Contribution of fibre profile to performance characteristics of polyester-viscose and polyester-cotton ring and MJS yarns

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The influence of fibre cross-sectional shape and production speed on the performance potential of polyester-viscose and polyester-cotton ring- and MJS yarns has been studied. The data indicate significant differences in the performance of the yarns produced with different spinning speeds and the yarns spun with high spinning speed display better structural integrity, high compressional resilience, low compressional energy, high abrasion resistance and more hairiness than the yarns spun under identical condition but with lower speed. Incorporating non-circular fibre in the mix greatly reduces structural integrity, abrasion resistance and hairiness for both yarn structures. The reduction in their characteristics is highly dependent on the fibre mix and production speed. For all experimental combinations, the MJS yarns possess better structural integrity, better compressional resilience, less hairiness and lower abrasion resistance than the ring - spun yarns.

Keywords: Compressional energy, Jet- spun yarn, Ring- spun yarn, Structural integrity, Trilobal polyester fibre, Wrapper fibre
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1 Introduction
The high rate of recent and projected growth in jet-spun yarn has led to a substantial increase in research aimed at establishing link between the structural and the desired properties, and enhancing their effectiveness in terms of quality and processing performance. A comprehensive bibliography of the considerable literature on the jet - spun yarns can be found in publication by Basu.1 Numerous reports2-5 have also yielded insight into how their structures respond to applied low - stress deformation. However, the impact of fibre profile on low-stress response of jet-spun yarns has not yet been well documented. The low - stress properties of yarn are the major factors limiting its processibility and end - use performance. Besides, fabric handle is also influenced by the yarn low - stress properties. Consequently, the low - stress response of jet-spun yarns needs to be predicted, which is therefore the focus of this investigation. To gain a better insight into the phenomenon, polyester-viscose and polyester-cotton ring and MJS yarns have been produced with varying fibre profile, blend ratio and spinning speed.

2 Materials and Methods

2.1 Preparation of Yarn Samples
Four sets of 16.8 tex yarns were spun from two different blends of polyester-viscose and polyester-cotton fibres on ring and air-jet spinning systems with different spinning speeds ranging from 160 m/min to 200 m/min. Shankar-4 cotton having the following specifications was used : 2.5% span length, 35mm; fineness, 1.52 dtex; maturity ratio, 0.97; tenacity, 30.5 cN/tex ; and breaking extension, 6.30%. 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 combed cotton was mixed with polyester in opening room. The proportion of polyester was kept about 1.2% lower than the ultimate required proportion in the yarn. Two different types of polyester fibre , viz. circular and trilobal , were used. The conversion to drawn sliver was carried out using a MMC carding machine and a Lakshmi Rieters’ draw frame DO/2S. Two drawing passages were given to carded slivers. The linear density of finisher slivers was adjusted at 2.8 ktex. The drawn slivers were spun into yarns on Murata air - jet spinner 802 MJS. The machine parameters used for spinning of MJS yarns included a

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Table 1 — Specifications of polyester and viscose rayon fibres

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Fibre profile</th>
<th>Length, mm</th>
<th>Linear Density, dtex</th>
<th>Breaking Strength, cN/tex</th>
<th>Breaking Extension, %</th>
<th>Co-efficient of friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyester</td>
<td>Circular</td>
<td>44</td>
<td>2.22</td>
<td>45.02</td>
<td>29.2</td>
<td>0.399</td>
</tr>
<tr>
<td>Polyester</td>
<td>Trilobal</td>
<td>44</td>
<td>2.22</td>
<td>40.61</td>
<td>30.0</td>
<td>0.424</td>
</tr>
<tr>
<td>Viscose</td>
<td>-</td>
<td>44</td>
<td>1.66</td>
<td>24.24</td>
<td>18.5</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2 — ANOVA test results

