Effect of spinning conditions on characteristics of polyester-viscose
MJS core yarns

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Received 5 July 2005; revised received 25 October 2005; accepted 21 November 2005

The effect of processing conditions in air-jet spinning on the characteristics of polyester-viscose core-spun yarns has been studied. It is observed that the increase in main draft leads to a significant increase almost in all mechanical characteristics. Reduced yarn linear density also has a potential for an appreciable increase in these characteristics. Increased spinning speed also provides a noticeable increase in yarn tenacity, breaking extension, initial modulus, energy-to-break, flexural rigidity, elastic recovery and abrasion resistance.

Keywords: Core-spun yarn, Feed ratio, Main draft, Murata air-jet spinning, Polyester filament, Wrapper fibres
IPC Code: Int. Cl. D01H7/00, D02G3/00

1 Introduction
Non-elastic core-spun yarns use nylon or polyester continuous filament as the core and are covered with natural or other staple fibres. These yarns are used in such articles as tarpaulins, car safety belts and net twins, which require strength and toughness provided by the core combined with such properties as softness and suitable frictional properties derived from the sheath. Besides, swim suits, stretch fabrics and form-persuasive garments are some other applications of core-spun yarns with non-elastic core. Core yarns can be successfully spun on ring, rotor and friction spinning systems. Though the literature contains many references on the production and properties of core yarns produced by these spinning systems, there is no report in regard to air-jet yarns. The present work was, therefore, undertaken to elucidate the effects of feed ratio, main draft and spinning speed in air-jet spinning on the mechanical properties of polyester-viscose MJS core-spun yarns. This work is also a continuation of the initial study of production and evaluation of the properties of jet-spun core yarns.

2 Materials and Methods
2.1 Preparation of Yarn Samples
Two sets of yarns of 11.8 and 18.4 tex were spun from 100% polyester core (50 denier/36 filaments) and 100% viscose fibre sheath (51 mm, 1.1 dtex and 21.06 cN/tex) on ring- and air-jet spinning machines. The polyester filament had a tenacity and breaking extension of 34.59 cN/tex and 27.32% respectively. The laps of viscose rayon fibre were made on a Lakshmi Rieters’ blow room line and carded on a MMC card. The carded sliver was given three drawing passages on a Lakshmi Rieters’ draw frame (DO/2S) to produce a finisher sliver of 1.57 ktex which was then spun into yarns on Murata air-jet spinner (802 MJS) operating under normal mill conditions. The pre-tensioned polyester filament from the supply package placed at the creel, modified to accommodate the package of filament yarns, was drawn through a guide. It was accurately positioned at the center of the drafted ribbon of fibres and fed into the nip of the front drafting rollers of the Murata air-jet spinner. The twisting action produced by two nozzles causes the viscose fibres to wrap around the polyester filament core. Table 1 shows the important process parameters used for the spinning of yarns. For ring spinning, the finished drawn sliver was converted into a suitable rove using an OKK roving frame. Equivalent core yarn (11.8 tex) was spun from the polyester filament and viscose materials on Lakshmi Rieters’ ring frame G 5/1 using the following process parameters: spindle speed, 13500 rpm; total draft, 25; and tex twist factor, 33.49.

2.2 Tests
Yarn tensile properties were measured on an Instron tensile tester (Model 1122), using 500 mm test specimen and 200mm/min extension rate. