Colouration and Finishing for Designers and Retailers

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1. Introduction

Colouration and finishing for wool fabrics encompasses a large range of processes with a simple aim to change the appearance, handle, and performance of a fabric. This simplification hides a multitude of options in wool selection, spinning and weaving that can have a major influence on a fabric's properties. However, within the constraints of colouration and finishing there are combinations of processes that can provide outcomes as diverse as a lightweight, pastel shade, crepe fabric for women's wear to a check-designed, heavy, horse blanket for saddlery. Both are made from wool and both go through a range of different colouration and finishing routines designed to produce the required fabric.

While designers and retailers are most concerned with the outcomes of colouration and finishing, it is important they have a basic understanding of the technical background and limitations of the processes so that there is an appreciation of what the dyer and finisher can do to achieve the required product. From the dyers and finishers perspective it is important that they know as much information as possible about the end product and the performance needs. This means that where options are available, to achieve a desired outcome, the correct combination of colouration and finishing processes are selected.

2. Colouration and finishing options

2.1 Dyeing

There are three options for colouring wool and wool containing fabric. It can be dyed as a sliver or top prior to spinning; it can be dyed after spinning as yarn; or it can be dyed after weaving in fabric or piece form.

When wool fibre is dyed in the top form it is most often dyed using reactive dyes. These dyes have a very high affinity for wool fibres and therefore combine with the wool fibre very rapidly and very permanently. The top dyeing vessel contains of a series of perforated spindles over which the tops are placed. Dye liquour is pumped through the spindles and out through the perforations and subsequently though the top. A conventional cycle would have the liquour flow in this direction for a period and then flow in the reverse direction for a similar time to ensure all parts of the top have access to the dye liquour. This reversal of direction may happen every 4 minutes during a dyeing cycle which lasts about 4 hours. This process has a set of advantages and disadvantages that will be covered in the top dyeing section.

When wool fibres are dyed in yarn form it is regularly dyed using premetalised and milling dyes. These dyes have a slightly lower affinity for wool fibres than reactive dyes. This means there is an increased tendency to migrate and thereby provide a more level dyeing. The yarn dyeing vessel is similar in construction to the top dyeing vessel. The yarn packages are placed over perforated spindles and the dye liquour is pumped and reversed in a similar fashion to top dyeing. The yarn dyeing cycle is a longer cycle than top dyeing as the package is harder to pump liquour through so everything must happen slower. A dyeing cycle might last about 6 hours for yarn dyeing. Yarn dyeing has a set of advantages and disadvantages that will be covered in the yarn dyeing section.

When wool fibres are dyed in fabric or piece form the dyer usually only uses leveling dyes, with the lowest affinity for wool, in a process that can take 8 hours. It is only with the use of dyes that migrate readily on and off wool, under dyeing conditions, that a level dyeing in this process is possible. When the fabric is a solid shade, and more so if a dark, solid shade, an unlevel-dyed piece of fabric is commercially unacceptable. When panels are cut from a piece and assembled into a garment, the two sides adjacent to the seam are invariably not from adjacent locations on the piece. Under these conditions if the levelness is not within commercial limits, the colour difference will become obvious. This also applies to non-garment end uses where fabric from different pieces, or parts of a piece, are joined or otherwise used in close proximity to one another. Any unlevelness becomes obvious here also. The piece dyeing process has other advantages and disadvantages that will be covered in the piece dyeing section.

2.2 Physical Finishing

Physical finishing is a general term given to all the various finishing processes that use a physical action, normally in the presence of either water or steam, to change the fabric in some way. These processes are often further divided into wet and dry finishing as wool fabric goes through the traditional water based washing (scouring and milling) processes before being dried to go through the traditional steam pressing and setting processes to prepare the fabric for the garment maker, or raising and other processes to develop different fabric characteristics.

These processes will be covered in more detail in section 4.

