Friction Spinning — A New Spinning Technology *

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The technical and economic limitations of conventional ring spining have been a subject of much discussion and are proving to be an ever increasing burden for all spinners of staple fibres in cotton, wool and man-made fibres. As a result, staple fibre spinners and textile machinery manufacturers have been continuously engaged in research and development work to find new methods of spinning which will overcome the limitations imposed by the conventional ring spinning system. This paper introduces a new concept of open-end spinning, developed and designed by Platt Saco Lowell (UK) Limited, for the short staple spinning industry.

1. Introduction

As a background to this new technology it will be useful to consider briefly the various spinning methods which were developed in recent years as a substitute to ring spinning.

Rotor Spinning

The most successful and commercially accepted system is rotor spinning (Fig.1). This system has now

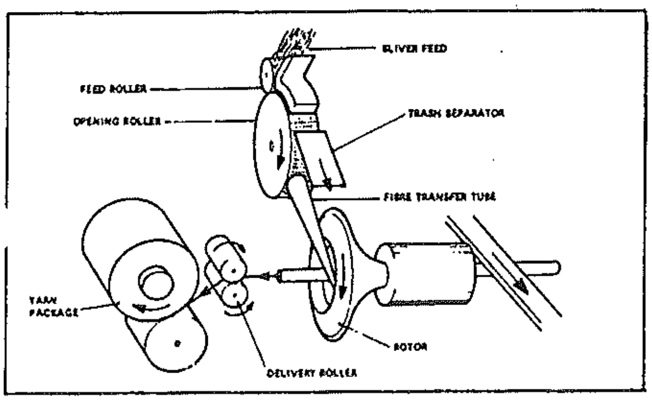

Fig. 1 Rotor Spinning System

been commercially used for some 15 years and although the market penetration initially expected was not achieved, in terms of volume of yarn produced, rotor spinning represents a significant market share.

Rotor Spinning showed the most early promise of the open-end systems and initially most machines were operating at speeds in the range of 30,000 to 45,000 rpm rotor speed. In the 1970's considerable effort was devoted to developing, Rotor Spinning machines able to operate at rotor speeds of 100,000 rpm. This work highlighted that rotor spinning had two fundamental and unavoidable drawbacks which imposed speed limitations. The first was the necessity to rotate a relatively large metal rotor at high speed. This problem led many companies to investigate various types of bearings including "air" and "magnetic" bearings and individual motor drives. Although technically viable, most of these systems would be discounted due to high costs.

The second drawback is more fundamental and relates to the effect of increased rotor speed on spinning tension. The yarn is twisted by a yarn crank which leads from the doffing tube to the rotor wall; any increase in rotational speed increases the centrifugal forces in the crank and consequently increases the spinning yarn tension. This can be somewhat compensated by a reduction in the size of the rotor but on the other hand there is a minimum diameter which is determined primarily by fibre length. However with improvements in spinning technology and bearing design rotor spinning machines are now being operated commercially at rotor speeds in the range of 60,000 to 80,000 rpm.

It is our opinion that rotor spinning production rates are gradually reaching a plateau and that it is doubtful whether they will rise much above present levels due to the penalties imposed by a combination

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of higher capital cost, significantly increased power costs, higher noise levels and spinning limits imposed by an increase in spinning tension.

3. Vortex Spinning

The objectives of vortex spinning were to overcome the first fundamental problem of rotor spinning in that the metal rotor was replaced by an air vortex (Fig. 2.) This system still requires a radial

