1. Overview of Early Stage Wool Processing

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Learning objectives

On completion of this topic you should be able to:

- Outline the main wool processing systems, from greasy wool through to finished yarn;
- Describe the essential features of the worsted, woollen and semiworsted processing routes, using an appropriate flow diagram;
- Explain the similarities and differences between these routes with respect to (a) the raw material requirements, (b) complexity of each route, and (c) the properties and uses of the yarn produced by each.
- Describe the essential differences between a woollen and worsted card.

Key terms and concepts

Worsted, woollen, semiworsted, blending, lubricating, scouring, carbonising, carding, gilling, combing, spinning, drafting, slubbing, top, sliver, roving

Introduction to the topic

This topic provides an overview of the steps involved in the early stage processing of wool (ESP), ie, the conversion of greasy wool into yarn. Subsequent topics in this unit provide more details on each processing step in early stage processing, as well as the steps involved in late stage processing.

A brief outline of wool processing is provided by Teasdale (1995). Comprehensive information is provided Hunter (2002), Lawrence (2003), and in the review paper by Harrowfield (1987). Technical information relevant to this topic is available via the AWI website www.wool.com.

1.1 Overview of early stage processing

There are two main systems used for processing wool from fibre into yarn: the *worsted* system and the *woollen* system (Figure 1.1). The *semiworsted* system, which was developed as a high production spinning route for synthetic fibres, is also used to process wool for carpet yarns. There are a number of processes common to both systems: *blending* of the wool types to be used; *scouring* of the wool to remove a range of impurities (e.g. dirt and grease); *carding* to disentangle the fibres and remove impurities like vegetable matter; *spinning* of fibres into a yarn. However, the technical aspects of these processes do differ between the systems due to differences in the 'raw materials' used by each. Also, there are additional processes specific to each system. The result is that worsted and woollen yarns differ in their structure and properties which ultimately influence the attributes of the fabrics produced from each system.

The main steps in worsted and woollen processing are shown in Figure 1.1, together with the principal products and typical losses incurred at each stage of processing. Processes such as shrinkproofing, mothproofing, dyeing and finishing, for which there may be major differences between particular products, have not been shown for simplicity.

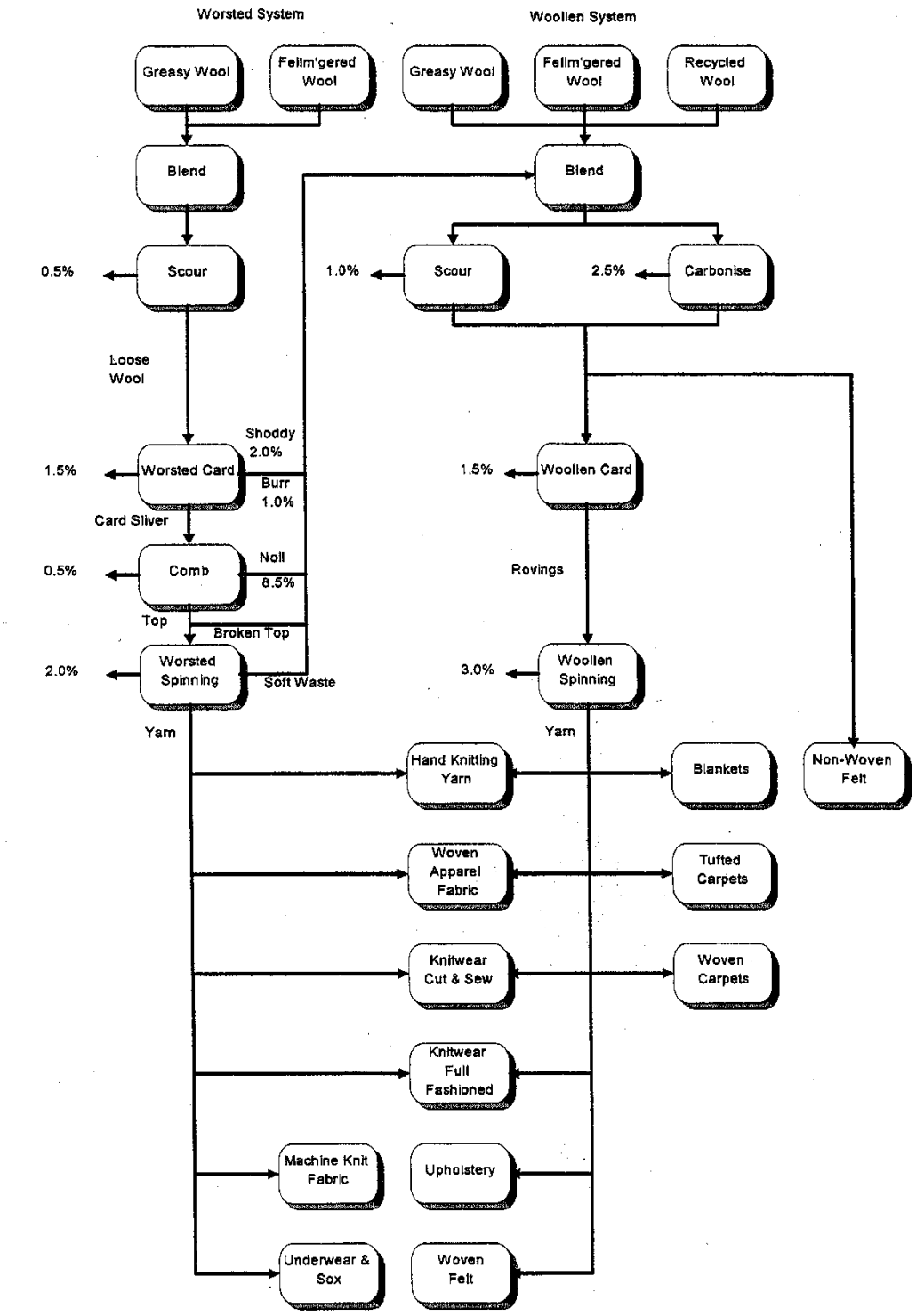

Figure 1.1 Basic processes in the worsted and woollen systems, figures show percentage of losses or by-products at each processing stage. Source: Teasdale, 1995.

Approximately 80% of the Australian wool clip enters the worsted system. It only uses virgin wools, generally finer than 27 micron, longer than 40 mm and with low levels of vegetable matter. The worsted system utilises *gilling* and *combing* operations to give greater alignment of the fibres, resulting in a smooth and strong yarn. Both woven and knitted fabrics can be produced from these yarns, the fabrics being characterised by a smooth (or less hairy) surface. Men's suits and women's dress fabrics are examples of worsted garments.

1.2 Scouring

Scouring is an essential step in the conversion of wool into consumer products. The main objectives of scouring are to remove contamination and to minimise fibre damage in the process. Success in scouring is generally indicated by low levels of:

- contamination (ie, residual grease, dirt, suint, vegetable matter and wool fragments)
- fibre breakage
- fibre entanglement

and the achievement of good colour in the scoured product.

Traditionally the wool scouring process has been carried out in water, and today almost all wool is aqueous scoured rather than solvent scoured.

Figure 1.2 shows schematically the main components of a modern wool scouring plant designed to handle fine, apparel wools. The number of bowls and the number of hoppers in each bowl is influenced by the types of wool to be scoured. Care must also be taken not to over–scour very fine wools with treatments that are too long or too vigorous, otherwise excessive entanglement will ensure. Typically, the first two or three bowls will be scouring bowls, containing water and detergent at around 60-70^{o}C. The final three bowls are rinse bowls, with water temperature generally around 40-50^{o}C.

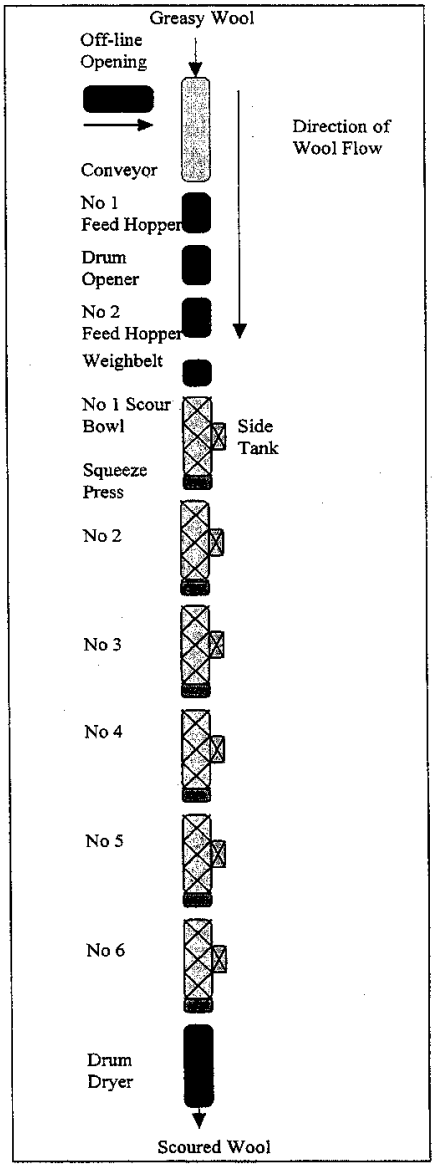

Figure 1.2 Typical worsted scour configuration. Source: Teasdale, 1995.

Associated with a wool scouring line are:

- Blending facilities, with machines for opening and dust removal;
- Heat recovery systems to transfer the heat from the effluent to the incoming water;
- Effluent treatment systems for separating woolgrease from the effluent, and for ensuring that the discharged water has minimal contaminants;
- Hot air dryers to remove water and achieve the required level of regain;
- Baling machines to conveniently package the wool for shipment to a topmaking or a spinning plant.

Topic 2 examines wool scouring in more depth.

1.3 Carbonising

Some fine wools contain high levels of vegetable matter (VM) of types which cannot be fully removed mechanically. Fragments of VM remaining in a yarn can cause serious problems for the apparel manufacturer. The only feasible way of ensuring that problematic VM types can be removed by mechanical action is to carbonise them first.

The carbonising process comprises a number of operations which must be matched to each other to provide a commercially acceptable product. Because of the chemical and physical processes involved (sulphuric acid, high temperatures and physical crushing), there must be a balance between:

- maximum removal of vegetable matter;
- minimal damage to the wool fibres (colour, strength and entanglement); and
- minimum fibre losses.

The following processing steps are involved in carbonising:

Acidising

The wool passes from the scour directly into one or more acid bowls where it is immersed in about 7% sulphuric acid.

Drying and baking

The wool is rapidly dried in a drum or conveyor dryer at temperatures below 70°C to prevent fibre damage. It then passes into the baking oven to dry and bake at around 120°C to l30°C. Here the vegetable matter becomes charred and brittle. A conveyor dryer is usually used for baking. Intermediate crushing and de-dusting may occur between the dryer and baking oven.

Crushing and de-dusting

The wool then passes through a number of sets of crusher rollers to break up the carbonised vegetable matter which should be brittle. These rollers operate under high force and care must be taken to limit fibre damage.

Neutralising

The dust–free wool then passes into the neutralising line which usually comprises about 4 or 5 scour bowls. Remaining sulphuric acid is neutralised with alkali such as soda ash and the wool is given a final wash and rinse before being dried as for normal scoured wool.

The acidic nature of the carbonising process inevitably weakens the wool fibres and makes them unsuitable for worsted processing. However, carbonised wools may be used as part of blends for woollen processing.

Topic 4 examines wool carbonising in more depth.

1.4 Mechanical processing of wool

The mechanical processing stage in the wool pipeline commences with clean scoured wool and ends with the yarn ready for the fabric manufacturing stage. The main objectives of mechanical processing are to:

- disentangle and mix the fibres;
- remove vegetable matter;
- form a uniform strand of fibres (ie, sliver or slubbing);
- attenuate the strand (i.e. reduce its thickness) and
- impart cohesion using twist to form a yarn of the required specifications and quality.

Other operations (which include some wet processing steps) include:

- lubrication of the fibres, to assist carding and spinning
- removal of short fibre and residual vegetable matter (combing in the worsted system only);
- dyeing (as loose stock, sliver, top or yarn);
- folding (or plying), winding, clearing,
- yarn scouring and twist setting (for carpets)
- shrink-proofing (loose stock or sliver).

All of the above processes must take place with maximum efficiency and quality, and with the minimum cost, fibre damage and breakage, and fibre loss.

The mechanical processing of wool can be divided into three main steps: sliver formation, sliver preparation and yarn formation.

Sliver or slubbing formation

This involves disentangling and mixing the fibres, removing vegetable matter and forming a continuous web, sliver or slubbing. This step is achieved by *carding*.

Preparing the carded sliver for spinning

This involves aligning the fibres (parallelisation), evening (doubling), drafting and the removal of short fibres, neps, vegetable matter and other contaminants. These are achieved by *gilling*, *combing* and *drawing*.

Yarn formation

This involves drafting the fibres into a thin strand and imparting cohesion to the strand (usually by inserting twist). This is the *spinning* step, which produces a singles yarn. Two or more singles yarns may be twisted together (plied) to form a folded yarn.

1.5 The three yarn manufacturing systems

The three alternative systems used for processing scoured wool into yarn are similar in many respects, such as the prior application of a special lubricant (as an emulsion with water) to assist processing, and the principles of the carding and spinning steps. The common features are shown in Figure 1.3.

However, the three routes have significant differences, in terms of the number of steps required to produce a yarn, the type of machinery used at each step, the types of wools that can be economically processed, and the properties of the yarns produced (see Figure 1.4 and Table 1.1).