2.2 Chemical Finishing

This area of finishing is has gone through an explosion in options over the last decade as well as a multitude of name changes to satisfy the marketing opportunities of the chemical manufacturers. The classic chemical finishes regularly used on wool and wool blend fabric 10 to 20 years ago included; resins to impart machine washability, fluorocarbons to impart soil release properties, Zirpro to improve fire retardant properties, waxes to impart shower proof properties and micro emulsion silicones to impart softness. Now the “Nano” buzz word is associated with most chemicals and with the ability to microencapsulate chemicals and fix them securely to fabric, has opened up an even larger list of products to put with fabric. These processes will be covered in more detail in section 4.

3. Dyeing

3.1 Top Dyeing

Top dyeing’s most significant advantage is associated with the processing stage that it occurs. By dyeing the fibre in top form, prior to blending and spinning, means that any unlevelness in dyeing is lost in the blending operation. The advantage here is that the dyer can use the fastest dyes possible for colouration. This will result in a fabric with the highest colourfastness to washing, perspiration, rubbing and light. This is an important performance consideration for garments and in some cases is part of the garment specification.

However, while that advantage exists there are a number of disadvantages to top dyeing. The most significant is again associated with the processing stage that it occurs. When dyeing at such an early processing stage it means that a commitment to colour is made at anything up to 3 months or more before the fabric is available. This can be a disadvantage for the fashion industry where colour commitment is preferably made closer to the time the fabric is needed. The other disadvantage is the size of the order required for top dyeing as a commercial batch size for spinning needs to be achieved and this might equate to a 1000 mtr minimum fabric order or more.

3.2 Yarn Dyeing

Yarn dyeing is a process that suits a number of end use needs most notably the production of small runs of patterned fabric. On a commercial basis it is possible to dye as little as five kilograms or less of yarn to be used as a decoration stripe or as a small component in a complex colour design.

The main disadvantage to yarn dyeing is associated with the nature of the package being dyed. Given that yarn and tops are dyed in very similar, or the same machines, the two forms of the fibre are very different. A ball of top is a loose collection of fibres that enables the dye liquour to flow through very easily. The yarn package on the other hand is a dense, tightly wound assembly of fibres that is much harder to get the dye liquour to flow through. Because of this it can be difficult to get the dye liquour to all parts of the package and this can result in unlevel dyeing unless great care is exercised.

3.3 Piece Dyeing

Piece dyeing probably has the greatest advantages and disadvantages. Because leveling dyes are used to achieve a level dyeing it means that the fastness of the dyes are lower than for yarn and top dyeing. This does not mean that the dyes will wash off the fabric. The ability of dyes to move off and on wool is under dyeing conditions of acid pH and 98ºC. The best way to compare the fastness of the different classes of dyes used in the different dyeing methods is to look at typical test results for the worst fastness conditions for wool dyes, i.e. alkaline perspiration. With a 5 the best result and a 1 the worst result, we would get on average a 3 for piece dyeing, 4 for yarn dyeing and 5 for top dyeing. To put this in perspective a 3 result would be an acceptable minimum specification for general use.

The great advantage to piece dyeing is that fabric can be produced in advance and be waiting for the colour commitment. This can result in coloured fabric being available in as little as a week or two from order if the greige is available. The other advantage of piece dyeing is that depending on the dyeing machines available, it is possible to dye as little as one piece or as many as 24 pieces in a single dyeing. This flexibility is what makes piece dyeing popular for many end uses.

3.4 Lab Dyeing and Shade Matching

Prior to bulk dyeing of any top, yarn or fabric there is a need to establish a recipe to achieve the desired shade. This is not a simple task but is made easier by two essential dyehouse resources. Firstly, is a spectrophotometer with good colour software. This can measure the colour you are trying to match and give a “best guess” recipe to start doing laboratory dyeings to match the shade. The second resource that supports the spectrophotometer and the dyer is an extensive library of dyeings and shades. At Macquarie Textiles we have in excess of 8,000 different recipes and shades so it is possible that for any new shade that is requested we will have a very close match in our records.

From the first laboratory dyeing there might be as many as 6 or more further laboratory dyeings needed to achieve a commercial match of a requested shade and while commonly referred to by many in the trade as “lab dips” the process of doing one lab dyeing takes as long as a full bulk dyeing. It is not simply dipping a piece of fabric in a dye solution.

