

Friction spinning — the Masterspinner

A detailed assessment of the machine and the process by
I. Karnon, Platt Saco Lowell (UK) Ltd.

The technical and economic limitations of conventional ring spinning have been the subject of much discussion, and are proving to be an ever-increasing burden for all spinners of staple fibre in cotton, wool and man-made fibres.

As a result, machine makers and research institutes throughout the world are continuously studying new spinning methods. The aim of most of these developments is to increase productivity, improve or at least retain yarn quality, and ensure increased efficiency in subsequent processing.

Over the past decade, rotor spinning has captured a significant share of the short staple spinning market. The introduction of third generation machines has helped this spinning system to be even more widely accepted. However, as rotor speeds are reaching 100,000 rpm and, on the other hand, rotor diameter has to be decreased to 35 mm to accommodate such speeds, it is felt that this system, too, is now approaching its practical limits.

In developing the Platt Saco Lowell Masterspinner friction spinning process we had a number of objectives:-

1. To develop a spinning system with higher processing speeds than those of existing commercial systems.
2. To reduce the overall processing costs of the spinning process.
3. To produce 100% staple fibre yarns without the aid of a filament core or wrap yarn.
4. As a short staple spinning machinery maker, we were particularly anxious to be able to spin 100% cotton yarns as well as 100%

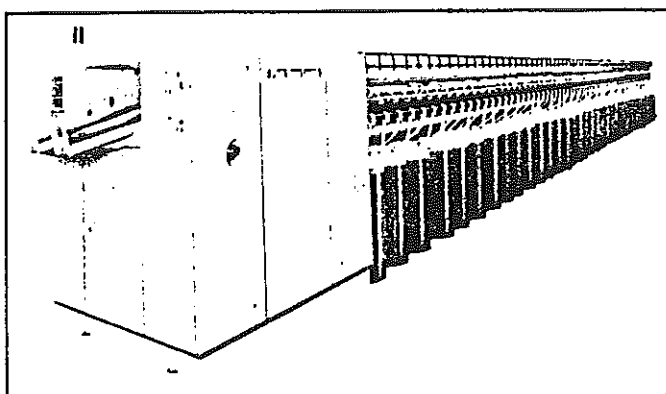
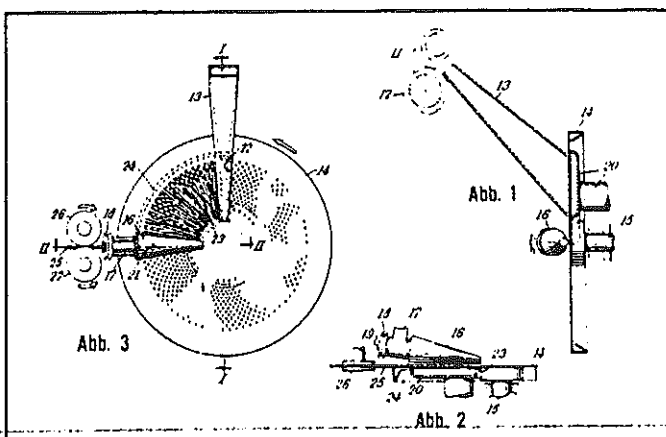


Fig. 1 (top): Detail from the 1967 patent application. Fig. 2 (above): View of Masterspinner machine.

synthetic fibres and cotton and synthetic fibre blends. Today our objectives have been substantially achieved, and the friction spinning process is becoming a reality in our industry.

In 1967, the first patent application was filed by Platt Saco Lowell referring to a spinning system using the friction principle. Fig. 1 shows individual OE fibres being deposited on a rotating perforated disc by means of a feed duct, and held on to the disc by means of suction through the perforation. Owing to the rotation of the disc the fibres are carried forward towards a non-perforated roller (or cone). The roller and the disc are positioned in such a way

that a narrow gap exists between them. As the fibres reach the gap, they are rolled between the two surfaces and form a tail end of a yarn. The yarn is then drawn off along the gap and wound onto a package. This principle forms the basis of the Masterspinner friction spinning machine (Fig. 2).

