Influence of process parameters on flexural rigidity and elastic recovery of polyester OE rotor-spun yarns

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Fibre cross-section is an important factor in determining flexural rigidity and elastic recovery of OE rotor-spun yarns. The level of spin finish, tex twist factor, draw-off nozzle profile, rotor speed and opening roller speed have profound influence on flexural rigidity. The variation either in twist factor or in rotor speed hardly affects elastic recovery; the elastic recovery, however, increases with the increase in level of spin finish. The increase is highly dependent on the draw-off nozzle profile and opening roller speed.

Keywords: Circular fibre, Elastic recovery, Flexural rigidity, Polyester yarn, Spin finish, Trilobal fibre, Wrapper fibre

1 Introduction
The quality of any yarn is governed by the properties of the constituent fibre and the spinning conditions. In rotor spinning, these will obviously be dependent, to a considerable extent, on the design of the components and the spinning parameters used. The fibre properties include strength, length, fineness and crimp. Other influencing variables in yarn quality are the level of spin finish and the cross-sectional shape of the fibre. The fibre cross-section determines the degree of stiffness, and hence the fabric handle. The influence of fibre and machine parameters on rotor yarn quality has been thoroughly studied. There are occasional references to the bending properties of yarn in the literature. However, no publication regarding the contribution of fibre profile to yarn quality is available so far. The present work was, therefore, undertaken to establish a more indepth understanding of the influence of fibre cross-sectional shape and other processing factors on flexural rigidity and elastic recovery of polyester OE rotor-spun yarns.

2 Materials and Methods
2.1 Preparation of Yarn Samples
Four sets of 29.5 tex yarns were spun from three different polyester staples of linear densities 1.66 and 2.22 dtex, and length 44 mm on rotor spinning machine using different process parameters. The conversion to drawn sliver was carried out by using a Platts' carding machine and a Lakshmi Rieters' draw-frame DO/6. Two drawing passages were given to all the samples. The linear density of finisher sliver was adjusted at 3.0 ktex. The slivers were spun into yarn on Ingolstadt rotor spinner RU11/RU 80(4602). The process parameters used to produce these yarn samples are given in Table 1.

2.2 Tests
All the yarns were tested for flexural rigidity and elastic recovery on a Shirley weighted ring yarn stiffness tester by the ring loop method. For each sample, fifty observations were taken for each yarn property studied.

3 Results and Discussion
3.1 Flexural Rigidity
Figs 1-3 show the influence of fibre cross-section, draw-off nozzle profile, level of spin finish and opening roller speed on the flexural rigidity of polyester OE rotor-spun yarn. It is observed that the yarns spun with a trilobal fibre have substantially higher flexural rigidity than the yarns spun with fibre of circular cross-section. However, the flexural rigidity, in general, depends on the processing factors.

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Table 1 — Spinning parameters for rotor-spun yarns
[Yarn linear density, 29.5 tex]

<table>
<thead>
<tr>
<th>Yarn ref. no.</th>
<th>Fibre linear density dtex</th>
<th>Fibre profile</th>
<th>Level of spin finish</th>
<th>Tex twist factor</th>
<th>Draw-off nozzle profile</th>
<th>Rotor speed rps</th>
<th>Opening roller speed rps</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>1.66</td>
<td>Circular</td>
<td>Nil</td>
<td>43.06</td>
<td>Plain</td>
<td>833.33/1000</td>
<td>116.66</td>
</tr>
<tr>
<td>S2</td>
<td>1.66</td>
<td>Circular</td>
<td>Nil</td>
<td>52.63</td>
<td>Plain</td>
<td>833.33/1000</td>
<td>116.66</td>
</tr>
<tr>
<td>S3</td>
<td>1.66</td>
<td>Circular</td>
<td>Nil</td>
<td>57.42</td>
<td>Plain</td>
<td>833.33/1000</td>
<td>116.66</td>
</tr>
<tr>
<td>S4</td>
<td>2.22</td>
<td>Circular</td>
<td>Nil</td>
<td>43.06</td>
<td>Plain</td>
<td>833.33/1000</td>
<td>116.66</td>
</tr>
<tr>
<td>S5</td>
<td>2.22</td>
<td>Circular</td>
<td>Nil</td>
<td>52.63</td>
<td>Plain</td>
<td>833.33/1000</td>
<td>116.66</td>
</tr>
<tr>
<td>S6</td>
<td>2.22</td>
<td>Circular</td>
<td>Nil</td>
<td>57.42</td>
<td>Plain</td>
<td>833.33/1000</td>
<td>116.66</td>
</tr>
<tr>
<td>S7</td>
<td>2.22</td>
<td>Trilobal</td>
<td>Nil</td>
<td>43.06</td>
<td>Plain</td>
<td>833.33/1000</td>
<td>116.66</td>
</tr>
<tr>
<td>S8</td>
<td>2.22</td>
<td>Trilobal</td>
<td>Nil</td>
<td>52.63</td>
<td>Plain</td>
<td>833.33/1000</td>
<td>116.66</td>
</tr>
<tr>
<td>S9</td>
<td>2.22</td>
<td>Trilobal</td>
<td>Nil</td>
<td>57.42</td>
<td>Plain</td>
<td>833.33/1000</td>
<td>116.66</td>
</tr>
<tr>
<td>S10</td>
<td>1.66</td>
<td>Circular</td>
<td>Nil</td>
<td>38.28</td>
<td>Plain/Notched</td>
<td>833.33</td>
<td>116.66/133.33/150</td>
</tr>
<tr>
<td>S11</td>
<td>1.66</td>
<td>Circular</td>
<td>0.05</td>
<td>38.28</td>
<td>Plain/Notched</td>
<td>833.33</td>
<td>116.66/133.33/150</td>
</tr>
<tr>
<td>S12</td>
<td>1.66</td>
<td>Circular</td>
<td>0.10</td>
<td>38.28</td>
<td>Plain/Notched</td>
<td>833.33</td>
<td>116.66/133.33/150</td>
</tr>
<tr>
<td>S13</td>
<td>1.66</td>
<td>Circular</td>
<td>0.15</td>
<td>38.28</td>
<td>Plain/Notched</td>
<td>833.33</td>
<td>116.66/133.33/150</td>
</tr>
</tbody>
</table>