The colour matching process is an area where the dyer and the customer can sometimes have trouble communicating and agreeing. To help overcome these communication issues a number of facts need to be established. The first fact is that no two people see colour exactly the same. Age especially can influence how we see colour with older people seeing objects more yellow in general. The second fact is that colour looks different in different lighting conditions. The third fact is that colour matching is not an exact science, it is a matter of getting the shade near enough for commercial acceptance.

There are a few reasons why a perfect match is unlikely.

1. Often the coloured item being matched is not the same physical product as the fibre or fabric. It may be a Pantone card, coloured paper, paint, etc. It is very difficult to compare a glossy coloured Pantone card with a knitted or woven fabric sample that has little gloss and a textured surface.
2. The fibre or fabric to be matched contains completely different fibre types. This can effect both the depth and brightness of the colour. Wool saturates with dyes at about 4% add on whereas a fibre like polyester might take up to 7% of dyes meaning it will have greater depth of colour. Also wool in its natural state is quite a yellow product compared to polyester and other synthetic fibres. This means it is not possible to get the same level of brightness on untreated wool as is possible on say polyester.
3. It might be the same product but dyed elsewhere. In this case the combination of dyes or the class of dyes used to create the colour will most likely be different. This can result in metamerism (see below).
4. The repeatability of any dyeing process is not perfect but with skill and care a commercial match can be produced each time.

Within the trade and between dyers and customers there are objectively measured colour differences that are accepted. This takes out the subjective appraisal of individuals and can help in disputes. While systems may vary, a common measurement term for colour difference is DE or delta E. This measurement is a combination of DL, DC and DH which are the difference in Depth, Chroma and Hue between two colour measurements under a specific light source. It is often accepted that a DE of 1.2 under D65 (daylight conditions) is a reasonable commercial limit for piece dyeing and DE of 0.8 for top dyeing. It should be noted that a colour difference with a delta E of 0.4, if spread over DL, DC and DH, might not be detectable by the human eye.

Metamerism is a term that is sometimes used by dyers to explain a poor colour match. It is not an excuse but a fact, that unless the exact same dyes and class of dyes are used to achieve a given colour on the same substrate, then under different lights they may look very different. This is the reason that colour matching will be done against D65 daylight unless otherwise specified. The lighting conditions of D65 daylight are different to fluorescent lighting, and different again to tungsten lighting, and different again to sunset conditions etc.

The final topic in this section is language. It is not often enough that a dyer is communicating with a like-minded, technical person who can use terms like “the shade is a little full, bright and blue”. This would allow the dyer to understand the changes to the recipe that are required to get nearer to an acceptable match. Often the comments might be it is “too dark”, “too light”, “not vibrant enough”, “needs to be cleaner”. These comments, while well meaning, do not provide the type of information required to improve a colour match. This is another reason why the objective measure of colour can help overcome communication issues. However, with this aside, it is the visual appraisal that is always the first check that is done when matching colour. It is also why dyers, and others involved with colour matching and approving, should be regularly tested for their ability to assess colour and colour differences.

4. Physical Finishing

4.1 Wet Finishing

After a fabric is woven and mended (greige) or knitted, it is ready for finishing or preparation for piece dyeing. For wool and wool containing fabrics scouring is one of the first processes. The main aim of this process is to remove dirt and oils picked up or added during the combing, drawing, spinning and weaving/knitting processes. This process can also double as a means of changing the characteristics of the fabric.
From a consideration of the woven or knitted structure the scouring process can be very gentle, and have very little effect on the yarn and the weave structure, or be very aggressive and result in controlled felting of the fabric.
An open width aqueous scour or even a solvent scour is a means of cleaning a fabric with minimal disturbance to the yarn and weave. These machines are a single passage continuous process where the fabric remains open while it goes through the machine. Depending on the machine the fabric may spend a few minutes only for washing and rinsing. This process would be used to retain the clean lines of the weave, ensure the fabric surface is very clean and also to keep the handle as crisp as possible.
The next level of aggression in scouring would be to rope scour the fabric. In this process the fabric is allowed to collapse into a “rope” (it is not kept open width) and may run around in the machine for 20 minutes to an hour. This action disturbs the yarn and the weave and will also result in bringing some fibre to the surface of the fabric. The other outcome of this process is that it softens the fabric by allowing the fabric to relax more.
The ultimate in aggressive scouring is a process referred to as milling. This process is the controlled felting of the wool in the fabric. The process might result in the fabric shrinking 20% in the width and 30% in the length to achieve the desired handle and appearance. The outcome is a fabric where the weave is not visible, there is a lot of fibre on the surface of the fabric and it is much thicker and bulkier.

