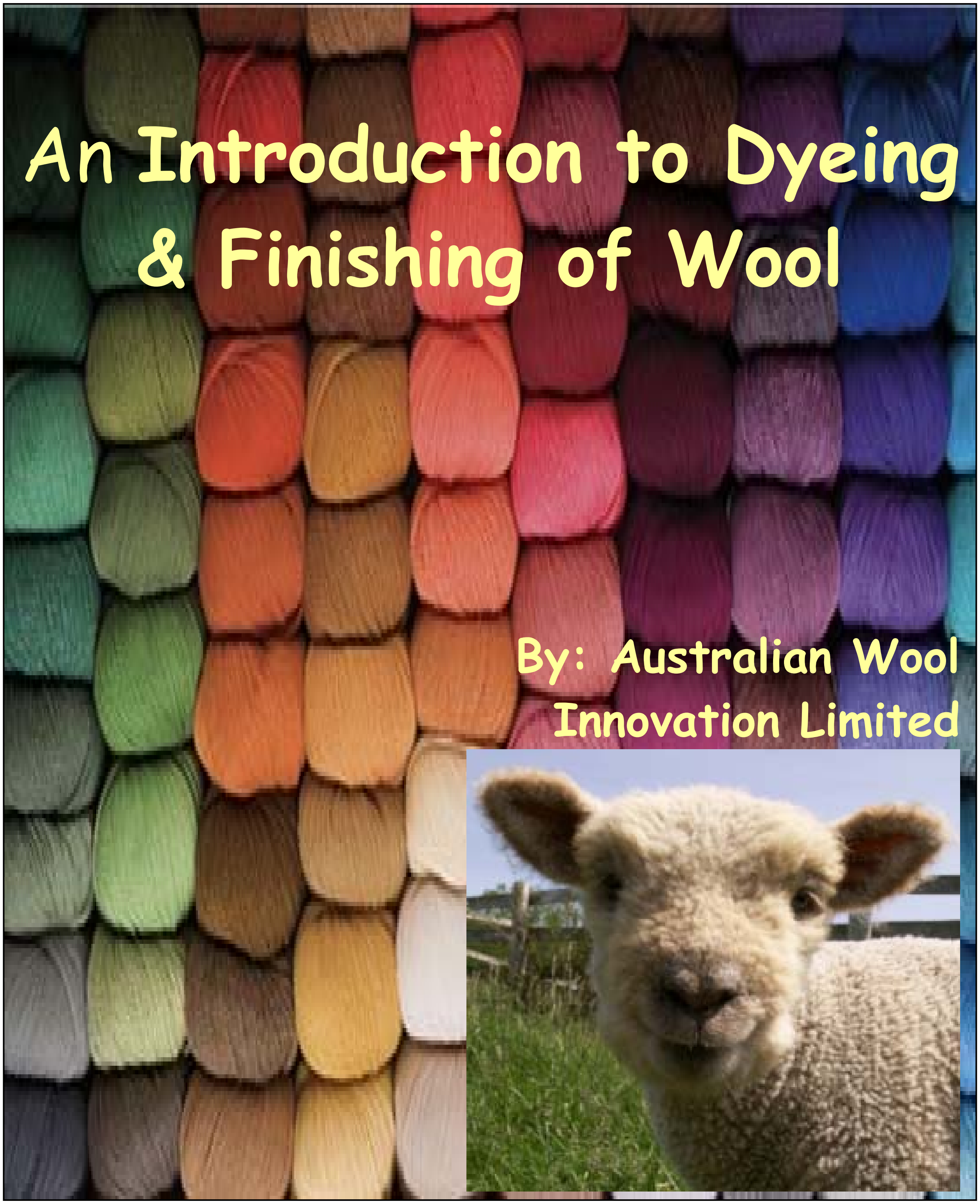
An Introduction to Dyeing & Finishing of Wool



By: Australian Wool Innovation Limited

An Introduction to Dyeing & Finishing of Wool

By: Australian Wool Innovation Limited

Dyeing of wool may be carried out at a number of different processing stages. Wool top, yarn, fabric and garments can all be dyed; the method selected will be the one which best suits the processor's requirements such as price and production lead times.

Finishing is an integral step in the manufacture of all wool products. How well it is done dramatically impacts upon the handle, appearance and wear performance of the final knitted garment.

In knitted garments and fabrics finishing aims to reduce or eliminate relaxation shrinkage, improve handle and appearance and remove any residual processing aids.

Worsted spun knitwear receives a very light wash and steam whereas woollen spun knitwear is washed more intensively to create the bulk and hairiness for which it is famous.

In woven fabrics finishing aims to relax and stabilise strains within the fabric that are introduced during spinning and weaving and remove any residual dirt, lubricants and waxes through washing. The typically smooth surface of a woven fabric is achieved by shearing-off surface fibres then pressing with high-temperature steam.

In both knitted and woven products finishing allows for the application of value or functional finishes.

Colouration Stages

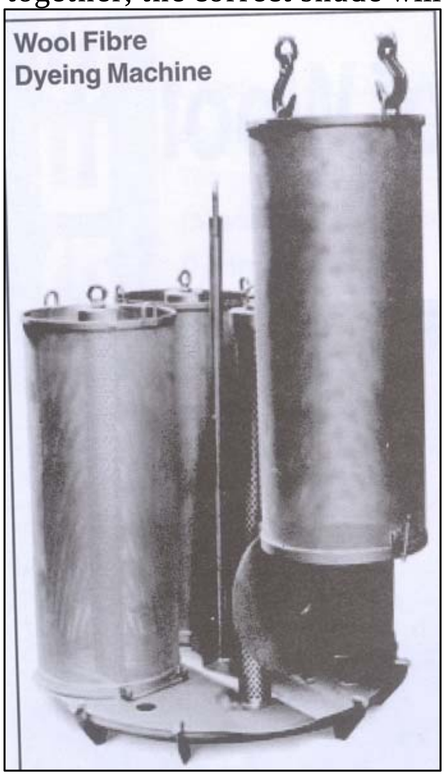
In both woollen and worsted manufacturing there are three stages at which wool undergoes colouration:

- Fibre - loose wool or tops
- Yarn - as hank or packages
- Piece- in fabric or garment form

The requirements of the dyer are to produce goods that are of the correct colour with fastness properties appropriate to the end product and having uniformity of shade.

Raw wool is not dyed before scouring, because of the contaminants that it contains. Dyeing of loose wool is carried out in woollen processing but 'wool for worsted yarns is not dyed until after combing. The reasons for this are that coloured noils have less value than ecru noils and the combing of relatively small lots of dyed wool would not be cost effective. The dyes used for fibre dyeing must have good fastness to wet treatments, because the yarn into which the fibre is spun will normally undergo further processing. These processes almost invariably involving scouring (washing) to remove processing lubricants or other, more severe wet treatments, such as milling or potting.

Dyes having good wet fastness are generally less level dyeing i.e. more difficult to achieve uniformity of shade than those having lower wet fastness. However, levelness of shade is less critical in fibre dyeing than for yarn and piece, because any minor non-uniformity will be eliminated in carding or gilling, which thoroughly mix the dyed fibres. Shade matching is also easier to achieve in fibre dyeing, because each processing lot normally consists of several dye batches. If the initial dye batch is not quite the correct shade the dyer can adjust the recipes of subsequent batches so that, when blended together, the correct shade will be achieved.



The reasons for dyeing wool in fibre form are therefore:

1. To produce large lots of yarn with good shade uniformity
2. For mixture (mélange or heather) shades
3. For high wet fastness properties
4. For fibre blend products

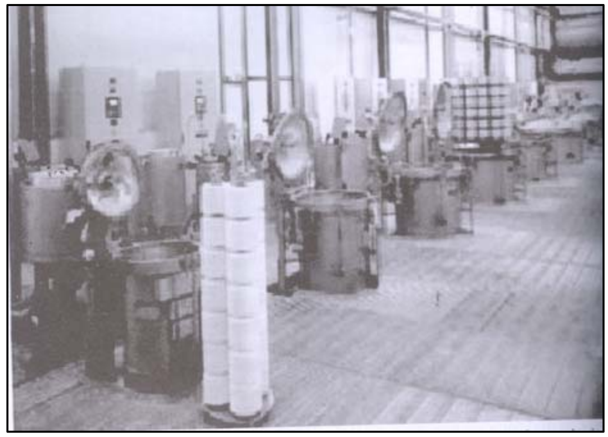
A disadvantage of fibre dyeing is that wool may be damaged during the dyeing process, which reduces the efficiency of spinning in comparison with undyed wool. There is also a commitment to shade selection at an early stage in the manufacturing process. It should be noted that the time from fibre dyeing to the end product sale is a minimum of three months and probably much longer. Therefore there is more difficulty in predicting which shade will be fashionable, so far in advance.

Fibre dyeing is carried out in machines where the dye liquor is pumped through a compressed pack of loose fibre or tops and a typical machine is illustrated in the above picture.

