Technological aspects of spinning superfine cotton yarns

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During the past few years ring spinning technology has made considerable progress with respect to automation and spindle speed. In combination with smaller ring diameters (less than 38mm) spindle speeds of 20-24,000 rpm may well become industrially viable, provided, however, that the number of ends down can be kept below a certain reasonable level.

With respect to the use of extremely small ring diameters (about 30 mm), spinning trials are now running in Japan, as well as in Switzerland to produce superfine cotton yarns (Ne 300 and finer). Spinning such fine staple yarns implies great requirements from raw material, processing machines and a very carefully selected spinplan. As far as the ring spinning machine is concerned, several problems arise while running these trials. In the course of this article some of these problems are considered and possible solutions are discussed.

Problems of spinning superfine counts

First amongst possible problems is fibre loss during spinning. Possible fibre loss takes place with the upper and lower rollers of the drafting system, specially, for edge fibres (Fig. 1). Any fibre loss during spinning fine count will substantially reduce the number of fibres in the yarn cross section.

Another problem is fibres partially not contributing to yarn strength. This effect takes place while fibres are passing through the spinning triangle. Some leading fibre ends are not caught by the spinning triangle causing leading end hairiness and some trailing ends are also not imbedded into the yarn body while leaving the nip line causing trailing end hairiness. This effect increases with the increase of the height h of the spinning triangle.

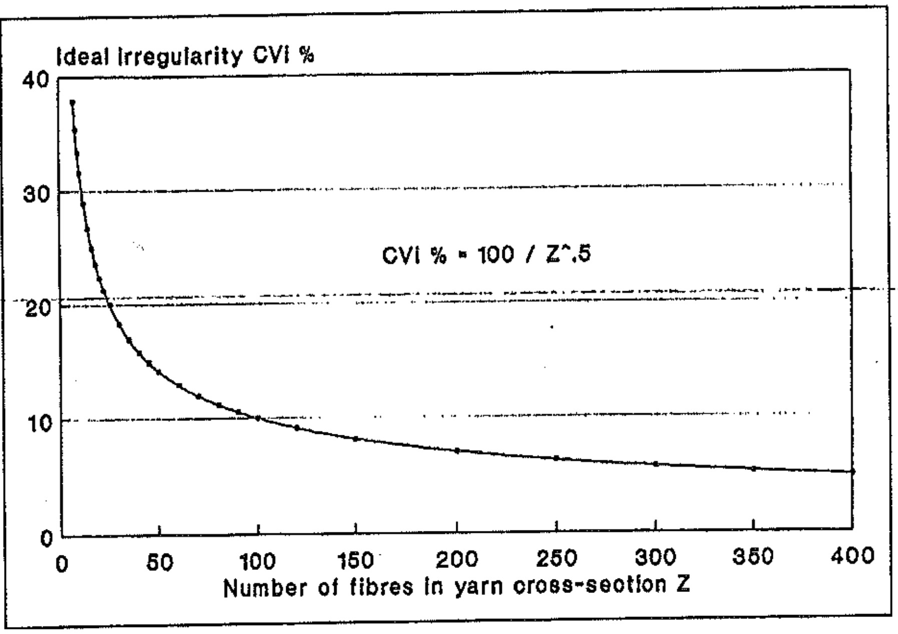

Fig. 2. Effect of the number of fibres in yarn cross-section Z on ideal regularity.

Variability of the number of fibres Z in yarn cross section (Fig. 2) is also a concern. As it is known, the variability of the number of fibres Z in the yarn cross section leads to mass variation in the yarn along its length which is expressed by CVm %. The ideal yarn irregularity (CVj % = 100/Z ^0,5) depends on the number of fibres in the cross section Z and increases very rapidly as shown in fig. 3 for fine counts with number of fibres Z less than 50.

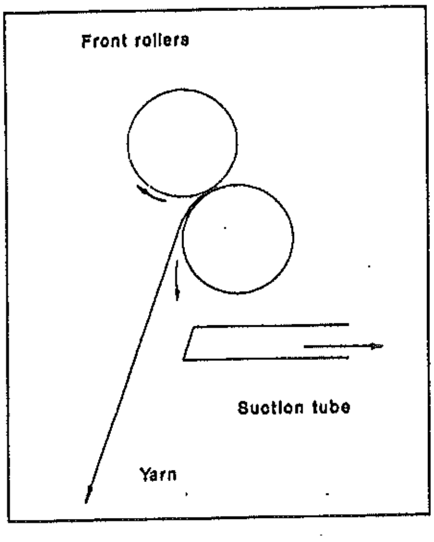

Fig. 1. Fibre loss

The variability of fibre length substantially reduces the resistance of the spinning triangle. The number of fibres which are double gripped between the twisting point and the nip line is reduced for higher fibre length variation.

