9. Spinning

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Learning objectives

On completion of this topic you should be able to:

- Describe the preparation of the materials required for the three main spinning systems
- Explain the purpose and device used for drawing to form a roving
- Outline the principles of ring spinning, in particular the functions of the key parts of a spinning frame
- Explain the role of the traveller and the parameters that control its performance
- Describe what an end-break is, and why it occurs
- Outline the process of package formation
- Compare the essential features of worsted, semiworsted and woollen ring spinning frames
- Explain the purpose of the false twist device in woollen spinning
- Explain the purpose and means of drafting in worsted and semiworsted spinning
- Describe the methods used to dye wool yarns
- Outline the steps required after spinning to ready a wool yarn for weaving or knitting, in particular winding, clearing and twisting

Key terms and concepts

Woollen, worsted, semiworsted spinning, drawing, gilling, drafting, roving, ring spinning, false twist, traveller, bobbin, balloon, end breaks, package build, roller drafting, dyeing, clearing, twisting, two-for-one twisting, winding

Introduction to the topic

While the term 'spinning' is commonly used to describe the entire yarn-making process, in this topic the more specific meaning applies, i.e. the formation of yarn by drafting a strand of fibres, inserting twist and winding the yarn onto a package.

The ultimate aim of spinning is to produce a continuous, cohesive strand of fibres (i.e. a yarn) of the required linear density (count) and which has good evenness, tensile properties and a minimum number of faults.

Spinning can be divided into three basic operations:

1. Attenuation (ie, drafting) of the roving (worsted), sliver (semiworsted) or slubbing (woollen) to a fine strand of the required linear density;
2. Imparting cohesion to the strand, usually by the insertion of twist, to form a yarn;
3. Winding the yarn onto a package.

Spinning machines can be divided into two main groups:

a) Intermittent operation (e.g. mule)
b) Continuous operation (ring, flyer, cap, open-end, self-twist, etc.)

Today the mule spinning machine is only found in museums and a few specialty yarn spinning plants, while cap spinning is limited to a few spinners producing very fine yarns, and flyer spinners are sometimes used for coarse count yarns, such as for hand knitting.

Ring spinning using a traveller to guide the yarn onto the package was invented by Addison and Stevens (USA) in 1829. It has developed into the most successful form of spinning and is widely used for spinning cotton, wool, flax, silk and manmade fibres. Because of its versatility in terms of the range of yarn linear densities and fibre types it can handle, and also the superior quality and character of the yarn it produces, conventional ring spinning remains by far the most popular system for spinning wool. This topic will therefore focus on this spinning method, and recent adaptations to it.

The references for this topic are Lawrence (2002), Hunter (2002) and Oxtoby (1987).

9.1 Preparation for spinning

The amount of preparation required for spinning depends on the processing route used.

Preparation requirements

Woollen
The slubbing produced by a woollen card is ready for spinning, and no further preparation is required.

Semiworsted
The sliver, which has received several gillings (usually three) after carding, is ready for spinning and no further preparation is required. However, eliminating intermediate stages such as the roving requires high drafts, precise drafting and also good fibre control. Alternatively, rovings may be used for fine yarn production, with similar preparation as for worsted yarns (see below).

Worsted
The raw material for worsted spinning is a top, a highly uniform sliver prepared by topmaking, which is a sequence of carding, gilling and combing steps. The top must be further processed in the worsted spinning plant before spinning can commence.

It is not possible to spin relatively fine, even yarns in the semiworsted process because the steps that eliminate the beneficial effects of sliver feed reversal and doubling are limited. The worsted process uses a sequence of steps, called *drawing*, to gradually reduce the linear density of a sliver by a drafting action. At the same time, the movement and alignment of fibres and the sliver linear density and evenness must be controlled.

A top has typically 25,000 fibres in its cross-section, a roving around 800 fibres and a singles yarn, 40 - 80 fibres. Drawing, which combines both drafting and doubling actions, enables a roving (twisted or twistless) to be produced from a top. In this form, the efficient spinning of a yarn of the desired linear density and quality is possible.

Worsted drawing

Gilling
The top delivered from a top-making plant requires further mechanical processing to produce a quality worsted yarn. This preparation stage is drawing, with these objectives:

- Reduction in the linear density (weight) of the top sliver
- Blending and regularising the sliver
- Fibre straightening.

Drawing (i.e. doubling plus drafting) consists of three or four gilling processes, the first two with autolevellers to enhance sliver evenness. The pinning on the fallers becomes progressively finer with each process. The more gradually the sliver weight is reduced, the better the resulting yarn. In order to improve production rates 2, 3 or 4 head deliveries are used.

Typical gilling conditions for three-gill sequence are shown in Table 9.1

Table 9.1 Gilling conditions in worsted spinning. Source: Wood, 2006.

Gilling	Doubling	Draft ratio	Output linear density
1	8	8	~ 16 ktex
2	4	8	~ 8 ktex
3	3	6.5	~ 3.5 ktex

Roving

The roving process is the final step before spinning. The objectives are:

- Reduction in the linear density of the sliver
- Blending and regularising the sliver
- Improvement of strength and cohesion
- Package formation.

The sliver produced by the final gilling of the drawing process is drafted by a factor of 8-20 between two pairs of rollers, using double aprons for fibre control. The resulting strand of fibres is extremely delicate and needs to be consolidated to improve its strength and cohesion.

This is done either by (a) passing the strand between oscillating rubbers, as in rub roving or (b) inserting some twist. The section of roving shown in Figure 9.1 has a thickness of approximately 5 mm.

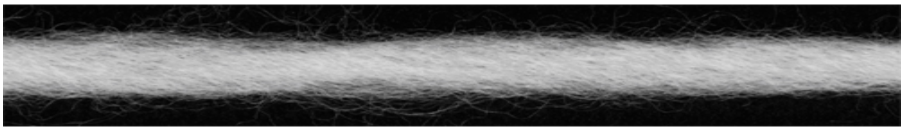

Figure 9.1 Roving. Source: Wood, 2006.

