10

Staple systems and modified yarn structures

10.1 Yarns of complex structure

Traditional ring spun yarns consist of fiber spirals and parts of each fiber approximate to helices of the same pitch. Yarns of this sort can be untwisted to give roughly parallel fibers. The qualifiers inherent in the above definition arise because of lateral fiber migration, fiber hooks, and convolutions created in processing. Despite such distortions, a fully untwisted yarn possesses very low strength. Processes such as open-end spinning, air-jet spinning, and other specialist systems produce a structure that contains varying pitches of the helical fiber segments. As a result, they can never be untwisted to a point where the fibers are all roughly parallel. The yarns thus possess significant strength when untwisted to give a minimum value of strength. The variety of structures is wide. Structures for rotor spun and air-jet yarns are described in Chapter 7 and Appendix 10. The process of rotor spinning also is considered in Chapter 7.

10.1.1 Composite yarns

A series of developments related to the various specialist systems have been made in which staple yarns and filaments are combined to give composite yarns. Usually, the filaments are used as the core of the yarns, and staple fibers make up the surrounding sheath. In this way, the filament yarns are placed where their strength is of the greatest advantage and the staple fibers are placed where they can have the greatest aesthetic value. Unfortunately, filaments are relatively expensive and so increase the cost/lb of the yarn. Also they are often shiny, so that if the sheath does not cover the core properly, the shiny filaments ‘grin’ through the cover to give streaky effects in the final fabric. A description of one technology to produce composites by wrapping is given later is Section 10.6.

10.2 Processes using modified twist

10.2.1 Processes using false twist

The advantage of using false twist is that there is no need to rotate a yarn package to put in the twist needed, but the twist created is transient. The following sections sketch two examples of how difficulty can be circumvented. The first example is the air-jet spinner, which encourages a structural change in the yarn before the false twist is released (Section 10.4). The second example is of self-twist yarns in which one yarn with an alternating twist is plied with another to make a stable ply yarn (Section 10.7).

10.2.2 Processes using another form of modified twist

Streams of untwisted fiber can be encouraged to merge in such a way as to produce a structure that looks like a ply yarn (one might call it a mock ply). It does this by exploiting the conservation of torque. Torque applied to the outgoing ply can be made to transfer to the ingoing component strands to create a ply twist (Fig. 10.1). (Reactions *R* occur at the front drafting rolls.) The result is similar to a regular plied yarn and it is made without the mechanical complexity of the traditional plied yarn operation. The yarn structure is either an S-on-S or Z-on-Z ply rather than the conventional balanced torque type of S-on-Z or Z-on-S. The yarn and process is described in Section 10.7.

10.3 Compact spinning

10.3.1 Fibers in the twist triangle in ring spinning

The twist triangle in ring spinning determines much of the character of a ring yarn. As discussed in Section A5.2.1, each fiber leaving the nip of the front rolls of a conventional drafting system has a tension that depends on its lateral position with respect to the rolls. There a wide distribution of fiber tensions and fibers traversing at least one of the two selvages of the triangle exist at a high tension. Fibers in the central zone often go slack. Cameras using short duration exposures have produced images which have shown so-called wild fibers emerging from the front roll nip of the drafting system and these are also slack. Parts of these wild fibers exist in space remote from the twist triangle itself and contribute to the hairiness of the yarn. Fibers

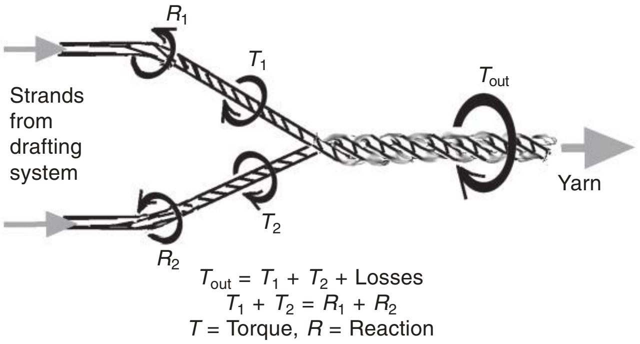


Fig. 10.1 Torque balance in mock ply

under high tension migrate to the center of the yarn as they enter the twisted transition structure at the output of the triangular zone. Slack fibers migrate to the outside of the yarn and form part of the loose hairy surface. The structure of fibers within the twist triangle changes continuously (although for simplicity, descriptive models often assume that the average tension distributions are symmetrical about the center-line of fiber flow but this is not always true). Consequently, there is good reason to try to control the distribution and variability of the fiber tensions within the twist triangle.

10.3.2 Processes of fiber control

If the fiber tensions can be controlled externally by a system of restraints, it becomes possible to reduce the migration of what have been slack fibers and which might otherwise have formed a loose structure at the surface of the yarn. Such a constraint would be expected to produce leaner yarns with well-organized surfaces, in which the outer fibers can bear a larger percentage of the load applied to the yarns.