Comparing the two cases of a constant fibre length l and a variable fibre length l^1 with a triangular distribution by weight, the number of fibres which are carrying load in a spinning triangle of height h = 0,1 of the fibre length is 90% of the fib gripped in the nip line in the first case and only about 64% in the second case. This high level of variability in fibre length will reduce the resistance of the spinning triangle and thus increase the ends down during spinning.

Generally, the spinning tension is not equally shared by all the fibres in the spinning triangle. This causes the well known phenomenon of fibre migration during spinning .

Another factor to be considered is variability of fibre strength (Fig. 3). It is well known that cotton fibres have great variation in strength, stiffness and breaking elongation. Assuming normal distribution of both breaking strength and elongation, the two equations f(λ) and CV(λ) given in Fig. 3 are derived, where f is the strength factor = max. breaking load of a fibre bundle/ (No. of fibres Z * average fibre strength F), CV is the coefficient of variation of the single fibre strength and (λ) is a parameter for max. breaking load of the fibre bundle. Eliminating the parameter (λ) from both equations, we get the relation between f and CV shown in Fig. 3; which gives the reduction of the max. breaking load of a fibre bundle for different values of CV. A coefficient of variation CV of 20% reduces the bundle strength more than 30%.

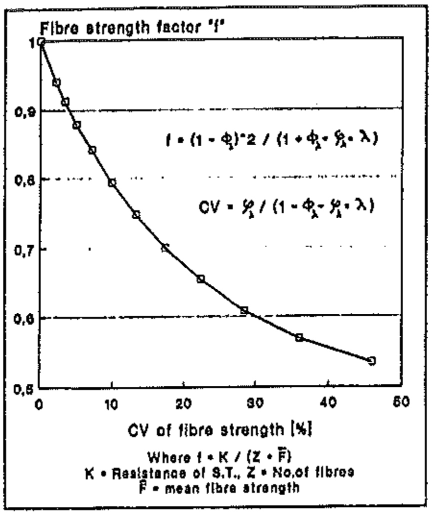

Fig. 3. Effect of variability of fibre strength.

The effect of fibre obliquity in the spinning triangle also has to be considered. The obliquity of the fibres in the spinning triangle reduces its resistance. This reduction is given by the obliquity factor as a function of the angle of inclination of the edge fibre in the spinning triangle to the yarn axis.

Also, the effect of the variation in fibre strength along its length. The strength of a cotton fibre varies also along its length. Thus its strength depends on the gange length l under tension and the variability of the strength CV^l.

It is important to consider the fibre configuration in the yarn, especially for extremely fine yarns. Assuming the fibre cross section to be circular, which is not exactly true for

