Opportunities for friction spinning

by Alan Parker, Belroy Engineering Partnership, Bolton, UK

The high level of installed spindlage of both ring and rotor ensures that for many years to come they will remain the dominant forces in the industry.

However, a major factor as to which spinning technologies achieve future machinery sales will be determined by the suitability of the yarn structure for the product for which it is to be used.

Rotor spun yarn is becoming closer in surface appearance to jet spun yarn, and inevitably therefore, further away from ring spun yarn. Purchasers of fabrics are going to be increasingly discerning and there will therefore be a preference for fabrics from yarns which are dependent on yarn twist, rather than wrapper fibre, for their surface characteristics.

It is the possibility of achieving a true twist structure that affords a great opportunity for open-end friction spinning to make a major impact on future spinning machinery sales.

Old technology

Friction spinning is not a new technology. The first patents were filed over 25 years ago and the fundamental technological patents have lapsed, thus opening up the technology to be commercially exploited.

There are a number of alternative ways to apply the twist to create a friction spun yarn and a wide range of different yarn types that can be produced.

There have been a multitude of patents filed covering different derivatives of the basic friction spinning concept. The common feature of all the systems is that negative air pressure is employed to help to restrain the forming yarn as this forming yarn is rotated.

The DREF system uses suction through both of the surfaces which are also used to rotate the yarn. Other systems apply suction through one of the yarn twisting surfaces and yet other systems separate the twisting and yarn formation into separate zones.

Economics

It goes without saying that a new technology needs to offer an economic advantage over existing systems, but this on its own will not be sufficient to achieve a large market penetration.

I have been involved with friction spinning for a number of years during which time I have also carefully examined many other spinning technologies. The engineering components to form and rotate the yarn on any of the friction spinning processes are more expensive and complex to manufacture than on a rotor spinner. Therefore, taking a simplistic view, the throughput speed needs to be greater to be economically competitive with rotor spinning.

There can be no doubt that, in common with many processes, the friction spinning concept was established many years before there was the engineering capability to transfer the concept into a commercial process.

Friction spinning undoubtedly has the potential for far higher speeds than will ever be achieved by rotor spinning. It will also be possible to achieve these higher speeds across a far wider spectrum of fibre specifications than can be achieved with rotor spinning.

It is quite the dramatic strides that continue to be made in the mass production engineering processes that make the friction spinning technology an increasingly economically attractive process.

Fibre alignment

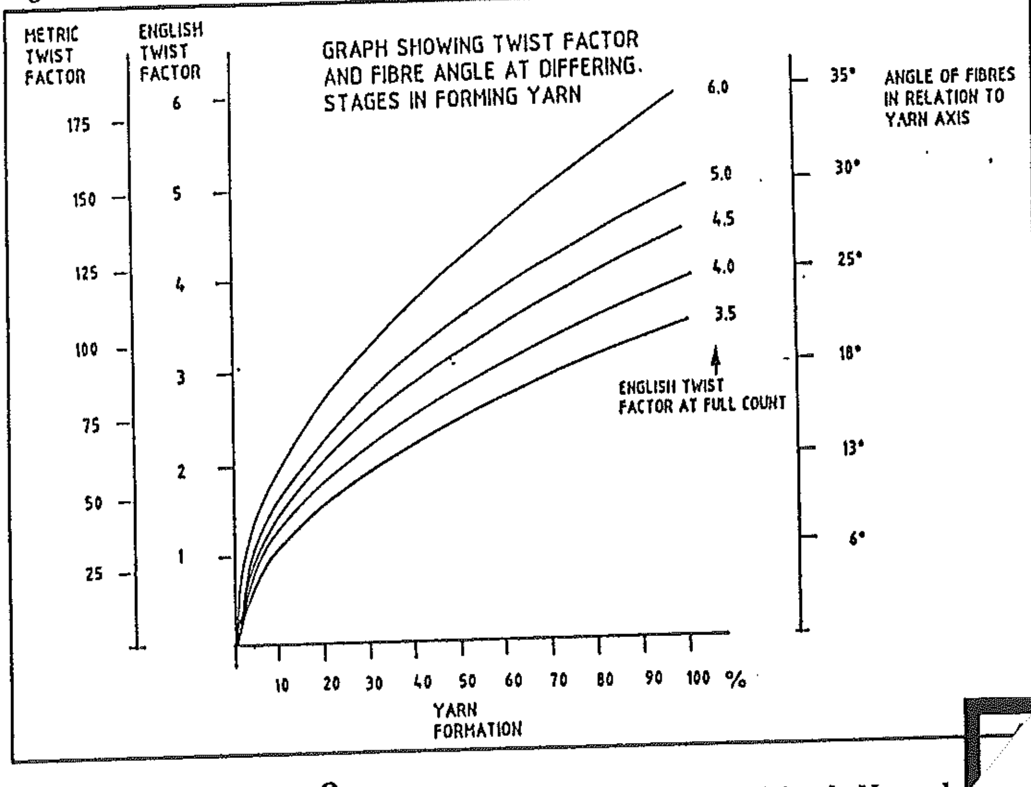
On any spinning process, the better individual fibres are aligned along the yarn axis, the greater is the potential for achieving maximum yarn strength. Transferring this potential into practical reality requires the optimisation of many other factors, particularly those related to providing inter fibre friction.

