Influence of Number of Draw Frame Passages on Fibre Hooks inside Rotor

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The number of draw frame passages had a marginal influence on the magnitude of hooks in the rotor; the direction of feed had no effect. The mean hook extent of the rotor fibre ring was affected neither by the draw frame passages nor by the direction of feed, but was always less than the mean hook extent of the feed sliver.

Keywords: Draw frame, Fibre hooks, Rotor spinning

1 Introduction

The structure of rotor-spun yarn is entirely different from that of its ring-spun counterpart. The presence of hooked, looped and folded fibres gives the yarn much of its unique character. However, at the same time, these fibres are partly responsible for the lower tenacity of rotor yarn compared to ring yarn. In rotor spinning, once the desired number of layers of fibres is deposited inside the rotor, the accumulated layers are simply twisted and then lifted from the rotor groove to form the yarn. The configurations of fibres in the yarn core will therefore be almost similar to those of fibres in rotor fibre ring. Hence, the parameters affecting the configurations of fibres in the rotor ring will also influence the fibre shapes in the yarn. Besides, according to Artz, fibre configuration in rotor ring can also affect the spinning properties. Singh and coworkers have shown how the configurations of fibres and their orientation are affected by various processing parameters like opening roller speed, wire angle and density, and suction draft. However, information on how and to what extent the number of draw frame passages and the feed direction of the sliver influence the configurations of fibres in the rotor fibre ring is scanty. Hence the present study in which the fibre configuration has been characterized in terms of hooks.

2 Materials and Methods

2.1 Preparation of Sliver

The tracer fibre technique was used. Some fibres were dyed with a solution of a whitening agent (Skay White) and dried at room temperature. The dyed fibres were used as tracers. The tracer fibre thus prepared was mixed with the normal viscose rayon fibre, the concentration of tracer in the mix being 0.05%. About 40 g of the tracer-mixed fibre was spread evenly on the feed table of a Shirley miniature card and passed twice through it. The web produced at the second passage was passed through a trumpet to obtain a carded sliver of 0.56 hank. The card was then stopped, cleaned and the procedure was repeated so as to produce a sufficient quantity of sliver. A part of the carded sliver was separated and the rest was processed on a Platt's miniature draw frame, by keeping a draft and doubling six. Part of this once-drawn sliver was kept as such, the rest being given one more passage. The process was repeated to obtain slivers drawn once, twice, thrice and four times.

2.2 Collection of Fibre Rings

Three ends of the same sliver, containing the tracer fibres, were fed simultaneously to a Suessen OE spin tester, so that the resultant linear density of the sliver fed was 3.2 g/m (0.185 hank). The feed rate, opening roller speed and the rotor speed were 8.3 mm/s, 108.3 rps and 750 rps respectively. The slivers were fed both in the normal and in the reverse directions so as to enable the majority hooks to be fed as leading and trailing hooks to the opening roller. The machine was stopped after 10s of running and the deposited fibre ring was gently removed from the rotor groove. The procedure was repeated a number of times in order to collect a large number of fibre rings from each type of sliver.

2.3 Noting down Fibre Configuration

The parent sliver and the corresponding fibre rings were put under ultraviolet light and viewed through a
powerful magnifying glass so as to note the configurations of the tracer fibres. The extent of hooks was then measured. The fibre configuration in the sliver was classified as majority, minority and both-end hooks. Majority and minority hooks are those that trail and lead in the carding respectively. The fibre hooks in the rotor fibre ring were classified as leading and trailing hooks. Here, leading hooks are those whose hook direction matches the direction of rotation of the rotor and the reverse is true for trailing hooks.

The mean hook extent was determined by calculating the average of the values collected on individual hook extent; the total hook extent was determined by multiplying the mean hook extent by the total number of hooked ends (in percentage) observed.