4.2 Dry Finishing

After the wet finishing processes or piece dyeing the fabric is dried. This is done, for woven fabric, in a stenter which holds the fabric open while passing it through a heated chamber. For knitted fabric drying might also occur on a stenter but can also be done in a continuous drum dryer.
The aim of the various dry finishing processes that follow is:

1. To create the fabric surface characteristics that achieve the required handle, performance and appearance.
2. To establish the dimensional stability characteristics that meet the required performance and appearance.

The operations of cropping or singeing are used to remove surface fibre from the fabric. The processes are quite different and are used to remove varying amounts of surface fibre. Cropping is a process where the fibre ends are cut from the fabric surface. The cutting process limits the closeness of the process as the fibres must be removed without damaging the fabric. Singeing, as the name implies, uses a flame to burn the fibres off the surface. This process is able to remove the ends of the fibres to a greater depth in the fabric and results in a "cleaner" fabric surface. These processes are important for giving a clean, smooth handle; improving pilling performance; and allowing fine detail of the weave and design to be seen. This process is also used to tidy up the pile on a velour or flannel fabric so the pile has a uniform length.

The process of raising does the opposite to cropping. This process teases fibres out of the yarns and makes them protrude from the fabric surface. This would normally be done after milling and is most commonly used in the manufacture of blanketing fabric.

The processes of pressing, setting and decatising are used to flatten the fabric, make the fabric thinner, stabilize the dimensions, apply a degree of luster to the fabric surface and generally make the fabric feel softer and sleeker. While there are a number of machines that come within this category, they have common actions. Most hold the fabric while in the presence of heat or steam. This action is responsible for "setting" the wool which stabilizes the dimensions and takes stresses and strains out of the fabric. Most also compress the fabric while in the presence of heat or steam. This action is responsible for making the fabric thinner and also for imparting lustre to the surface. The major difference between the machines is the degree of compression and the temperature of the heat or steam. This effects the degree of lustre and setting obtained.

5. Chemical Finishing

Chemical finishing covers an ever increasing list of products that can be applied to a fabric, usually to impart specific functional properties. The following is a brief list of some of the available chemicals or properties with a brief comment on their use.

5.1 Hydrophobic

These chemicals impart a water repellant finish to fabrics. They are applied to the finished fabric by padding and drying and range from chemicals that are durable to washing and dry cleaning to those that are not. For those not durable the effect will diminish with laundering. They include fluorocarbon chemicals like Teflon and Scotchguard which impart water and oil repellant properties to assist the easy removal of stains. There are also wax emulsions that are not durable and impart shower-proof properties to the fabric.
As well as chemicals it is possible to laminate various films and coatings to fabric which have waterproof properties but are less able to allow vapour transmission than the chemical treatments.

5.2 Hydrophilic

These chemicals impart a water absorbing or attracting property to fabrics. They are not regularly used and only a few exist. They are mainly cationic chemicals and resins and have only few specific functional uses with wool fabric. They can be put on knitting yarns and fabrics and are exhausted on or padded and dried.

5.3 Antimicrobial

These chemicals are being used more frequently and are associated with specific end uses like socks. Common brand names include Sanitize and Ultrafresh. There is now a new group of chemical compounds containing silver which have antimicrobial actions and are being promoted widely. These chemicals can be padded or exhausted onto the fabric.