Fig. 3 illustrates the thread path in the spinning position. A sliver can be positioned underneath each spinning unit. The sliver enters the unit through a feed pedal and the fibres are opened and cleaned by a pinned beater which includes a trash removal action. The opened fibres pass into a transfer duct located between the beater

and the friction rollers and are drawn to the yarn formation zone by means of suction through the perforated roller. A secondary suction, at the end of the transfer duct, helps to give fibre orientation, and so to keep the fibres parallel to the yarn axis. When the fibres reach the gap between the rollers they are rolled together, and as the yarn is pulled out along its axis twist is inserted. The yarn exits through a doffing tube and passes through a delivery roller, yarn detector and tailing device to the traverse guide.

Parallel packages or conical package of $4^{\circ}20'$ can be produced and, if required, a yarn waxing device can be fitted at each position.

Fig. 4 shows a cone winding arrangement including the yarn waxing and a tension compensating device. A yarn length measuring device can be fitted to the machine as well as a full business information system.

Each Masterspinner machine has 144 spinning positions (72 per side) and normally one air system is provided for a two machine installation. The air system can be positioned away from the machine itself. Being a true open-end system the Masterspinner does not have the high speed components associated with rotor spinning, and therefore overcomes the problems and limitations arising from such high speeds.

Raw materials

Most fibres suitable for short staple (cotton system) processing can be spun on the Masterspinner. The main fibres which are currently processed are shown in Fig. 5. All fibres are 40 mm long.

Fibres for Masterspinner

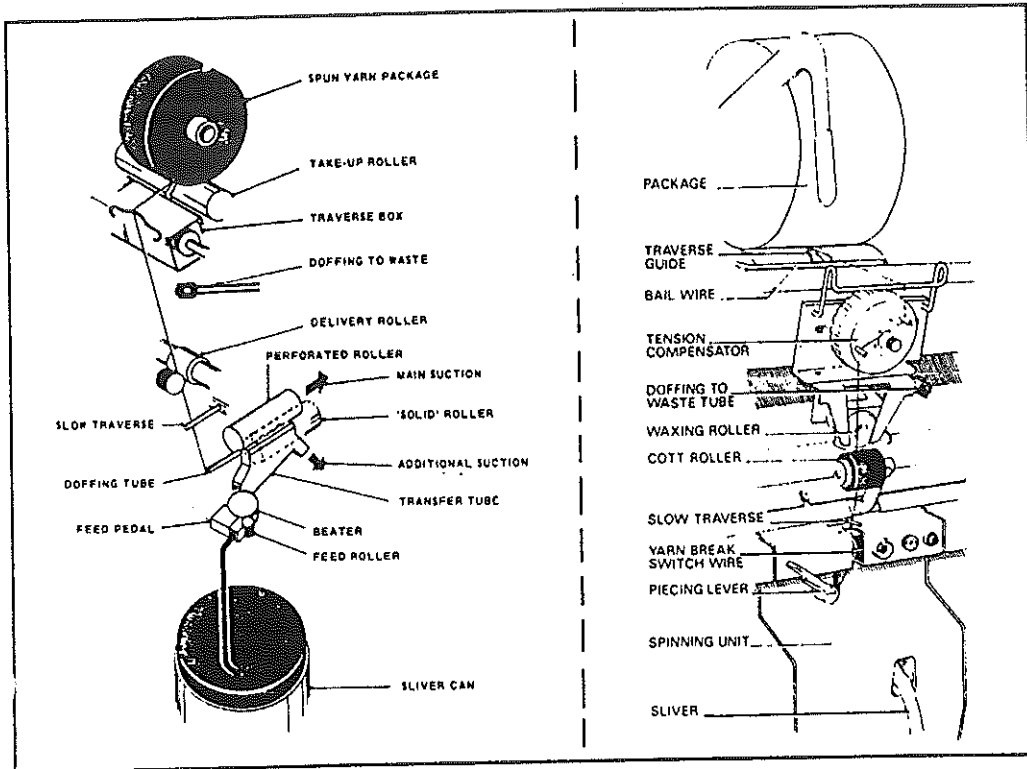


Fig. 3 (far left). Fig. 4 (left).

processing can be categorised as follows:

1. 100% cotton.
2. 100% polyester (including high tenacity fibre). 1.7 dtex, 1.3 dtex.
3. 100% acrylic of 3.3, 2.2, 1.7, 1.3 and 0.6 dtex.
4. 100% viscose (including high tenacity viscose of 1.7 and 1.3 dtex.
5. Blends of cotton/acrylic, cotton/polyester, cotton/viscose and viscose/polyester.