Tops are dyed in "ball" form, where the sliver is wound like a bobbin, each one being of about 5kg.

Alternatively, "bump" (coiled) tops may Wool yarns are dyed in the form of be dyed and this form is regarded as being rather easier to dye uniformly. Bump tops are produced by the top maker, without the need for rewinding into the ball form, and a typical weight for dyeing is 10 kg. Top dyeing machines normally have, perforated spindles onto which the tops are placed and compressed. Each spindle will hold five or six tops and the number of spindles will vary, according to the machine capacity, up to about ten.

Yarn Dyeing



Wool yarns are dyed in the form of hanks (skeins) or packages. Examples of yarn packages and package dye' machines are shown above

For dyeing yarn packages are load onto perforated spindles in the dye; machine, as shown. Uniformity density of the packages is vital achieve uniform flow of the dye liquor which is pumped through the yarn. Packages are therefore either precision wound on rigid centres or random wound and then compressed as a column on the centre spindle. The latter form requires package centres that either compressible or are biconical and can slide one inside the other.

For hank dyeing yarn must first be wound into the hank form. Special machines must are used for dyeing hanks, having "sticks" (metal rods) across the top of the machine on which the hanks are hung. "Sticks" are often also used at the bottom of the hank to keep it in an extended form, although some yarns, particularly for carpets, are dyed with only a top "stick". Dye liquor is circulated through the mass of yarn to achieve uniformity of shade.

Dye selection for yarn dyeing is important if adequate shade levelness and fastness properties are to be achieved. Levelness of shade is much more critical than for fibre dyeing but there is more tolerance than in piece dyeing, particularly if the yarn is to be used in multicoloured, patterned products. However, yarn dyeing would seldom be used to produce, for example, plain coloured woven fabrics.

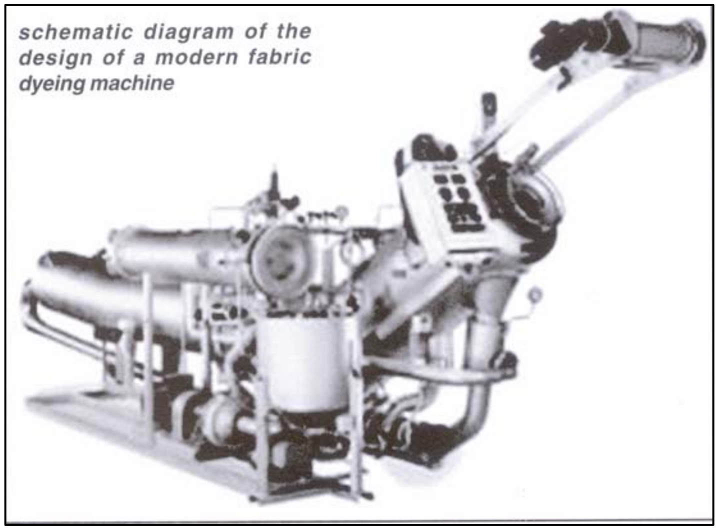
The advantages of dyeing in yarn form are that it allows efficient spinning of undyed fibre, shades can be selected nearer to the time of end product sale and smaller dyelots are feasible than for fibre dyeing.

Fabric Dyeing

Dyeing in fabric form minimises the time between shade selection and retailing for woven goods. However, it IS limited to the production of plain shades.

Uniformity of shade is critical in piece dyeing and it is therefore essential to use dyes that are capable of producing level dyeing. These dyes generally do not have good fastness to washing or wet processes but this is not a serious problem, because most of the products that are manufactured from piece dyed material will require fastness to dry cleaning only.

Unlike yarn and fibre, fabric is dyed in machines in which the material is circulated through the liquor. The following schematic diagram illustrates the design of a modern fabric dyeing machine.



Traditional "winch" dyeing machines are being superseded by "overflow" and "soft flow" machines. In all these machines the fabric is fed over a winch reel and the two ends sewn together. The driven reel (and dye liquor in overflow and soft flow machines) circulates the fabric through the dye liquor. A time of 1 .5-2 minutes for each revolution of the fabric rope is normally regarded as adequate to produce a level dyeing.

Garment Dyeing

Garment dyeing is a most critical operation but gives the manufacturer dyeing and it is therefore essential to the opportunity to colour his product at the latest stage possible in production process. For wool products this route is used only for knitwear (the dyeing of knitted panels, although not strictly garment dyeing, is also included here). The criticality of the process arises because much knitwear that is garment dyed is to be sold as machine washable or hand washable. This requires dyes of good wet fastness, which are generally not very level dyeing. However, because garment dyeing produces plain shades, it is vital that there is a very high degree of shade uniformity.

