Physical characteristics of polyester-viscose and polyester-cotton yarns spun on ring- and rotor-spinning systems

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Rotor-spun yarns are slightly weaker, more extensible, more regular and have fewer imperfections and higher yarn quality index than their ring-spun counterparts. However, polyester-majority yarns require higher twist factors than polyester-minority ones in spinning on a rotor frame. Further, the effect of twist factor on yarn characteristics, in general, depends upon the fibrous components and polyester content.

Keywords: Polyester-cotton yarn, Polyester-viscose yarn, Ring-spun yarn, Rotor-spun yarn, Spinning, Twist factor, Yarn quality index

1 Introduction
The production of high quality synthetic fibre yarns on rotor spinning machines after careful optimization of yarn and machine parameters is beyond dispute. However, the translation of constituent fibre characteristics into ring- and rotor-spun blended yarns has not received much attention from researchers. The translation of fibre characteristics into yarn characteristics, which, in turn, depend upon the interaction between the characteristics of constituent fibres and the mechanism of yarn formation, on a rotor frame is expected to be different from that on the ring spinning frame. In other words, whereas twist insures the generation of sufficient transverse forces to creat frictional forces between fibrous components in ring yarns, which results in a stronger yarn, it may not react in the same way on the rotor spinning frame. The effect becomes even more complex in blended yarns owing to the non-homogeneous characteristics and varying stiffness of the fibre mix. This paper aims at characterizing this effect.

2 Materials and Methods
2.1 Preparation of Yarn Samples
Four sets of yarns (29.5 tex) were spun from blends of polyester, viscose and cotton fibres on ring- and rotor-spinning machines with different twist factors ranging from 29.5 to 39.2. Shanker-4 cotton having the following specification was used: effective length, 33.4 mm; mean length, 27.7 mm; fineness, 4.48 micronaire; and pressley index, 5.98. The specifications of polyester and viscose fibres are given in Table 1. For blending polyester and viscose fibres, each of the two components was hand opened and sandwiched well to produce a homogeneous blend. However, for polyester-cotton yarns, the cotton was first combed and then mixed with polyester in opening room. The proportion of polyester was kept about 1.2% lower than the ultimate required proportion in the yarn. The conversion to draw sliver was carried out by using a MMC carding machine and a drawing frame. Two drawing frame passages were given to the carded sliver. The slivers were spun into yarns on Ingolstadt rotor spinner RU/11/RU80(4602). The rotor and opening roller speeds were kept constant at 40,000 rpm and 6000 rpm respectively. For ring spinning, the drawn sliver was converted into a suitable rove.

2.2 Tests
All the yarns were tested for single strand strength and breaking extension on an Instron, 100 mm long

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Fibre length mm</th>
<th>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>4.71</td>
<td>25.5</td>
</tr>
<tr>
<td>Viscose</td>
<td>38</td>
<td>1.5</td>
<td>2.32</td>
<td>15.7</td>
</tr>
</tbody>
</table>
test specimens being elongated at 200 mm/min extension rate. Mean breaking strength and extension were averaged from 30 observations for each yarn sample. Yarn unevenness and imperfections were recorded by an Uster evenness tester. The yarn quality index (YQI) was calculated from the expression:

$$\text{YQI} = \frac{\text{Yarn tenacity (g/tex)} \times \text{Breaking elongation} \times \text{Unevenness}}{100}$$

3 Results and Discussion

3.1 Measured and Nominal Twists

Unlike for ring yarns, the difference between the actual and nominal twists appears to be quite considerable for rotor-spun yarns (Table 2). The twist efficiency is higher in polyester-cotton yarns than in polyester-viscose yarns and it decreases with increasing polyester content owing to the higher torsional rigidity of polyester fibre, the torsional rigidity being proportional to the ratio of the fibre linear density to fibre density and is higher for polyester fibre. Burlet also found it difficult to spin 40 mm, 3.3 dtex polyester fibre on rotor frame due to its higher torsional rigidity, though it was possible to spin merino wool on a rotor with a diameter of 60 mm in spite of the fact that 24 μm wool has a linear density of 6.3 dtex. The incidence of wrapper fibres in yarns spun from stiffer fibres increases, which, in turn, increases the twist loss. Nield and Ali also reported a lower twist efficiency for the viscose yarn than for the polyester yarn. For all the yarns, the twist efficiency significantly decreases as the twist factor is increased. Such a trend can be attributed again to the higher incidence of wrapper fibres.