3 Results

3.1 Influence of Number of Draw Frame Passages on Hooks inside Rotor

In Fig.1, the proportions of hooked fibres in the rotor fibre ring and in the respective feed slivers are shown as a function of draw frame passages. As is expected, the proportion of hooked fibres in the feed sliver decreases progressively with increase in the number of draw frame passages. 71% and 17% hooks of the feed sliver correspond to approximately 66% and 45% hooks in rotor fibre ring. The slopes of the two lines are different, the line representing the hooks in feed sliver has a higher negative slope than that of rotor ring, implying the percentage of hooks present in the feed sliver to be much more sensitive to the number of draw frame passages than that of rotor fibre ring. The direction of feed does not seem to have any effect on the magnitude of hooks present inside the rotor. The same trend was observed by Lunenschloss also.

Irrespective of the direction of feed till once-drawn sliver, the proportion of hooked ends in the rotor ring is almost the same as that of feed sliver, but beyond this the number of hooks in the rotor is greater than that in the feed sliver. The opening roller has, therefore, the capability to generate hooks.

Since the hooks present in the rotor also consist of leading, trailing and both-end hooks, it becomes necessary to know how the same factor influences separately the proportion of leading and trailing hooks inside the rotor. Fig.2 shows that both types of hooks have a general tendency to decrease with increase in the number of draw frame passages. The proportion of leading hooks is always more than that of trailing hooks, irrespective of the direction of the feed.

To assess the degree of association between the proportion of hooks fed in and the proportion of hooks observed in the rotor fibre ring, correlation coefficients and regression equations were found out for both the directions of the majority hooks present. For majority hooks being fed in the leading and trailing directions, the correlation coefficients were 0.69 and 0.71 respectively. The equations of the best-fit lines were:

\[ Y = 0.24X + 44 \text{ (majority hooks fed as leading)} \]
\[ Y = 0.32X + 39 \text{ (majority hooks fed as trailing)} \]

where \( Y \) is the proportion of hooked ends in the rotor, and \( X \) the proportion of hooked ends in the sliver.

3.2 Influence of Number of Draw Frame Passages on Mean Hook Extent

Fig.3 shows that the mean hook extent of the hooked fibres inside the rotor is always less than that of the feed sliver. Both the direction of feed and the number of draw frame passages seem to have no influence on the mean hook extent of the rotor fibre ring.

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Fig. 1—Effect of the number of draw frame passages on proportion of hooked ends

Fig. 2—Effect of the number of draw frame passages on leading and trailing hooks in the rotor ring
3.3 Influence of Number of Draw Frame Passages on Total Hook Extent

In Fig. 4, the total hook extent for the rotor fibre ring and the respective feed slivers are plotted against the number of draw frame passages for the two different directions of feed of the majority hooks. Here also the total hook extent in the rotor fibre ring follows the same downward trend. The direction of feed also appears to have no effect. However, the total hook extent of feed sliver is much more than that of rotor ring till once-drawn sliver; beyond this the trend is reversed. The considerable reduction in the total hook extent till once-drawn sliver owes to the reduction in the mean hook extent since the proportion of hooks does not change much as shown in Fig. 1. Beyond this, the increase in the total hook extent compared to feed is either due to increase in the proportion of hooked ends or to the hook extent.

The total hook extent of the leading and trailing hooks of the rotor fibre ring for the two different directions of feed of the majority hooks is plotted against the number of draw frame passages in Fig. 5. As in the case of the magnitude of hooks, the total hook extent of the leading hooks, irrespective of the direction of feed, and total hook extent of both types show a diminishing trend with draw frame passages.

The correlation coefficients between the total hook extent of the feed sliver and rotor fibre ring, for the two different directions of feed, were 0.71 (for majority hooks being fed, as leading, to the opening roller) and 0.65 (for majority hooks being fed, as trailing, to the opening roller) respectively. The equations of the best-fit lines were:

$$Y = 0.23X + 238 \text{ (majority hooks fed as leading)}$$

$$Y = 0.22X + 257 \text{ (majority hooks fed as trailing)}$$

where $Y$ is the total hook extent of rotor fibre ring; and $X$, the total hook extent of feed sliver.