Thus a spinning arrangement with good fibre alignment does not always produce strong yarns. However a spinning system with poor fibre alignment will always produce weak yarns.

Friction yarn structures

At one end of the spectrum, friction spinning

Figure 1. Graph showing twist factor and fibre angle at differing stazges in forming yarn.



can produce yarns, as for instance DREF 3, in which the surface of the yarn consists of layers of wrapper fibres around a substantially untwisted core.

At the other end of the spectrum, friction spinning offers the potential to make a significant impact.

Analysis of the structure of friction yarns

The formation of any spun yarn is an extremely difficult subject to analyse, owing to the very nature of fibres, the inherent variability between fibres, and the need to control these fibres during drafting and the insertion of twist.

On open end spinning systems there is also the need to control individual fibres in their passage through air. Inevitably, in such a complex system, any conclusions drawn are only broad assessments of what will occur to the majority of fibres.

The characteristics of an open end friction spun yarn are primarily determined by the twist in the yarn, how effectively the fibres are aligned to lie along the yarn axis and the way individual fibres relate to each other within the structure.

The factors which affect friction yarn characteristics and provide a model based on experience with this technology are discussed in the following paragraphs.

Twist

All my investigations indicate that there is substantially uniform twist from the core to the surface of an open-end friction spun yarn. This would confirm the view that once a fibre has become attached to the forming yarn, the fibre undergoes no further rotational movement in relation to the remainder of the yarn structure.

When examining twist in a yarn, the important factor is the so-termed twist factor, and not merely the level of twist. Open-end friction spun yarns are formed in interlocking layers of fibres. Therefore, if it were possible to gradually strip away fibres from the outside of the yarn inwardly to the core the twist factor of the part of the yarn still remaining would gradually reduce. This theoretical scenario for different twist factors is shown in Figure 1.