Consider a system containing a perforated surface with fibers flowing on one side of the perforations and suction applied to the other side. Friction forces will be generated between the fibers and the perforated surface, which increase the fiber tensions by a small amount. If the flowing fibers are those in the twist triangle, and sufficient suction is applied, there should be few, if any, slack fibers entering the twist transition zone and the tendency for what would have been slack fibers to migrate to the surface will be lessened. Furthermore, if the suction apertures are controlled to fit the shape of the twist triangle, the number of wild fibers can be controlled, which again tends to reduce the loose structures mentioned and to reduce hairiness.

There are several possible arrangements that could fit this specification. A few of them are: (a) a perforated hollow front roll with suction applied to the inside, (b) a 'back-to-front' perforated apron projecting from the front roll under (or over) the twist triangle with suction acting through the apron thickness, (c) an option similar to (b) but with a slot or aperture in a cover plate to control the position of application of the suction. Several such designs were shown in the 1999 ITMA machinery exhibition. Possible drawbacks to such designs are:

1. When an end breaks, it is more difficult to apply the conventional pneumafil devices because the two suctions compete with the result that the dangers of a lap-up are greatly increased.
2. Some machines have to be specially engineered, which increases the cost.
3. Accumulations of fiber debris from fibers entrapped in the perforation are likely to increase maintenance problems.
4. Ineffectiveness for heavy yarn counts.

Relating to (1) above, the use of a roving-stop system to solve the lap-up problem increases the cost of the machine, but the roving-stop mechanism does have the advantage of eliminating pneumafil waste and all of the problems involved in recycling it. Advantages include the possibility of producing smooth strong yarns, which would be of interest to weavers because of the reduction in hairiness, coupled with a modest increase in strength. This would make beaming, slashing, and weaving easier and more efficient. Another area that could benefit would be in thread production, where it might be possible to dispense with singeing. This suggests that, if such devices become commercially viable, the first users are likely to be producers of yarn for weavers or thread makers.

10.4 Air-jet spinning

10.4.1 The principle

Air-vortex and air-jet developments led to air-jet machines, which are not truly open-end spinning machines but are related. In OE spinning there is an open-end, which can be rotated, whereas in some of the yarns about to be discussed, continuity in flow is given by a core. Fibers outside that core can be rearranged and trapped in the structure to give different yarn characteristics. Götzfried [1], and later Pacholski [2], showed that air-jets entering tangentially with respect to the bore of a nozzle cause a vortex within it, and the high speed rotation of the air can be used to twist yarn passing coaxially through the vortex. The pure air-vortex spinners did not succeed commercially but they laid the groundwork for the modern air-jet spinning system. They also laid the groundwork for some of the textured and composite yarns. If the jet in the nozzle is inclined in the direction of yarn flow, it can help transport the yarn. This is by virtue of the extra increment of yarn tension generated due to the axial component of the air drag between the air and the yarn. The rotational speeds of the vortex can approach a million r/min but the yarn rotation is likely to be limited to a region around 200 000 r/min [3]; there is a large potential for high speed yarn production.

An important development was that of the 'fasciated' (wrapped) yarn principle [4]. The original idea was based on the addition of fibers to a flowing, false twisted structure followed by the removal of torque at the exit of the false twister, which causes the added fiber to be reverse twisted as shown in Fig. 10.2. Closely related to this was the idea that the hairs on an incompletely formed yarn could be wrapped about its core. Such hairs, entrapped in the structure, give enhanced cohesion to the strand, even after untwisting. In patents by various authors [5–8], several sets of apparatus and processes were disclosed which produced similar effects. The most important of these will now be discussed.

In some examples, which are attributable to Murata [5, 6, 8], two twisting devices were used, one to produce, say, S twist at the exit of the twist triangle, followed by a device producing the opposite twist. The second device removes the false twist from