Rub roving
This is the most common method of roving formation for fine, cohesive wools. The strand of fibres produced in drafting is passed between a pair of oscillating leather aprons. These roll the fibres, thereby consolidating them in the strand and increasing the inter-fibre friction. The resultant roving is wound on to a barrel, with normally two rovings side by side. Modern machines run at 200 metres per minute, and often have automatic doffing facilities. Horizontal and vertical frames operate on the same principle.

Figure 9.2 shows the layout of a horizontal roving frame, with the drafting section opened up to display the pair of slivers in position.

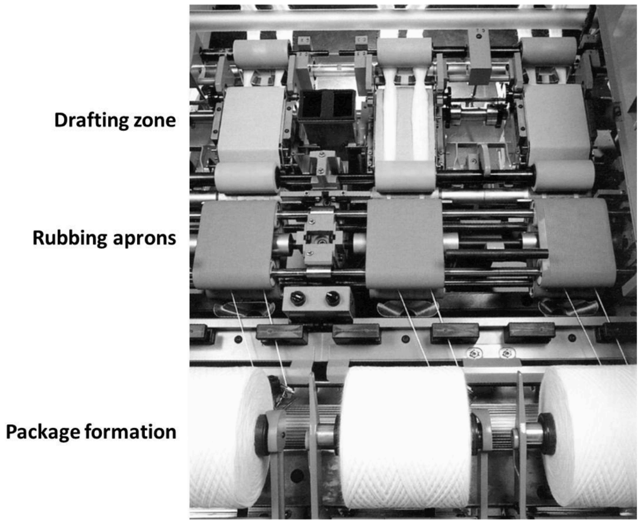

Figure 9.2 Vertical roving frame (Schlumberger)
Source: NCS Schlumberger (a).

Twisted (flyer) roving
The sliver is usually drafted first, using an apron drafting system. The strand of fibres thus produced is passed down the inside of an arm of a positively driven rotating flyer on a cone roving machine (Figure 9.3). This causes the fibres to be twisted together and the resulting compaction of the strand gives it cohesion. The roving produced is wound onto a positively driven bobbin. The level of twist inserted is usually quite low.

Because it is required to rotate large flyers, this method of producing rovings is much slower than the rub roving method. Maximum achievable speeds are around 100 metres per minute. However, because the bobbin is positively driven and the roving does not have to pull the bobbin around, a large package can be formed. The spindles may rotate at around 1,800 rpm or higher.

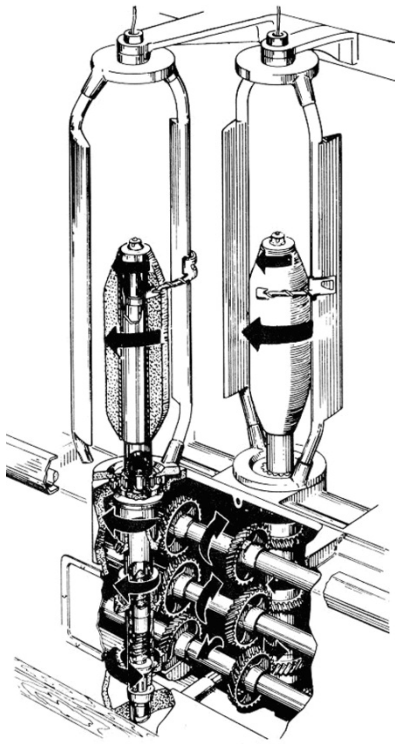

Figure 9.3 Twisted roving on a cone roving machine, showing the positive drives to the spindle and flyer. Source: Wood, 2006.

9.2 The principles of ring spinning

The input into a ring spinning frame can be any of the following:

- Rovings – worsted and semiworsted system
- Sliver – semiworsted system
- Slubbings – woollen system

Figure 9.4 shows the essential features of a single spindle which is one production unit of a ring spinning frame.

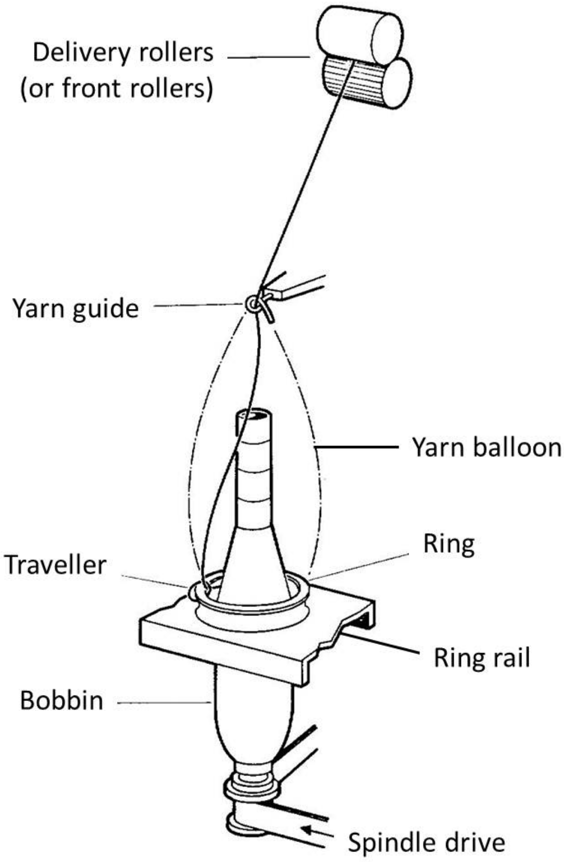

Figure 9.4 A single spindle of a ring spinning frame. Source: Wood, 2006.

The spindle is driven by a tape or belt, making the yarn tube or bobbin rotate at speeds of up to around 17,000 rpm. Surrounding each spindle is a flanged metal ring fastened in a ring plate. During the operation of the frame the ring plate traverses up and down to distribute the yarn on the bobbin.