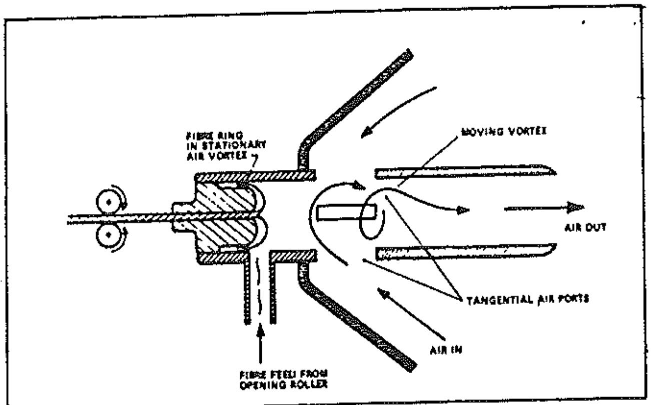

Fig. 2 Air Vortex Spinning (Polish PF 1)

portion of yarn in a crank to be rotated at high speed, with the obvious resultant high centrifugal forces. There are further drawbacks with the system:

- Problems can be caused due to trash
- The fibres are less controlled than on rotor spinning which invariably result in weaker yarn
- There is a high level of fibre loss.
- The machine has a high power consumption primarily due to air usage.

This system has found suitable applications for production of core yarns with a filament core.

4. Air Jet Spinning

The primary patent on air jet spinning was filed as far back as 1961 by Du pont. Subsequently an acrylic rotofil yarn was marketed by them under the trade name 'Nandel'. Average fibre length was of the order of 100 mm with a specially selected very wide fibre length distribution to provide the fascinated structure. Further patents were filed by Toray and Murata in the early 1970's introducing improvements which allow the system to operate more successfully on short staple fibres. Both patents refer to features positioned between the front drafting roller and the twisting jet. The Toray system (Fig. 3) has a specially constructed apron arrangement. The aprons prevent the edge fibres from being rotated by the air jet and therefore as the yarn passes through the jet these edge fibres are caused to wrap around the main body of the yarn. The Murata air jet system employs a contra rotating air jet, called an opening nozzle which, it is claimed, creates a partial open end and thus allows short staple fibres to be processed.

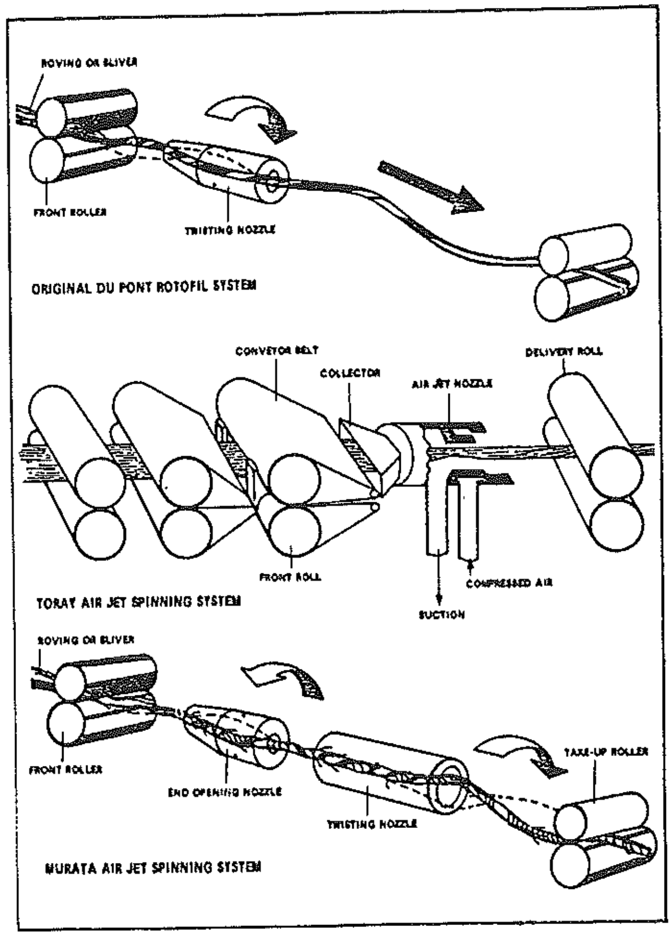

Fig. 3 Air Jet Spinning Systems.

