Effect of Fibre Length on the Quality of Rotor Yarns

K R SALHOTRA & TALAL S ALAIBAN
Department of Textile Technology, Indian Institute of Technology, New Delhi 110016

Received 12 September 1983; accepted 4 November 1983

It is generally accepted that fibre length is not as important a factor in determining the quality of rotor spun yarns as in the case of ring yarns. The influence of fibre length on yarn tenacity has been commented upon by many researchers. While some of them have reported increase in yarn strength with increase in fibre length, others have reported the reverse correlation. The present work in which the fibre length was varied, keeping all the other parameters same, has revealed the existence of an optimum fibre length for achieving the best yarn quality. A plausible explanation for such a behaviour has been offered.

It has been reported that in comparison to ring spun yarn the strength of rotor yarn is relatively insensitive to fibre length but much more sensitive to fibre linear density. Further, the effect of fibre length on the strength of rotor yarn is not as critical as in the case of ring yarns. London and Jordan also observed that the strength of rotor spun yarn is relatively insensitive to fibre length. Very little change in yarn strength was found when the fibre length was changed from 32 to 50 mm. According to Lüenschloss et al., short fibres are not detrimental to yarn strength in rotor spinning. However, they pointed out that over-long fibres can be particularly damaging while spinning on a rotor frame equipped with opening rollers. Vaughn and Rhodes found that yarns spun from short staple fibres are stronger and more even and have fewer thin places and neps than yarns spun from medium length fibres. From yet another study, it has been found that the strength of rotor yarn deteriorates rather than improves with increase in staple length. For instance, as the staple length was increased to 28.6 mm, the yarn strength deteriorated. Contrary to these findings, the yarn tenacity was found to increase with increase in fibre length for cottons. Another study with similar findings revealed that increase in mean fibre length causes increase in the strength of rotor yarns. According to yet another report, beyond a certain fibre length, there is no further increase in yarn strength. It can, therefore, be concluded that there is a wide disagreement in respect of the effect of fibre length on yarn quality, especially the yarn strength. The present study was aimed at investigating this aspect and providing a plausible explanation.

Materials and Methods
As the specific aim of the present investigation was to study the effect of fibre length on yarn quality, it was essential to ensure that all the other fibre characteristics were kept constant. To fulfil this requirement, a tow of viscose rayon was procured and cut into staple fibres of 25, 30, 35 and 40 mm lengths with a tow cutter. The fibre denier was 2.0.

Preparation of yarn samples—From the cut staple of a given fibre length, 40 g material was taken and passed twice through the Shirley miniature card and then given two passages on Platt's drawframe to produce a resultant sliver of 0.2 Hk. The sliver was fed to Suessen OE spin tester to spin 20° yarn. Some other particulars on this rotor frame were as follows: Rotor diam., 46 mm; rotor speed, 40,000 rpm; and yarn twist multiplier, 4.5. The opening roller speed was varied from 4000 to 8000 rpm. The clothing of the opening roller was OS21, as recommended for processing man-made.

Testing of yarn samples—Yarn samples were tested for tenacity on Uster single thread tester and for evenness and imperfections on Uster evenness tester. The sensitivity level was 3 for thick places and neps and –50% for thin places. The number of readings for tenacity and evenness was 200 and 8 respectively.

Results and Discussion
The effect of fibre length on yarn quality is obvious from the data given in Table 1. Initially, there is an increase in yarn tenacity as the fibre length increases followed by a drop in tenacity at the longer lengths. The trend is the same at all the opening roller speeds, viz. 4000, 6000 and 8000 rpm, with the highest speed producing the weakest yarns. The curves in Fig. 1 indicate an optimum fibre length from the point of view of yarn tenacity.

The unevenness of yarn (U%) and the total number of imperfections (Table 1) also show that there is an initial improvement in these properties with increase in
fibre length followed by deterioration. The relationship between yarn unevenness (U%) and fibre length at three different opening roller speeds is shown in Fig. 2. The curves show similar trends as those for tenacity.