The traveller

Attached to the upper flange of each ring is a small metal or synthetic clip called a traveller (Figure 9.5), which is free to 'travel' around the ring. The traveller guides the yarn on to the tube as it moves around the ring and also traverses up and down with the ring rail. The travellers are typically C-shaped and are made of steel, nylon, nylon with glass or carbon fibre and nylon with steel inserts in contact with the yarn.

The yarn coming from the front rollers is threaded through this traveller and wrapped around the bobbin. Winding-on of the yarn is accomplished by the travelling lagging behind the spindle and bobbin, the yarn thus being drawn on to the bobbin; i.e. the traveller guides the yarn on to the bobbin. The level of twist inserted in the yarn is governed by (1) the surface speed (metres per minute) of the front rollers and (2) the rotational speed (rpm) of the spindle.

To reduce friction between traveller and ring, oil is continually applied to the ring as a lubricant.

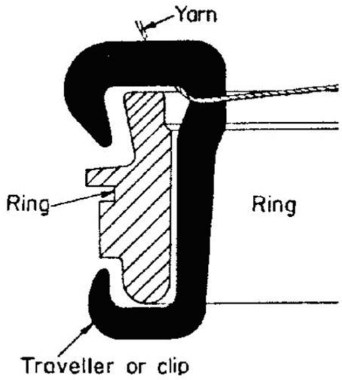

Figure 9.5 Traveller on ring. Source: Wood, 2006.

Ring spinning frames are used for worsted, semiworsted and woollen yarns, the major differences being the sizes of packages and travellers, the diameter of the ring and the drafting rollers.

Figure 9.6 shows the mechanism by which twist inserted as the traveller moves around the ring. One cycle of the traveller on the ring inserts one turn of twist in the strand.

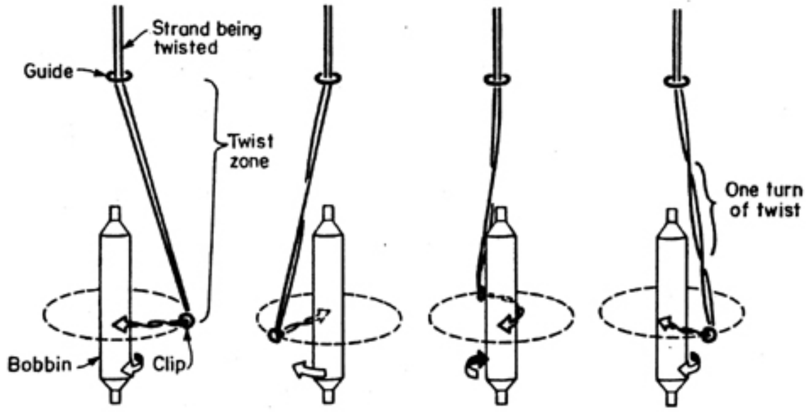

Figure 9.6 Inserting one turn of twist. Source: Wood, 2006.

The tension applied to the yarn is affected by the air resistance on the yarn, the friction of the ring and traveller and the centrifugal force set up as the 'balloon' of yarn and the traveller revolve. (The balloon is the curved section of yarn between the guide and the traveller). These forces are influenced by:

a) the mass and shape of the traveller
b) the yarn count and twist
c) the diameter of the ring in relation to the diameter of the bobbin
d) the speed of the bobbin, which impacts on the speed of the traveller.

The usual method of altering the tension on the yarn is to change the size (mass) of the traveller. A heavier traveller imposes a greater tension while a light traveller causes more ballooning. In general, heavier travellers are used for heavier counts and usually the maximum traveller mass is used which is consistent with good spinning performance, i.e. an acceptable rate of end-breakages. As a last resort it may be necessary to reduce the spindle speed to control the end-breakage rate.

The speed of the traveller is the limiting factor in ring spinning, with a maximum traveller speed of around 45 m/s. Smaller ring sizes enable high spindle speeds to be achieved whilst keeping traveller speed below the maximum. Spindle speeds range from 2000 - 17,000 rpm while ring sizes go from around 45 mm to 300 mm. Figure 9.7 shows the effect of ring size on the shape of the balloon. The balloon profile becomes larger and bulges out more at the base as the tension decreases.

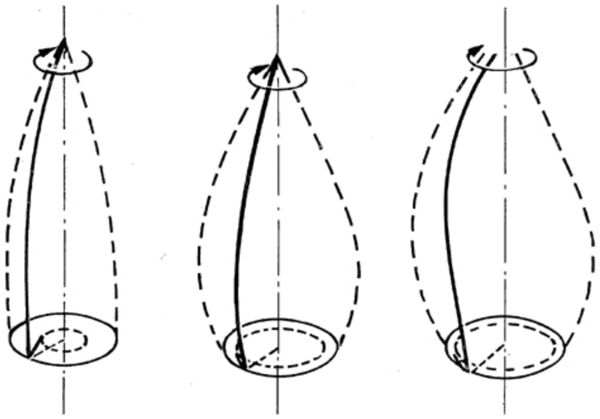

Figure 9.7 Balloon shapes under various ring spinning conditions. Source: Wood, 2006.

Separating plates between each spindle prevent each yarn balloon from fouling the yarn in neighbouring spindle positions.

To maximise production, it is usual to try to run the spinning frame as fast as possible without an excessive number of end breaks occurring. The maximum spindle speed is generally determined by the end break rate, the number of operators manning the frames and the speed and dexterity of the operators in making a good *piecening* in a yarn after an end break.

Spinning speeds can be increased by reducing the ring size and by reducing the height of the balloon. However, both of these options reduce the volume of yarn that can be wound onto the bobbin before it has to be doffed and replaced by an empty bobbin.

The usual method of altering the tension or drag in ring spinning is by changing the size or weight of the travellers. A heavier traveller imposes a greater tension, while a light traveller allows more ballooning of the yarn to occur. Most traveller weights vary between 7 and 70 mg. The choice of traveller depends on the spindle speed, the ring diameter, the yarn count, the yarn type and yarn strength.