The jet spinning principle produces a unique yarn which does not contain true twist, and therefore twist cannot be selected according to the requirements of the end product. On the other hand, it has the possible advantage that yarns are less twist-lively than true twist yarns. The machine is a sliver to yarn spinner using a 3-line double apron drafting system. Drafts of the order of 50-250 are available at an operating speed up to 180 metres/minutes. At present the machines do not process 100% cotton yarns.

5. Friction Type Open-End Systems

For quite sometime we at Platt Saco Lowell (UK) Ltd have appreciated that the preferred open-end arrangement is one in which the yarn tail remains straight, and is twisted about its own axis by contact with a moving surface. This avoids high centrifugal forces and high rotational speeds because each turn of twist is inserted by one rotation of a yarn with a diameter of approximately 0.15 to 0.30 mm, whereas on rotor spinning it requires one revolution of the rotor with a diameter of at least 38 mm to insert one turn of twist. This represents a surface speed approximately 125 to 250 times less than rotor spinning for the same twist insertion and is generally achieved by utilising the principle of friction spinning.

A number of systems of this type were patented around the late 60s by Platt Saco Lowell and The Shirley Institute.

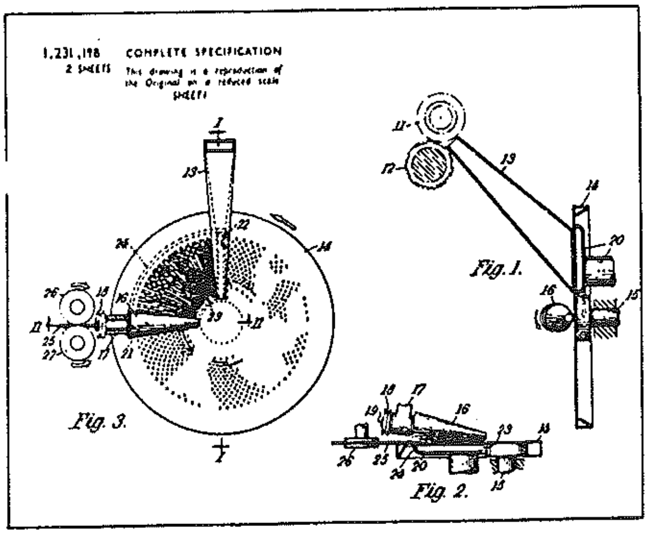

Fig. 4 Platt Saco Lowell Friction Type Spinning System.

Fig.4 is a drawing from a patent filed by Platt Saco Lowell in 1967. In this patent individual fibres are fed into a feed duct and drawn onto a perforated disc by suction through the disc. These fibres are carried by disc towards a non-perforated roller which is mounted so as to form a narrow gap between itself and disc. The direction of movement of the disc and roller are opposite so that instead of feeding the fibres through the gap they are rolled into the tail end of the yarn, twisted by the rolling movement and drawn off along the gap. The patent also discloses the use of the outer surface of a cylinder as an alternative to the disc.

Due to the more advanced stage of rotor spinning at that time, this development was not pursued by our company and the first commercial friction spinning system was introduced by Dr. Fehrer with DREF machine (Fig. 5). This machine was introduced for coarse count woollen type yarns and is based on the use of two perforated suction rollers to which fibres are fed from a carding cylinder. A rotating fan was subsequently introduced in an attempt to improve fibre alignment.

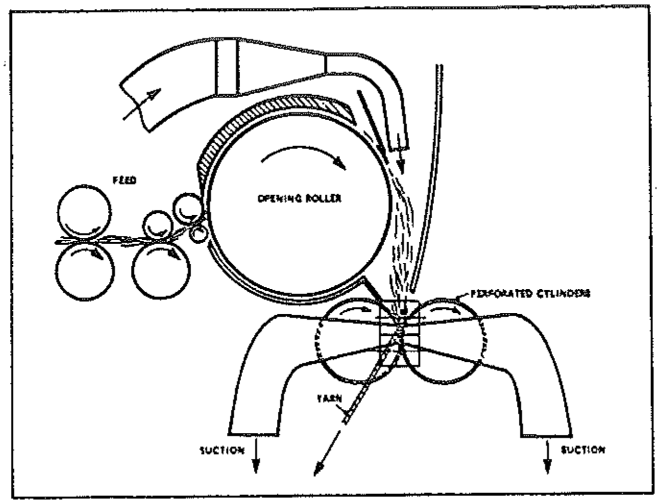

Fig. 5 DREF Spinning System.