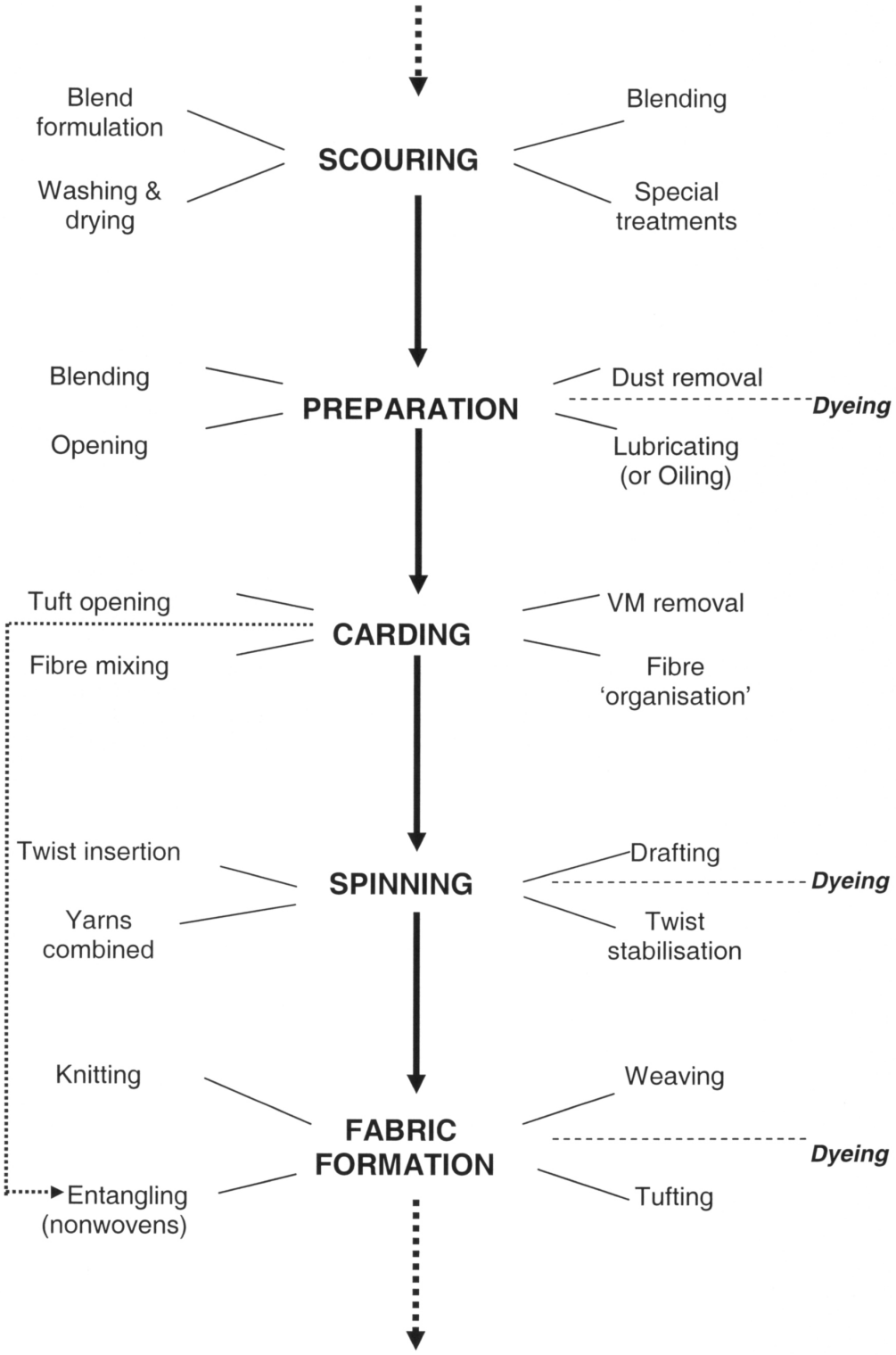

Figure 1.3 General steps in wool processing. Source: Wood, 2006

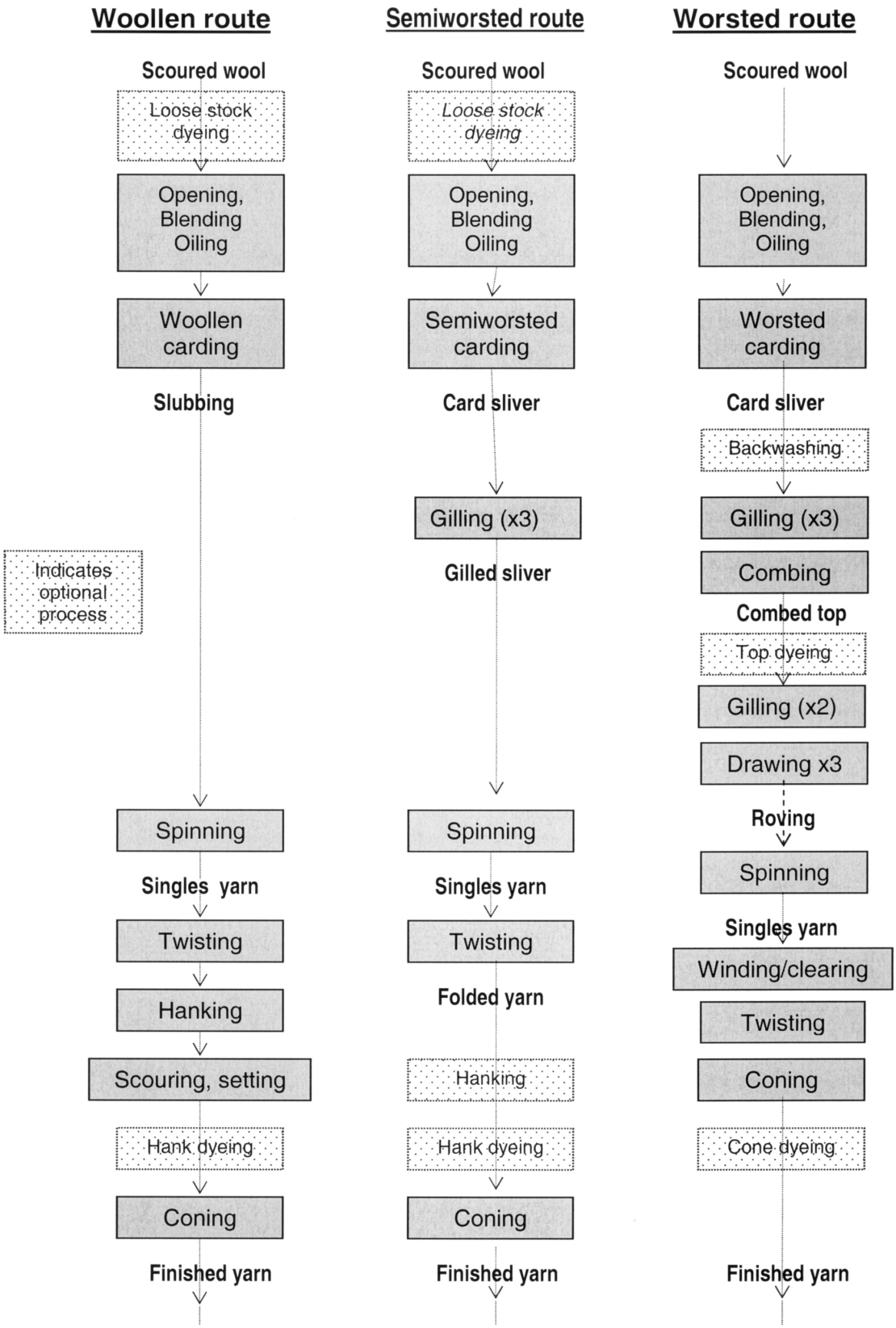

Figure 1.4 Steps in wool yarn manufacture. Source: Wood, 2006

Table 1.1 Comparison of the three processing routes. Source: Wood, 2006

	Woollen	Semiworsted	Worsted
Wool requirements:	Versatile; can handle all wool types, but more suitable for shorter wools rather than very long	Wools should be sound, staple length 75-125 mm, and low vegetable matter content	Requires wools which for their diameter are longer, better style and sounder
	Usually a wide range of blend components	Usually a limited range of components in blend	Similar wools used rather than a mixture of types
	All fibre diameters used, from very fine to very coarse wools	Mainly medium fineness wools; 27 - 35 μm	Mainly fine wools; less than 30 μm, usually less than 24 μm
	Can use reprocessed wools of all types	Not suitable for short reprocessed wools	Waste wools never used
	Blend cost generally lowest	Blend cost higher than woollen	Blend cost highest
Complexity of the processing system	Shortest route with fewest steps, large woollen card has low production rate	Compact, high production system, cheaper to operate than worsted system	Most complex route; largest number of steps; card similar to semi-worsted card
	Card removes some VM but cannot tolerate high levels of vegetable matter	Limited ability to remove vegetable matter and short fibres	Vegetable matter and short fibres removed by combing
	Carding is very critical because it sets the yarn count, and is the final opportunity for blending	Carding is less critical because of substantial blending and drafting in subsequent steps	Carding is less critical because of substantial blending and drafting in subsequent steps
Properties of yarn:	Minimal alignment of fibres, many may be hooked	Reasonable degree of fibre alignment	Fibre alignment very high, giving most even yarn
	Hairy yarn - many fibres protrude from surface	Fewer fibre ends and loops protrude from surface	Few fibre ends and loops protrude, so least hairy
	Yarn is bulky, soft and resilient	Medium bulk and resilience	Low bulk (lean, smooth), and firm handle
	Tends to be weakest, with breaking strength of 3-5 g/tex	Stronger, with typical breaking strength 5-7 g/tex	Tends to be strongest yarn; breaking strength 7-9 g/tex
	Requires at least around 110 fibres in yarn cross-section	Requires at least around 90 fibres in yarn cross-section	Requires at least around 40 fibres in yarn cross-section
End product uses:	Suitable for all purposes: apparel, carpets, furnishings.	Carpets and knitwear mainly	Fine weaving and knitting yarns for quality apparel