Spinning end breaks

As the yarn is wound onto the bobbin it is under tension. A component of this tension is the force required to move the traveller against the friction between the ring and the traveller. The centripetal force of the balloon rotation also contributes to the tension, and air resistance, yarn count and twist also have an effect. If the tension on a strand exceeds its breaking strength, an end break will inevitably occur.

The important factors influencing end breaks are:

1. the number of fibres in the strand
2. the propagation of twist up the strand to this point
3. the mean tension and tension fluctuations on the strand.

The weakest part of forming a yarn will be at the point where the twist is inserted. In ring spinning this point is just below the front drafting rollers (the so-called ‘spinning triangle’), and most breakages occur here. No twist exists for fibre cohesion at this point, so when the number of fibres becomes too low to support the tension on the strand of fibres, the end breaks.

Obviously, the more fibres in the cross-section of the strand, the more the yarn will be able to withstand the tension applied. Problems will arise when the number of fibres in the cross-section of the strand varies significantly or the peak value of the tension fluctuation is too high. The number of fibres is determined by the laws of probability, so that even if the number of fibres in the yarn cross-section is 35, the actual number will be lower than this 50% of the time.

The variation of the number of fibres in the cross-section causes thin and thick places in the fibre strand. As these pass through the twist insertion point, the thin places are more easily twisted than the thick places; hence thin parts will tend to have more twist than the thicker parts. A very thin part of the ribbon will become over twisted and weak, and this will make the yarn susceptible to peak tension fluctuations.

The tension on the yarn is greatest when the winding circumference is smallest. This encourages the common practice of having slow start up speeds for spinning frames.

Package build

Variable speed drives are often used on ring frames to counteract the effect on tension of a varying winding-on diameter, especially when a new set of tubes is being started. A slow speed is needed when the package is small and the tension is highest, and is then gradually raised to its maximum value. As the package increases in size the speed of the spindle is kept almost constant, and then is gradually reduced until the package is complete.

The drives can also be used to control the speed of the spindle throughout the up and down cycle of the ring rail, with the highest speed at the bottom of the cycle where the package (or cop) has its maximum diameter. The lowest speed occurs at the top of the cycle where the yarn is being wound onto the diameter of the empty tube.

When the twisted yarn passes down on to the package it is necessary to wind the yarn on in an orderly manner so that it forms a package which can withstand handling and which will unwind without become entangled. This is achieved by controlling upward and downward traverses of the ring rail. A common form of traverse is shown in Figure 9.8, along with the shape of the package produced. This shape of package is called a *cop*. Here the yarn moves down slowly and up quickly to provide locking coils and to avoid sloughing-off when the yarn is subsequently unwound.

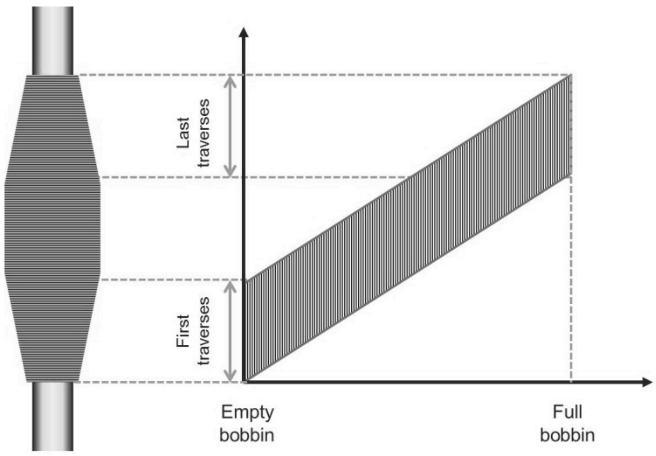

Figure 9.8 Ring rail traverse and package shape for cop build. Source: Wood, 2006.

Advantages and disadvantages of ring spinning

The most expensive process in yarn production is the insertion of twist into a strand of fibres. This is due to the fact that at each spindle position both the strand mass per unit length and the strand velocity are very small. As a result, the production at each spindle is severely limited. The capital cost, power cost and labour cost per spindle have been reduced as far as possible by the spinning machinery manufacturers, but they still remain very high in relation to the production rate. This follows directly from the method used both to insert twist and to wind the yarn onto a package.

Generally, ring and traveller spinning systems have the following technical advantages and disadvantages:

Advantages
- Offer a wide spinning count range (5 – 300 tex)
- Can process most natural and man-made fibres, and blends
- Produce yarns with tensile strength and handling aesthetics suitable for the majority of fabric end uses.

Disadvantages
- Even with ideal situation of no end breaks, spinning is still discontinuous because each spindle must be stopped individually for doffing (removal) of the full bobbins.
- To attain high twisting rates (and hence high production) the yarn package must be reduced in size, resulting in more frequent stoppages for doffing.
- The maximum speed is restricted by the frictional contact of ring and traveller (which generates heat), and the yarn tension
- Bobbin size is restricted by ring diameter
- Yarn has to be subsequently re-wound to larger size packages.

9.4 Ring spinning machines

While the same general principles hold for worsted, semiworsted and woollen ring spinning, there are major differences in the machines used in the three systems. These differences are summarised in Table 9.2. Wide ranges within each spinning system are evident in the draft levels, ring diameters and spindle speeds. These may be varied depending mostly on the twist and count of the yarn being produced.

Table 9.2 Comparison of spinning machines (typical). Source: Wood, 2006.

	Worsted	Semiworsted	Woollen
Input material	Roving	Sliver	Slubbing
Drafting system	Rollers and aprons	Rollers and aprons	Rollers
Level of draft	15 – 30	80 – 120	1.2 – 1.3
Diameter of ring (mm)	45 – 65	75 – 180	100 – 300
Spindle speed (rpm)	7,000 – 17,000	3,000 – 6,000	2,500 – 4,000

Woollen ring spinning
A woollen ring spinning frame, as shown in Figure 9.9, comprises:

- an overhead creel to hold the spools of slubbing, with positive let-off drum feed
- a drafting system incorporating a false-twist device, and
- collapsed-balloon spindles.