4 Discussion

The suppression of hooks and the extent to which they are suppressed during fibre separation and transportation may be ascribed to the following factors: (i) The combing action of the teeth of the opening roller on the leading ends of the fibres held in the feed nip; (ii) the brushing action the trailing ends of the fibres experience when they are released from the feed nip and pass through the fibre beard held at the nip; (iii) the action of suction draft operating in the transport channel; and (iv) the rubbing action of the trailing part of the fibres against the inner surface of the transport channel when the leading ends, after
having been deposited on the rotor wall, are carried forward rapidly.

Of these, the last three will be effective in straightening out the trailing hooks, whereas the first will be effective in removing leading hooks only.

The generation of hooks, when a well-parallelized sliver is fed, could be due either to the action of the teeth of the opening roller, which remove the fibre after making them hook around the teeth\(^2\), or to the impact of the fibres against the wall of the transport channel when they are thrown with a high force owing to the centrifugal force acting on them. When a card or once-drawn sliver, where hooks are too many, is fed, the proportion of hooks straightened out by these four factors is almost equal to that of hooks generated out of the small percentage of straight ends present in the sliver as well as of the percentage escaping straightening-out action. As a result, there is no change in the magnitude of hooks compared to that of feed. Therefore, the total reduction in hook extent compared to feed is basically due to the reduction in mean hook extent. As one feeds a well-parallelized sliver, the mean hook extent of the fibre ring does not change as such, but the hooks generated out of the large number of straight fibres present in the sliver outnumber the hooks removed from a small percentage of hooked ends present in the sliver. As a result, there is an overall increase in the proportion of hooked ends to such an extent that even though the mean hook extent of the feed sliver remains always greater than that of the fibre ring, the total hook extent of the fibre ring becomes more compared to that of the feed sliver.

The mean hook extent of the fibre ring was influenced neither by the number of draw frame passages nor by the direction of feed. However, the mean hook extent of the fibre ring was always less than that of feed sliver. This is because a large number of hooks is reduced in size rather than being completely straightened out, resulting in a reduction in the mean hook extent. Since the total hook extent is the product of mean hook extent and the total number of hooks, and since the mean hook extent is not influenced by both the number of draw frame passages and the direction of feed, the response of the total hook extent of the fibre ring to draw frame passages and feed direction would be exactly similar to the response of the total number of hooks to draw frame passages and feed direction. The ultimate number or proportion of hooks to be expected inside the rotor depends upon the balance of factors like the proportion of hooks generated or removed and the proportion of hooks passing intact to the rotor groove. Similarly, the mean hook extent depends upon the balance of factors like the number and size of the newly generated hooks and the number of hooks reduced or increased in size. For a sliver that has undergone a particular number of draw frame passages, the above-mentioned factors probably balance each other in such a fashion that the direction of feed ultimately shows no effect. The slight reduction in the proportion of hooks with draw frame passages is probably due to the reduction in the proportion of hooked ends of the sliver being fed to the machine. When hooked fibres pass through transport channel the trailing hooks only possess a fair chance of getting straightened out by the suction draft and factor (iv) mentioned earlier. Hence the leading hooks are always in excess of trailing hooks.

The correlation coefficients show that the degree of association between the hooks or the hook extent of sliver and rotor ring is not very poor. The higher values of the correlation coefficient in both the cases when majority hooks are fed in the leading direction could be due to a lesser probability of a leading hook being straightened out during the separation and transportation process. The physical significance of the intercepts of the regression equations is the fact that even if a sliver completely free from hooks is fed, one could expect a larger number of hooked ends in the rotor ring.

5 Conclusions

The magnitude of hooks and their total extent in the rotor ring are only marginally affected by the number of draw frame passages. The direction of feed of majority hooks does not seem to have any effect.

The mean hook extent of the rotor fibre ring, which is always less than that of feed sliver, does not change with draw frame passages. The direction of sliver feed has no influence on it.

The total hook extent of the rotor fibre ring is much less compared to that of feed sliver till once-drawn sliver; beyond this the trend gets reversed.

A certain proportion of hooks in the rotor can always be expected even if a sliver free from any hooks is fed.

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