Rotor machine variables and yarn structure: Part II—Influence of machine variables on fibre reversal during deposition and peeling-off of the fibres

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Fibre reversal is more during peeling-off of the fibre from rotor groove in comparison to that during fibre deposition at rotor groove. Fibre reversal at rotor groove first decreases and then increases with the increase in rotor speed, whereas it increases with the increase in opening roller speed. The percentage of reversed fibres during peeling-off increases on increasing rotor speed but it is not influenced by the increase in opening roller speed and rotor diameter.

Keywords: Fibre deposition, Fibre peeling-off, Fibre reversal, Yarn structure

1 Introduction

It is well known that the fibres in rotor spinning change their direction during the process of laying in the rotor groove and transformation into a yarn. Neild and Lawrence and Chen have proposed the mechanism of fibre reversal at rotor groove. Chattopadhyay and Sarkar have studied the effect of opening roller speed on fibre reversal and Ishtiaque et al. have studied the influence of fibre denier and fibre cross-section on fibre reversal.

If the fibres get reversed during deposition, the smooth flow of fibres in the transport tube might be affected, resulting in the disorderness of fibres in the rotor groove and finally in the yarn. This means that hook formation or complete reversal of fibre in rotor spinning will significantly deteriorate the yarn quality. The influence of opening roller speed on fibre reversal has been studied by several researchers but very less information is available about the combined influence of machine variables on fibre reversal. Therefore, in the present work, an attempt has been made to study the influence of rotor machine variables, viz. rotor speed, rotor diameter and opening roller speed, on fibre reversal during fibre deposition at rotor groove and peeling-off from rotor groove.

2 Materials and Methods

Tracer fibre technique was used in the present study. The polyester fibres of 38 mm × 1.2 D were dyed with their one half with red colour and other half with black colour. The second drawn sliver of 0.18 hank, after adding the tracer fibres, was fed to rotor with tracer fibres having their black end in the leading direction. In total, 100 rings were collected and simultaneously the yarn samples were prepared for all the combinations by using three-variable design proposed by Box and Behnhen, as discussed earlier, to see the influence of fibre reversal at rotor groove and during peeling-off from the rotor groove.

3 Results and Discussion

It may be observed from contours in Figs 1 and 2 and Tables 1 and 2 that the percentage of reversed fibres at rotor groove marginally decreases up to 55,700 rpm rotor speed and then increases with further increase in rotor speed, while on increasing the opening roller speed, it continuously increases. For higher rotor and opening roller speeds, the increase in the percentage of reversed fibres is more. It is noticeable that the opening roller speed is more responsible for fibre reversal. The reversal of fibres decreases up to 50.4 mm rotor diameter after which there is not much change with further increase in rotor diameter.

In case of yarn, it is observed that the percentage of reversed fibres increases with the increase in
Fig. 1—Effect of opening roller speed, rotor speed and rotor diameter on percentage of reversed fibres during deposition (rotor diameter: (a) 36 mm, (b) 46 mm, and (c) 56 mm)

Fig. 2—Effect of opening roller speed, rotor speed and rotor diameter on percentage of reversed fibres during peeling-off (rotor diameter: (a) 36 mm, (b) 46 mm, and (c) 56 mm)
rotor speed, while it is not affected much with the increase in opening roller speed. At the same time, the change in rotor diameter also has not shown any influence on fibre reversal. On comparing the fibre reversal at rotor groove and in yarn, it is observed that the fibre reversal is more from rotor groove to yarn in comparison to that from feed sliver to rotor groove. This indicates that peeling-off from rotor groove is more responsible for fibre reversal. It is also observed that the opening roller speed and rotor diameter have a significant effect on the contribution of broken fibres towards the fibre reversal. Results show that with the increase in the opening roller speed and rotor diameter, the fibre reversal of broken fibres increases, while rotor speed does not show any effect on it.

3.1 Reversal due to Deposition at Rotor Groove

In general, the possibility of fibre reversal is to be placed at the following stages: Opening zone; Transport zone; Circumferential opening to the trash box; and Rotor groove.

In the rotor spinning machine, when a fibre arrives at stripping zone, the high velocity air stream, along with the reduction in pressure in the radial direction away from the opening roller and turbulence due to air associated with the opening roller and sucked air, tries to dislodge the fibre from the surface of opening roller\(^3\). But if the front end of fibre is firmly held by the teeth of the opening roller, either by being hooked around the teeth or by its frictional association with other fibres attached to the teeth, the high velocity air stream (which normally moves at much higher speed than the opening roller surface speed) will move the fibre trailing end by the time the fibre reaches the stripping plate, resulting in fibre reversal. If this is accepted as the reason for fibre reversal then we can work out the extent of reversal to be influenced by the magnitude of relative velocity between the opening roller surface and the air stream passing over it, and the firmness of the grip by the teeth at the leading end of the fibre. The increase in the extent of reversal at high opening roller speed at rotor groove may therefore be due to the increase in the magnitude of relative velocity. But Chattopadhyay and Sarkar\(^3\) found that the extent of the fibre reversal decreases with the increase in opening roller speed.