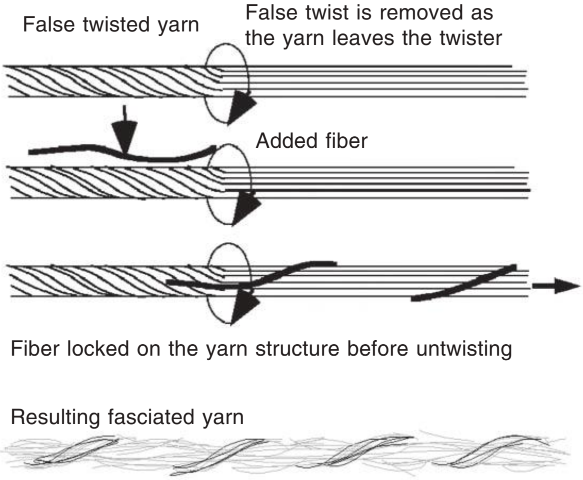
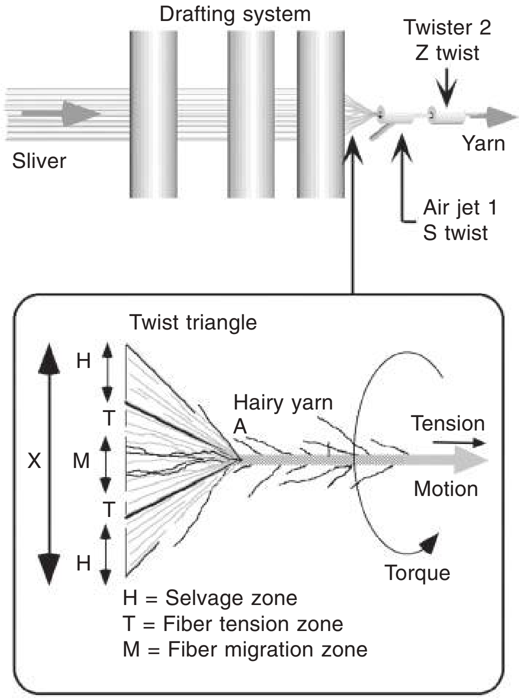


Fig. 10.2 Fasciated yarn

the core and completes the wrapping of the outer fibers about the core. The twisting devices shown are air-jets, but other devices can be used. Directions of twist can be reversed to produce a yarn that simulates the opposite yarn twist but this requires different nozzles or settings. The common use of such machines is for the longer-staple fibers in the short-staple range. For example 1.5 inch (38 mm) polyester or cotton fibers spin well.

It is normal for the wrapper fibers to be in the Z direction. In air-jet spinning, the idea is to use the twist triangle leaving a roller drafting system to produce a very hairy intermediate. The portion of the fiber flow that makes the core of the yarn, and the extent of the yarn hair, are unlike the corresponding values with conventional yarn. This is because the feed ribbons are much wider and the fibers in the triangular zones (marked H in Fig. 10.3) are a greater proportion of the total than normal, and there is a greater degree of drafting there. Zones marked T contain fibers under tension derived from the pull of the air-jet. The zone marked M contains fibers that go slack due to their shorter path length (when compared with the others) between the nip of the drafting rolls and the vertex of the triangle. Slack fibers migrate laterally in the core structure to interlock it, give it fiber cohesion, and create fiber loops and hairs (see also Appendix 5). Compared with a conventional yarn, there is a wider range of fiber tensions distributed over a greater width, and this promotes migration and hairiness. Hairs on the outside of the core at A in Fig. 10.3 are more or less autonomous and make only a loose and easily disturbed sheath structure. Figure 10.4 shows fibers emerging from a roll nip that have then been twisted by an air-jet; the fiber flow coalesces into yarn (shown at Y) due to the twist and the yarn is taken off in the direction of the black arrows. The separation of the surfaces of the rolls creates a depression along



Enlargement of twist triangle zone

Fig. 10.3 Air-jet spinning

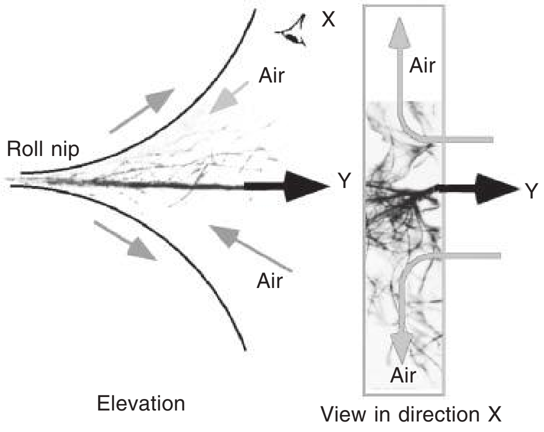


Fig. 10.4 Air and fiber flow in a roll nip

the nip zone that induces airflow (shown with gray arrows) into the nip and this airflow aggravates the hairy condition. The diagram shows two views of this airflow, and the limited view in direction X also shows how disorderly the fiber mass can be in this region. The major part of the twist triangle cannot be seen because it is masked by the top roll. Similar, but much clearer, pictures were obtained by Jones [9].

An extension of the principle just explained is to feed two adjacent yarns being made on an air-jet machine to a single take-up mechanism to create an assembly package (Section 9.3.1). The yarn can be twisted later to make a ply yarn. This idea has been used successfully on long-staple yarns and an example of it is given by the Suessen Plyfil system, which can spin up to about 8 inch (220 mm) wool (and similar fibers) from sliver in the range from 160 to 380 yd/min (150–350 m/min).

