Influence of draw-off nozzle type on characteristics of polyester-viscose rotor-spun yarns

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The effects of yarn twist, yarn composition and draw-off nozzles (notched and spiral) on the properties of polyester-viscose rotor-spun yarns have been studied. It is observed that the surface characteristics of the draw-off nozzle have greater influence on the polyester fibre yarns than on viscose fibre yarns. Yarns spun from 100% polyester fibre or its blend with viscose rayon exhibit considerably higher tenacity, breaking extension, unevenness and imperfections than the viscose fibre yarns. Notched draw-off nozzle produces stronger, more extensible and more even yarns. The improvement, however, depends upon the yarn composition and tex twist factor.

Keywords: Draw-off nozzle, Polyester-viscose yarn, Rotor-spun yarn, Twist translation efficiency, Tex twist factor, Wrapper fibres

1 Introduction

The production of man-made fibre yarns on rotor machine is receiving increasing attention. However, the spinning of polyester on this machine presents a peculiar set of problems. Factors that could be expected to have an adverse influence on the spinnability of polyester and its blends especially with viscose rayon and acrylic fibres include spin finish, contamination, crimp and lapping. Further, in processing polyester fibres at rotor speeds above 50,000 rpm with plain draw-off nozzle, the twist to be employed increases, narrowing the twist range. This occurs due to the combined effect of lowered yarn strength because of excessive twist and increased tension. Therefore, the steps taken to improve the productivity of rotor spinner often yield poor results. Since most of the end-breakages on a rotor frame occur at or near the collecting groove, the draw-off nozzle surface characteristics can be modified to increase the false twist to spin at lower twist levels and at higher rotor speed. Two types of draw-off nozzles, viz. notched and spiral, are used for this purpose. However, too much false twist can extend the twist-propagation zone and may increase the wrappers, and thus decrease the yarn strength. The level of false twist has, therefore, to be decided carefully for specific type of fibre, yarn linear density, rotor diameter and rotor speed. This paper deals with the characteristics of polyester-viscose rotor-spun yarns in relation to changes in yarn twist, blend composition and type of draw-off nozzle.

2 Materials and Methods

2.1 Preparation of Yarn Samples

Yarns (42 tex) were spun from 100% polyester, 100% viscose rayon fibres and their blends (67:33 P/V and 48:52 P/V) on rotor spinning machine with notched/spiral draw-off nozzles using tex twist factors ranging from 30.62 to 42.11. The specifications of polyester and viscose rayon fibres are given in Table 1. For blending polyester and viscose fibres, a predetermined quantity of each of the two components was hand opened and sandwiched to produce a homogeneous blend. Laps were made on a Laxmi Rieter's blow room line and carded on a MMC Card. The carded sliver was given two passages of drawing on the Laxmi Rieter's draw frame to produce

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Fibre length mm</th>
<th>Fibre denier</th>
<th>Tenacity g/den</th>
<th>Breaking extension %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyester</td>
<td>38</td>
<td>1.5</td>
<td>4.64</td>
<td>25.6</td>
</tr>
<tr>
<td>Viscose</td>
<td>38</td>
<td>1.5</td>
<td>2.43</td>
<td>15.2</td>
</tr>
</tbody>
</table>
a finished sliver of 3.2 ktx. The slivers were then spun into yarns on an Ingolstadt Rotor Spinner RU 11/RU 80 (4602). Spinning of 100% polyester and blended yarns was carried out using 48 mm rotor running at 60,000 rpm, an opening roller speed of 9000 rpm, and two draw-off nozzles: spiral (external diam., 20 mm; internal diam., 3 mm) and notched (external diam., 15.50 mm; internal diam., 3 mm) as shown in Fig. 1. The same process parameters were used for 100% viscose rayon yarns, except that the opening roller speed was kept at 6000 rpm.