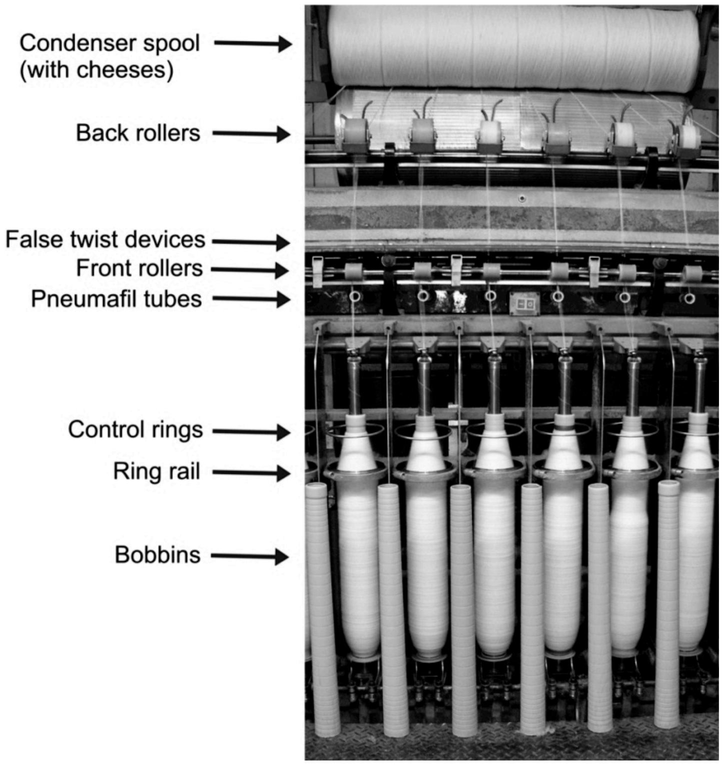

Figure 9.9 Spindles on a woollen ring spinning frame. Source: Wood, 2006.

Drafting and the false twist device

The drafting of the slubbings is in the range 20-30%, which is exceptionally low in comparison with the drafts used in worsted and semiworsted spinning. Drafting of the delicate woollen slubbings is only feasible because they are given temporary cohesion by the application of false twist. The false-twist device (Figure 9.10) rotates at about half the speed of the spindle and inserts about 80 – 160 turns per metre of twist in the strand.

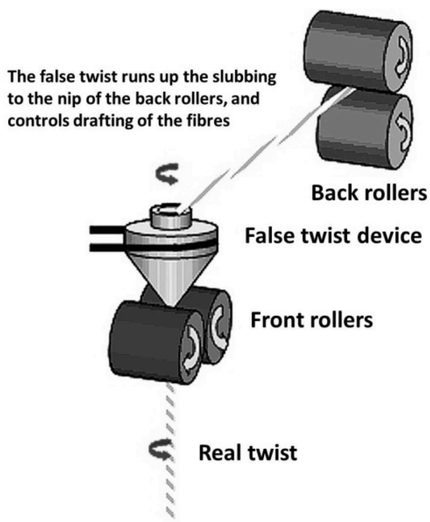

Figure 9.10 False twist device. Source: Wood, 2006.

The count and quality of the yarn produced by a woollen frame are largely determined by the quality of the slubbings supplied from carding. Small corrections to the count of the yarn can be made by adjusting the draft. Drafting is controlled by the speed of rotation of the false-twist unit, which increases the inter-fibre friction and thereby provides greater fibre control during drafting. It reduces the strand irregularity by preferentially drafting thick places with low twist since twist generally runs into thinner places thereby increasing the inter-fibre cohesion there.

A speed that is too high on the false-twist unit causes the fibres to bind and this inhibits drafting. On the other hand, fibre control is lost when the speed is too low and the number of end-breaks increases. Longer fibres need less drafting twist than short fibres.

Operation of the spinning frame

The operation of the ring spinning frame is as follows (Figure 9.11).

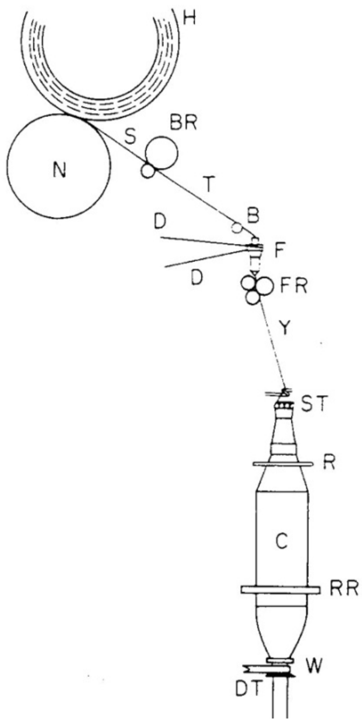

Figure 9.11 Spindle parts on woollen spinning frame. Source: Wood, 2006.

Slubbing from each of the cheeses is unwound by frictional contact between the cheeses H and the drum N. Each slubbing end S is taken through the nip of the back rollers BR. The thread T then passes through the false twisting device F which is close to the nip of the front rollers FR.

There are many variations of the path of the yarn Y from the nip of the front roller until the yarn is placed on the yarn package C via the traveller. The traveller slides on the inside of the ring RR and rotates around the rotating spindle. Friction between the traveller and ring as well as drag on the yarn causes the traveller to lag behind the spindle. The difference in speed between the spindle and traveller causes the yarn to wind onto the package.

The spindle is driven by the driving belt DT connected to the spindle wharve W. A suction tube is positioned just below the front rollers of each spindle to collect a broken end and send it to a cabinet for collection (and subsequent recycling back to the card hopper). This helps to keep the spinning frame clean, prevents fibres from lapping around the front roller and makes it easier to join (*piecen*) a broken end.

During ring spinning a balloon is formed, due to the action of the centrifugal force. Woollen ring frames have relatively large rings in comparison with worsted spinning in order to obtain an adequate length of yarn on the yarn packages. But when larger rings are used and acceptable spindle speeds are maintained, yarn tension is increased due to the larger diameter of the balloon and a higher chance of end breaks is the result.