10.4.2 Machine design aspects of air-jet spinning

As mentioned, the hairs are important because they are laid on the core of false twisted yarn leaving the twist triangle; the false twist is removed with the hairs in place. The spinning action wraps the hairs around the core and there is enough lateral fiber migration to lock the structure. The final product has little or no twist in the core, but has a twisted sheath, which gives the structure integrity. Leaving aside the single nozzle versions of air-jet machines, the false twist and rearrangement of the sheath fibers are usually carried out by two air-jet nozzles set in line, close to the drafting system. However, it is possible to replace the second nozzle by a mechanical twister. The entry of the air-jet orifices has one component angle tangential to the cylindrical main channel through which the yarn moves, and another component angled relative to the axis of yarn flow. The latter is an important parameter because it helps define the relationship between the twisting and linear translation speeds. Oxenham and Basu [10] showed that if the jet orifice was inclined more than 60° to the axis of the yarn there was difficulty in spinning, but at 45° spinning went on well. The diameter of the vena contracta of this channel was usually 1.6 mm and the orifice was 0.5 mm. In their experiments, the frictional characteristics of the chambers of a first nozzle were altered by coating the surfaces with PTFE to give a low coefficient of friction. Another nozzle was made from a ceramic material to provide a higher coefficient. The PTFE coated nozzle produced the best yarn tenacity and the ceramic one produced the greatest CV of tenacity. Air pressures of up to 3 kg/cm^2 were used in the first nozzle and 4 kg/cm^2 in the second.

Air-jet spinning machines with more sophisticated drafting, fiber reconsolidation, and twisting systems than those shown have now become established. Table 10.1 shows some data relating to different fiber finishes and it will be seen that finishes with high coefficients of friction give poor results.

New machines with mechanical twisters following the first fiber consolidation nozzle have appeared. The mechanical twister, which replaces the second air-jet false twister, is formed by pairs of rolls with their axes crossed (Fig. 10.5). This layout of rolls gives torsional as well as transport components of motion to the yarn as it leaves the consolidation nozzle. The greater force acting on the hairs to press them towards the center of the yarn increases the chance of integration into the yarn structure. One certain result is that this arrangement produces less hairy yarn and possibly increases the range of fiber length that can be spun successfully.

Air-jet machines often feature a five-roll drafting system with two pairs of double aprons capable of drafts up to 400. The drafted strands are entangled or fasciated by air-jets, as just described. The use of a wide ribbon passing through the drafting zone helps enormously in this respect. In this way, a sliver-to-yarn system is possible, which avoids the use of a relatively expensive intermediate roving. The machines can produce cheeses or cones and thus separate winding costs are eliminated. Traditional assembly winding is also avoided (assembly winding is discussed in Section 9.3.1). Adjacent pairs of air-jet yarns can be laid side by side before winding to create an assembly wound package and then pairs of yarn can be twisted subsequently, usually by a two-for-one twister, to make plied yarns. Although variants exist, the basic idea

Table 10.1 Characteristics of air-jet yarn

Fiber length (mm)	Fiber fineness (d tex)	Yarn tenacity (cN/tex)	Imp per km	CV (%)	Stops per hr
38	1.7	18.0	280	15	18
38	2.2	15.3	–	16	38
38 a	1.4	15.5	48	14	85
38 b	1.4	15.0	20	14	20
32	1.7	19.5	40	14	40

Notes a = high friction fiber finish, Imp = Imperfection, b = low friction fiber finish, CV = CV of linear density.

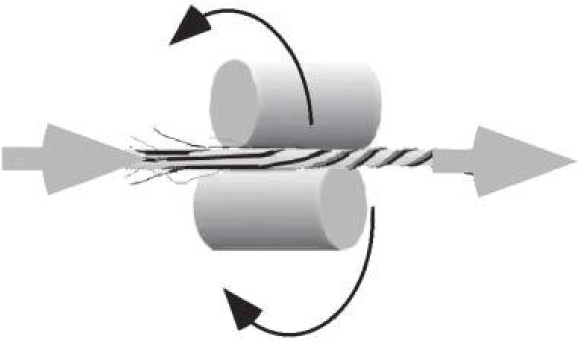


Fig. 10.5 Crossed-roll twister

is to avoid the roving and winding operations and to produce the equivalent of traditional plied or singles yarns.