At a later date a system known as DREF III (Fig. 6) was introduced for short staple fibres in which a ribbon of short staple fibre is fed from a pair of drafting rollers along the axis of the perforated rollers to form a staple core. Additional "wrapping" fibres are added at a number of different positioins along the perforated rollers to form a yarn of 100% staple fibre. DREF III is not a true open end spinning system and is restricted in yarn count terms to about 18s Ne (Nm30).

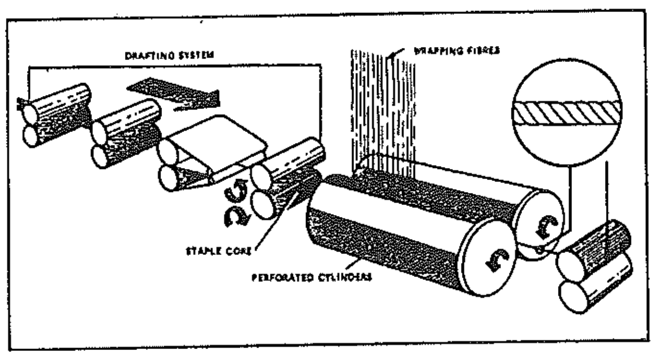

Fig. 6 DREF III Spinning System.

The work carried out by Platt Saco Lowell (UK) Ltd since 1978 on Friction spinning has been aimed at developing a system for short staple fibres able to operate at significantly higher speed than rotor spinning over the count range 10s to 45s Ne (17Nm to 76Nm). A key objective was that the process should be able to handle a wide range of fibre types including 100% synthetic and 100% cotton without any special fibre preparation requirements.

At the outset it was appreciated that to achieve a commercial yarn, the fibres must lie basically along the yarn axis and be twisted together whilst in this state.

Considerable progress has been made in achieving these objectives. The first area to be discussed is fibre alignment. In ring spinning fibre alignment is achieved in the preparatory processes, carding, drawing, roving, combing if employed, and drafting at the ring frame itself. In open-end systems the fibres are at some stage in free flight in an air stream and hence are not under proper control. The deposition of the fibres from the air stream into the yarn structure is therefore of paramount importance to obtain as parallel a structure as possible. In rotor spinning this is achieved by the acceleration of the leading end of each fibre as it encounters the rotor wall thus stretching the fibre out along the wall. In the friction spinning system there is no high speed moving part to achieve this function and therefore it must be achieved as the fibres move in the air stream toward the yarn formation area. Various systems have been tried to align the fibres parallel to the yarn axis including electrostatic forces and rotating fans.

Platt Saco Lowell (UK) Ltd have, however, developed a system employing an entirely new principle. In this system (Fig.7) the fibre transfer duct leading from the opening roller to the yarn formation area includes an additional suction duct close to the yarn formation zone which is balanced with the suction passing through the perforated roller. Therefore the fibres as they move along the transfer duct, turn towards the additional duct to lie parallel to the yarn, and then move in this orientation towards the yarn. The fibre transfer duct opens into a nozzle at the additional duct to give room for this turning movement. This effect is enhanced by the fact that the fibre transfer duct is directed at a carefully selected angle to the yarn itself in a direction opposite to the withdrawal direction.

Having first developed a system that cause the fibres to lie substantially along the yarn axis, it is essential to assemble the fibres in a way which optimises the textile properties of the final yarn. The system (Fig.7) developed by Platt Saco Lowell (UK) Ltd uses one perforated roller which turns towards the throat and includes a suction slot within the roller, and one non-perforated metal roller turning away from the throat. The fibre feed duct extends close to the yarn formation area and is biassed towards the perforated roller so that fibres attach to the yarn by rolling between the yarn and the perforated roller rotating towards the throat.