Therefore, there is a wide scope for fibre blends, and these can be spun in the count range of 10-40 NeC (17-68 Nm).

Fibre choice

The correct choice of fibre is of fundamental importance to the process. Synthetic fibres must be suitable for beater opening. Fibres of

finer decitex, such as 1.3 or even 0.6, tend to improve spinning performance and yarn quality, particularly of finer counts. The friction properties of the fibre will affect the twist insertion potential and it is not unusual to find a situation whereby in order to obtain for example a 24 NeC (40 Nm) yarn with 800 t.p.m., the friction roller speed will be say, 4000 rpm when processing polyester, and 6500 rpm when processing acrylic fibres. However, once the correct twist level has been selected, and providing that there is no change in fibre properties, the twist levels in the yarn remain unchanged. Fibre crimp and spin-finish can influence processing conditions and yarn properties, and if selected correctly can help to increase the versatility of

products produced on this machine.

In the case of cotton fibres, the choice of fibre is determined by:

1. *Count to be spun*

A minimum of 110 fibres per cross section is recommended in order to obtain optimal processing conditions and yarn-properties.

2. *Desired yarn properties*

The type of cotton used, will affect yarn properties therefore, if for example, maximum strength is required, fibres with a high "Pressley" value are required. Lustre, resilience and handle can also be selected to reflect optimum properties to suit the required end product.

The graph in Fig. 5 gives an illustration of the part played by fibre origin and surface characteristics

in the formation of a yarn. Slivers of different cotton origins, but of equal weight per unit length, were spun on the same machine with identical processing conditions, with the exception of the friction rollers speed which was increased in steps of 500 rpm.

Clearly, an increase in roller speed increased the twist in the yarn. Other interesting facts emerging from this investigation show that a cotton of different origins behaves differently in terms of twist insertion, for example Sudanese cotton accepts more twist than Egyptian Giza and, American cotton will require higher friction roller speed to attain the same twist level.

Carded cotton in all cases accepts more twist than combed cotton, probably because of the short fibres which add cohesion to the blend and reduce the fibre slip in the yarn formation zone.

Friction yarns

The friction yarn has a character of its own. Fibres lie parallel to the yarn axis, there are no wrapper fibres, and the yarn contains true twist. It can be said that the twist in the yarn is inserted by a gentle rolling action as opposed to a conventional twisting action which results in much greater forces acting on the fibres.

Friction yarns have, therefore, a softer handle, they give a better cover and a full and regular fabric appearance. They have a

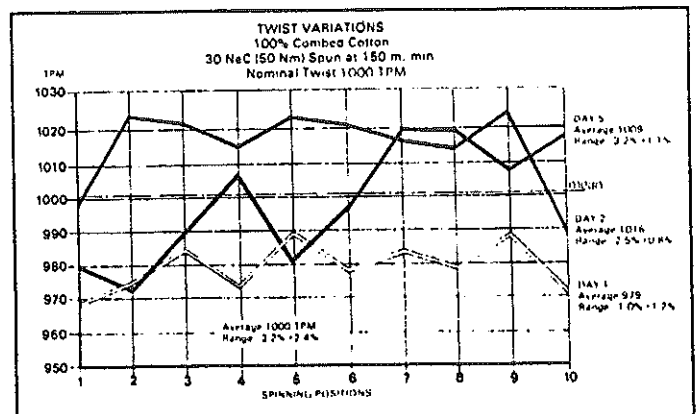
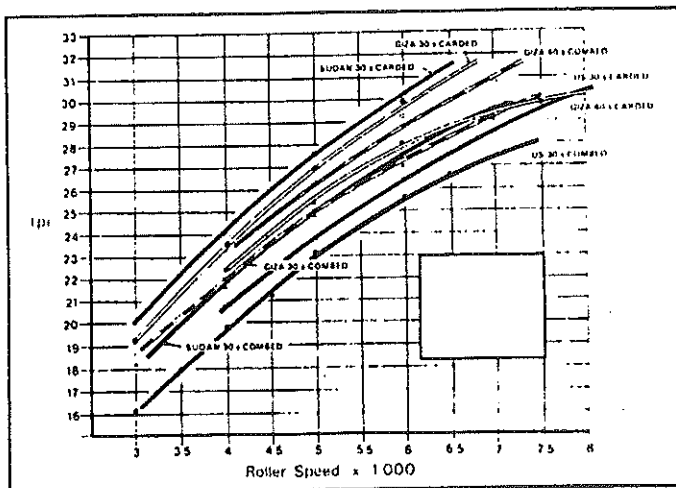