These results on yarn tenacity and evenness, therefore, bring out the following facts:

1. Fibre length has a significant effect on yarn quality parameters like tenacity, evenness and imperfections.

2. There is an optimum fibre length (in the present case 30 mm) which gives the best yarn quality.

The deterioration in yarn quality cannot possibly be attributed to the rotor diameter being small for longer fibres. According to Grosberg and Mansour, the value of the ratio of rotor diameter to fibre length should not be below 1.1. Accordingly, the diameter needed for processing 40 mm fibre, the longest fibre used in the present study, should not have been lower than 44 mm, which obviously had been so.

These trends in yarn tenacity could possibly be explained by the influence of the following four factors in relation to fibre length: (i) Change in fibre strength, (ii) percentage of wrapper fibres, (iii) twist loss, and (iv) mean fibre extent.

It has been shown earlier that fibres during opening may suffer loss in tenacity, especially at higher opening roller speeds. Chattopadhyay, while working on similar fibres as used in the present study, found that long fibres, especially 40 mm fibres, suffer significant loss in tenacity. This loss increases with increase in opening roller speed, as is evident from Table 2. There is practically no loss in fibre bundle tenacity for 25, 30 and 35 mm fibres at 4000 rpm opening roller speed. At 6000 and 8000 rpm, there is...
some reduction in tenacity for these fibre lengths. Such a loss in fibre tenacity could be partly responsible for a sharp fall in the tenacity of yarn spun from 40 mm fibres.

Regarding the incidence of wrapper fibres in relation to fibre length, it has been well established that long fibres give a higher percentage of wrappers\textsuperscript{12,13}. This second factor can, therefore, further contribute to the lower strength of yarn spun from long fibres, as the wrappers do not contribute much to the yarn strength.

The phenomenon of twist loss seems to be equally important in this regard. It has been shown earlier\textsuperscript{12} that there is a very good correlation (negative) between the percentage of sheath fibres (wrappers) and the twist efficiency. Longer fibres, therefore, produce yarn with a greater twist loss, i.e. a lower actual twist. This factor can therefore further lead to reduction in the strength of yarns produced from long fibres.

The mean fibre extent in the yarn seems to be one factor that can possibly go in favour of using long fibres, which will obviously give a higher mean fibre extent. A higher mean fibre extent makes a stronger yarn\textsuperscript{14}. However, after a certain length, increase in mean fibre extent is not expected to be much.

Considering the above-mentioned facts, it can be expected that the yarn from short fibres would be weak due to the low mean fibre extent in the yarn. Increase in fibre length can, therefore, lead to increase in yarn strength. However, after a certain fibre length, the factors adversely affecting the yarn strength, i.e. loss in fibre bundle strength, lower twist efficiency and increased wrappers, could outweigh the advantage of slightly higher mean fibre extent and produce a weaker yarn.

Yarn unevenness and imperfections depend primarily on the extent of fibre separation, which, in turn, is determined by the clothing specifications of the roller and its speed in relation to feed. At a given opening roller speed, a shorter fibre is expected to be better separated than a longer fibre. The results do show that yarns spun from 35 and 40 mm fibres give a higher U\% than yarns spun from 30 mm fibres (Table 1). It is also observed that increase in opening roller speed gives a more regular yarn with all the fibre lengths used. These facts testify to the hypothesis that better fibre opening gives more regular yarn. However, the reasons for higher unevenness and imperfections in yarns spun from shorter fibres (25 mm) are not very clear. In an earlier study\textsuperscript{7} too, the same trend was observed for viscose rayon fibres, though for cotton fibres there was no such deviation from the expected trend, i.e. the shorter the fibre the better is the yarn evenness.

Conclusion
There is an optimum fibre length for achieving the best quality in rotor spun yarns. This optimum length is the same irrespective of the opening roller speeds used. A higher opening roller speed gives a slightly lower yarn tenacity, but a better evenness.

References
1 World OE Bull, 1(3, 7 and 8) (1977).
5 Am Text, The Knitter, 3(5) (1972) 52.
11 Chattopadhyay R, Indian Institute of Technology, New Delhi, Personal communication.
14 Nield R, Open-end spinning (The Textile Institute, Manchester), 1975, 52.