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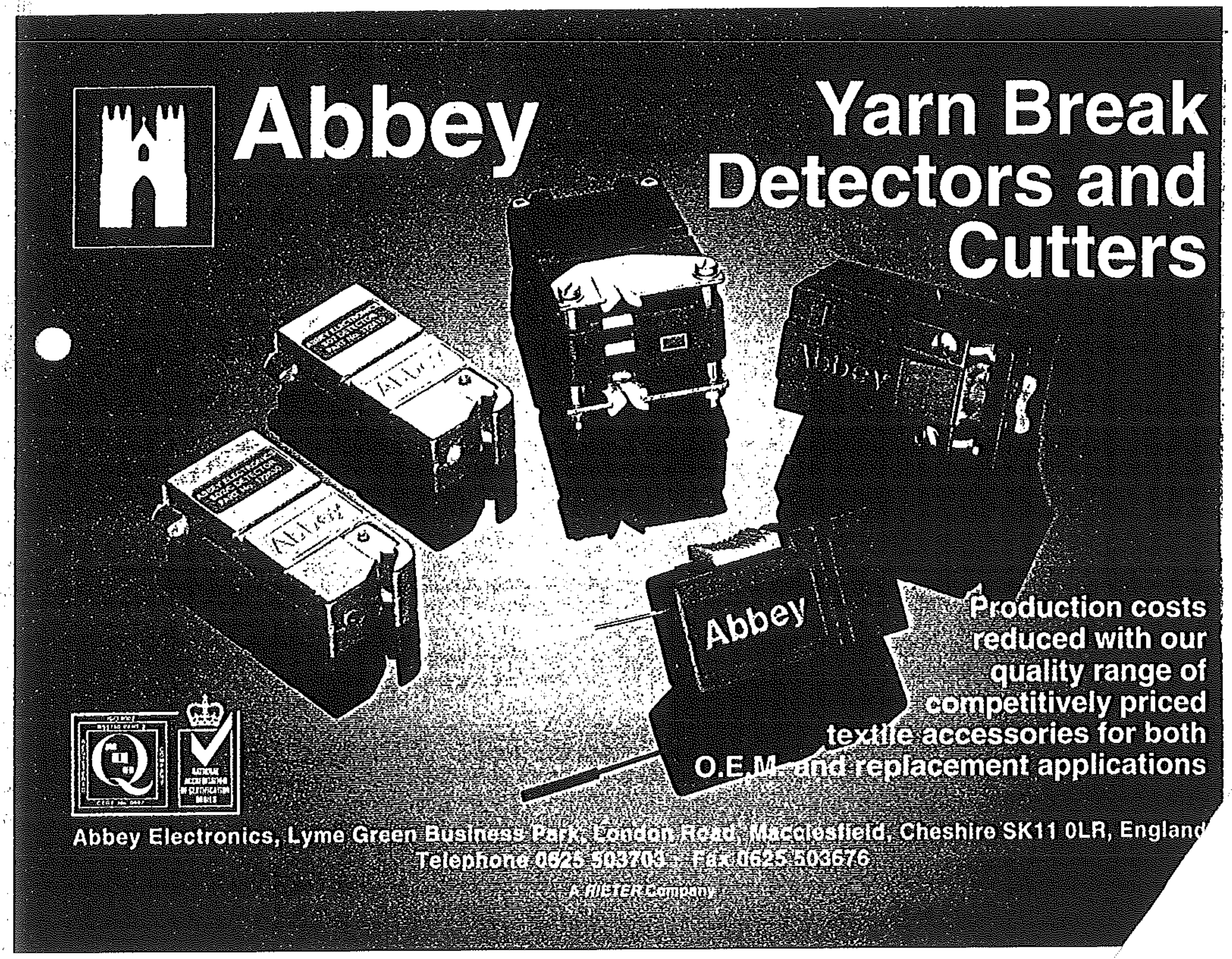

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cotton but holds true for many man-made fibres. Considering a fibre fineness of 2,8 Micronaire and 1,1 dtex (very fine cotton fibre, e.g. Giza 45), the corresponding yarn count and tex is given. A compact (also balanced) configuration can theoretically be achieved with number of fibres of 7, 19, 37, . . . etc.

The compact configuration with the least number of fibres (7 fibres) seems to be non-realistic (Ne 766 is unthinkable, as the absence of one fibre will greatly disturb the balance of the others). The theoretical number of ends down is also calculated and will be given in the following. The next compact configuration has 19 fibres and corresponds to Ne 282. Our spinning trials around this number of fibres are very promising. The fibre configuration is becoming less important for a larger number of fibres (> 40) in the yarn cross section.

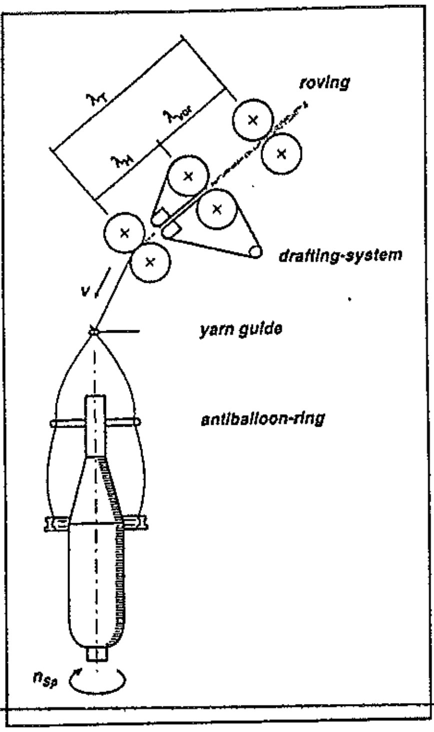

Fig. 4. Conventional spingeometry.

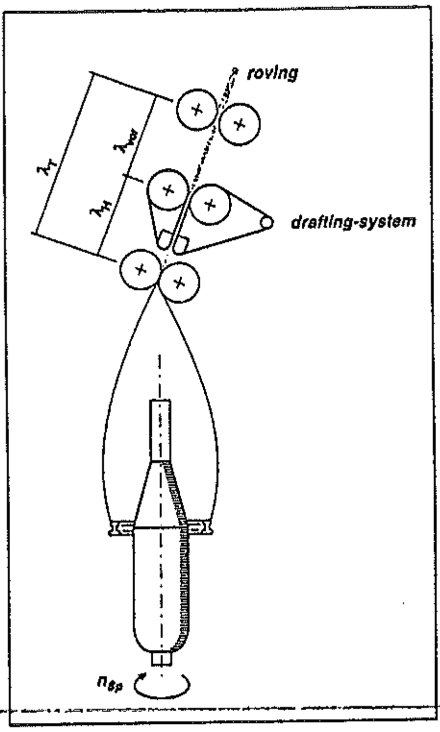

Fig. 5. Spingeometry of Super fine yarns.