Fig. 5 (left). Fig. 6 (above).

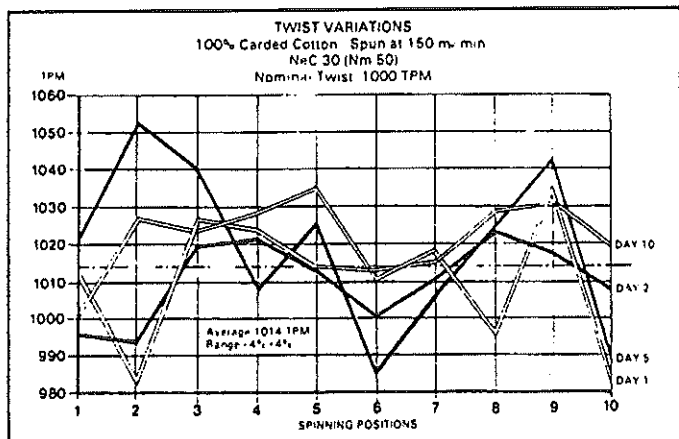
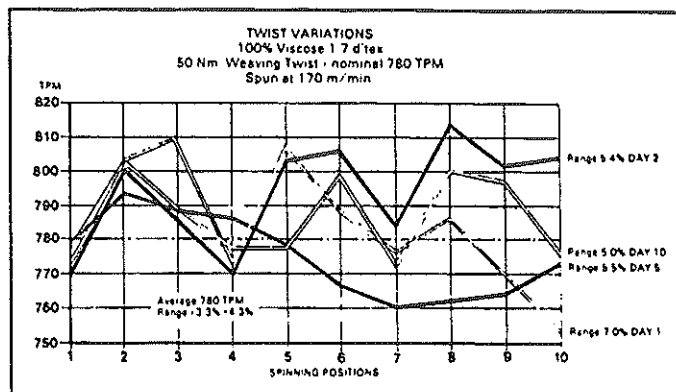
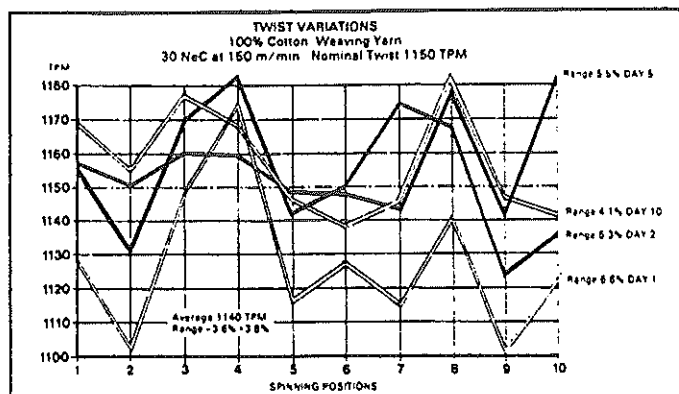
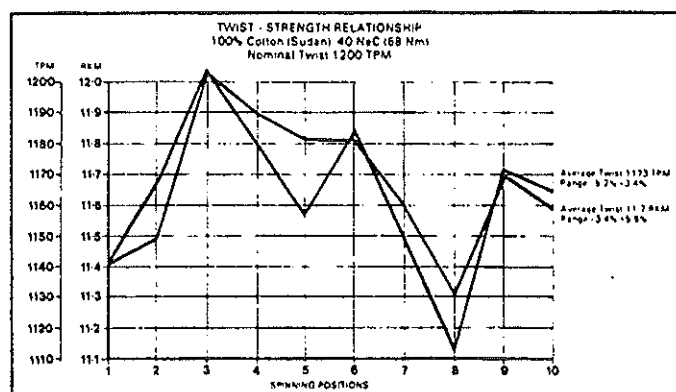


Fig. 7 (above left). Fig. 8 (above). Fig. 9 (left). Fig. 10 (below). Fig. 11 (bottom).



greater absorption than either ring or rotor yarns. Generally, the number of faults (and, particularly, the number of neps) in friction yarns is lower than that of similar ring and rotor yarns.