One or two balloon control rings R may be used to restrain the size of the yarn balloon. Almost invariably there are also separating plates to restrain the balloon. The spindle top (or *crown*) ST may have a 'finger' attached to it which entraps the yarn and brings the top of the balloon down to near the top of the spindle. Alternatively, the spindle top may be shaped with notches so that the balloon is completely collapsed, except in the region of the traveller. The yarn, instead of ballooning, coils around the spindle and also around the yarn tube near the top. The yarn then travels out to the traveller before it is wound onto the yarn package.

With this 'collapsed balloon' spinning it is most desirable that the yarn guide (or lappet or 'pigtail') be maintained at a certain distance above the spindle top ST. The notched spindle top inserts twist in the yarn – by driving twist up to the nip of the front rollers where the thread of fibres is twistless and weakest, the rate of end breaks is reduced at higher spindle speeds.

Notable recent developments in the ring spinning of woollen yarns mostly involve automation, i.e.:

- Automatic doffing of full packages, fitting of new tubes, replacing slubbing packages, and joining of slubbings. Automatic doffing reduces labour and improves productivity.
- End-break detectors and monitors allow problem spindles to be identified.
- Data on traveller, roller and spindle speeds enables yarn production and twist to be determined by computer-controlled monitoring systems.
- Adjustment of the various spinning operations and parameters at an electronic console.

Worsted spinning frame

Figure 9.12 shows a typical worsted spinning frame with:

- A pair of rovings wound off the package
- Drafting zone with a combination of aprons and rollers
- Spindles including control rings.

The sizes of the travellers, rings and packages are much smaller than those on a typical woollen spinning frame, reflecting the finer counts of yarn produced on such machines.

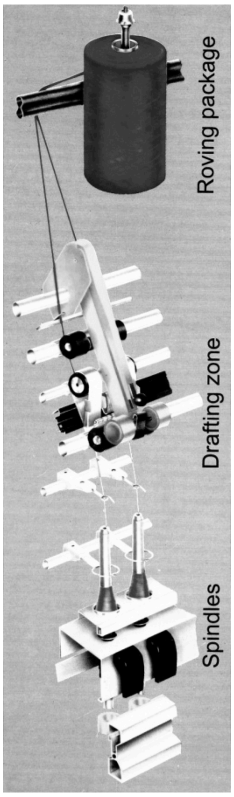

Figure 9.12 Worsted spindles. Source: Cognetex.

Semiworsted spinning frame

For most semiworsted yarns spinning takes place directly after the third gilling step. However, for fine yarns it is necessary to produce a finer sliver than can be produced on a gillbox. In these cases a roving frame is used prior to spinning. As an alternative, a two-zone drafting system may be used on a spinning frame to provide the high drafts required.

Figure 9.13 shows the drafting section of a semiworsted spinning frame used for the production of carpet yarn. The top drafting rollers have been raised to reveal the slivers in position for drafting.

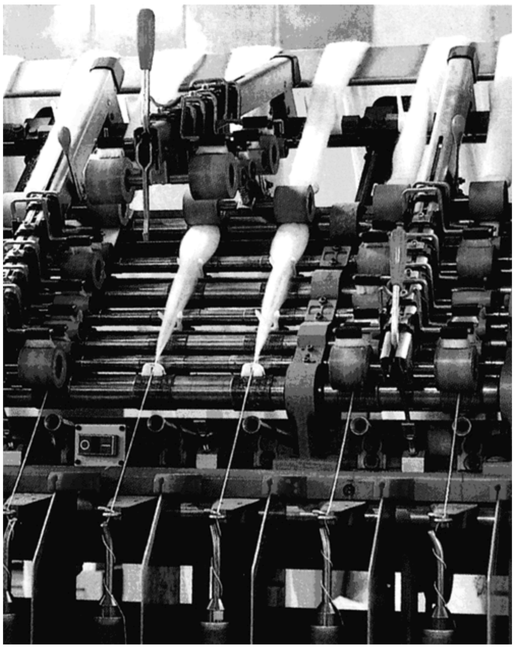

Figure 9.13 Drafting section of semiworsted spinning frame. Source: Houget Duesberg Bosson.

Figure 9.14 shows a relatively complex, double zone drafting device.

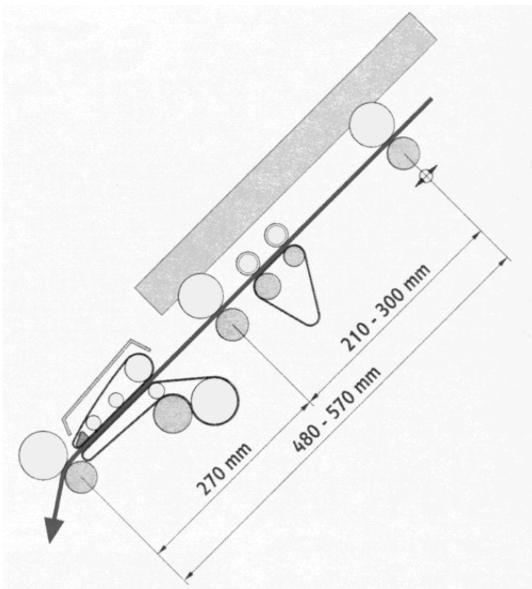

Figure 9.14 Double zone drafting system. Source: NCS Schlumberger (b).

The ratch (the distance between the back and front drafting rollers) should be set such that no fibre has both ends nipped at the same time. Fibres a little shorter than the ratch will pass easily from the back nip to the front nip. Short fibres are not nipped at all for a significant period of their passage across the drafting zone. Such “floating fibres” tend to be carried in groups towards the front rollers, creating thick and thin places in the yarn. The function of the drafting aprons and the intermediate rollers is to control the movement of the floating fibres and hence promote evenness.