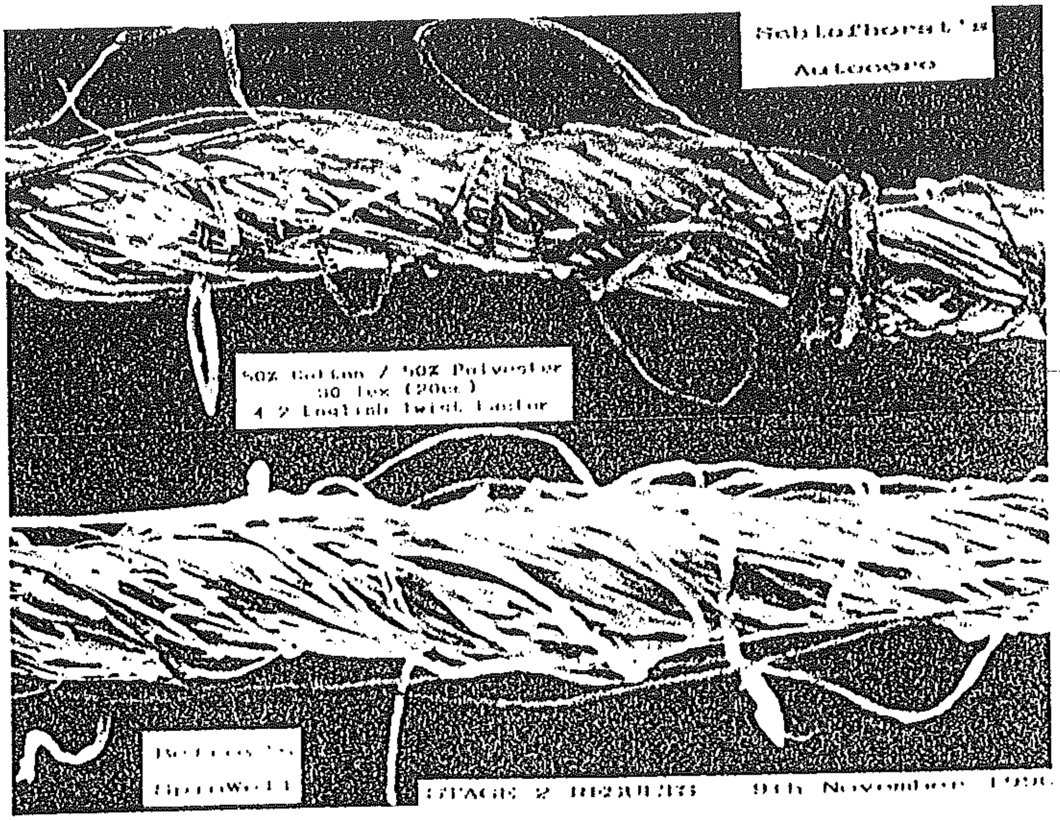


Figure 2

If one examined, say, any count of yarn with an English twist factor of 4.5 (a metric twist factor of 135) at its full yarn count this would be represented on the graph as 100%. At the half count stage (represented by 50%) the twist factor would be only 3.2 and at the 25% stage the twist factor would be 2.5.

A 30 c.c. (20 Tex) yarn, for example, with an English twist factor of 4.5 (metric twist factor 135) would have the fibres lying at an angle of about 26 degrees to the yarn axis at full count. At half count (60 c.c.) the fibres would be lying at 20 degrees to yarn axis, and at quarter count (120 c.c.) at only 14.5 degrees to yarn axis. This is also shown in Figure 1.

On a ring spun yarn, in which a ribbon of fibres is twisted, there is also a lower twist factor on the fibres lying closest to the core of the yarn, but due to fibre migration in the ribbon it is a far more random effect than on friction spinning.

Fibre alignment

The two extremes of a friction yarn are represented by:–

Fibres fed at right angle to forming yarn

Fibres which are fed at right angles to the forming yarn are wrapped in a helical fashion around the forming yarn.

The fundamental problem is that fibres are being fed at a speed faster than they can be taken up. Therefore the fibres buckle as the leading edge of the fibre becomes attached to the forming yarn. As a result of this buckling, random loops form in the individual fibres between the leading edge of the fibre and other random points along the fibre at which the fibre gets locked into the yarn structure.

Some of these loops are trapped within the body of the yarn by other fibres, whereas other loops protrude from the surface of the yarn. This arrangement produces a very bulky yarn. However the yarn is also relatively very weak, and has both a poor lustre and a rough surface. It can therefore provide a perfectly acceptable yarn when strength is not important, and yarn bulkiness, rather than surface appearance is a priority objective.

Although this is still a twisted yarn the high degree of looped fibre makes the level of twist impossible to measure directly. On the yarns of this type I have examined the fibres were lying at an angle of 35 degrees or greater indicating an English twist factor of at least 6.0 (metric twist factor 180).

Fibres fed with their axis parallel to forming yarn axis

This might appear the perfect way to achieve optimum fibre alignment on a friction spun yarn. However this theory is only applicable to a static and not a dynamic situation. In a dynamic situation the optimum fibre alignment is achieved by an extremely complex relationship between the following:-

- Angle at which fibres approach forming yarn.
- Speed at which fibres approach forming yarn.
- Surface speed of yarn at points at which fibres are attached to forming yarn.
- Method by which fibres are attached to, and retained on, the forming yarn.
- Yarn withdrawal speed.
- Rigidity of fibres.
- Fibre length.
- Friction characteristics of fibres.

Wrapper fibre

All friction spun yarns produced on the commercial machines which have so far been available have had either a very high level of wrapper fibre, or a lower level of loosely bound wrapper fibre. The loosely bound wrapper fibre contributes little to yarn strength, but severely disrupts the unwinding characteristics of the yarn, increases the possibility of the yarn snagging, and gives a less lustrous yarn surface.

As distinct from rotor spinning, there is no fundamental reason why friction yarns must contain wrapper fibre.

There is clear evidence that the use of strategically placed air jets in the fibre transport area can increase both the level and binding effect of wrapper fibre which, in some instances, increases the strength of friction spun yarn. Such yarns, due to the effect of this wrapper fibre, indicate a lower measured twist value, are less twist lively but have a rougher less attractive surface characteristic. There are almost certainly other means by which similar effects could be achieved.

I have always conceived friction spinning as a process which should try to compete with the attractive surface appearance offered by ring spun yarn and therefore it must depend only on twist and good fibre alignment to achieve its yarn strength and that wrapper fibre is an evil to be avoided at all costs.