To resolve this dilemma specific dyeing processes have been developed that allow dyes of good wet fastness to be applied. The softer yarn twist of most knitwear is also more conducive to dye liquor penetration of the material than, for example, woven fabrics.

Wool garments are dyed in "paddle" machines or rotary drum machines. These have a gentle mechanical action to circulate the garments through the dye liquor and thereby avoid undue felting. The dyeing process is often combined with scouring, milling and shrink resist routines.

Dye and process selection

The table below lists the main classes of dyes used on wool and gives some of their properties. Within each dye class there are variations between individual dyes and there are therefore overlaps between some of the classes.

From a technical standpoint the better the level dyeing performance, the easier the dyes are to apply to wool. However, other properties, such as fastness, shade limitations and price will all influence the decision, when selecting dyes. There is a general trend in wool dyes for the wet fastness properties to increase as the migration (level dyeing) performance decreases.

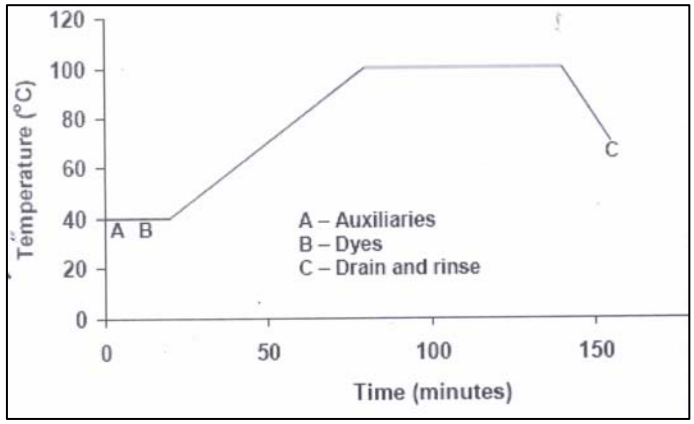
Wool Dye Classification				
Dye Class	**Level Dyeing Performance**	**Wet Fastness**	**Application**	**Relative Cost**
Level dyeing acid	Very good	Poor	Bright shades on fabric, carpet yarn	Low
Half milling	Good	Moderate	Bright shades on piece goods, carpet yarn, knitwear	Medium/low
Milling	Poor	Good	Bright shades on loose fibre, tops, yarn, knitwear (hand washable)	Medium/high
1: 1 Metal complex	Very good	Moderate	Dull shades on fabric (particularly carbonised)	Low/medium
1 :2 Metal complex	Moderate	Good	Dull shades on loose fibre, tops, yarn, knitwear	Medium
1 :2 Metal complex and milling mixtures	Moderate	Good	Most shades on all substrates except fabric	Medium
Chrome	Good	Very good	Dull and heavy shades on all substrates	Low
Reactive	Moderate/poor	Very good	All shades, mainly for machine washable	High

The exception to this rule is chrome dyes. These dyes are very similar to level dyeing acid dyes and therefore readily give shade uniformity. However, they are then treated with chromium salts, which form large complex molecules with the applied dye inside the fibre. These large molecules are difficult to remove and therefore exhibit good wet fastness. A negative aspect to chrome dyes is that chromium is regarded as an environmentally unacceptable heavy metal and legislative restrictions on its discharge are restricting the use of these dyes. Additionally, the application process is very long and can lead to fibre damage, which adversely affects the efficiency of subsequent processing. However, because of their good economy and wet fastness they are still widely used for deep shades, such as black and navy.

Dyeing application methods obviously vary from shade to shade and between different substrates and dye classes. However, the general principles are the same and are illustrated in the figure above.

Dyeing is normally started in a dyebath at around 30-50°C and the chemicals (auxiliaries) required for dyeing are added. When the auxiliaries have been well circulated in the dyebath the dyes are added and they too are allowed to circulate fully. The dyebath temperature is then raised slowly, typically at 1°C per minute to around 95-

100°C, which allows the dyes to be taken up uniformly by the fibre. Dyeing is continued at 95-1 OO°C for 30-90 minutes, under which conditions the dyes penetrate the fibre. The dyeing cycle is completed by draining the dyebath and rinsing the material or by giving an after treatment to remove loose dye (particularly for machine washable materials).