9.5 Post-spinning steps

Once the yarn is spun, several more steps are usually required to make it ready for weaving or knitting. Carpet yarns spun on the woollen system may require aqueous scouring to remove any residual processing lubricant. If yarn is destined for cut-pile carpets, the twist must be stabilised by steaming, boiling or chemically setting the yarn. Twist stabilisation, which is necessary to preserve the appearance of cut-pile carpets in use, is briefly discussed in Topic 13.

Autoclaving

Newly spun yarn is usually twist-lively, ie, it will tend to snarl (ie, twist up on itself) if it is not held under some tension. It will need to be autoclaved prior to further processing in order to relax and stabilise the yarn.

For effective autoclaving, air must be removed from the yarn so that steam may penetrate uniformly. This can be partially achieved by means of a vacuum pump, but as steam condenses to heat the yarn, entrained air may accumulate and prevent the full penetration of steam. Hence, multiple vacuum/steam cycles may be necessary.

Yarn is steamed in the autoclave at 105 – 115^{o}C for 5-20 minutes. As prolonged high temperature steaming will yellow the yarn, this treatment must be carefully controlled.

Winding and clearing

Relaxed yarn from the spinning stage needs to be wound onto larger, more suitable packages for twisting. This is done on cone winders which can achieve speeds exceeding 1000 metres per minute.

Whilst winding, the yarn is cleared. The yarn is passed through a clearing head, which detects and removes faults in the yarn which may cause problems in later processing. Fault removal is desirable to reduce mending costs in fabrics, to avoid rejects or seconds, and increase the efficiency of subsequent processes. For example, thick places may jam in weaving and initiate a break.

Clearing may be accomplished by mechanical, optical or capacitance (ie, electrical) type detectors. The most sophisticated optical detectors can detect and remove dark fibres and vegetable matter particles as well as thick places and thin places.

The air splicing technique is mostly used to re-join the yarn. The two ends of yarn are overlapped and held in a suitably shaped chamber. A turbulent blast of air into the chamber is mingles and entangles the fibres. The result is a join that is slightly thicker than, and slightly lower in strength (~ 75%) than the parent yarn.

Twisting (or plying)

In order to achieve greater strength, stability and evenness than can be achieved with a singles yarn, two (or more) singles yarns are twisted together. Two types of twisting machines are commonly used – ring twisters and two-for-one twisting.

Ring twisters

Ring twisters are very similar in principle to ring spinning frames, the major difference being that there is no drafting zone. Tensioning units are used to ensure that the yarns twisted together are at equal tension and a sensing device on each spindle stops the spindle if one of the singles yarns is missing. Spindles rotate in the opposite direction to the spinning frame in order to twist in the opposite direction.

Two-for-one twisters

Prior to the twisting operation, the singles yarns are wound onto large packages during the winding and clearing operation. When producing a two-fold yarn, either two packages can be placed in the twisting chamber (one package on top of the other), or an intermediate step can be undertaken to wind the two (or more if desired) singles yarns onto a single package which is placed in the twisting chamber. As shown in Figure 9.15, the yarn is taken from and over the top of the packages to the inlet of a rotating hollow spindle. It is within this hollow spindle that the 'first' turn of twist is inserted for every revolution of the spindle. The yarn then exits the bottom of the spindle and around and over the packages to the take-up package. It is while the yarn is rotating around the packages that the 'second' turn of twist is inserted.

Two-for-one twisters produce twisted yarns at higher speeds, but of slightly inferior quality in comparison with ring twisting. The final yarn produced is likely to be twist lively, and the yarn needs to be relaxed by autoclaving prior to further use. Because knitted fabric dimensions are critically dependent on yarn friction, paraffin wax is usually added to machine knitting yarns to provide a low, uniform yarn tension.

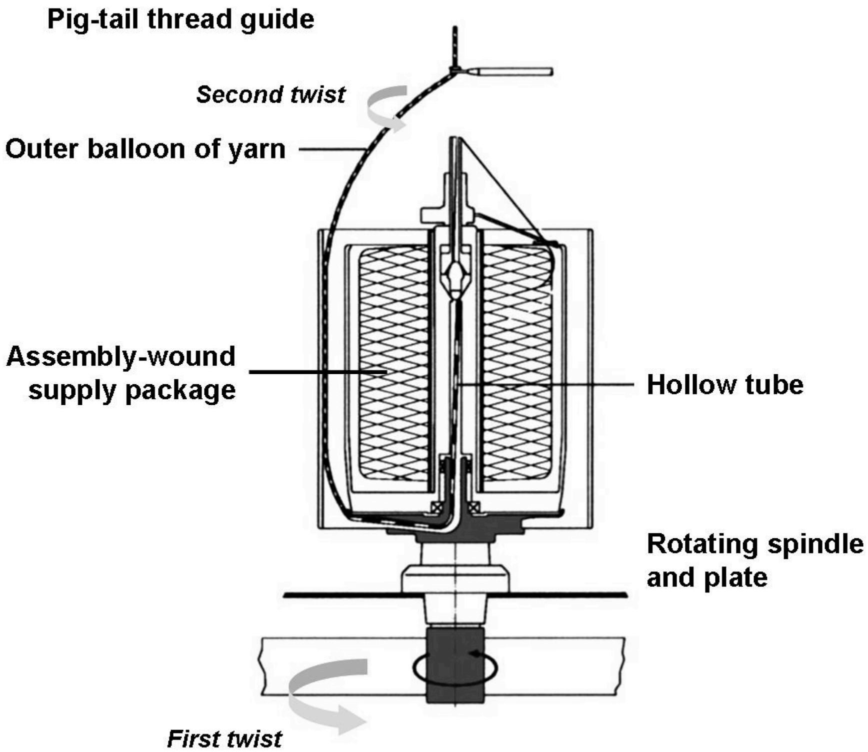

Figure 9.15 Two-for-one twisting principle. Source: Wood, 2011.

