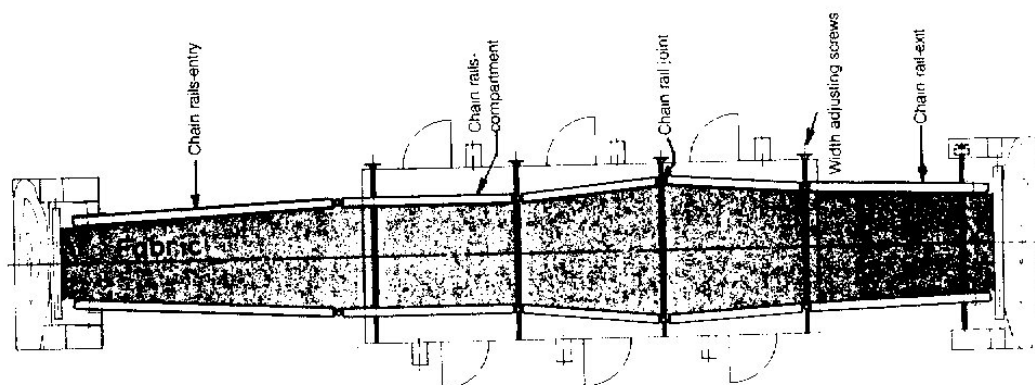
Figure 26.2 Fabric being overfed onto the pin-tracks, thereby allowing the fabric to shrink in the length direction. Photograph supplied by M. Pailthorpe, Canesis Network, Ltd.



Careful control of the temperature settings and throughput speed is essential in order to avoid overheating of the cloth, thereby preventing faults such as poor handle, loss of elasticity and discoloration.

At the exit zone, the fabric can be either plaited, rolled up as one or more pieces per roll, or batched onto a jumbo roll on a special "A" frame.

Figure 26.3 Plan view of a 3-bay stenter showing variable separation of the pin-tracks. Source: Pailthorpe, 2006.



26.2 Conditioning

As a result of over drying in the stenter, the dried wool fabric may contain less than its normal regain moisture for the prevailing atmospheric conditions. For example, at 65% RH the moisture regain of wool is typically 14-16% and this level of moisture content is required to achieve good results in subsequent dry finishing processes such as raising, cropping, pressing and decatizing. Thus the dried fabric should be conditioned to normal regain before further processing takes place.

Wool fabric conditioning machines are based upon a number of principles including spraying water onto the fabric, passing moist air over the fabric and steaming the fabric (followed by cooling).

26.3 Raising (brushing)

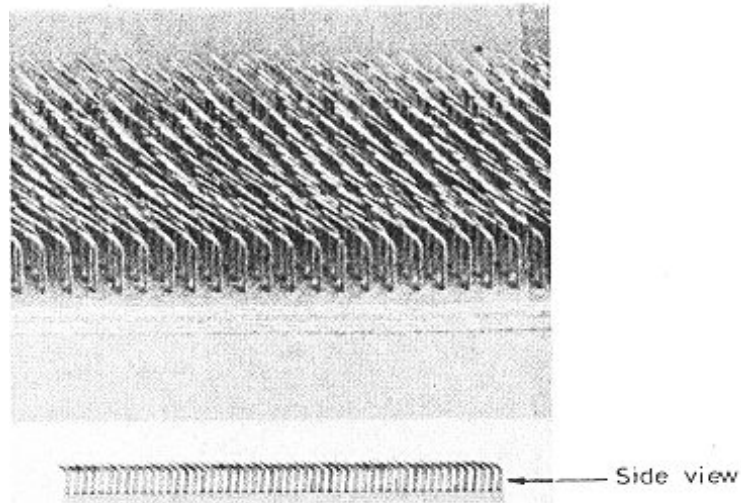
The aim of raising is to achieve desirable surface characteristics in the wool fabrics and to soften the handle. Raising is achieved using bristles (natural teazles), or bent metal wires, to catch and lift fibres out of the plane of the fabric surface and make the fibres protrude as a pile or nap.

Since damp wool fibres are more pliable, and less fibre loss is suffered, the majority of wool fabrics are raised while damp. The typical wool regain employed would be 60-70% and lubricants may be also be used to reduce friction. Some fabrics may be pre-raised under damp conditions and then given a second brushing after drying.

Examples of wool fabrics that are raised include blankets, fleecy fabrics and velours.

In raising, fabric surfaces are subjected to a tearing action that pulls fibres from the surface yarns and from within the fabric to form a raised surface or pile. The fabric is passed over rollers covered with strips of rubber-backed fabric in which bent wires are embedded, similar to those used in carding machines. The wire surface travels faster than the fabric and so tears at the fabric surface. Metallic card wire raising “teazles” are shown in Figure 26-4.

Figure 26.4 Metallic card wire raising “teazles”.
Photograph supplied by M. Pailthorpe, Canesis Network, Ltd.



When raising knitted fabric made from continuous filament yarns, the action is controlled so that filaments are lifted out to form loop pile, which is not broken. In wool and cotton fabrics, raising generally lifts up and breaks the fibres to make the pile. Knitters sometimes use the term brushed for raised knitted fabric.

Raising machines may be either single action or double action planetary machines.

Figure 26-5 shows the operation of a single action planetary raising machine. Pile rollers mounted around a large cylinder rotate very fast so that the surface speed of the wire is faster than the movement of the fabric. In a single action machine the orientation of the hooks of the metallic wires is the same, and the pile rollers rotate in the same direction, being anticlockwise in Figure 26-5. The inset in Figure 26-5 shows the relative movement of the raising wire to the fabric. Notice how the wire points dig into the fabric. The cylinder on which the planetary pile raising rollers are mounted rotates in the opposite direction (clockwise) to the anticlockwise fabric movement. Single-action machines have 24 to 36 pile raising rollers mounted on the main drive cylinder.

Figure 26-6 shows a double action planetary raising machine, where alternate rollers have the metallic wire pointing in opposite directions.

The insets in Figure 26-6 show that the pile rollers pluck at the cloth in the same direction as in single action raising, while the counter pile rollers pluck in the opposite direction. The cylinder and counter pile roller speeds are much faster than the fabric feed and pile roller speeds. The cylinder rotates in the same direction (anticlockwise) as the fabric movement. Double-action machines have a total of 24 to 36 pile and counter pile raising rollers mounted on the main drive cylinder.

Fabric tension and the relative speeds of the fabric, rollers, and raising cylinder are varied to produce different effects.

Figure 26.5 A single action planetary raising machine. Source: Pailthorpe, 2006.

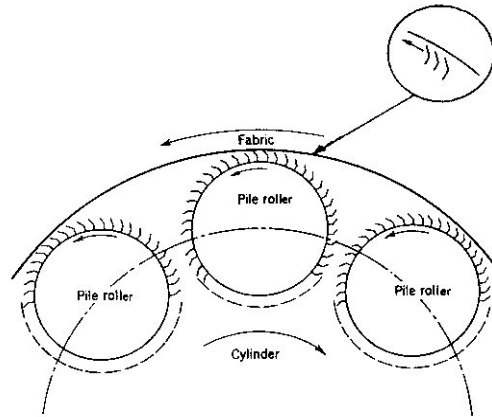
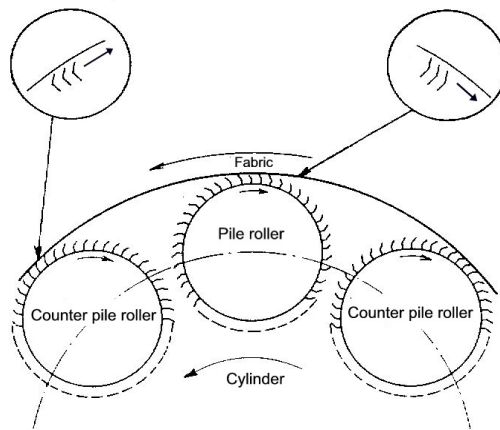


Figure 26.6 A double action planetary raising machine. Source: Pailthorpe, 2006.



Reasons for raising include:

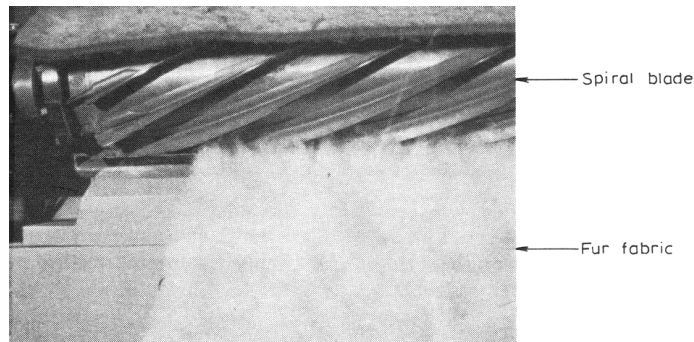
1. Warmth. A napped surface insulates by increasing the still air space in the cloth.
2. Softness. A soft handle is important in baby clothes.
3. Appeal. Raising improves the appearance of the fabric, partially blends colours, conceals the structure, and breaks the outline of patterns.
4. Water repellency. Fibre ends at the fabric surface slow down wetting.

Many kinds of woven fabric and knitted fabric can be raised. The ease of raising the fabric and the length of the pile depend on how easily fibres or filaments can be pulled to the fabric surface.

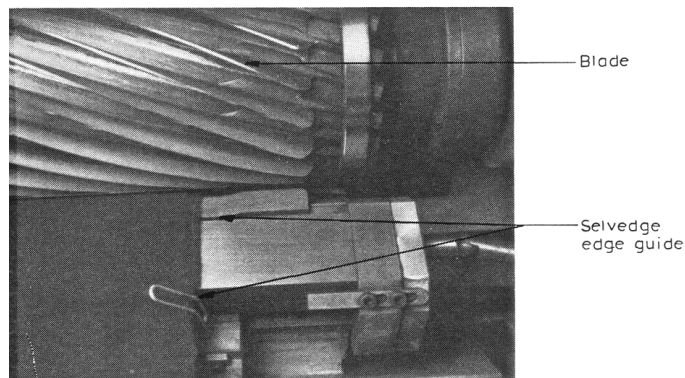
26.4 Shearing (cropping)

Shearing or cropping, like singeing, removes surface fibres to give the clear finish required of fine worsteds. Shearing can also be used to cut the pile of raised fabrics to an even length and hence appear more regular. This is called *levelling the nap*. Intermittent shearing can produce sculptured effects on pile fabric. A shearing machine works like a reel lawnmower, as shown in Figure 26-7.

Figure 26.7 The helical and fixed (ledger) blades of a shearing machine.
Photograph supplied by M. Pailthorpe, Canesis Network, Ltd.



(a) Fur fabric being sheared



(b) Selvedge guide for worsteds

Machines have several shearing heads, each with a spiral blade cylinder, a ledger blade, and a shearing bed. The face only, or both sides, can be shorn at one or more of the shearing heads. A fibre-lifting roller-brush before each shearing roller makes the fibres stand up from the cloth surface. Suction devices remove fibre from the brushes, and remove flock from the shearing head.

26.5 Singeing

Singeing removes protruding fibres from the fabric surface, leaving it smooth and bare with a clear finish. Two methods are used to remove surface fuzz from fabric, being:

- gas-flame singeing, and,
- plate singeing.

Gas flame singeing

Dry fabric passes in open-width at speeds of from 10 to 300 metres per minute over a row of fine gas flames.

Machines, with suitable arrangements of rollers and burners, singe both sides of the fabric in one pass. Before singeing, the fabric is brushed and vacuumed to remove dirt and loose fibre. After singeing, the fabric passes through a water trough to quench any sparks on the cloth.

Plate singeing

In plate singeing the fabric passes over heated rounded plates to produce a clear and lustrous surface. Plate singeing is not as common as gas-flame singeing.

Cotton cloths are usually singed in the loom state before desizing. The quenching trough, essential for highly flammable cotton, may also contain desizing agents.

Polyester and polyester/cotton cloths are singed after dyeing because the little melted balls on the ends of polyester fibres will dye darker if dyed after singeing. Polyester should be free of lubricating oils when singed because the heat makes polyester absorb oil.

Wool cloths are usually singed early in finishing but further wet processing tends to create more surface nap. This feature is made use of in wool/polyester fabrics because there is little or no polyester in the new nap. Unless singed, polyester fibres are very prone to pilling.

26.6 Pressing

Pressing is really an ironing process mainly used for woven wool fabrics and may be used as a preparation for decatizing. In pressing, the wool fabric is compressed under very high pressure between smooth heated surfaces, after which the fabric is cooled. Pressing produces a smooth handle and imparts lustre (without glazing the surface) whilst also reducing the thickness of the fabric.

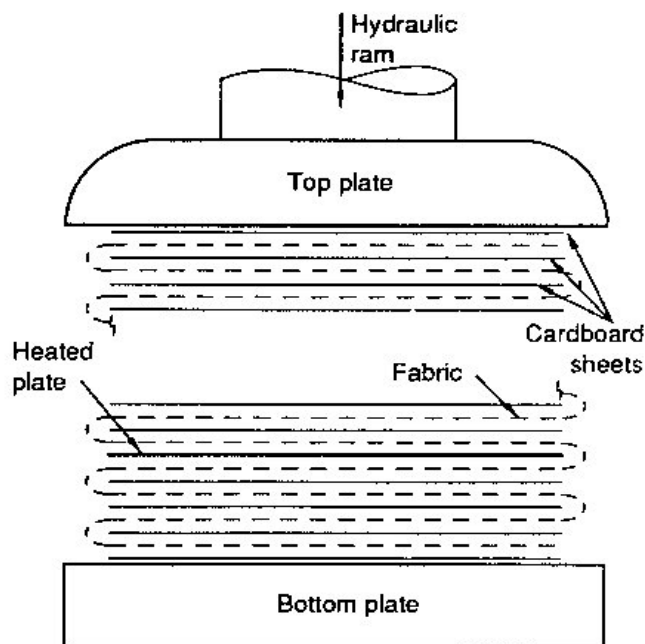
Wool fabrics are pressed using three types of press, being:

- flat hydraulic press (also known as a paper press),
- rotary press, and,
- belt press.

Flat pressing

In flat pressing, sheets of special glazed cardboard, called *pressing paper*, are placed alternately between fabric layers with special electrically heated plates interleaved at regular intervals. The fabric, usually woven wool worsted, is dampened by water, mist or steam before pressing. The applied pressure is typically in the range 10-40 MPa. Moisture, heat, and compression produce the ironed finish. Fabric is pressed twice. The second time, the fabric folds from the first pressing are positioned in the middle of the press. Many fabric lengths are butt-joined for pressing. Flat pressing takes hours to complete. Figure 26-8 shows the principle of flat pressing.

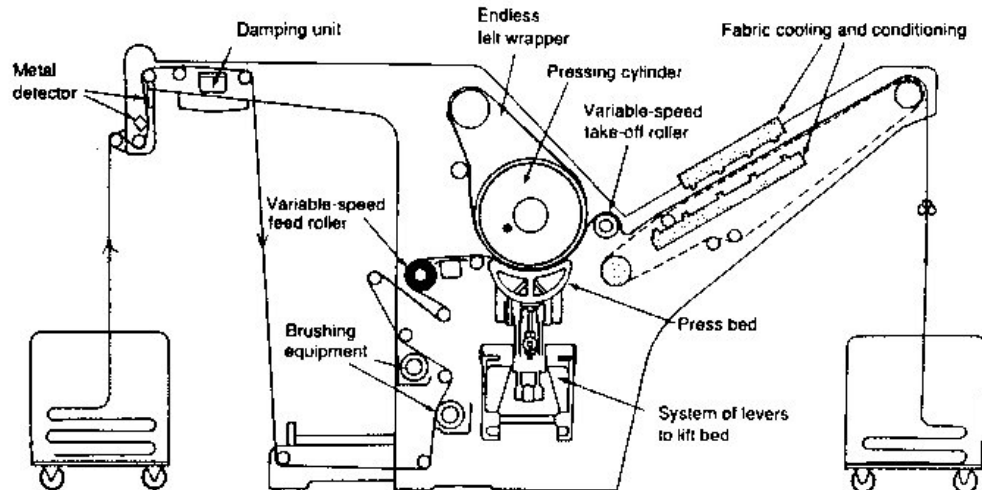
Figure 26.8 Schematic side elevation of a flat press. Source: Pailthorpe, 2006.