10.4.3 Air-jet performance

Figure 10.6 shows a micrograph of an air-jet yarn made from 50/50 polyester/cotton staple fibers, the polyester fibers having a length of 1.5 inches (≈ 38 mm) and the cotton an upper half mean length of 1.05 inches (≈ 27mm). The wrappers that give the structure cohesion are denoted by W in the micrographs. Polyester dominates the wrappers and cotton is more prevalent in the core. This illustrates the importance of fiber length. Long fibers produce longer hairs approaching the final twister and they have a greater chance of becoming entangled with the core. Thus they generate tension within themselves as they wrap around the structure in helical form. The greater these tensions, the more radial forces are produced and the more cohesion within the structure is produced. Short cotton fibers give problems with this sort of spinning and long ones are relatively expensive. Nevertheless, a good reason for persisting with cotton fibers is that consumers seek cotton yarns. A successful air-jet process to make 100% cotton yarns is a worthwhile target. A 100% cotton yarn is hairy and this suggests a deficiency in integrating the hairs entering the twister. However, in general, it is claimed that the yarn defect level is lower than with comparable ring yarns. Looney [11] showed that the fault rate for 100% polyester was reduced to about 40% of that of the blend. He concluded that the result was, in part, due to the relatively short, high micronaire cotton fiber used (0.93 inch (24 mm) and 4.24 micronaire). It is interesting to note that some of the traditional remedies intended to improve quality sometimes do not produce the intended result. For example, increasing the number of drawings from two to three caused a decrease of about 20% in the fault rate as expected but it decreased the sliver cohesion by about 75%, which made the handling of the sliver difficult. Mishandled sliver caused stops and faults. Intimate blending can produce a reduction of up to 20% in yarn fault rates over drawframe blending. Delivery rates up to nearly ten times that of a ring frame were reported.

Some idea of the performance traits of an air-jet machine when spinning polyester yarns is shown in Fig. 10.7, based on data given by Looney [12] in 1984. The point being made was that the yarn CV increases with the linear density of the fiber and the yarn tenacity decreases. The system seems best suited for fine fibers.

In contrast, the work of Oxenham and Basu [10] showed that, when spinning 32 mm (1.26 inch) cotton of 26 g/tex fiber strength, yarn tenacities did not exceed 5 cN/tex (5.1 g/tex) and the yarn elongations at break were less than 8%. Thus, despite the use of long cottons, there can be some problems in running 100% cotton, although polyester/cotton blends are usually satisfactory.

Fig. 10.6 Micrograph of an air-jet yarn

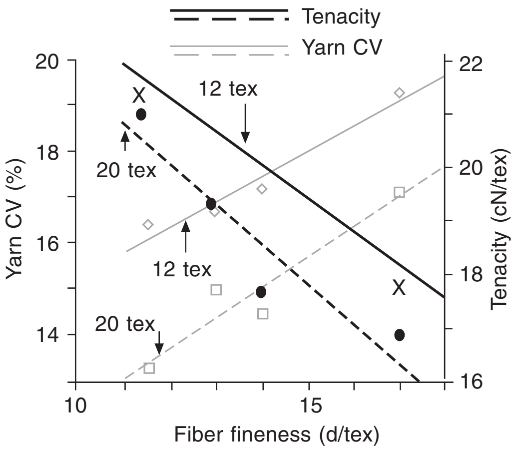


Fig. 10.7 Air-jet spinning performance, 1984

10.5 Sirospun yarns and process

10.5.1 Sirospun yarns

As mentioned previously, worsted warp yarns are often doubled (i.e. plied). Plying has a number of benefits: (a) plied yarns have a better evenness because of doubling, (b) they weave more easily and this reduces costs in weaving [13], and (c) fabric made from them is more durable and less likely to pill. Surface fibers on a singles worsted yarn are sometimes loosely wrapped around the body; plying avoids difficulties due to such wild fibers [13]. The Sirospun process makes S-on-S or Z-on-Z ply yarns with somewhat similar characteristics to a normal S-on-Z ply yarn except that the unidirectional structures can never be completely balanced.

10.5.2 The Sirospun process

A structure that is similar to the plied yarn can be produced on an ingeniously adapted ring frame (Fig. 10.8). The yarn is called Sirospun. Two rovings (A and B) are fed to a ring frame, with separators to ensure that each roving is drafted individually. The two strands emerging from the drafting system converge into a single yarn, at J, before they reach the lappet guide (otherwise known as a pigtail guide). The variations in linear density and tension cause a random fluctuating twist to be generated in the emerging yarn structure which gives it some of the characteristics of a plied yarn. If a Sirospun yarn is untwisted, the individual strands have a low fluctuating twist, which defines the strands such that, when they are twisted, they give the character of a ply. Quite low levels of random twist generate enough surface fiber trapping to improve weavability significantly; it is not necessary for the random twist to be unidirectional for this purpose. A typical strand twist is of the order of 1 turn/inch and this is sufficient to bind the wild fibers in place. The low twists result in potentially high productivities. However, the system is restricted to long-staple fibers. A disadvantage of the system is that if one strand breaks, long lengths of singles yarn will be interspersed with the quasi-plied yarn. Such faults are known as ‘spinners singles’. The difficulty is overcome by having a break-out device (shown at B in Fig. 10.8), which stops production when either of the two component strands is missing. A suction then removes the fiber from the emerging strands. There is a cost to this