9.6 Innovations in the spinning of wool yarns

Insertion of twist is very expensive. Ring spinning is more expensive than the total cost of all the processes from scouring up to the spinning frame but it produces a yarn with the desired attributes. A lot of effort has gone into improvements to ring spinning in order to increase production and performance (quality) or to reduce costs. These include methods to avoid the need for two-folding of yarns or sizing in order to make them weavable, ie, Sirospun, compact spinning and Solospun (Hunter 2002; Lawrence 2003). These methods are discussed in detail in Topic 10 – Latest Developments in Spinning and Nonwovens.

Readings

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

1. Anon, 1955, 'The Scientist Looks at the Wool Industry: Worsted spinning,' *Wool Science Review*, vol. 14(3).
2. Anon, 1957, 'The Scientist Looks at the Wool Industry: Woollen ring frame spinning,' *Wool Science Review*, vol. 17(3).
3. CSIRO Textile and Fibre Technology, Wool For Spinners, Wool for Spinners, Message from Sirolan-Yarnspec.
4. Oxenham, W. 2003, 'Developments in spinning,' *Textile World,* Technology: Spinning.
5. P R Lamb, 'Advanced Ring Spinning.'

Summary

While the term 'spinning' is commonly used to describe the entire yarn-making process, in this topic the more specific meaning applied, i.e. the formation of yarn by drafting, the insertion of twist and forming a package. The ultimate aim of spinning is to produce a coherent and cohesive strand of fibres (i.e. a yarn) of the required linear density (count) and which has good evenness, tensile properties and a minimum number of faults.

Because of its versatility in terms of yarn linear density and fibre type, and also the superior quality and character of the yarn it produces, conventional ring spinning is the most popular system for spinning wool into woollen, worsted and semiworsted yarn. This topic will therefore focus on the principles and technologies for the ring spinning route.

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Cognetex, Spinning Frame and Automatic Devices, product marketing brochure, Cognetex.

Houget Duesberg Bosson, MS-MM Semiworsted Spinning Frames, product marketing brochure, Houget Duesberg Bosson, Belgium.

Hunter, L. 2002, Mechanical Processing for Yarn Production, in: *Wool: Science and Technology*, W.S. Simpson and G.H. Crawshaw, (eds), Textile Institute, Woodhead Publishing Ltd, CRC Press, ISBN 1 85573 574 1.

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

NCS Schlumberger (a), FM 8 Horizontal Rubbing Frames, product marketing brochure, NCS Schlumberger, France.

NCS Schlumberger (b), CF50 Ring Spinning Frames, product marketing brochure, NCS Schlumberger, France.

Oxtoby, E. 1987, *Spun Yarn Technology*, Butterworths, ISBN 0-408-01464-4.

Glossary of terms

Apron	Small, continuous belt used for (a) rubbing of rovings, and (b) controlling fibres in drafting zone
Balloon	The curved path of a yarn between the yarn guide and traveller in a spinning frame
Bobbin (or tube)	A cylindrical or slightly tapered former, for holding slubbings, top, rovings or yarn
Compact (or condensed) spinning	The drafted strand is compacted in an extra zone before twist is inserted, enabling a smoother, less hairy yarn to be produced
Creel	A device for holding packages of slubbing, sliver, roving or yarn in position, and delivery ends to a process (gilling, combing, spinning, tufting)
Doffing	Removing full yarn packages on a spinning frame and replacing them with empty tubes
Doubling	Feeding two or more ends of sliver into a drafting device in parallel to facilitate mixing
Draft	The ratio of the front roller surface speed to the back roller surface speed
Drafting (attenuation)	The process of reducing the linear density of a sliver or roving, often using two pairs of rollers rotating at different speeds (roller drafting)
Drawing	A sliver operation which combines doubling and drafting
End break	A stoppage in spinning where one end breaks due to excessive tension etc., and requires attention of the operator to *piecen*
False twist	Insertion of temporary twist in a slubbing to provide it with sufficient strength for drafting and twist insertion in woollen spinning
Floating fibres	Fibres in a sliver or roving in a drafting zone that are not in contact with either pairs of rollers
Headstock	The drive unit of a spinning frame, where speeds can be set
Mule spinning	An intermittent method of spinning where the formation of yarn (drafting and twisting) is undertaken in one operation, and winding to the package is undertaken in another. Drafts of 1.2 – 1.6 are used
Package build	The formation of a yarn package of the required shape
Piecening (or piecen)	The joining of two strands of fibre in yarn manufacture, either manually or automatically, usually by overlapping the ends
Pneumafil tube	Suction tube for removing broken end from the spindle area of a woollen spinning frame
Ratch	The distance between the front and back rollers in a drafting device
Ring	Provides the circular path for the traveller in a ring spinning frame
Ring spinning	A method of spinning in which twist in inserted in a yarn using a rotating traveller
Roving	A relatively fine, even strand of fibres drafted from a sliver, and it is the input material to worsted ring spinning
Semiworsted spinning	Yarn manufacture route involving carding gilling and ring spinning in which the fibres are substantially parallel and are not combed
Sirospun	A modification to a worsted ring spinning frame that enables two rovings to be drafted in parallel, then twisted together. It is an example of twin-spun (or two-strand) spinning which eliminates the need for a twisting step
Sliver	A thick, continuous strand of staple fibres, without twist
Slubbing	The untwisted strands from a woollen card that have been consolidated by the rubbing action of the condenser
Solospun	An adaptation to a worsted ring spinning frame to enable a weavable singles yarn to be produced
Spindle	The rotating shaft drives the bobbin in a spinning frame
Spinning frame	A machine for making yarn comprising many spindles, each with a bobbin, ring and traveller

Spinning triangle	The zone immediately in front of the front rollers of a ring spinning frame where the twist is inserted into the strand of fibres
Traveller	A small plastic or metal clip that moves around the ring of a spinning frame and guides the yarn onto the bobbin
Woollen spinning	Yarn manufacture route involving the spinning of condensed slubbings produced by a woollen card
Worsted spinning	Yarn manufacture route involving the spinning of fine, even yarns following carding, gilling combing and drawing steps