Producing friction spun yarns without wrapper fibre poses a major technological challenge. Since the second half of 1990 we have examined this problem in great detail. We have recently established a unique friction yarn structure, which can substantially eliminate the loosely bound wrapper fibre. Additionally the yarn is now smoother, and has an improved fibre alignment, thus giving it a much better lustre than rotor yarn spun from the same stock. The smoother yarn surface also permits good unwinding characteristics.

Although I am not yet prepared to divulge the precise details of this structure the accompanying stereoscan photograph (Figure 2) of the yarn illustrates how we have already bettered the fibre alignment of rotor yarn and that the surface appearance is dramatically closer to a true twist structure. Even if one ignores the clearly visible wrapper fibre on rotor yarn, there are still far less fibre loops on our friction yarn and a better alignment along the yarn axis.

There is considerable scope to be able to further refine this structure to meet the many differing fibre and process parameters mentioned above and which are required for the wide range of yarns and fabric types which comprise the short staple yarn spinning industry.

Commercial exploitation

Transferring concept into a commercial process is an extremely difficult task on friction spinning. As in most new technologies, there are many operational problems for which solutions are having to be found, and the provision of automation with high quality piecing is being established.

For friction spinning to make a large commercial impact the base line in terms of strength should be that achieved by rotor spinning. It must also be able to process a wide range of different yarn types on a basically common machine.

Because the friction yarn will depend primarily on twist to provide inter fibre friction, and have no wrapper fibre, it is only by having an improved fibre alignment in relation to rotor that a similar strength will be achievable at an equivalent twist level.

We have enclosed in Table 1 an assessment covering all aspects of yarn quality of our already achieved, and expected achievements, for our friction spun yarn, which we term the SpinWell.

A good surface structure is the key feature for a friction spun yarn to gain widespread commercial acceptance, and is even more important than meeting a defined yarn strength, because it is universally applicable in both knitting and weaving. Strength, on the other hand is far less critical for knitting than weaving.

The Spinwell is less sensitive to fibre, especially cotton, specifications than the high speed rotor machines fitted with small rotors, and is already able to process yarn at significantly higher delivery speeds than rotor machines.

Our unique yarn structure will not only permit us to process in the medium to fine counts but should also allow yarns without wrapper fibre to be processed in the coarser count range. Hitherto loosely bound wrapper fibre on coarse yarns have been especially troublesome.

Table 1: Features of Spinwell yarn.

Fibre alignment	Already better than rotor. Targeted to be as good as ring.
Twist	True twist, no wrapper fibre.
Yarn regularity	Already at least as good as rotor. Targeted to be better.
Nep	Better than rotor. Can be improved further but at a price which may not be justifiable.
Strength	It is at the moment weaker than rotor. Targeted to be at least as strong as rotor.
Fabric regularity	Potentially very uniform. The yarn from any one position produces extremely regular fabrics. This very regularity requires good unit to unit consistency to achieve regular commercial fabrics.
Fabric handle	Softer than rotor at the same twist level.
Lustre	Better than rotor now. Targeted to be as good as combed ring.
Abrasion resistance	The abrasion resistance of Spinwell yarn without wrapper fibre will depend on twist and yarn structure. The unique structure of our friction yarn will enable a good abrasion resistance to be achieved in relation to its twist.
Hairiness	Yarn hairiness makes a very significant contribution to the aesthetic appeal of fabrics from staple yarns. A key feature of the structure of our friction yarn is that the hairiness is similar to ring and not rotor yarn. It is targeted to be able to select hairiness characteristics according to the needs of different end products.

Conclusions

There is little doubt that in the present depressed market machinery makers and yarn producers are having to examine their future with some concern. The dramatic fall off in the sales of rotor spinning machines has been particularly evident.

Undoubtedly in such a large worldwide industry there are a variety of factors contributing to this situation and in an industry affected by fashion trends there are some areas which are still buoyant and others particularly hard hit.

I believe the most important legacy will be the acceptance that, although the automated rotor spinning machines have done everything that could be expected of them, rotor yarn, primarily because of wrapper fibre, is technologically inferior to ring spun yarn for the majority of yarn applications.

With such a large number of rotors already installed, there will remain a significant contribution from rotor yarn for many years to come, although they are going to have to increasingly depend on economic advantages to try to retain their existing markets.

I believe that friction spinning, because of its potential for high speed, and an opportunity to achieve a true twist structure, combined with the ability to produce the most regular fabric of any of the spinning systems, is the technology that is best suited to compete with ring spinning on a combined technological and economic basis.