	Yarn structure often not apparent in finished product	Yarn structure may or may not be clearly visible	Yarn structure is usually well-defined in product

Fibre preparation for spinning

Before yarn manufacture can commence, some preparation is required in the spinning or topmaking plant. Preparation involves opening, blending and lubricating, processes which prepare the wool for spinning by:

- separating the scoured wool into smaller clumps;
- removing as much dust and short fibre as possible by vigorous agitation;
- combining different types of wool and other fibres into the processing blend and thoroughly mixing them;
- spraying a light film of lubricant (oil and water) on the wool, to assist processing.

A common opening machine is a Fearnought, shown in Figure 1.5. It operates rather like a card, with rotating toothed rollers that interact to reduce the size of the clumps of scoured wool.

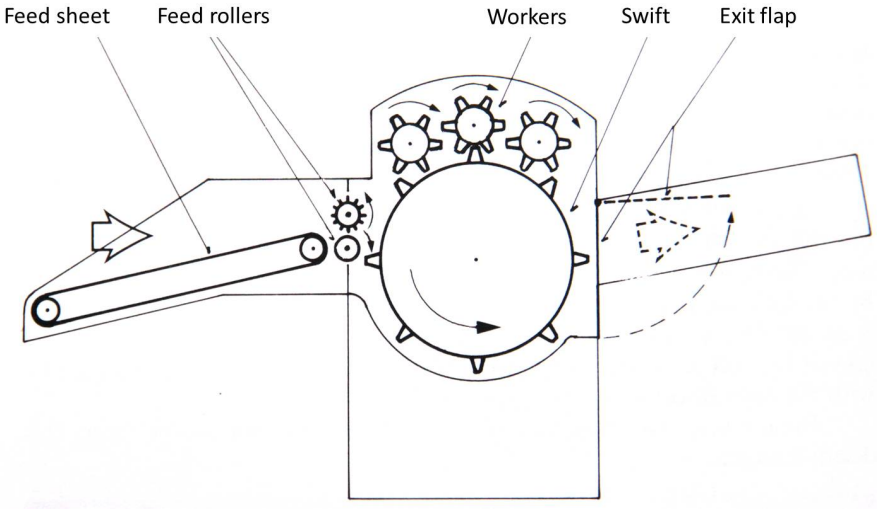

Figure 1.5 Fearnought wool opener. Source: Wood. 2006

While all three routes require these processes to be carried out, a higher level of lubricant (~3%) is usually applied for woollen spun yarns than the other routes to promote sufficient fibre cohesion. Furthermore, woollen blends tend to require more thorough blending because:

1. A wider variety of wool types is generally used, and
2. The woollen route provides no significant opportunities for blending after the carding step.

Figure 1.6 shows a typical blending system for woollen yarn manufacture.

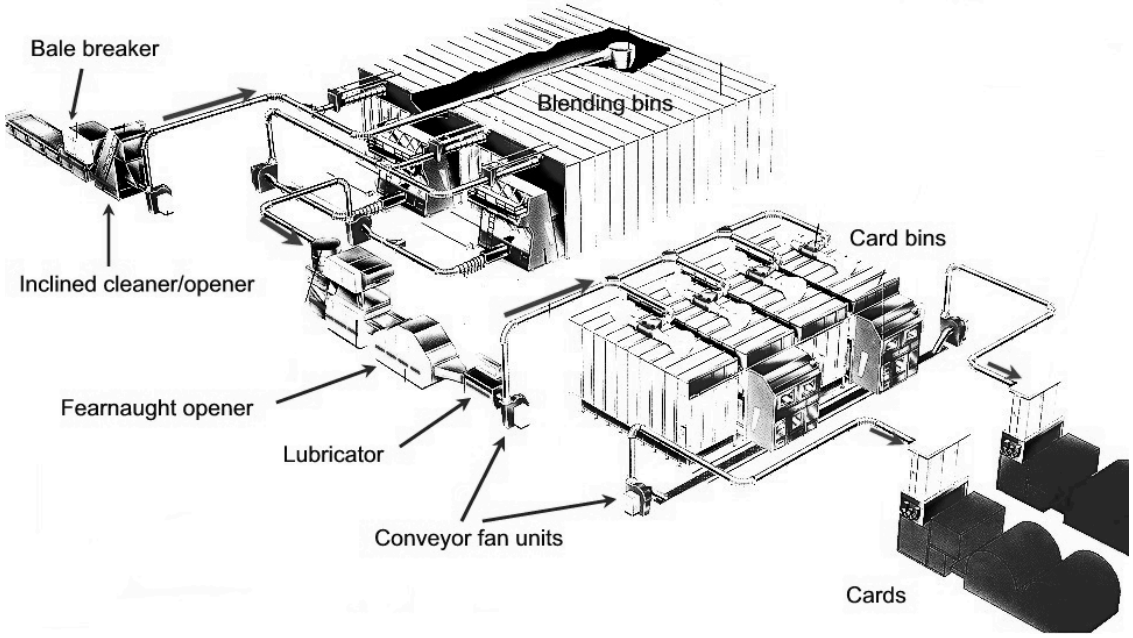

Figure 1.6 Typical blending system for woollen yarns. Source: Wood, 2010

Worsted system

The worsted system has the most steps of the three routes. Better-style, sound wools are required to ensure efficient processing and acceptable yarn quality. There should not be any defects in the wool, such as tenderness or cotts, or too much vegetable matter. Fine and medium wools are preferred to produce a fine, lean, flexible yarn, and ultimately a light, soft-handling fabric.

Carding

After the scoured wool is opened, blended and a lubricant applied, carding is carried out. This is the process where metal teeth or pins (on rollers rotating at different speeds) tease the tufts of fibres apart and lay the fibres roughly parallel into a card sliver. Carding also removes some of the vegetable matter present in the wool. . The wool is removed from a worsted card and coiled into a can as a thick ribbon of fibre, called a *sliver*.

Figure 1.7 shows a typical arrangement of the rollers in a worsted card. A semiworsted card is very similar to a worsted card in construction, but generally runs at a higher production rate.