<table>
<thead>
<tr>
<th>Process variable</th>
<th>Structural integrity</th>
<th>Compressional energy</th>
<th>Compressional resiliency</th>
<th>Abrasion resistance</th>
<th>Hairiness</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>13722.8(21.2)</td>
<td>1441.6(10.0)</td>
<td>8856.4(13.7)</td>
<td>48.9(21.4)</td>
<td>35.9(16.2)</td>
</tr>
<tr>
<td>B</td>
<td>623.0(21.2)</td>
<td>36.2(10.0)</td>
<td>2069.6(13.7)</td>
<td>4265.1(21.4)</td>
<td>1089.0(16.2)</td>
</tr>
<tr>
<td>C</td>
<td>880.6(21.2)</td>
<td>15.0(10.0)</td>
<td>78.4(13.7)</td>
<td>1026.8(21.4)</td>
<td>1849.0(16.2)</td>
</tr>
<tr>
<td>D</td>
<td>517.2(21.2)</td>
<td>18.5(10.0)</td>
<td>313.6(13.7)</td>
<td>1654.4(21.4)</td>
<td>841.1(16.2)</td>
</tr>
<tr>
<td>E</td>
<td>1260.3(21.2)</td>
<td>253.5(10.0)</td>
<td>6590.8(13.7)</td>
<td>330.5(21.4)</td>
<td>15129.0(16.2)</td>
</tr>
</tbody>
</table>

A – Spinning mode, B – Fibre mix, C – Polyester content, D – Fibre profile; and E – Spinning speed. Figures in parentheses indicate table values.

4 mm ribbon width, an injector jet pressure of 3.0 kg/cm², and a twisting jet pressure of 4.5 kg/cm². For ring yarns, the drawn slivers were converted into a suitable rove of 1.5 hank, and the roves were then fed to a Lakshmi Rieter ring frame G5/1 using a spindle speed of 15000 rpm.

2.2 Test Methods

All the yarns were tested for structural integrity on Instron tensile tester using 200 mm gauge length and 20 mm/min cross-head speed. The upper limit was fixed at 2 % strain and twenty cycles were fixed on the Instron universal tester. The yarn performance was assessed in terms of percentage decay using the following expression:

\[ \% \text{Decay} = \left( \frac{A_1 - A_{20}}{A_1} \right) \times 100 \]

where \( A_1 \) and \( A_{20} \) are the areas under the curve for first and twentieth cycles. Yarn rigidity was determined on a weighted ring yarn stiffness tester using ring loop method⁵ and hairiness on Zweigles hairiness meter (Model G565). The yarns were tested for compressional energy on the Instron universal tester according to the method described by Basu and Chellamani.⁶ A parallel array of yarn was compressed between two parallel compression plates to a pressure of 2.5 g/cm² with the anvil and foot diameters of 120 mm and 40 mm respectively. The initial separation between the plates was kept as 10 mm and cross-head speed as 0.5 mm/min. The compressional resiliency was calculated by expressing unloading curve area as percentage of loading curve area. The abrasion resistance was measured in terms of abrasion cycles required to rupture the specimen by CSI abrasion tester. Twenty readings were recorded for each yarn sample.

3 Results and Discussion

The significance of independent variables of yarn type, fibre cross-sectional shape, yarn composition, and spinning speed on various yarn properties was assessed with the help of ANOVA analysis (Table 2); the confidence level used was 99%.

3.1 Structural Integrity

Decay values provide an indication of the degree of disintegration, and thus a measure of the structural integrity of a textile substrate. Table 3 shows the effect of fibre profile and spinning speed on the structural integrity of polyester-viscose and polyester-cotton ring- and MJS yarns. Expectedly, the differences in the decay patterns reflect the differences in the spinning processes. For both ring- and MJS yarns, the structural integrity is better in polyester-viscose yarns than in polyester-cotton yarns due to higher tenacity and higher breaking extension of polyester and viscose fibres which ultimately lead to an increased yarn breaking strength. In order to produce a sufficiently strong MJS yarn, it is important for highest possible number of wrapper fibres to be available. In case of polyester-cotton MJS yarns, the higher bending rigidity and short length of cotton restrict the formation of sufficient wrapper fibre and hence fewer wraps/cm, and as a results the self locking feature of the yarn is lost. The spinning speed seems to be a major factor influencing structural integrity of MJS yarns. Increasing spinning speed
from 160 m/min to 200 m/min significantly improves the structural integrity due to higher incidence of wrapper fibres and wrapped-in length which restricted the possibility of fibre slippage during load cycling. The fibre cross-sectional shape is also a dominant factor in determining yarn structural integrity. As may be seen from Table 3, the yarn spun from a trilobal fibre displays substantially poor structural integrity compared to its circular fibre counterpart. This difference is presumably due to the lower fibre tenacity accompanied by a reduction in packing densities. The packing densities are observed to be 0.546 and 0.527 for 65:35 polyester-cotton yarns made from circular and trilobal fibres at 160 m/min spinning speed respectively. Besides, fewer wrapper fibres in yarn produced with non-round polyester fibre also adversely affect the yarn structural integrity. An increase in proportion of polyester fibre in the fibre mix leads to a marked improvement in structural integrity regardless of processing parameters.