On leaving the opening roller, the fibres enter in the transport tube from where they are transported to the rotor sliding wall, generally with the help of air suction. This air suction or negative pressure is essential to accelerate the fibres in order to maintain and even improve the degree of opening and fibre orientation. The state of the order of fibres at the entrance of the transport tube has a decisive influence on the degree of opening and orientation of fibres at the exit of the transport tube and thus on the properties of the spun yarns. It is, however, desirable that the air flow inside the transport tube
must maintain a velocity gradient suitable to accelerate the leading ends of the fibres throughout their uncontrolled journey in the transport tube. The velocity of air flow at the entrance of the transport tube is 1.5-4.0 times of the circumferential speed of opening roller which suitably gets further increased along the transport tube as it tapers towards the rotors. The fibre which is floating in middle of the transport tube will reach the rotor surface in straight condition. The fibre whose leading end touches the inner wall of the transport tube reduces the speed of leading end. There are chances that the speed of the trailing end of such a fibre may exceed over that of the leading end and/or the trailing end of the fibre may come in contact with another fast moving fibre, causing the fibre reversal.

It is clear from the results that the fibre reversal first marginally decreases with the increase in rotor speed and then increases with further increase in rotor speed. This can be explained on the basis that the fibre which is moving in the middle of the transport tube will reach at rotor groove without any reversal. But the fibre whose leading end touches the inner wall of the transport tube reduces the speed of leading end. There are good chances that the speed of the trailing end of such a fibre may exceed over that of the leading end and/or the trailing end of the fibre may come in contact with another fast moving fibre, causing the fibre reversal.

As rotor diameter increases, the curvature of fibre at rotor groove reduces which helps in decreasing the fibre reversal.

3.2 Reversal during Peeling-off of Fibres

There are equally good chances of fibre reversal while the fibres are peeled-off from the rotor surface. The fibres leaving the transport tube are deposited on the inner surface of rotor groove and then peeled-off and withdrawn in the reverse direction. It may be seen from the results that the increase in rotor speed increases the fibre reversal. The fibres picked up in this way would be expected to assume basically a helical form, distorted to some extent by migrating from the yarn surface to its axis and back again as a result of difference in tension in the fibre. Such type of fibres will definitely improve the fibre extent in the yarn and thus yarn tenacity.

Obviously, some disturbances must take place whenever the yarn arm passes the fibre entry point. Some fibres are overtaken by the yarn while they are in the process of emerging from the tube before they become fully deposited on the surface of rotor. One possibility is that the leading end of the fibre is picked up by the yarn while its trailing end is thrown onto the surface of the rotor. In this case also, the fibre in the yarn would be expected to assume helical form distorted by migrating. But in this case, one may notice two important points. Firstly, there is no fibre reversal and secondly, the trailing end of the fibre is drawn through the fibres on the surface of the rotor so that it disturbs and distorts some of them and thus decreases the fibre extent in yarn.

The other category is where the fibres are partly emerged from the tube so that although their leading ends are on the surface of rotor, trailing ends are in the tube when the yarn arm sweeps off. Such fibres may or may not reverse and this will depend on picking point by yarn tail along its length. But such fibres will have certainly leading hooks. Therefore, such fibres will definitely decrease the fibre extent in the yarn significantly. The probability of such fibres in this category will depend on fibre length and rotor diameter. The increase in rotor diameter decreases the proportion of such fibres in yarn.

On the basis of our findings, about 71-77% fibres are falling in the first category and rest in second and third categories. The fibres of second and third categories are responsible for fibre disorder in the yarn.

4 Conclusions

4.1 The percentage of reversed fibres at rotor groove first decreases and then increases with the increase in rotor speed, whereas it increases with the increase in opening roller speed.

4.2 At higher rotor and opening roller speeds, the increase in percentage of reversed fibre is more.

4.3 The reversal of fibres decreases with the increase in rotor diameter up to 50.4 mm and remains almost constant with further increase in rotor diameter.

4.4 The percentage of reversed fibres during peeling-off increases on increasing rotor speed but it is not influenced with the increase in opening roller speed and rotor diameter.
4.5 Fibre reversal is more from rotor groove to yarn (i.e. during peeling-off) in comparison to that from feed sliver to rotor groove (during deposition). The reversal at these zones will also be responsible for fibre orientation at rotor groove and will influence the yarn characteristics significantly.

References