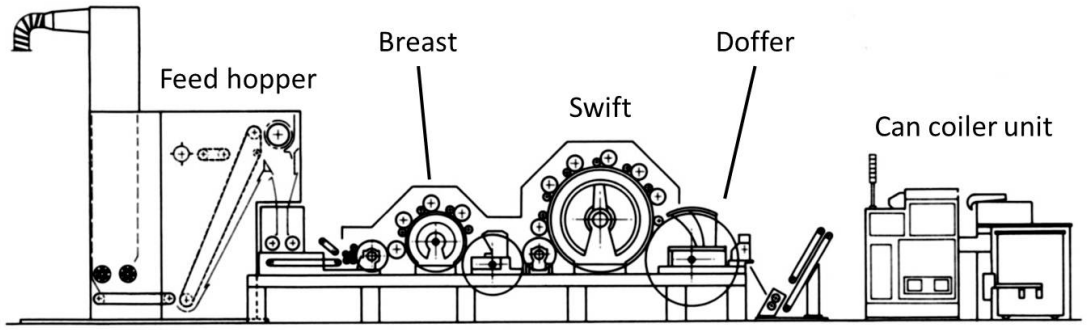

Figure 1.7 Worsted card. Source: Wood, 2010

The principles of carding are discussed in Topic 5.

Gilling

More extensive fibre organisation steps are required in the worsted system, so the card sliver is passed through a series of *gilling* steps to straighten and align fibres in a neat, parallel arrangement. The action of a *gillbox* (Figure 1.8) closely resembles the combing of hair. Gilling involves lines of metal teeth, mounted on a series of steel bars (fallers), being drawn through the sliver as it moves through the machine.

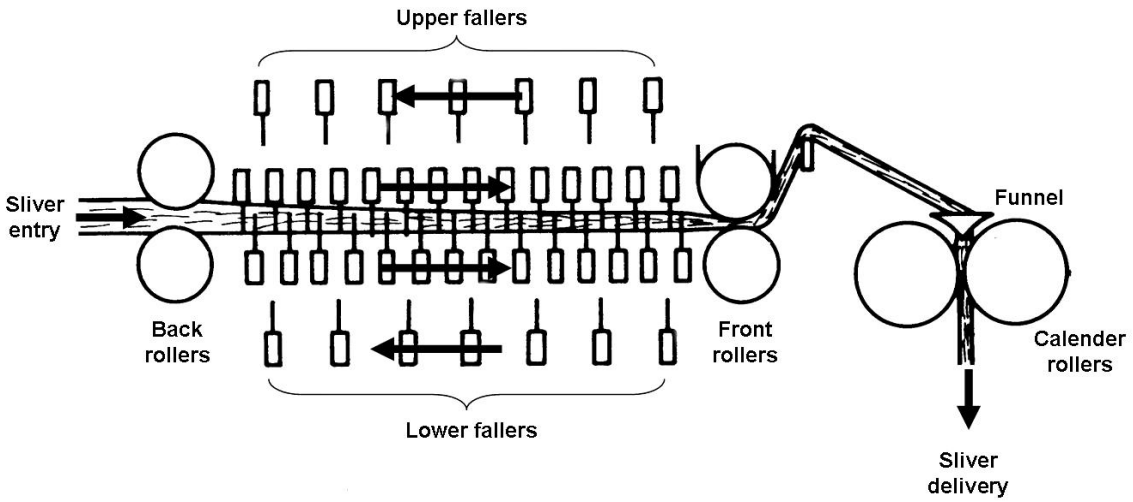

Figure 1.8 Principles of gillbox operation. Source: Wood, 2006.

Combing

The gilled sliver is *combed* to remove short fibres (*noils*), *neps* (tiny clumps of fibre) and vegetable matter (Figure 1.9), then gilled again to restore the parallel alignment to form a *top*. An optional *backwashing* treatment may be included at this stage, where the top is scoured to provide a whiter, cleaner product.

Gilling and combing are discussed in more detail in Topics 6 and 7 respectively.

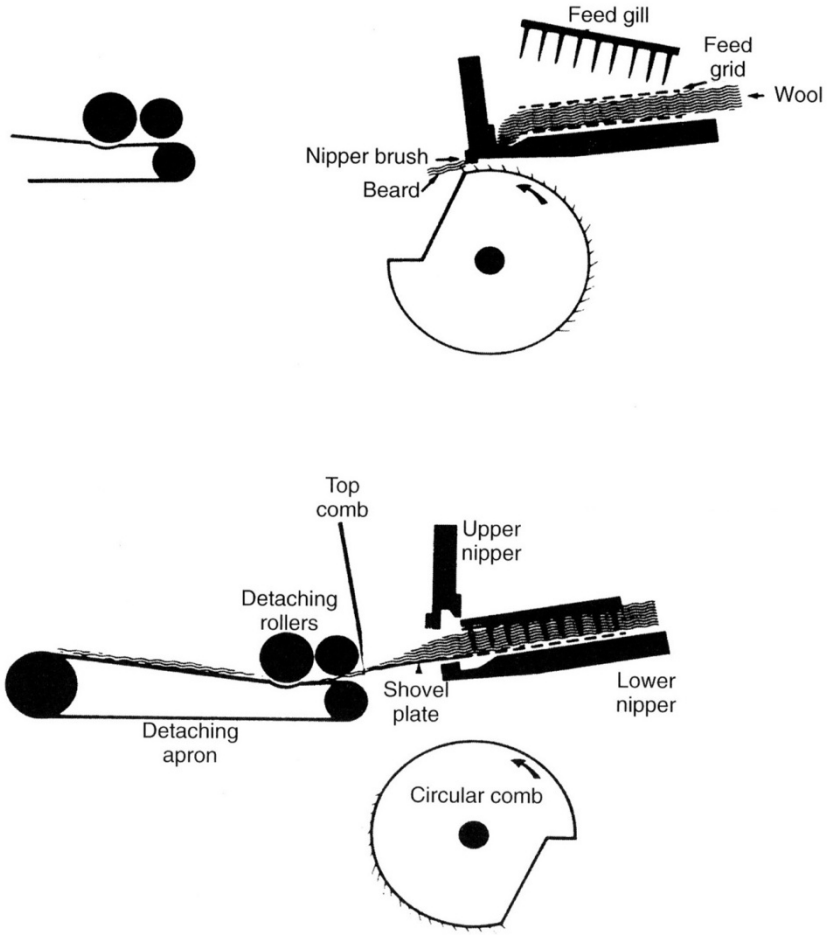

Figure 1.9 Combing action. Source: Wood, 2006.

The top is drafted (i.e. drawn out to reduce its thickness) to form a thin, uniform ribbon of fibres, called a *roving* (Figure 1.10), before being further drafted and twisted in spinning to form a singles yarn (Figure 1.11). In the worsted system the first group of processes, i.e. blending, carding, gilling and combing is called *topmaking*.

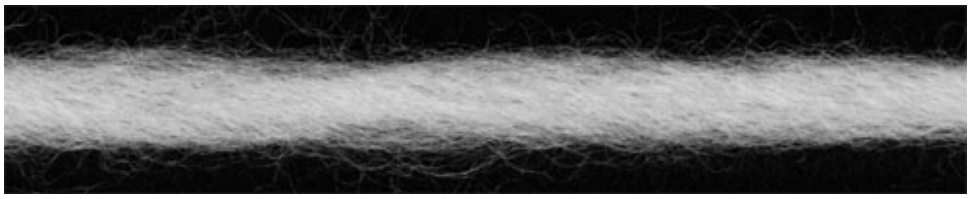

Figure 1.10 Roving. Source: Wood, 2006.

Figure 1.11 Worsted yarn. Source: Wood, 2006.