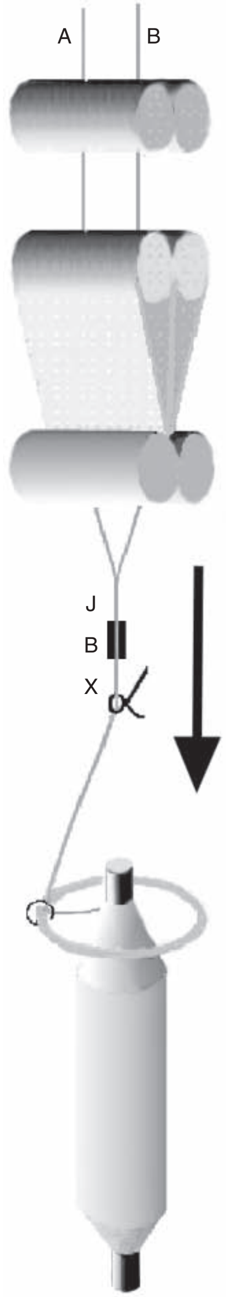


Fig. 10.8 Sirospinning

solution inasmuch as each spinning position has to have an extra piece of equipment compared with regular spinning. Remembering that the productivity per spinning position is still low, any extra cost of this sort is not trivial. On the other hand, the cost of the detector is considerably less than that of a traditional plying operation set-up on a comparable basis. It has the advantage that existing frames can easily be modified.

According to Lorenz [14], the Sirospun system has gained a respectable share of the worsted market and it remains to be seen to what extent it can penetrate other sectors. In short-staple spinning, the existing alternatives to ring spinning offer much higher productivity and lower costs and penetration of that market will be difficult.

Lamb and Junghani [15] compared wool yarns made by the Sirospun system with similar ones and found that the index of irregularity of the Sirospun yarns was between those of conventional two-fold and Plyfil (air-jet) yarns. Three twist multiples were tested ($\alpha = 73$, 96, and 122) with similar results. The two-fold yarns were ring twisted. They noted an increase in short-term unevenness in Plyfil yarns, which they attributed to the high draft. The question of whether the twist levels could be reduced was not resolved and it was pointed out that it is not the tenacity of the yarn that is important but rather the weavability. Both the Plyfil and Sirospun yarns were torque unbalanced, which was a disadvantage for knitters.

10.6 Hollow spindle spinning

10.6.1 Wrap spun yarns

The basic idea of a wrap spun yarn is for the machine to insert little or no twist in the core and, at the same time, wrap another yarn or filament around the core at high speed to make a composite yarn. The wrapper yarn or filament provides the forces to compact the yarn structure. Frequently the wrapper yarn is a filament, which being strong, can be wrapped at high speed without suffering the number of end-breaks that would be encountered by a staple yarn.

10.6.2 Wrap spinning by the hollow spindle process

This technology provides a means of wrapping filaments about core yarns to enhance the performance of the composite. Figure 10.9 is a diagram of a hollow spindle system in which filament is taken from a bobbin mounted coaxially with the yarn Y. A hollow spindle with a hook rotates about the same axis. The hook engages the yarn and creates false twist above the hook, but the staple strand below the hook should have little or no twist. The filament yarn, F, passes through the hollow spindle and should have sufficient twist induced above the hook for the filament and staple components to be brought into firm contact. The hook acts like an untwister similar to a false twist spindle in texturing. Most of the false twist in the staple component is removed as it passes through the hook. The twisting action causes the filament to follow the surface of the staple component and the filament becomes tightly wrapped about the very low twist staple core that emerges from the hook (yarn Y′). Because of the high tenacity of the filaments, high production speeds are possible (up 35 000 r/min, which is about twice that of ring spinning). Sometimes, sliver-to-yarn systems are used and the filament is wrapped around the drafted sliver. Occasionally, both a filament and a staple strand (roving or sliver) are passed through the drafting system to produce a bouclé or other effect. The system can handle short or long staple but it is predominantly used for long-staple wrapped yarns. Xie *et al.* [16] created a theoretical model and tested 64s wool yarns to find that yarn tenacities of up to 12 g/tex were possible, with wrapper twists in the range 3 to 5 wraps/cm (≈ 1.2 to 2 tpi).