Dyeing blends

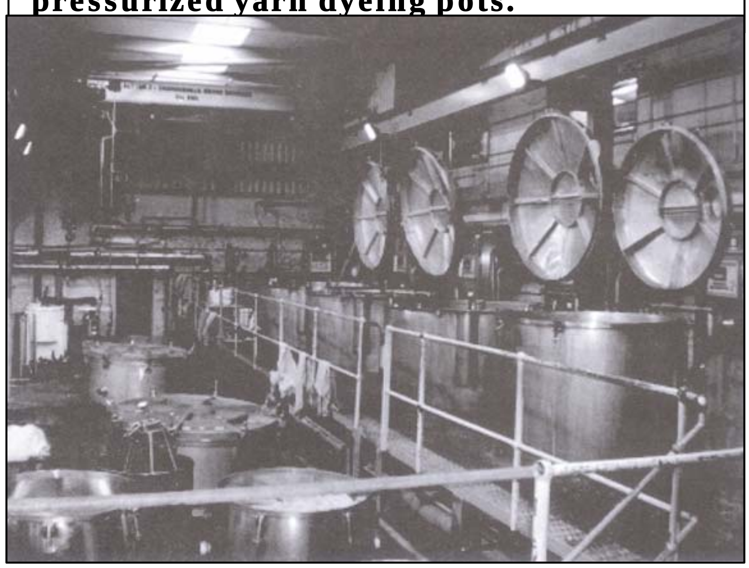
It is often necessary to dye wool in yarn and fabric form, when blended with other fibres. This can present difficulties for the dyer if the two or more fibre types need different dyes. There are also issues related to matching the same shade on two different fibres.

Wool / Acrylic

Wool/acrylic is a popular blend for knitwear and yarns are often dyed in blended form. Wool dyes are anionic (electrically negatively charged) and dyes for acrylic are cationic (positively charged). There is therefore potential for these two classes of dyes to interact and precipitate in the dyebath.

It is therefore usual to add wool dyes to the dyebath and allow them to be taken up by fibre, before adding the dyes for acrylic. Chemicals are also added to reduce the interaction of the two dyes classes.

A Modern Dye house for Wool: A State of the art loose stock dyeing plant having pressurized yarn dyeing pots.



Wool / Cellulosic

The term Cellulosic includes both natural fibres, such as cotton and linen, and regenerated fibres such as viscose. The major issue in dyeing these fibres in blends with wool is that dyes for cellulose are often applied under alkaline conditions, which would severely damage and possible even dissolve wool. A further difficulty in dyeing wool/cellulose blends is that wool absorbs a significant proportion of the cellulose dyes. Very careful selection of dyes and application conditions is therefore needed for successful dyeing of these blends. It is often necessary to dye one fibre and then refill the dyebath with different dyes and chemicals to dye the second fibre.

Wool / Polyamide

Wool and polyamide are similar chemically and can therefore be dyed with the same type of dyes. The also challenge for the dyer is to counteract the difference in affinity for dyes that exists between the two fibres. In pale to medium shades polyamide has a greater affinity and, if no action were taken by the dyer, it would dye to a much deeper shade than wool. In increasingly deeper shades the polyamide fibre becomes saturated before wool and the situation is reversed. This difficulty is overcome by adding to the dyebath specific chemicals that “block” the polyamide and reduce the uptake of dye.

Wool / Polyester

Wool/polyester is a very popular blend for woven apparel and, although some is produced via a fibre dyeing route, a significant quantity of yarn and fabric is dyed in the blend form. The challenge in dyeing this blend is to achieve satisfactory dyeing of the polyester component. Polyester is normally dyed at 130-135°C, at which temperatures wool is severely damaged and discoloured. Lower dyeing temperatures must therefore be adopted and dyes for the polyester component selected very carefully to enable the desired fastness properties to be achieved at the reduced temperature.

One solution is to add a "carrier" (a chemical to increase the uptake of dye on polyester) may be added to the dyebath. Another solution is to dye at slightly lower temperature than for 100% polyester, e.g. 120°C, and include in the bath chemicals to protect the wool fibre from excessive damage.

Often a combination of the two approaches is used.

Recent developments

Recent developments have concentrated on reducing the damage that dyeing causes to wool. These include reductions in the time of dyeing, reductions in the temperature of dyeing and the application of chemicals to block the damaging chemical reactions.

Other developments have been in the dyes themselves. The aim has been to develop dyes that can be used on most substrates, using the same application methods. This simplifies the dyeing processes and reduces the inventory of dyes that dyehouse needs to hold.

Machinery developments have also taken place, the main advance being in the area of automation. Virtually all modern machines are equipped with microprocessors to control the main operations. Systems are also available, particularly for yarn dyeing, to use robotics to fully automate the dyeing process.

Originally published in the New Cloth Market, March, 2012.