Rotary pressing

Rotary pressing is a continuous process in which cloth is pressed between a heated pressing cylinder and a heated press bed. Both the pressing cylinder and press bed are heated to about 120-135°C. As can be seen in Figure 26-9 the fabric is fed in open-width past a metal detector, through a dampening unit (to achieve the ideal moisture content) and then on into the pressing zone. After pressing the fabric is cooled and conditioned before being cuttled (as shown in Figure 26-9) or rolled up onto a beam.

Figure 26.9 Side elevation of a rotary press. Source: Pailthorpe, 2006.



Rotary pressing is more economical than flat pressing, and a wider range of fabrics can be pressed, although on wool fabrics the result is not as good as that from flat pressing. The endless felt wrapper shown in Figure 26-9 is extra, which, when used, makes the fabric less flattened, softer, and not so stretched.

Rotary pressing, whilst more productive than flat pressing, has the disadvantage that the fabric is under tension during pressing. Furthermore, the metal cylinder must be regularly etched to prevent it from becoming smooth. A smooth pressing cylinder would allow the fabric to slip, leading to a poor pressing result. It should be noted that the endless felt wrapper shown in Figure 26-9 overcomes this problem to some extent.

Even so, in recent times, rotary presses have been superseded by belt presses.

Belt pressing

In belt pressing the fabric is sandwiched between a heated metal roller and an endless rubber belt. Since the metal cylinder and the belt are both moving at the same speed, there is no tension applied to the wool fabric during pressing. The rubber belt is under high tension, ensuring high contact pressure where the fabric passes between the cylinder and the belt. The pressing cylinder is heated to about 120-135°C.

After pressing the fabric is cooled down by drawing ambient air through the fabric while it passes across a cooling table.

26.7 Decatising

Decatising is also known as decating, blowing and open blowing.

Decatising produces a smooth, wrinkle-free finish and lofty handle in woollen and worsted fabrics and in wool blends with man-made fibres. Heavier knits such as double jersey may be decatised.

Decatising is usually the final finishing process, often carried out after steaming or some other shrinking process, to ensure dimensional stability. Decatising should last through garment making, and beyond if done under pressure. Most wool-rich woollen and worsted fabrics are decatised. Figure 26-10 shows a photograph of a traditional batch decatiser and also a side elevation of the machine.

The perforated-metal blowing cylinders are wadded and covered with a special cotton or cotton/synthetic canvas wrapper. Steam can be fed to the inside of each cylinder. The wrapper cloth is tightly woven and is smooth on both sides, strong, and stretches very little under tension.

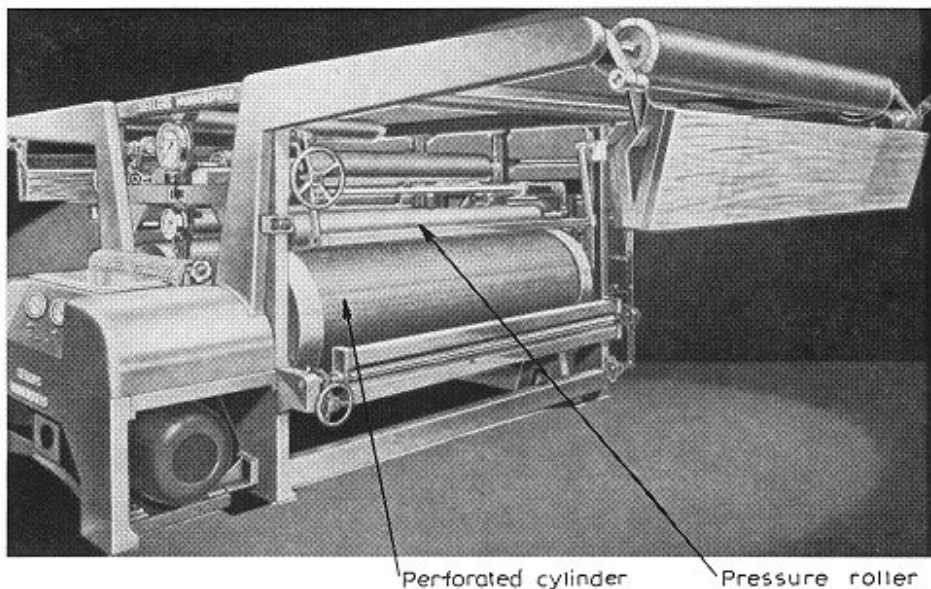
The dry fabric is loaded onto the cylinder with the wrapper, forming alternate layers of fabric and wrapper on the cylinder. While one cylinder is loading, the other is unloading. The fabric is fed in under minimum tension, while the wrapper rolls on under tension to compress the fabric.