2.2 Tests
The yarns were tested for tensile properties on an Instron tensile tester using 500 mm long test specimen and 200 mm/min extension rate. The mean yarn tenacity and extension at break were averaged from 50 observations for each yarn sample. Uniformity and imperfections were recorded by an Uster evenness tester using 50 m/s yarn speed and 150 s test duration as per the standard procedure. Apparent twist in all the yarns was determined by Eureka twist tester using detwist-retwist method. The twist loss was calculated using the following expression:

\[
\text{Twist loss (\%)} = \frac{\text{Nominal twist} - \text{Actual twist}}{\text{Nominal twist}} \times 100
\]

3 Results and Discussion
The false twisting action of draw-off nozzle is shown in Fig. 2. False twist is inserted due to the rolling of yarn over the surface of nozzle between A and B. The level of false twist obviously depends on the friction characteristics of the surface of the nozzle. The false twist is in addition to any real twist which slips past A. The total twist between A and B is, therefore, higher than the real twist. This twist influences the incidence of wrapper fibres and, therefore, the twist translation efficiency.

3.1 Twist Translation Efficiency
Table 2 shows that the maximum twist translation efficiency corresponds to 100% viscose yarn and it decreases with the increase in polyester content owing to the higher torsional rigidity of polyester fibre. The incidence of incompletely bound fibres in yarns spun from stiffer fibres increases, which, in turn, decreases the twist translation efficiency. For all the yarns, the twist translation efficiency decreases with the increase in tex twist factor. Such a trend can be attributed again to the higher incidence of wrapper fibres. Table 2 also shows that the yarns spun with spiral nozzle exhibit considerably lower twist translation efficiency than those spun with notched nozzle. The lower twist translation efficiency in case of spiral nozzle could be ascribed to the increased false twist caused by the larger diameter of this nozzle, which, in turn, extends the yarn formation zone and increases the incidence of wrapper fibres. Further, the polyester fibre is more sensitive than the viscose fibre to the type of draw-off nozzle.

3.2 Tenacity
The tenacity values (Table 3) show that polyester yarns are considerably stronger than the viscose rayon yarns, and are followed by the 67:33 P/V and 48:52 P/V yarns. Such a trend can be attributed to the higher tenacity of polyester fibre. Increase in tex twist factor from 30.62 to 42.11 hardly affects the yarn tenacity, although the tenacity of all the yarns, except 100% viscose, initially increases and then decreases with the increase in tex twist factor. The general explanation for this is that at higher twist levels, the
increase in tenacity due to higher inter-fibre cohesion is levelled off by the decrease due to the obliquity effect. Besides fibre composition and processing factors, the twist loss in rotor yarns also contributes significantly to the yarn tenacity. Table 2 shows that the twist loss is correspondingly higher at higher tex twist factors. Therefore, the low twist translation efficiency at higher twists also appears to be responsible for the lower yarn tenacity. Interestingly, the yarns spun with the spiral nozzle possess significantly lower tenacity than those spun with the notched nozzle. Further, the decrease in tenacity is more in polyester-majority yarns owing to the higher torsional rigidity of the polyester fibre; the torsional rigidity is closely associated to the incidence of wrapper fibres which do not contribute to yarn
tenacity. The lower yarn tenacity in case of spiral nozzle occurs because the shape and larger bearing surface of the spiral nozzle increase the false twist which extends the twist-propagation zone and thus the number of wrappers, leading to a decrease in tenacity. Apart from this, the core-to-sheath ratio is also lower with longer twist-in-zone. This partly explains the lower tenacity observed with spiral nozzle.

3.3 Breaking Extension

Table 3 shows that, in general, the yarns spun from polyester or its blend with viscose rayon are more extensible than viscose yarns. Surprisingly, alteration in yarn twist does not affect the breaking extension of the yarns under investigation. All the yarns, except viscose, register a marginal increase in breaking extension with increase in tex twist factor which slightly decreases on further increase in tex twist factor from 34.45 to 42.11. This is well-known and can be accounted for by the role played by the wrapper fibres.

Apart from the yarn composition and tex twist factor, the breaking extension of polyester-viscose rotor yarns is considerably influenced by the type of draw-off nozzle. Table 3 further shows that the yarns spun with the spiral nozzle exhibit lower values of breaking extension due to the more unfavourable formation of wrapper fibres, the latter cause an unequal distribution of yarn strain on fibres along their length during tensile loading, thus leading to loss in breaking extension. This agrees with the findings of Marino et al.