Drafting

In the production of a worsted yarn, the wool goes through a number of intermediate stages to gradually reduce its linear density (or thickness). A top may have 25,000 fibres in its cross-section while a worsted yarn may have only 50 fibres or less. To achieve the required yarn fineness, a considerable reduction in the thickness of the structures must occur, through successive *drafting* at each stage. The sequence of fibre structures in the worsted system is:

scoured wool – card sliver – gilled sliver – top – roving – singles yarn – folded yarn

Roller drafting (or drawing) is carried by passing a sliver or roving between two pairs of driven rollers. The delivery (or front) rollers have a higher surface speed than the feed (or back) rollers. For example, if the surface speed of the front rollers is ten times the surface speed of the back roller (i.e. draft ratio = 10), there will be a ten-fold reduction in the thickness of the sliver. Thus a thinner strand will emerge from the drafting zone. The drafting of slivers and rovings is discussed in more detail in Topic 6.

Spinning

Figure 1.12 shows the spindles on a worsted ring spinning frame, which is the most commonly used machine for spinning worsted yarns. The rovings (top of picture) pass through the drafting zone (middle) and the yarn is wound onto the bobbins (bottom), which rotate at high speed on spindles.

Figure 1.12 Worsted spinning frame. Source: Wood, 2006.

As a result of (1) the removal of short fibres in combing, (2) the parallel arrangement of the fibres presented for spinning, and (3) the high degree of twist imposed, a worsted yarn is sufficiently strong to permit a minimum of around 40 fibres in the cross-section. Hence fine, even, firm yarns with sufficient strength for weaving or knitting can be spun by the worsted process. Figure 1.13 shows the regular helical path of a typical fibre, imposed by the twist in a worsted yarn.

Figure 1.13 Helical path of a fibre in an ideal worsted yarn. Source: Wood, 2006.

After spinning, two (or more) singles yarns may be twisted together to form a plied yarn. At the same time the yarn may be ***cleared***, ie, have faults such as thick or thin places removed and the yarn re-joined automatically.

Characteristics of worsted yarns

Worsted-spun yarns are mostly used in high-quality woven suiting fabrics, and hand and machine knitting. In these products it is important that the yarn be free from faults such as *neps*, *slubs* (lumps), vegetable matter and short, protruding fibres. Short fibres can cause discomfort in wear due to the prickle sensation. Long, protruding fibres have a propensity to entangle and form *pills* (small clusters of fibres on a fabric surface), which are visually unattractive.

Spinning techniques are discussed in more detail in Topics 8 and 9.

Woollen system

The woollen system is the simplest of the three yarn manufacturing routes, and because it is the most versatile, it tends to be used to process blends of wools which vary in length and fibre diameter. The system is capable of handling the poorer-style wools and the short and tender wools. Noils (combing waste) and recycled fibres (e.g. combing noils and from rags and yarns) may also be included in woollen blends. Crossbred wool blends destined for carpets are mostly processed on the woollen system.

Woollen carding

A woollen card is, by necessity, a more complicated machine than a worsted card because it provides the final opportunity for fibre mixing before spinning, and it also determines the count (or thickness) of the yarn. Instead of producing a sliver (as in the worsted and semiworsted cards) it forms *slubbings* using a device called a *condenser*. A slubbing is similar to a worsted *roving*, but it is less uniform and the fibres in the strand are much less well-aligned and straight. Any variations or irregularities in the slubbings persist through spinning and hence may affect the quality (i.e. evenness) of the finished yarn. A woollen card may be up to 3.5 metres wide and 15 metres or more in length.

From the hopper feed the wool generally passes through two carding stages (termed the *scribbler* and *carder* parts respectively) to ensure a thorough opening of the wool tufts and the mixing of fibres, and the removal of contaminants (Figure 1.14). A *web-purifier* (or *Peralta*) is a pair of smooth steel rollers that crushes the vegetable matter into fragments, hence making them more easily removed from the web. The *intermediate feed* conveys the card web from the scribbler section to the carder section.

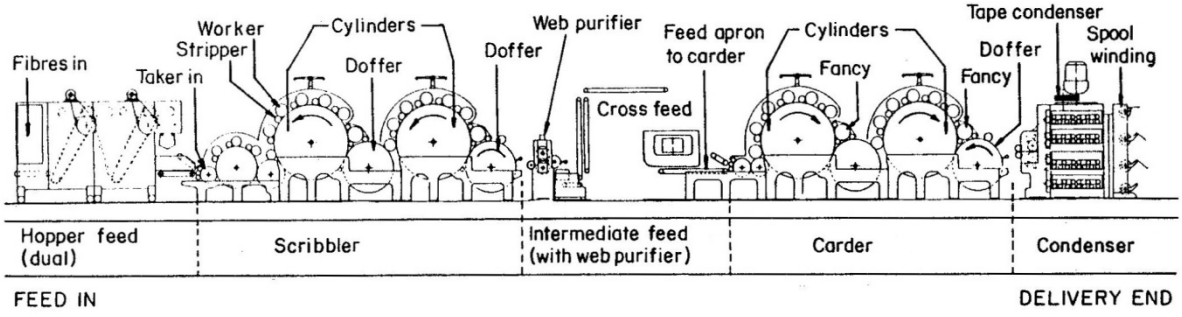

Figure 1.14 Layout of a woollen card. Source: Wood, 2006.

At the tape condenser (Figure 1.15), the web (ie, a thin fibrous film) of carded fibres is separated into narrow strips which are consolidated by a rubbing action into slubbings. The condenser tapes convey the strips of fibres into the rubbing aprons and the slubbings formed there are wound onto spools (or cheeses) ready for spinning.

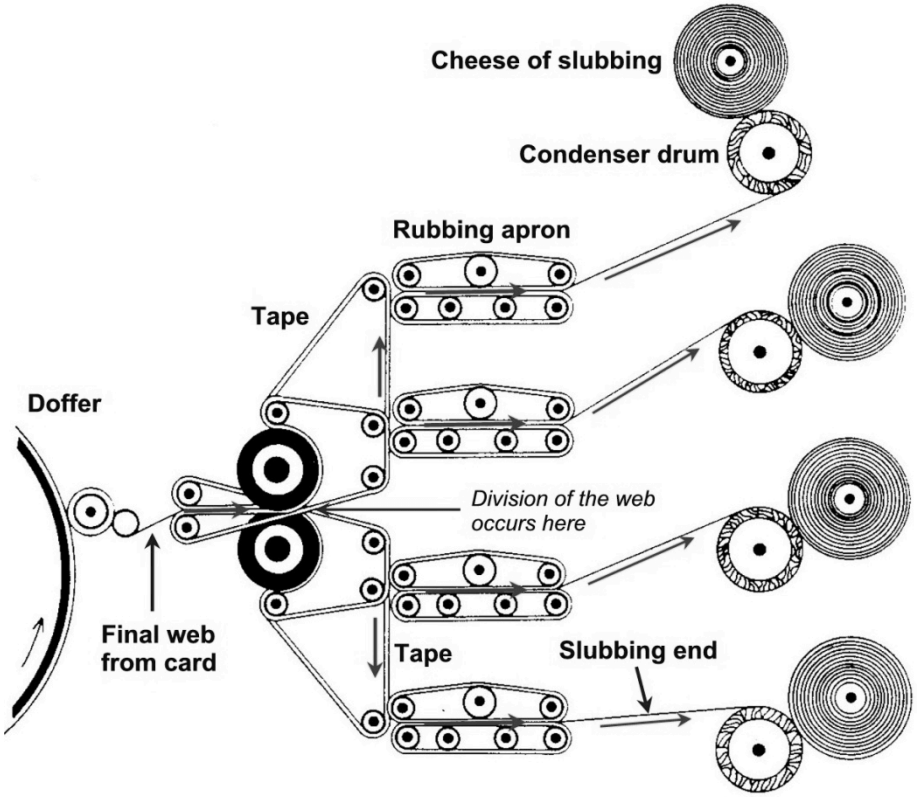

Figure 1.15 – Parts of the condenser on a woollen card. Source Wood, 2006.