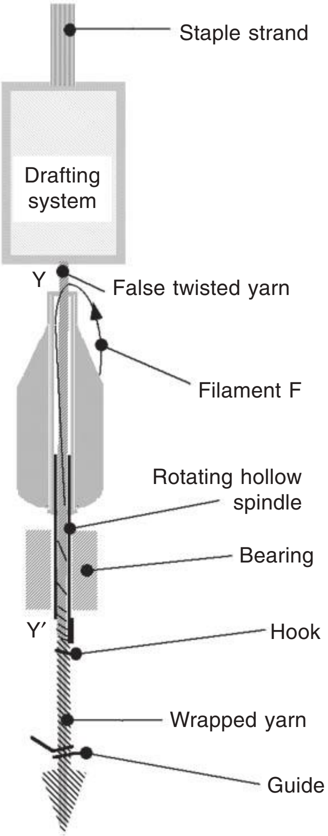


Fig. 10.9 Hollow spindle spinning

10.7 Self-twist spinning

10.7.1 Self-twist principle

If a pair of worsted rovings are drafted and the emerging strands are passed through a twisting system such as is shown in Fig. 10.10, a plied yarn is produced in which both the ply and strand twists alternate. The emerging strands are called self-twist (ST) yarns. The torque of the freshly emerging strands from the front rollers of the drafting system causes them to try to untwist. Hairs from one strand are caught by the other; the individual yarns twist about their own axes and consolidate the grasp of the hairs from the other yarn. Meanwhile, the pair of strands twist about their common axis to relieve the torque in the individual strands (Fig. 10.11(a)). There is a discernible zero twist zone at each changeover and this zone increases as the yarns wrap around each other in the separate twisted zones. The transfer of torque from the component strands is reduced as the local ply twist increases and the system comes to equilibrium. There is a resulting series of slightly extended zero twist zones, interleaved with ply twisted sections of yarn (Fig. 10.11(b)).

10.7.2 Self-twist yarns

Let the length between changeovers be *L* (variable) and let the staple length of the fiber be fixed at *S*. The zero twist zone is a weak link in the chain because any fiber

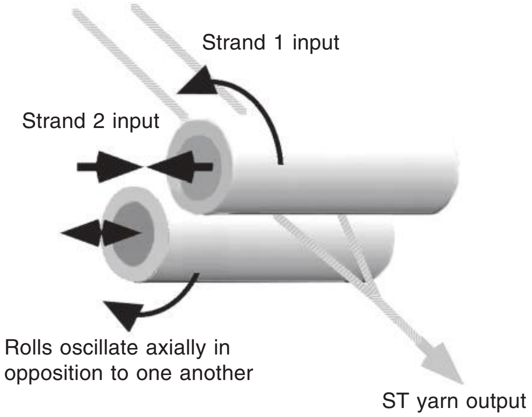
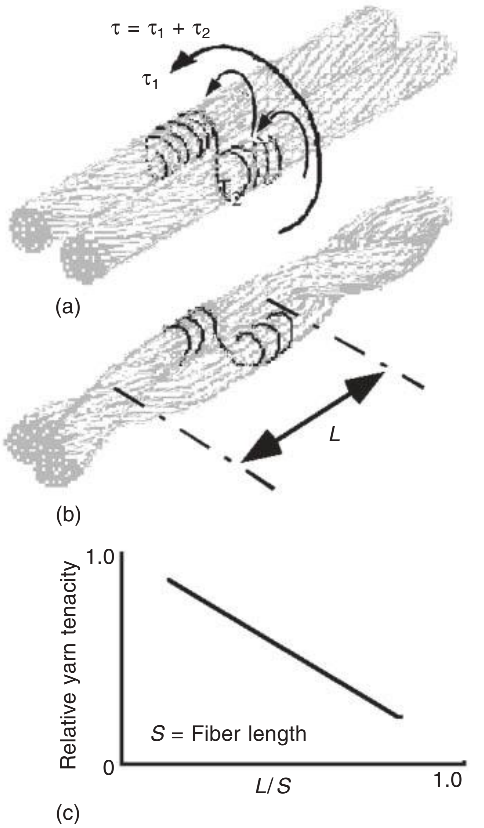


Fig. 10.10 ST yarn process



Relative yarn tenacity is a measure of yarn strength relative to that which might be expected from using a similar fiber in a ring spun yarn.

Fig. 10.11 ST yarns

that has an end in the zero twist zone contributes no strength. Assume that the fiber ends are randomly distributed and let m be the number of fibers in the whole cross-section. It is necessary for $L<S$ to provide fibers to transmit load across the weak section. The number of ungripped fiber ends per cross-section in the zero twist zone relative to those in the twisted sections will then be L/S and the number of load-bearing fibers is:

$$[1 - L/S]m \qquad [10.1]$$

Ignoring fiber obliquity effects, the relative strength of the zero twist zone is:

$$[1 - (L/S)] \times 100\% \qquad [10.2]$$

Growth of the zero twist zone has to be limited. Unless the strands are prevented from rotating about their own axes, the torque in the strands tries to balance by removing more twist from the twist changeover zones. This was briefly alluded to earlier. Fortunately, long fibers catch on the other strand easily and the process of binding fibers from the co-operating strand joins them and forms a torque stop. Lengths of the zero twist zones are determined by this licking-in process. To get the necessary fiber wraps, twist flows between zones. As the strands untwist, the length of the zero twist zone increases. The strength of the zero twist zone varies with staple length in the manner shown in Fig. 10.11(c). It will be seen that it is necessary to use a staple length of several inches (unless the weak points are strengthened by some means) to get a reasonable strength. Of the various means to stabilize the weak zones, a few will be mentioned. Stomph [17] used intermittent air vortices created by switched nozzles to false twist the individual strands before assembly at what would have been the weak points. The system was complex and limited in speed to some 100 m/min; also piecing was not simple. Morgan [18] sized the yarns with a water-soluble adhesive before further processing, but this system did not achieve wide usage either. Air-jet texturing can create lateral fiber migration and this is useful in locking the structure. In practice, the ST process is confined to long-staple fibers.