Once loaded, the cylinder is flooded with saturated steam until it has penetrated all of the layers of the fabric and wrapper and then escapes. Free steam escapes for about 90 seconds, during which time the wool fibres become plastic as the cross-links within the fibres are broken.

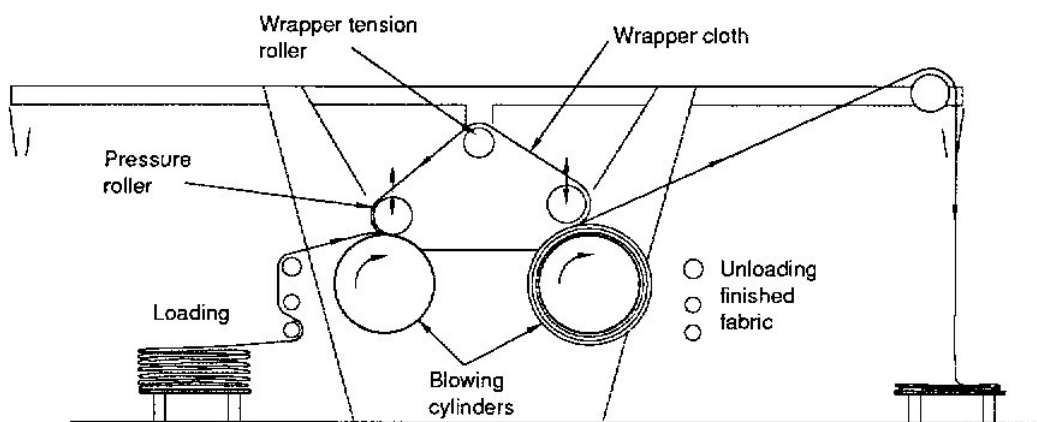
The steam is then turned off and a pump draws cold air through the fabric into the cylinder. The cold air partially sets the fabric in its relaxed state by reforming the cross-links.

Wet fabric may be wet decatized. To give fabric maximum set, flatness, and lustre, the wrapper is wound on under maximum tension, and the fabric blown twice and then cooled. For a fuller, less firm handle, fabric is compressed less, lightly steamed, and not thoroughly cooled before unloading.

Figure 26.10 A traditional batch decatizing or blowing machine.
Photograph supplied by M. Pailthorpe, Canesis Network, Ltd.



(a) Double cylinder machine



(b) Cross section

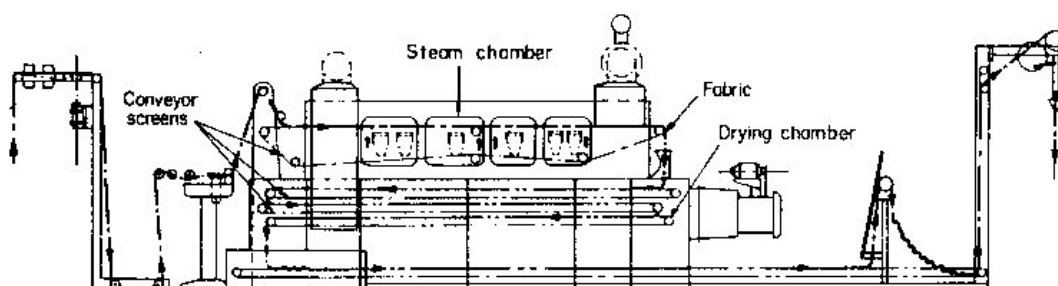
Modern decatizing machines include continuous decatizers and machines that operate under vacuum or pressure. These machines have controls for temperature and fabric tension plus safety features. Because of the short time steam is in contact with the fabric, continuous decatizers can only give wool fabrics a light finish. This light finish may suit acrylics, polyamides, viscose and blends of these with polyester and wool.