Woollen spinning

The slubbing produced by the card is spun into yarn by applying twist to it. This step is most commonly carried out by a machine called a *ring spinning frame* (Figure 1.16). A ring frame consists of a series of *spindles* which rotate at high speed (around 6000 rpm or higher) onto which the yarns are wound. The yarn is guided onto the tube by a small clip called a *traveller*, which is drawn at high speed around a metal ring by the rotation of the spindle. At the same time, the ring rail oscillates slowly in the vertical direction to enable a tidy, compact package of yarn to be formed on each tube.

Unlike worsted and semi-worsted spinning, the shorter blends mostly used in the woollen system are not suited to roller drafting. Strands of short, poorly-aligned fibres do not draft as well as longer, straighter fibres. Hence, the draft used on a woollen frame is minimal (i.e. a draft ratio ~ 1.3 compared with 20-30 in worsted spinning and up to 50 in semi-worsted spinning).

A false twist device between the front and back rollers inserts a temporary twist in the slubbing. This provides strength for drafting as well as assisting in producing a more even yarn. The thicker and less twisted sections draft more than thinner, more tightly twisted sections.

The sequence of fibre structures formed in the woollen system is:

scoured wool – slubbing – singles yarn – folded yarn

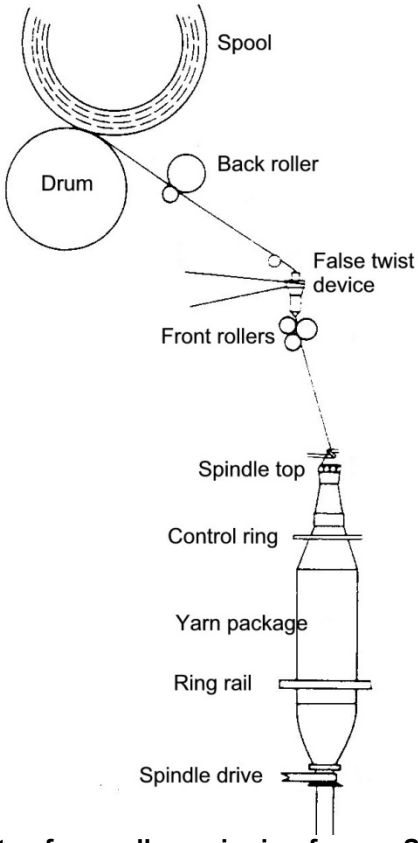

Figure 1.16 Key parts of a woollen spinning frame. Source: Wood, 2010.

Mule spinning

Ring spinning, which is the most common method of producing a woollen spun yarn, is a continuous process, ie, the steps of drafting, twist insertion and winding onto a package operate simultaneously without interruption. The alternative method of producing a woollen yarn, mule spinning (Figure 1.17), is an intermittent process. Here, the drafting and twist insertion steps alternate with the winding-on step.

While mule spinning frames have slower production rates than ring frames, use smaller packages and occupy more floor space this method of spinning is undergoing a small resurgence. This is because, in comparison with with ring spinning, mule spinning is said to give a more even, finer yarn, and better quality yarns from shorter blends, such as those containing lamb's wool, possum and cashmere fibres.

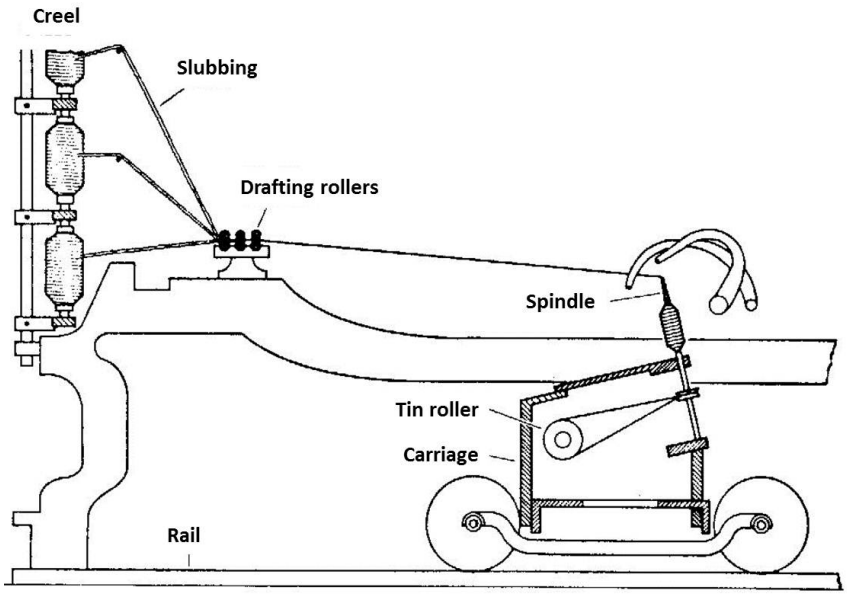

Figure 1.17 Mule spinning frame. Source E J Wood, 2010.

Other steps in the woollen system

Lubrication

In conventional woollen spinning, a *processing lubricant*, an emulsion of oil with water, is sprayed as a mist onto the wool before carding. (The usual rate of application of about 3% on weight of fibre is significantly higher than for worsted and semiworsted spinning where levels around 0.3% are common.) The lubrication treatment has three purposes:

- Increasing the moisture content of the wool fibres, making them more extensible, hence more resistant to the stresses of carding, and also reduces electrostatic effects
- Reducing the friction between fibres, and between fibre and the card teeth, thereby reducing fibre breakage in carding,
- Improving web cohesion, so fewer fibres are lost as droppings or fly.

Twisting (or plying)

To provide sufficient strength and improve the uniformity of woollen yarns, and reduce the tendency to untwist, two or more singles yarns produced are usually twisted together to form a *folded* or *plied* yarn. It is usual to ply worsted and semiworsted yarns too. The methods used for wool yarns are ring twisting and two-for-one twisting.

Yarn scouring and twist setting

To avoid downstream problems such as excessive soiling of the yarn, the processing lubricant must be removed from the yarn in a process that is similar to wool scouring. At the same time, for yarns destined for cut-pile carpets, one bowl will contain the chemicals required for a *setting* treatment that enables the yarn to resist untwisting when cut. Insect-resist agents can also be applied to the wool during this process. If scouring is not required, a wool yarn can be set by steam in a continuous autoclave such as the Superba system.

Characteristics of woollen spun yarn

A woollen-spun yarn is characterised by a high proportion of short fibres distributed very much at random throughout the yarn. Longer fibres often undergo reversals in direction and may protrude from the yarn, to contribute to a hairy and quite irregular appearance, as shown in Figures 1.18 and 1.19.

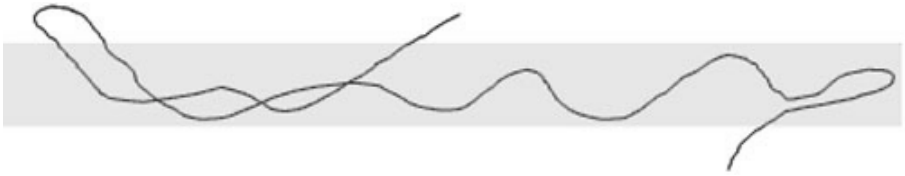

Figure 1.18 Typical fibre path in woollen yarn. Source: Wood, 2006.

Figure 1.19 Two-fold woollen spun carpet yarn.
Photograph supplied by E J Wood.