The increase in twist factor increases the flexural rigidity due to the increased fibre cohesion which leads to increased clustering of fibres in the yarn. Consequently, more and more fibres group together and act as one unit. In addition to this, the higher incidence of wrapper fibres in the yarns spun with high twist also impairs the freedom of fibre movement. Rotor speed is another important factor in controlling yarn rigidity. As is evident from Fig. 1, the flexural rigidity consistently increases with the increase in rotor speed. However, the increase in flexural rigidity with the increase in rotor speed is less marked in the yarn spun from fine denier fibres.

With respect to the application of spin finish, the yarn flexural rigidity shows dramatic trends, indicating that the opening roller speed has more profound influence on flexural rigidity in the presence of spin finish than that it does without spin finish (Fig. 2). As compared to the yarns spun with different levels of added spin finish, the flexural rigidity of yarns spun without adding spin finish initially decreases with the increase in opening roller speed and then increases at the opening roller speed of 150 rps owing to the deterioration in fibre straightness and degree of alignment along the yarn\(^{10}\). In case of yarns produced with different levels of spin finish, the
flexural rigidity values exhibit an ascending trend with the increase in opening roller speed. Among the three different opening roller speeds studied (116.66, 133.33 and 150 rps), the 150 rps produces more rigid yarns. This is expected to be the consequence of higher fibre-to-fibre friction which limits the fibre separation and hence demands higher opening roller speed.

Further, with regard to the influence of spin finish on yarn flexural rigidity, at the same opening roller speed the yarns spun with higher level of spin finish show higher flexural rigidity than the yarns spun with lower level of spin finish for both types of draw-off nozzles. This may be due to the increased cohesiveness of the fibres in the yarn on account of the higher fibre-to-fibre friction, which restricts the freedom of fibre movement during bending. On the other hand, the flexural rigidity is affected by draw-off nozzle profile at all the opening roller speeds studied. Fig.3 shows that the flexural rigidity is significantly higher for the yarns spun with a notched draw-off nozzle than that for the yarns spun with a plain draw-off nozzle. This is due to the fact that the notched draw-off nozzle adds false twist to the strand which ultimately increases the number of wrapper fibres. The higher incidence of wrapper fibres limits the freedom of fibre movement.

3.2 Elastic Recovery

Figs 4-6 show the effects of different processing factors on the elastic recovery of polyester OE rotor-spun yarns. In general, the yarns spun with trilobal fibres have substantially higher elastic recovery. Both the rotor speed and twist factor hardly affect the elastic recovery, although the yarns spun from polyester fibres of coarse denier do exhibit considerably lower elastic recovery owing to the more unfavourable formation of wrapper fibres in the yarns. Spin finish also seems to influence elastic recovery. As can be observed from Fig. 6, the minimum elastic recovery is obtained for the yarns spun without spin finish and it markedly increases as the level of added spin finish increases to 0.15%. This can be ascribed to the higher fibre-to-fibre and fibre-to-metal frictions obtained as a result of spin finish. This is due to the greater yarn twist with higher fibre-to-metal friction and higher inter fibre friction owing to the higher fibre-to-fibre friction. With opening roller speed, the yarn elastic recovery exhibits distinct trend. Invariably, the elastic recovery of the yarns spun with 0, 0.05 and 0.10% spin finish decreases with the increase in opening roller speed. However, for 0.15% level of spin finish, the elastic recovery does not change much as the opening roller speed is increased. The decrease in elastic recovery at higher opening roller speed arises due to the greater fibre damage. This is born out by the fact that the fibre breaking extension of 28.8% reduces to 25.6% after opening at 150 rps, irrespective of the process parameters.

4 Conclusions

Polyester OE rotor yarns spun from trilobal fibres possess considerably higher flexural rigidity and elastic recovery than the equivalent yarns spun from a
fibre with circular cross-section. The flexural rigidity initially decreases with the increase in both the level of spin finish and opening roller speed and then increases on further increase in the level of spin finish from 0.10% to 0.15% and opening roller speed from 133.33 rps to 150 rps. A finer fibre, lower tex twist factor, lower rotor speed and a plain nozzle are needed to reduce rigidity. The variation either in tex twist factor or in rotor speed hardly affects elastic recovery of rotor yarns; the elastic recovery, however, increases with the increase in level of spin finish. The increase is highly dependent on the draw-off nozzle profile and opening roller speed.

References