3.2 Breaking Strength

Table 3 shows that the rotor-spun yarns are weaker than the ring-spun yarns depending upon the yarn composition and twist factor. The lower strength of rotor-spun yarn has been related to its unique structure by several researchers. For both rotor and ring yarns, the tenacity is higher in polyester-majority yarns due to the higher breaking strength and extension at break of polyester fibre which ultimately lead to an increase in yarn breaking strength. Lord et al. reported that the use of small amount of polyester fibre actually reduces the breaking strength of polyester-cotton blends due to poor load sharing, particularly for rotor yarns. More than 50% of polyester fibre was required for an improvement in yarn strength. In rotor yarns, the tenacity is lower at low twist factor. It first increases with increase in twist factor and then decreases with further increase in twist factor due to the higher incidence of wrapper fibres. However, the decrease being less in polyester-cotton yarns than in polyester-viscose yarns. The tenacity increases with increase in polyester content owing to the higher torsional rigidity of polyester fibre. With regard to the contribution of fibre characteristics to the quality of rotor yarns, Towery mentioned that stiffer fibres tend to become wrapper fibres.

3.3 Breaking Extension

The values of breaking extension for ring and rotor yarns spun from different blend compositions and twist factors are given in Table 3. It is observed that, in general, the rotor yarns are more extensible than ring yarns. Surprisingly, the variation in yarn twist appears to have insignificant effect on breaking

<table>
<thead>
<tr>
<th>Fibre type</th>
<th>Twist level</th>
<th>Twist efficiency</th>
<th>Twist</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tex factor</td>
<td>(Nominal) TPM</td>
<td>%</td>
</tr>
<tr>
<td>Polyester/viscose</td>
<td>29.5</td>
<td>488.1</td>
<td>81.80</td>
</tr>
<tr>
<td>(67:33)</td>
<td>34.4</td>
<td>566.9</td>
<td>79.87</td>
</tr>
<tr>
<td></td>
<td>39.2</td>
<td>645.6</td>
<td>79.25</td>
</tr>
<tr>
<td>Polyester/viscose</td>
<td>29.5</td>
<td>488.1</td>
<td>82.11</td>
</tr>
<tr>
<td>(48:52)</td>
<td>34.4</td>
<td>566.9</td>
<td>80.91</td>
</tr>
<tr>
<td></td>
<td>39.2</td>
<td>645.6</td>
<td>80.01</td>
</tr>
<tr>
<td>Polyester/cotton</td>
<td>29.5</td>
<td>488.1</td>
<td>84.48</td>
</tr>
<tr>
<td>(67:33)</td>
<td>34.4</td>
<td>566.9</td>
<td>83.07</td>
</tr>
<tr>
<td></td>
<td>39.2</td>
<td>645.6</td>
<td>81.17</td>
</tr>
<tr>
<td>Polyester/cotton</td>
<td>29.5</td>
<td>488.1</td>
<td>85.22</td>
</tr>
<tr>
<td>(48:52)</td>
<td>34.4</td>
<td>566.9</td>
<td>84.18</td>
</tr>
<tr>
<td></td>
<td>39.2</td>
<td>645.6</td>
<td>82.50</td>
</tr>
</tbody>
</table>
extension of rotor yarns. Both polyester-viscose and polyester-cotton rotor yarns register a little increase in breaking extension with increase in twist factor which slightly drops on further increase in twist factor from 34.4 to 39.2. This can be accounted for by the role played by the wrapper fibres. Since the wrapper fibres are comparatively few in low-twist yarns and increase with increase in twist factor, the applied strain during tensile loading leads to an unequal distribution of yarn strain on fibres along its length, thus leading to loss in breaking extension. Earlier studies\textsuperscript{11} had shown a decrease in breaking extension of 53 tex polyester-cotton (65:35) yarn from 12.0 to 11.2\% with increase in tex twist factor from 36 to 48. Table 3 shows that yarns spun from fibres with higher proportion of polyester have a higher breaking extension at all twist levels.