The rolling action, and absence of high inter-fibre forces, result in yarn strength inferior to ring yarn and in most instances inferior also to rotor yarns. The regularity, high extension, and low number of imperfections compensate to some extent for the lower strength and enable friction spun yarns to be processed successfully in many applications.

The following are some of the more successful applications currently used for friction-spun yarns.

- Knitting applications
- Weft in a variety of fabrics
- Towelling (pile warp and weft)
- Corduroy
- Velours
- Brushed fabrics
- Print cloths

Discussion of yarn properties

Twist variations within a spinning unit and between spinning units must be kept to a minimum. In the early days of the process,

variations were occasionally outside the acceptable tolerances. Today we are in a position to control twist levels to perfectly acceptable tolerances.

The accompanying illustrations show twist variations from 10 spinning units in continuous production. Each package was tested on an automatic twist tester (to eliminate operative errors and ensure greater accuracy) with 20 measurements per test. Fig. 6 shows the variations of a 100% combed cotton yarn spun to 30 NeC (50 Nm) with a nominal hosiery twist of 1000 T.P.M.

On Day 1, an average twist of 979 T.P.M. with a range of 1% + 1.2% was recorded. On Day 2, an average of 1016 T.P.M. was tested with a range of -2.5% to 0.8%. Day 3 and 4 gave similar results (not shown), and on Day 5 an average of 1009 T.P.M. was recorded with a range of -3.2% + 1.1%. The 5-day average was 1001 T.P.M. with a range of -3.2% + 2.4%

Fig. 7 shows the results of 10 days' continuous running of a 50 Nm 100% cotton weaving yarn with a nominal twist of 1150 T.P.M. with a total average of 1140 T.P.M. and a range of -3.6% + 3.8%.

An example of 100%

viscose 1.7 dtex 50 Nm weaving yarn with a nominal twist of 780 T.P.M. is given in Fig. 8. It is interesting to note that optimum strength was achieved for this fibre with a twist level of 780 T.P.M. (twist factor 110 metric) whilst for the previous 100% cotton yarn a twist factor 160 metric was required to give optimum strength. However, in friction spinning, the amount of twist inserted into the yarn does not affect the delivery speed of the yarn, and therefore twist can be selected to give the desired yarn handle and strength without affecting productivity.

A further example of 100% carded cotton spun to 30 NeC (50 Nm) is shown in Fig. 9. It can be seen that in

10 days' running there have been practically no twist variations within one position and between the 10 position. The total range over the 10-day running period is -4% + 4%.

In Figure 10 we have tried to superimpose the strength variations on the graph showing twist variations, for 100% cotton yarn 40 NeC (68 Nm). It is interesting to note that in this instance the curves follow the same tendencies. This is not always the case. The range is always within acceptable tolerances: for the twist -5.2% + 3.4%, and for the strength -3.4% + 5.9%. A similar situation is seen for the 30 NeC (50 Nm) yarn (Fig. 11). Again, the range of -3.1% + 4.6% for the strength and -2.8% + 3.1% for the twist.

for the twist are well within the commercial tolerances.

The results discussed in this section have been obtained from practical experience in running under mill conditions on a continuous basis. Most of the tests were carried out on 10-position machines, however, more recent work in spinning mills carried out on 144-position production machines confirm these findings.

We are often asked for a comparison between the properties of friction-spun yarn and conventional ring and rotor yarn. The following are some examples.

Table 1 shows 30 and 40 NeC (50 and 68 Nm) 100% cotton yarns spun from a combed sliver. Clearly the friction yarn is weaker, but in other respects compares favourably with this high quality ring yarn, notwithstanding the fact that it was produced at more than ten times the throughput speed.