3.4 Unevenness

Increase in polyester content increases the unevenness of polyester-viscose rotor yarns (Table 4). This could be ascribed to the increased incidence of wrapper fibres owing to the higher stiffness of polyester fibres. For all the yarns, U% increases slightly as the text twist factor is increased. The higher incidence of wrapper fibres at higher twists could be responsible for this increase in yarn unevenness. Interestingly, increase in unevenness and increase in twist loss for yarns spun with the spiral nozzle appear to be closely associated. We attribute this to the greater magnitude of false twist which extends the yarn formation zone too far and enables the incompletely bound fibres to be picked up by the yarn after some or all the twist has been inserted, resulting in deterioration in yarn evenness.

3.5 Imperfections

Table 4 shows that the thick places and neps generally increase with the increasing polyester content. This may be attributed to the increased disorientation of fibres, as these lie in the rotor groove, and to the increase in the number of wraps per

<table>
<thead>
<tr>
<th>Yarn</th>
<th>Tex twist factor</th>
<th>U%</th>
<th>Imperfections/1000m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Notched</td>
<td>Spiral</td>
<td>Thick places</td>
</tr>
<tr>
<td>Polyester</td>
<td>30.62</td>
<td>11.8</td>
<td>12.6</td>
</tr>
<tr>
<td></td>
<td>34.45</td>
<td>12.3</td>
<td>13.2</td>
</tr>
<tr>
<td></td>
<td>38.28</td>
<td>12.5</td>
<td>13.5</td>
</tr>
<tr>
<td></td>
<td>42.11</td>
<td>12.7</td>
<td>13.7</td>
</tr>
<tr>
<td>Polyester/viscose</td>
<td>30.62</td>
<td>10.8</td>
<td>11.5</td>
</tr>
<tr>
<td>(67:33)</td>
<td>34.45</td>
<td>11.4</td>
<td>12.1</td>
</tr>
<tr>
<td></td>
<td>38.28</td>
<td>11.8</td>
<td>12.4</td>
</tr>
<tr>
<td></td>
<td>42.11</td>
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</tr>
<tr>
<td>Polyester/viscose</td>
<td>30.62</td>
<td>10.4</td>
<td>11.0</td>
</tr>
<tr>
<td>(48:52)</td>
<td>34.45</td>
<td>10.6</td>
<td>11.2</td>
</tr>
<tr>
<td></td>
<td>38.28</td>
<td>10.9</td>
<td>11.5</td>
</tr>
<tr>
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<td>42.11</td>
<td>11.3</td>
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<td>30.62</td>
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<td></td>
<td>42.11</td>
<td>10.3</td>
<td>10.8</td>
</tr>
</tbody>
</table>
An increase in twist factor from 30.62 to 42.11 leads to an increase in the frequency of thick places and nepes which may be ascribed to the measuring principle of Uster evenness tester.

Apart from the polyester content and tex twist factor, the type of draw-off nozzle also affects the frequency of imperfections. Interestingly, the frequency of nepes increases very steeply with spiral nozzle for polyester yarn, less steeply for polyester-viscose yarns, and hardly for the viscose fibre yarns. This could again be ascribed to the higher incidence of wrapper fibres at higher false twist which adversely affects $U%$ and nepes owing to their contribution to mass irregularity of the yarn.

4 Conclusions

4.1 The type of draw-off nozzle has a marked influence on the twist translation efficiency in polyester and polyester-viscose rotor yarns. The higher twist translation efficiency is obtained with the notched nozzle and it decreases with the increase in tex twist factor and polyester content.

4.2 Polyester and polyester-viscose yarns show considerably higher tenacity and higher breaking elongation compared to viscose fibre yarns at all levels of twist studied. Increase in tex twist factor has little effect on both yarn tenacity and breaking elongation.

4.3 Viscose fibre yarns are more regular and have fewer imperfections compared to polyester or polyester-viscose yarns. Further, among the polyester-viscose yarns, the yarns with less polyester content show less unevenness. Increase in tex twist factor increases the unevenness. The increase in twist translation efficiency and the increase in yarn evenness are closely associated.

4.4 Polyester fibre is more sensitive than the viscose fibre to the type of draw-off nozzle. Notched draw-off nozzle produces stronger, more extensible and more even yarn than the spiral one. The improvement, however, depends upon the yarn composition and text twist factor used.

References