Both vacuum decatizing and high temperature/pressure decatizing provide a variety of finishes on wool fabrics. High-pressure decatizing produces wool fabrics that shrink less than 1.5% during the large-scale making up of garments, which includes pressing.

26.8 Steaming (sponging)

As a final finishing process, steaming, also called sponging, is used to completely relax the fabric so as to achieve dimensional stability before sewing. London Shrinkage, a process in which the wool fabric was dampened with water and allowed to relax for 1-2 days, has been replaced by steaming machines. Steaming removes any tension put into the fabric during earlier finishing and reduces relaxation shrinkage. The steaming machine shown in Figure 26-11 handles a full range of woollens, worsteds, synthetics and blends, knitted or woven.

Figure 26.11 Schematic diagram of a steaming or sponging machine.
Source: Pailthorpe, 2006.



Fabric is overfed by up to 20% into the steam chamber, where it is saturated with steam. It is then dried free of tension. The fabric is carried on screens and so the width is not controlled, as it is in stenters with pin chains. Steaming is used especially in the USA in place of London Shrinkage on wool worsted fabrics.

Note: Steaming should not be confused with steam setting and permanent finishes.

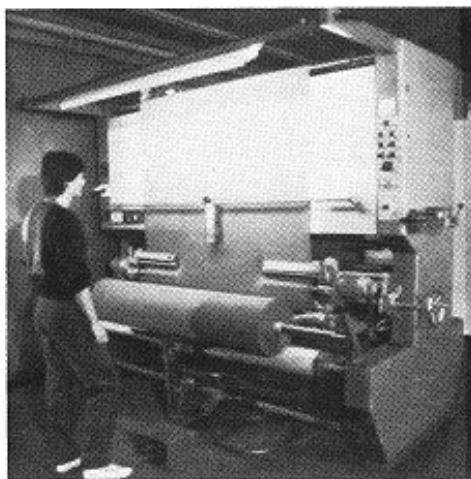
26.9 Final inspection

The final inspection of the fabric is carried out on a perch, so the process is also known as perching. The fabric is run over an inclined or vertical translucent plate and illuminated from face and back, as shown in Figure 26-12. Serious faults are marked with “strings” or tags in the selvedge.

Figure 26.12 Perching machines.
Photograph supplied by M. Pailthorpe, Canesis Network, Ltd.



(a) Knitted fabric



(b) Woven fabric

This is often the last quality control procedure. At final inspection, mending, spot cleaning, fault tagging, and downgrading are done as needed. Consistent standards of inspection, and between inspectors, must be maintained. Devices for measuring the length of rolls must be checked regularly, and inspection tables must be operated correctly so that fabric lengths, and hence invoicing, are correct.

Readings



The following readings are available on CD

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Summary



Summary Slides are available on CD

The dry finishing processing sequence begins with drying the wool fabric, i.e. after hydroextraction and scutching. Dry finishing processes include drying, conditioning, raising, shearing, pressing, decatizing and steaming.

The object of dry finishing is to develop the required properties in the wool fabric, including appearance, handle, lustre, set and dimensional stability. Relaxation shrinkage and hygral expansion should be minimised.

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Glossary of terms

Blowing	An alternative term for decatizing.
Brushing	An alternative term for raising.
Conditioning	The application of moisture to dried wool fabrics to achieve a regain of 14-16%.
Cropping	An alternative term for shearing.
Decating	An alternative term for decatizing.
Decatizing	A setting process used to stabilise the properties of wool fabrics developed during finishing.
Drying	The removal of adsorbed water from wool fabrics by the application of heat energy.
London Shrinkage	A process in which the wool fabric is dampened with water and allowed to relax for 1-2 days.
Napping	An alternative term for raising.
Perching	An inspection process used to identify faults in the finished fabric.
Pressing	The application of force to improve the appearance and lustre of wool fabrics.
Raising	A mechanical process use to create a pile on the fabric surface.
Shearing	The cutting of raised fibres to the desired height.
Singeing	The use of a high temperature flame to remove surface fibres from fabrics.