The benefits of friction spinning become more evident when using carded cotton as shown in Table 2. In many instances, it has become possible to utilise a carded friction-spun yarn in applications such as single jersey knitwear, where hitherto mostly combed ring yarns were used.

A comparison of a cotton/polyester blend in two counts 30 Nec (50 Nm) and 16 NeC (28 Nm) appears in Table 3. It is interesting to note that the carded cotton could be substituted for combed cotton. This, of course, cannot be reflected in the physical tests but resulted in excellent appearance of the fabric.

When comparing friction- and rotor-spun yarns having the same twist multiple the friction yarn is softer, loftier and has more bulk. This important quality can be further improved by utilising lower twist levels which are unattainable in rotor spinning. Table 4 shows such an example. The strength of the friction yarn is a little lower, but it contains less twist and in fabric form it gives a superior handle.

Production machines recently installed in a number of selected mills have confirmed these results and, indeed, have shown that particularly in terms of imperfections and Classimat

Table 1: Yarn properties comparison — 100% Sudan combed cotton				
	NeC 30 (Nm 50)		NeC 40 (Nm 68)	
	Friction	Ring	Friction	Ring
Strength (RKM)	12.9	19.2	10.4	17.8
CV%	7.4	4.9	8.5	6.1
Extension %	9.1	8.4	7.3	7.0
U%	11.8	9.1	12.1	10.9
Imperfections (1,000 yd.):				
Thin places	22	8	58	176
Thick places	37	8	53	6
Neps	23	29	50	43

Table 2: Yarn properties comparison — 100% carded SLM cotton			
	20 NEC (34Nm)		
	Friction	Rotor (Commercial yarns)	Ring
Strength (RKM)	11.7	11.5	14.4
Extension %	8.6	9.2	7.7
U%	11.4	12.4	13.7
Imperfections (1,000 yd.):			
Thin places	45	22	55
Thick places	17	78	315
Neps	20	500	287

Table 3: Yarn properties comparison — 50%/50% Diolen 12/cotton, 1.7 dtex			
	16 NeC (28 Nm)		
	Friction (Carded Cotton)	Rotor	Ring (Combed Cotton)
Strength (RKM)	13.4	17.6	22.0
Extension %	11.8	10.6	11.0
U%	10.0	11.2	12.3
30 NeC (50 Nm)			
Strength (RKM)	12.6	14.9	19.2
Extension %	10.0	9.0	9.0
U%	12.1	13.8	15.6

Table 4: Yarn properties comparison — 100% acrylic fibre, 1.7 dtex				
	NeC 18 (Nm 30)		NeC 30 (Nm 50)	
	Friction	Rotor	Friction	Rotor
Strength (RKM)	13.6	16.0	13.6	14.1
Extension %	27.8	30.3	25.6	26.2
U%	8.0	10.7	10.0	11.3
Imperfections (1,000 yd.):				
Thin places	8	2	8	2
Thick places	0	2	9	16
Neps	0	6	8	17
Twist factor (metric)	105	130	98	130
TPM	580	715	700	920

results further improvement in yarn quality can be achieved. The end break rate, in the Masterspinner friction spinning system is considerably lower than equivalent end break rates in rotor spinning. Large production runs on Masterspinners have recorded 10 breaks/1,000 position-hours for 100% cotton 16 NeC (28 Nm) weaving yarn, and 23 break/1,000 position-hours for 100% cotton 36 NeC (64 Nm) 100% cotton hosiery yarn.

The high yarn quality, low number of faults, minimal number of piecings, coupled with the facility to wind the yarn onto 4°20' cones, and the options of yarn waxing and measured yarn length, enable the spinner to provide spun packages directly from the machine

for subsequent knitting or weaving processes, without having to rewind the yarn.

Conclusions

We are entering a new era in spinning technology. Friction spinning can offer not only significant economic advantage, but also new possibilities to create new products.

We still have a lot to learn. The use of raw materials on the one hand and the application of the yarns produced on the other open new opportunities to the spinner and the fabric producers. We are all looking forward with great excitement to the next few years when we shall see an increased penetration of friction spinning into the textile industry. ■