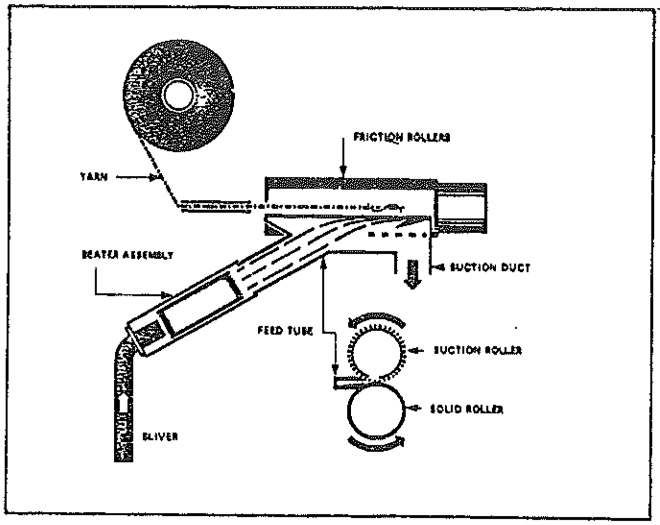

Fig. 7 Friction Spinner.

The quality of the yarn is determined by :

- The correct choice of surface characteristic of both the perforated and non-perforated rollers.
- The size and spacing of the holes in the perforated roller.
- The setting and width of the suction slot within the roller.
- The twist which is inserted into the yarn and is determined by the speed of the friction rollers (Fig. 8)

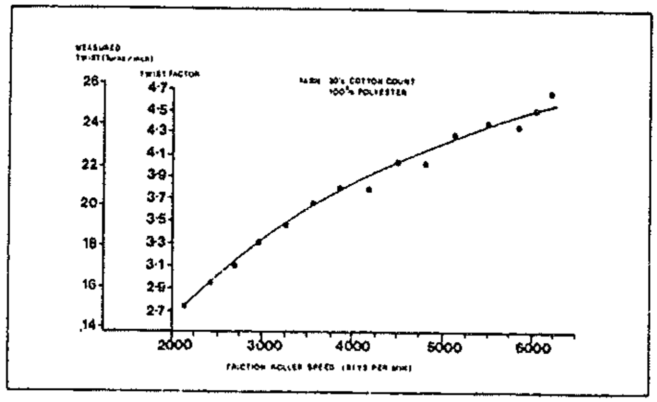

Fig. 8 Effect of Friction Roller Speed on Yarn Twist.

The structure of most of the yarns mentioned in this paper have been examined using stereoscan photographs (Fig. 9) :

- The combed ring spun yarn has a ribbon like appearance with well aligned fibres.
- On the rotor yarn most of the fibres are aligned along the yarn axis except for the wrapper fibres.
- The air jet yarn has fascinated structure.
- On the Platt Saco Lowell (UK) Ltd friction spun yarn the fibre orientatioin along the yarn axis is evident,