The loops and ends of fibres protruding from the surface have an important influence on the tactile and visual properties of a woollen-spun yarn. A fibre with reversals contributes less to the strength of a yarn than if it was fully extended without reversals, as it would be in a worsted yarn. Therefore, woollen yarns tend to have less strength than worsted yarns, and to obtain sufficient strength a minimum of around 120 fibres in the cross-section is required.

The yarns produced by this route tend to be of a coarse count (i.e. thicker), spun to a low twist, and hence are bulky, soft handling, hairy, and less regular than worsted yarns. The reversals and other irregularities in the paths of the fibres within the yarn create air spaces, which also contribute to the soft, bulky handle of woollen-spun yarns (provided the twist level is not high).

In the main, woollen spun yarns are used in woven, knitted and tufted products such as carpets, blankets, tweeds and heavier woven and knitted apparel.

The semi-worsted system

This system was originally developed to produce a yarn with greater strength than in the woollen system, but without the expense of removing short fibres in a combing step. Wool is passed through a high-production card, gilled several times to straighten the fibres, and spun directly from a thin sliver. In the semiworsted processing route the sequence of structures is:

scoured wool – card sliver – gilled sliver – singles yarn – folded yarn

Because of the need for superior fibre length for the high drafts often employed in spinning, the semi-worsted system requires sound wools of 100-120 mm staple length (with a minimum length of at least 70 mm). There is less opportunity for the removal of contaminants, so wools should be free of vegetable matter.

Semi-worsted yarns are intermediate in properties between those produced on the worsted and woollen systems. In New Zealand they are used mainly for manufacturing carpets and knitwear, but in other countries the semiworsted route is a high production yarn-making process, used mainly for synthetic staple fibres. Because of the greater fibre length and the degree of straightening introduced by the gilling step, semi-worsted yarns tend to be less bulky than woollen yarns. Hence bulkier wools are sought as a major component for a semiworsted blend if good fabric cover or a softer handle is required in products. However, the quite lean, lustrous appearance of semi-worsted carpet wool yarns means that their use is restricted to relatively dense, loop pile constructions, and they are rarely used in cut-pile products.

Readings

The following readings are available on the web learning management system:

1. Wood, E.J. 2004, *What makes a good yarn?* Canesis Network Ltd., New Zealand
2. Lappage, J. 2004, *The history of spinning*, Canesis Network Ltd., New Zealand
3. Lamb, P. 2007, Overview of the worsted processing route – from greasy wool to yarn.
4. Centre for International Economics, 2002, Prospects for further wool processing in Australia. (http://www.wool.com.au/attachments/Publications/Trade_development/ES_PropectsFurtherWoolProcessingAustralia.pdf).

Summary

To make almost all wool products the wool must first be scoured and impurities such as vegetable matter removed. The fibres are disentangled from the clumps of wool by carding, made parallel and then spun into yarn (unless intended for nonwovens). Finally the yarns are interlaced by weaving or knitting to form a fabric. The type of processing route, and the range of products that can be made, depends largely on the properties and quality of the wool. If the wool is heavily contaminated with vegetable matter, carbonising may be required to assist in its removal.

Three alternative yarn manufacturing sequences are used for wool; ie, the woollen, worsted and semiworsted routes. This topic briefly describes and compares the three routes, the steps involved and the types of yarn generally produced by each route. The specific processing steps are examined in more detail in subsequent topics.

References

Harrowfield, B.V. 1987, 'Early-stage worsted processing – from scoured wool to top', *Wool Science Review,* vol. 64.

Hunter, L. 2002, Mechanical processing for yarn production, in: *Wool: Science and Technology*, W.S. Simpson, and G.N. Crawshaw, (eds.), Textile Institute, ISBN 1 85573 574 1.

Lawrence, C.A. 2003, *Fundamentals of Spun Yarn Technology*, CRC Press, ISBN 1-56676-821-7.

Teasdale, D.C. 1995, *The Wool Handbook*, *The A to Z of Fibre to Top,* 3rd revised printing, Fast Books, Wild & Woolley Pty. Ltd., Glebe, ISBN: 0 646 24064.

Glossary of terms

Attenuate	To reduce the thickness (linear density) of a sliver, top or roving by roller drafting
Blend	The processing batch, a combination of many grower lots, entering the yarn manufacturing route
Blending	Combining and mixing wools to produce a homogenous batch for processing
Bulk	The ability of a fibrous structure (eg, yarn) to fill space. A bulky yarn has a softer handle than a lean yarn
Carding	A process carried out by a card (or carding machine). It involves opening clumps of wool, disentangling and mixing the fibres and the removal of vegetable matter as preparation for subsequent steps in yarn manufacture
Clothing	The metallic teeth covering the surface of card rollers
Combing	The straightening and parallelising of fibres and the removal short fibres and impurities
Condenser	The last section of a woollen card. It divides a broad thin web of fibres into narrow strips, which are then consolidated by rubbing them to form slubbings
Coning	Winding yarn onto a package (cone)
Count (or linear density)	The mass per unit length of a slubbing, yarn, sliver or top – measured in tex (grams per km) or kilotex (grams per metre)
Doublings	The number of slivers or rovings fed into a machine for drafting into a single end
Drafting (or drawing)	Reduce the linear density of a sliver, top or roving, eg, by the action of two pairs of rollers rotating at different speeds (roller drafting)
Draft ratio	In roller drafting, the ratio of the front roller speed to the back roller speed
Folding (twisting or plying)	Combining two or more singles yarns using twist, to form a folded or plyed yarn
Gill box	A drafting machine using in worsted and semiworsted processing, in which the motion of the fibres is in part controlled by pins fixed on moving bars (fallers)
Gilling (or pin drafting)	A system of drafting in which the direction of the fibres relative to one another is a sliver is controlled by pins. This action improves the fibre alignment and parallelisation in the sliver
Hank (or skein)	A quantity of yarn in coiled form
Loose stock	Wool without structure, eg, scoured wool
Lubricating	Applying a processing oil (in a water emulsion) to wool prior to carding
Ring spinning	A spinning system in which twist is inserted in a yarn by using a revolving traveller (that moves around a ring). The yarn is wound onto a spinning tube because the rotational speed of the tube is greater than that of the traveller.
Roving	A fine, well-aligned strand of fibres, the form in which wool is fed to a worsted ring spinning frame
Semiworsted system	A high-speed yarn manufacturing route, involving carding, gilling and ring spinning
Setting	The process of conferring stability on a fibrous structure, eg, yarn, by physical (steam/heat) or chemical means

Singles yarn	A single twisted strand of fibres
Sliver	A relatively thick strand of fibres in continuous form without twist
Slub	An abnormally thick place in a yarn
Slubbing	The strands of fibre from a woollen card that have been consolidated by the rubbing action of the condenser
Spindle	A rotating shaft that carries a yarn package (tube, bobbin cone, etc.)
Style	A subjective description of wool quality that encompasses colour, freedom from contamination and crimp
Tex	The unit of linear density (1 tex = 1 gram per kilometre)
Top	Combed sliver, the output from topmaking, characterised by a high level of fibre parallelisation and homogeneity, and an absence of short fibres
Topmaking	The first stage of the worsted yarn manufacturing route, involving carding, gilling and combing.
Twist	The number of turns in a yarn, per metre
Vegetable matter	Seeds, twigs, leaves, burrs etc. that contaminate some wools
Woollen system	The route for producing yarn, involving a condenser card and spinning.
Worsted system	The route for producing a smooth, fine yarn, involving carding, gilling, combing and ring spinning
Yarn scouring	Washing of finished yarn to remove processing lubricants and dirt acquired during processing