### 3.4 Yarn Unevenness

Table 4 shows that the rotor-spun yarns are more regular and have less imperfections than the corresponding ring-spin yarns. The effect of fibre composition on the yarn regularity shows opposite trends for ring- and rotor-spun yarns. In the case of
ring yarn, \( U\% \) is lower, as usual, for polyester-viscose yarns. However, in rotor yarns, \( U\% \) seems to be slightly higher for polyester-viscose yarns and it increases with increase in polyester content. Such an increase in irregularity can be attributed to the greater incidence of wrapper fibres in polyester-majority yarns owing to the higher stiffness of polyester fibre. Apart from fibre proportion, twist also seems to contribute significantly to yarn unevenness. For all the yarns, \( U\% \) increases slightly as the twist factor is increased. The increase in unevenness of rotor yarns can be attributed to the increase in twist loss with increasing twist. Since there exists a good correlation between twist loss and per cent sheath fibres\(^{13}\), the increase in twist loss and unevenness at high twist factor appears to be closely associated.

3.5 Imperfections

Table 4 shows that rotor-spun yarns have lesser imperfections than ring-spun yarns irrespective of yarn composition and twist factor. The suppression of drafting wave and embedment of nep's in the body of the yarn appear to be partly responsible for lower frequency of imperfections in rotor yarns\(^{13}\). Further, an increase in thick places and neps with increase in polyester content can also be observed due to the increased disorientation of fibres as these lie in the rotor groove and the increase in the number of wraps per unit length\(^{14}\). The increase in thick places and neps in both polyester-viscose and polyester-cotton rotor yarns with increasing twist factor may be ascribed to the measuring principle of Uster evenness tester.

3.6 Yarn Quality Index

The influence of blend composition and twist factor on yarn quality index (YQI) for different polyester-viscose and polyester-cotton ring- and rotor-spun yarns is shown in Table 3. It is seen that YQI decreases with decrease in polyester content but increases with increase in tex twist factor up to a certain level beyond which it starts decreasing. For both types of yarn, YQI starts decreasing at higher twist factor, indicating that blend composition and twist factor jointly influence YQI. Rotor-spun yarns give a higher YQI. Also, the yarns spun from polyester-majority blends give higher YQI.

4 Conclusions

4.1 The twist efficiency is higher in polyester-cotton rotor yarns than in polyester-viscose rotor yarns and it decreases with increase in polyester content and twist factor.

4.2 Rotor yarns are slightly weaker and more extensible as compared to their ring counterparts. The tenacity of all the yarns initially increases and then decreases with increase in twist factor. However, the variation in yarn twist has insignificant effect on breaking extension of polyester-viscose and polyester-cotton rotor yarns.

4.3 Rotor yarns, at all levels of twist, are more even and have fewer imperfections than ring-spun yarns. For both ring- and rotor-spun yarns, evenness deteriorates markedly with increasing twist factor; however, a decrease in polyester content minimizes the deterioration in quality of rotor-spun yarns.

4.4 YQI for rotor-spun yarns is higher than that for ring-spun yarns. However, at higher twist factors, all the yarns show a decrease in YQI but the polyester-viscose and polyester-cotton yarns spun from polyester-majority blends give higher YQI.

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References