Possible solutions

As mentioned before, a well prepared extremely fine roving (Ne 5-7) from top quality cotton (extra long staple and very high fineness) is a must for spinning superfine counts (Ne 300 and finer).

To study the problems of the ring spinning machine, some spinning trials were made at the Textile Institute of the Swiss Federal Institute of Technology (S.F.I.T.), in

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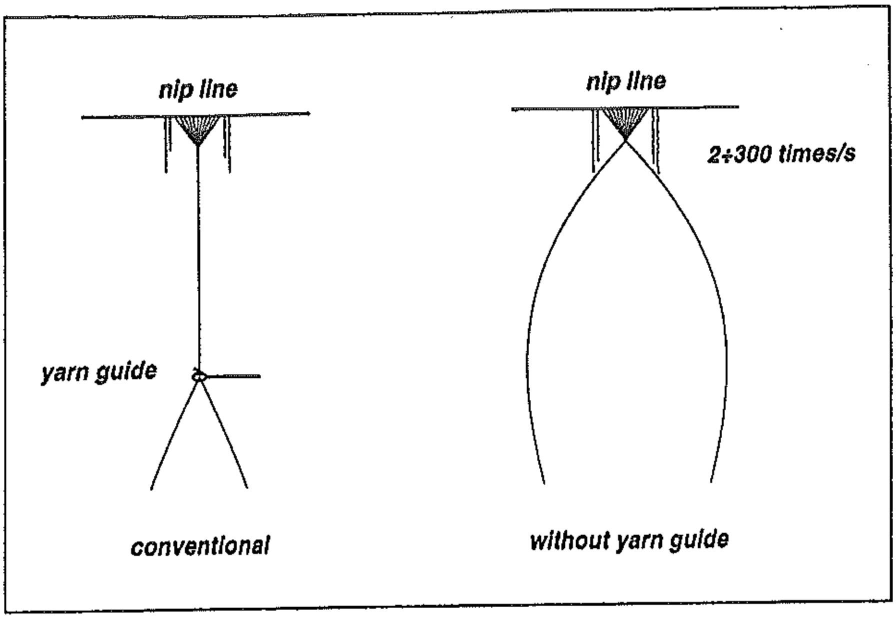

Fig. 6. Edge fibres during spinning.

Zurich, which will be reported shortly. The machine, used for these trials, was the Lab-Spinner of S.K.F., but with several changes in both spinning geometry and construction, as follows.

The friction between the yarn and the pig-tail and eventually between the yarn and the antiballoon-ring for conventional spinning geometry (Fig. 4) causes a twist accumulation in the down-stream of the yarn. This reduces the twist propagation to the spinning triangle with about 15% to 20% and in some cases even more. A modified spinning geometry (Fig. 5) eliminates this effect as it is possible to spin without both pig-tail and antiballoon-ring. The full twist is thus reaching the spinning triangle.

The height h of the spinning triangle is also reduced by increasing the inclination of the drafting system. This has some positive effects on different yarn properties as stated before.

The problems of the edge fibres are obviously reduced (Fig. 6), as the balloon apex is very near to the nip line. With this modified spinning geometry it was possible to spin counts up to Ne 300 with acceptable number of ends down and yarn quality.

For the three fibre configurations (with 13, 19 and 31 fibres), the theoretical ends down for ideal conditions according to Poisson's distribution of the number of fibres in the yarn cross section is given in against the relative yarn tension (the spinning tension as related to the strength of the yarn). The ends down are calculated as the Poisson's probability of the number of fibres in the cross section multiplied times the number of events corresponding to 1000 spindle hours. It is clear that the number of ends down increases very rapidly with high spinning tension and low number of fibres in the yarn cross section.

The DUOSPUN System

In this system two rovings are separately drafted, twisted and then doubled on the same spinning position. If one end breaks, the fibres are sucked to the other end by a specially designed tube (Fig. 7) and the single yarn break is automatically repaired. This system is already applied for long staple fibres (wool and man-made). Spinning trials are made with this system for long staple cotton to spin Ne 400/2. Satisfactory results are obtained as the probability of both ends to break at the same time is relatively small.■

Figure 7.