10.7.3 The self-twist process

The self-twist (ST) process was alluded to in Section 3.4.2 and the discussion is continued here. There is no conventional spindle or rotor and very much higher processing speeds than normal can be used for ST spinning. Twisting and winding are separated, with the result that large packages of unbroken yarn can be made. The shuffling/twisting rollers are capable of inserting twist at extremely high rates (>10 × ring frame productivity) and the system is capable of producing yarn cheeses containing up to 9 lb of yarn. To keep L small, high levels of alternating twists are required. The yarns tend to be weak but they can be produced at very high speeds at relatively low cost.

Phasing the component strands so that the zero twist portions of each strand no longer coincide with the zero twist zone of the ply (Fig. 10.12) can alleviate the problem in patterning. In practice, this is easily accomplished by making one of the component strands take a longer path than the other, on its way from the twisting rollers to the guide, J (Fig. 10.13). When the strands unite, one strand is out of phase with the other. If the phasing is properly set, the patterning, as well as losses in strength, reduced but it is still necessary to use a long-staple system. All commercial ST yarns are phased.

Fig. 10.12 Phased STT yarn

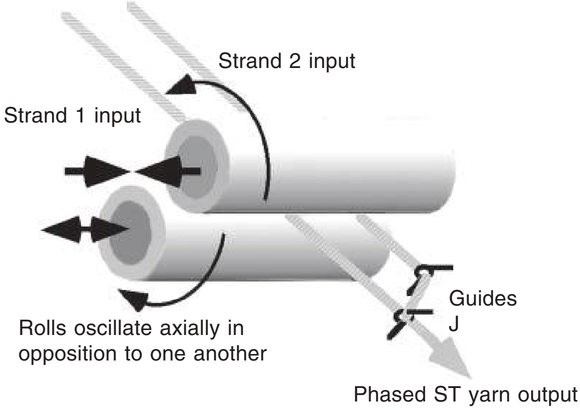


Fig. 10.13 Phased STT yarn process

The self-twist process is rather simple. A normal machine contains a number of production channels. Each channel comprises a roving supply package, a roller drafting section with an oscillating front roll (i.e. shuffling/twisting rollers), a strand combination system, and a take-up. The oscillating front roll provides the alternating twist as already described. The machines have an exceptional productivity, but even the phased product still causes some patterning in fabrics that makes them look streaky. The simple process has a restricted market and much of the yarn is twisted to make STT yarns as described in the next section.

10.8 Twisted self-twist yarns and processes

10.8.1 Twisted self-twist yarn

As already discussed, alternation of twist in ST yarns creates a streaky effect in a fabric but it is possible to superimpose real twist sufficient to make the ply twist unidirectional to minimize this effect. Such twisted self-twist yarns are known as 'STT' yarns. Nevertheless, even if real twist is inserted by two-for-one twisters, the cost of twisting is relatively large compared to the cost of spinning and it is therefore less attractive economically than it first appeared. Shaw [19] estimated in the early 1970s that the costs relative to the ring frame varied between 80 and 88% for counts between 30s and 9s worsted respectively.

When STT yarns are made, the real twist added has to be high to minimize the patterning. The result is that, with wool, the system produces a high twist, long-staple, plied yarn that has much of the character of a worsted yarn. A worsted yarn is a relatively high twist product and therefore the STT system is still quite attractive in this market.

10.8.2 Processes for twisted self-twist yarns

Two processes in series are needed to make STT yarns. The first is the manufacture of the ST yarn and the second is the plying process. This involves transfer of yarn packages between the processes, which increases the cost. It does, however, give increased manufacturing flexibility which may be useful in a specialty market.

10.8.3 Processes using modifications of the ST process

One development is to self-twist a staple strand with a filament and then self-twist this composite with another filament. This produces a staple core with filaments wrapped in opposite directions on the outside. Fine filaments are not very visible and the streaky effects can be minimized. The filaments add strength to the structure but they also tend to increase the cost/lb. The trade name for this type of composite yarn is ‘Selfil’.

A second development reported by Miao et al [20, 21] concerns STT yarns modified by air-jet texturing. The air-jets interlace the yarns with the result that yarns tested somewhere between 20% and 60% stronger than with non-interlaced yarns. Patterning in the fabric was diminished as compared to normal ST yarns and fabrics.

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