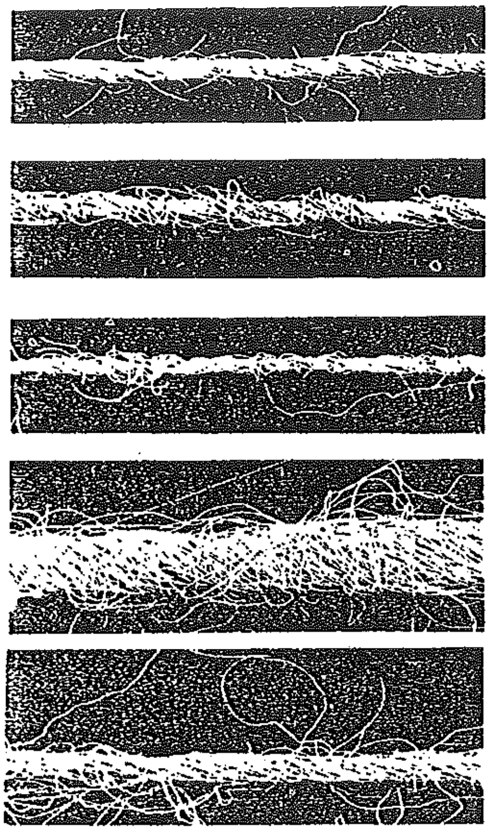

Fig. 9 Stereoscans of Yarns Spun on Different Systems

there is no evidence of wrapper fibres; and since these pictures were taken further progress has been made in eliminating the loose fibres evident on the surface of the yarn.

The technical characteristics of this new friction spinníng system, can therefore be summarised as follows :

- All fibres of 40 mm and less can be processed on the machine. These include 100% cotton yarns, 100% synthetics and blends.
- It is not necessary to have a special sliver preparation system, a conventional plant suitable for O.E. spinning is perfectly adequate.
- The system normaly produces a cleaner yarn than either ring or rotor spun when there is cotton in the feedstock, due to trash removal at the beater, and also the removal of micro-dust through the perforated roller.
- The spinning tension is low irrespective of throughput speed, and therefore does not create end breaks.
- The yarn is normally less neppy than either the one spun on the ring or the rotor spinning systems.

Fig. 10 shows examples of both knitted and woven fabrics from friction and ring spun yarns. It illustrates

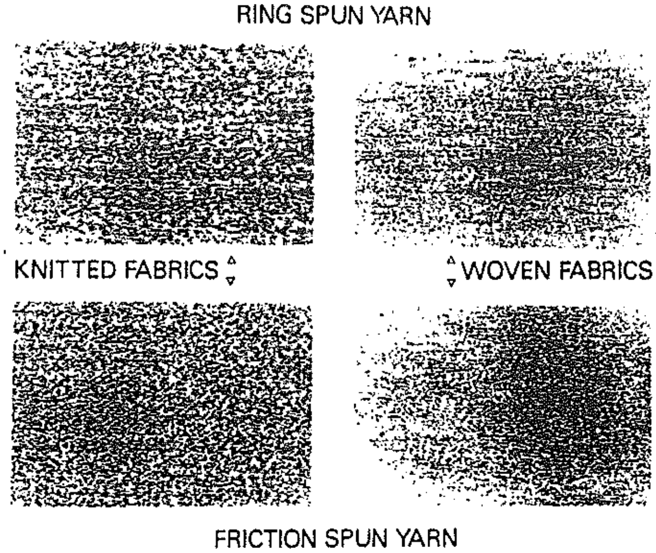

Fig. 10 Appearance of Knitted and Woven Fabrics from Ring Spun and Friction Spun Yarns.

the clean, regular appearance of the fabrics made from friction spun yarn.

- The productivity per position is 2 — 3 times greater than the latest rotor spinning machines and this is achieved without having any component operating at high rotational speeds; in fact the beater is the fastest moving part.

The machine was first publicly shown at the ITMA Exhibition at Milan in October 1983. Then we exhibited two 10 spindle spintesters operating respectively on :

Ne30s (Nm50) cotton with a delivery speed of 210 metres/minute

Ne24s (Nm40) 100% acrylic with a delivery speed of 250 metres/minute

The full length machine which is now in production is a double sided machine of :

144 spinning positions	
Machine gauge	224 mm
Draft range	60 — 240
Take-up package (cheese)	290 x 150 mm
Take-up package weight	4.2 kg
Sliver can size (dia x height)	400 x 900 mm
Yarn delivery speed upto	300 m/min

The machine can be delivered with cheese take-up or with cones up to 4°20'. Waxing attachments can be fitted for knitting applicatioins. The machine is prepared for measured length packages and for automatic peicing and doffing.