Effect of Doffing Tube Design on Yarn Quality and Rotor Spinning Performance

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It is well established that the design of the doffing tube has considerable influence on the spinning performance and the yarn characteristics due to its false twist action. The false twist, which increases the twist of the yarn between the peel-off point and the doffing tube, is a consequence of the rolling action of the yarn on the inner surface of the tube. This increases the torsional moment at the end of yarn at the rotor groove.

In rotor spinning, most of the end breaks occur at or near the collecting groove. The false twist effect can, therefore, be used advantageously to reduce end breakages. To this end, the use of grooved doffing tubes has been quite successful. However, too much false twist can extend the yarn forming zone (also known as peripheral twist extent) too far and can lead to bridging fibres being picked up by the yarn after some or all of the twist has been inserted. The level of false twist has, therefore, to be chosen carefully through correct selection of shape, position and surface finish of the doffing tube. Van der Merwe and Veldsman obtained an improvement in yarn characteristics by inserting a spacer and so reducing the distance between the doffing tube and the base of the rotor by 2 mm.

For the spinning of short staple Indian cottons, which ordinarily require very high twist levels, the lowering of minimum twist through proper selection of doffing tube, at which yarns could be spun satisfactorily, is of considerable importance. The present study has, therefore, been made on a number of short staple Indian cottons to compare the performance of two types of doffing tubes (differing in shape and length) provided by the manufacturers of BD 200 RC. The performance has been assessed in terms of yarn quality, spinning performance and rotor deposit.

Materials and Methods
Four cottons, including two varieties of J-34, were used for large scale trials. The main characteristics of cotton fibres used are given in Table 1.

Laps were made on a conventional blow room line from each variety and carded on the M M C Tandem card. The card sliver was given two passages of drawing on the Platts drawframe (4/4 drafting system) to produce a finisher sliver of 0.12Hk.

The finisher sliver was spun to 50 tex (128 cc) yarn on BD 40 RC (40 denotes the number of rotor units in the machine) at a speed of 31,000 rpm using the two types of doffing tubes. The tubes along with their dimensions are shown in Fig. 1. The combing roller speed was kept constant at 7000 rpm for all the spinnings.

At the end of each spinning, the machine was stopped. The rotor deposit was scraped by a soft pointed brush and collected on a piece of paper by tilting the rotor and brushing out the deposit. It was weighed on a sensitive digital balance and expressed in decigrammes per 100 g of material processed.

The yarns were then tested for tensile properties on the Uster single thread tester and for uniformity on the Uster evenness tester. The number of observations for these tests was 200 and 10 respectively.

Table 1—Characteristics of Cottons Used

<table>
<thead>
<tr>
<th>Cotton variety</th>
<th>Effective length (mm)</th>
<th>Proliferous bundle tenacity (g/tex)</th>
<th>Fineness (micronaire)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bengal desi</td>
<td>18.0</td>
<td>10.7</td>
<td>6.52</td>
</tr>
<tr>
<td>J-34, roller ginned (RG)</td>
<td>24.0</td>
<td>15.2</td>
<td>4.01</td>
</tr>
<tr>
<td>J-34, saw ginned (SG)</td>
<td>24.6</td>
<td>16.8</td>
<td>4.01</td>
</tr>
<tr>
<td>1007</td>
<td>28.6</td>
<td>17.2</td>
<td>4.14</td>
</tr>
</tbody>
</table>

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Results and Discussion
The characteristics of the yarns spun with large and small doffing tubes are shown in Figs 2-7. The yarns spun with the large doffing tube have, on an average, 10\textdegree, higher tenacity than those spun with the small doffing tube (Figs 2 and 3). The higher value of yarn tenacity could be the outcome of the following factors favourable to the large doffing tube: (1) The higher torsional moment at the end of the yarn, due to the larger bearing surface of the large doffing tube, and the reduced distance between the doffing tube and the base of the rotor causes increased compactness of the yarn during the initial yarn formation stage. This increased compactness is retained to a large extent by the ultimate yarn, resulting in increase in the inter-fibre cohesion, which is a significant factor for the rotor spun yarns from short staple cottons. This is borne out by the lower values of diameter of the yarn spun using
the large doffing tube. The average values of yarn diameter for the yarns spun with small and large doffing tubes were 0.36 and 0.32 mm respectively. As the tube is lowered because of the thicker trumpet portion (4.8 mm for the large tube as compared to 3.75 mm for the short tube), the spun yarn will lie partially on the base of the rotor. The yarn rolls against the base as the twist is inserted, so that the projecting fibres are tied into the yarn structure and do not become loose under tension. As one can expect, the changes in the level of internal twist will not influence the yarn unevenness. This is borne out by the fact that the U% values for yarns spun with the large and the small doffing tubes show very little difference (Figs. 6 and 7). However, the breaking elongation shows a lower value for yarns spun with the large doffing tube (Figs 4 and 5). This could be ascribed to the higher compactness of such yarns due to the higher internal twist in the rotor. As rotor spun yarns have higher breaking elongation compared to the ring spun yarns, such marginal difference will not be of much consequence.

Data presented in Table 2 show the breaks per kg of yarn spun with a range of twist multipliers which are likely to be used in practice. The breakage rate shows a substantial decrease when the large doffing tube is used. This decrease is brought about by the higher false twist action of the large doffing tube.

The above results bring out the interesting fact that the yarn tenacity and end breakages could improve simultaneously with a presumably higher false twist effect. It could, therefore, be recommended that for this rotor spinner the large doffing tube should be used for spinning the short staple Indian cottons. The recommendation for using the large doffing tube gets further support from the results on rotor deposit (Fig. 8). The rotor deposit values for the large doffing tube are almost one-half to one-fourth of those obtained with the smaller tube. This result is in conformity with the conclusions of some other workers who have shown that the rotor deposit goes down as the spinning twist is increased. An increase in the internal twist, whether through real or false twist, should have the same effect on the rotor deposit, as this is a function of the conditions prevailing at the yarn formation point.

The reduction in the rotor deposit with increase in the internal twist (whether real or false) has not been explained satisfactorily. A plausible hypothesis for this is being offered here. It is well accepted that the rotor has a very efficient self-cleaning function. The yarn in the peripheral twist extent or tying-in zone rotates around its axis when the twist is propagated to the yarn formation point. This rotation of yarn is against the rotor groove which if filled with dust will make the yarn to pick up and carry along this dust. The dust is thus being continuously deposited and removed. However, in the beginning, when the rotor is clean, the rate of deposit of dust exceeds the rate of its removal. After a certain running period, the total build up of the rotor deposit reaches an equilibrium. The amount of rotor deposit at this stage is a function of the self-cleaning action of the rotor. A large amount of this deposit can cause deterioration in the yarn quality and the spinning performance. A higher level of internal twist, which could result from the increased false twist action of the large doffing tube, reduces the amount of this deposit. This reduction could be attributed to the increase in the twisting torque and hence the length of yarn in the tying-in zone. A longer length of such yarn,
continuously rotating and rubbing against the rotor groove, would, therefore, pick up and carry along larger amounts of rotor deposit. This results in a lower net deposit in the rotor groove. The higher twist level can also effect reduction in the amount of the deposit due to the greater number of rotations of yarn against the rotor groove. The enhanced capacity of yarn to incorporate somewhat smaller trash particles could be yet another factor responsible for the decreased amount of the deposit with higher internal twist.

References
5 Text Topics, (3) (1975) 11.