3.3 Compressional Resiliency

Table 3 illustrates the effect of processing factors on the compressional resiliency of different yarns. Generally, the ring-spun yarns exhibit much lower compressional resiliency compared to the MJS yarns. With fibre mix having higher polyester content, the compressional resiliency is lower for both types of yarns. The compressional resiliency of yarns produced with higher spinning speed is significantly different from those produced with lower spinning speed, indicating that this parameter considerably influences the yarn compressional resiliency. The fibre cross-section also seems to exert a noticeable impact on compressional resiliency of MJS yarns. Under all experimental conditions, the yarn spun from a trilobal fibre possesses appreciably lower compressional resiliency compared to its circular fibre counterpart. The reduction in compressional resiliency occurs because rigid fibres restrict the formation of wrapper fibres and hence an increase in yarn bulk. Moreover, the compressional resiliency indices are considerably lower for polyester-cotton yarns than for polyester-viscose yarns, as expected.

3.4 Abrasion Resistance

Figure 1 depicts the influence of fibre profile, blend ratio and processing speed on abrasion resistance of various yarns. The data show that MJS yarns, in general, have a correspondingly lower
abrador resistance than ring-spun yarns. The high tension used during abrasion testing appears to result in quick rupture of fewer wrapper fibres, which, in turn, causes an early exposure of core fibres and hence lower abrasion resistance. For both these yarns, there is a marked improvement in abrasion resistance as the polyester content increases. For MJS yarns, abrasion resistance substantially improves as the spinning speed is increased from 160 m/min to 200 m/min. A higher spinning speed leads to an increase in incidence of wrapper fibres which shield the yarn core and consequently higher abrasion resistance. Alteration in the fibre cross-sectional shape also significantly improves abrasion resistance, and a circular fibre is preferable. Furthermore, regardless of processing parameters used, polyester-cotton MJS yarns have poor abrasion resistance than those spun from a polyester-viscose mix.

3.5 Hairiness

The hairiness differences between ring and MJS yarns of identical linear density determined on Zweigle hairiness meter are clearly visible in Fig. 2. The data reveals that, in general, MJS yarns are less hairy than the equivalent ring-spun yarns, the wrapper fibres in the former prevent the fibres to protrude from the main body of the yarn. The other factor that influences hairiness is blend composition. As shown in Fig. 2, the yarns produced with polyester-viscose mix show fewer hairs irrespective of polyester content and production speed, indicating that the viscose constituent impairs the formation of hairs. Change in fibre profile also noticeably reduces hairiness and the yarns spun with non-circular fibre are less hairy. The hairiness increases steadily with the spinning speed. This suggests that the spinning speed should be kept low with a view to keep fewer hairs, even though this may hamper yarn output.

4 Conclusions

4.1 MJS yarns display better structural integrity, lower compressional energy, higher compressional resiliency, lower abrasion resistance, and have fewer hairs than do the ring yarns. However, polyester-cotton mix with higher cotton content, trilobal polyester and lower spinning speed or combination of these factors may limit structural integrity and compressional resistance.

4.2 There is a large margin for improvement of MJS yarn abrasion resistance. The most important abrasion-limiting factor is fibre cross-sectional shape, and a circular fibre has a potential for a substantial improvement in yarn abrasion regardless of fibre-mix. In addition, higher spinning speed may also provide a marked increase in abrasion resistance.

4.3 Under all experimental conditions, MJS yarns spun from polyester-cotton mix are more hairy as
compared to the yarns made from a polyester-viscose mix. However, the hairiness markedly reduces when production speed decreases and, at the same time, when polyester content in the mix increases. In general, the trilobal fibre yarns are less hairy than the circular fibre yarns.

References