5.4 Micro-encapsulation

This method of performance enhancement for fabrics has had a major increase in available chemicals over the last 5 years. The heavily promoted initial products were mainly for the application of aromas. However, as the technique of microencapsulation has become more widely used there are now a multitude of functional chemicals that can be encapsulated and put on fabric. These include a range of chemicals which claim therapeutic benefits.

5.5 Softeners

Softeners to improve the handle of fabric have been around for many years. Currently the most popular chemistry for softeners are silicones which impart a "slippery" feel to the fabric which helps make the fabric feel softer. The original form of these softeners were micro-emulsions but as the molecular size of the products are made smaller for ease of application and durability they have moved to nano size. This has been cleverly marketed using the "nano technology" catch phrase which is now widely used for many chemical finishing products.

5.6 Mothproof

With wools susceptibility to attack by moths and beetles there has been a long history of applying a mothproofing agent to some wool containing products, especially carpets. There are a range of chemical forms for these products and they can range from durable products whose activity remains for many laundering cycles to those whose activity diminishes rapidly with laundering. Its use in apparel is mainly limited to fabric that is going to be stored for a period before use.

5.7 Crease "Resistant"

A range of chemicals and resins have been applied to wool fabric to either prevent the fabric from creasing easily or allow the creases to drop out easily after being folded. There have also been other resin developments used on wool fabrics that were aimed at retaining creases in garments, especially trousers. It is still believed that the most successful way of limiting the creasing in wool fabrics requires a combination of yarn engineering and weave structure to optimize the crease recovery of the base fabric before any additional treatment is applied.

5.8 Stretch

Fabric stretch is traditionally obtained by including elastane fibres such as Lycra or Spandex into the design. However, there have been attempts to develop stretch in wool fabrics using chemicals but the disadvantages of damaging the wool fibres and decreasing tear strength and abrasion made it commercially unacceptable. There are also non-elastane fibre options to produce a stretch fabric by engineering the yarn and weave structure as well as modifying the finishing. This method is unable to develop stretch levels of 20% plus as reached with elastane but remains an option.

5.9 Fire retardant

Wool has natural fire retardant properties due to its chemistry and the fact that it chars when burnt. This had given wool an unfair advantage in areas where fire is a hazard and safety is paramount. Now other man made fibres with superior fire resistant properties are available but wool is still the fibre of choice for furnishing, upholstery and safety wear where fire is a hazard. In some end uses and especially in lighter weight fabrics wool's fire resistance is inadequate to pass specific flammability tests. In these cases the flame retardant properties of wool are improved with a chemical treatment. The Zirpro treatment using potassium fluoro zirconate was developed many years ago and still remains the bench mark for flame retardant wool finishes for wool. There are also now a range of other halogenated chemicals that can help wool pass various flammability tests.

5.10 Machine washable

It was found out very early that wool fabric could not be washed in water without shrinking and much effort went into the CSIRO development that came up with the Hercosett superwash treatment. This treatment on wool top is widely used on wool for knitting yarns and less so for woven apparel. The treatment puts a coating of resin over the scales on wool fibres to prevent the felting that happens during washing. The treatment does adversely effect the handle of the wool product but the development of various softeners have helped minimise this effect.

In the last 10 years there have been other resin developments to apply machine washable function to wool in the fabric form. These new chemicals have dramatically reduced the harsh handle that was present with the earlier resin treatments that relied on "glueing" all the fibres together. This gave good machine wash performance but made the fabric very stiff. The development in softeners has also helped the new resins give an improvement in handle.

Other alternatives are either available or under development to impart machine wash function to wool fabric. These include treatments such as: ozone treatment, corona discharge, enzyme treatment and chlorination but they are either very expensive or not as effective as the current chemical treatments for top and fabric.

5.11 Environmentally Friendly

This is a growing area that includes far more than chemical finishing but is included here to recognize its growing importance and the role of functional dyes and chemicals in the environmentally friendly label. There has been for years a range of non metal dyes for wool that would be considered very “green”. However, the palate of colours for these dyes is limited to pale pastels. For chemical finishes we have a similar dilemma to address. It depends on how far we go with the definitions we use for “environmentally friendly” that will dictate whether we can continue to use some or all of the functional finishes we now have?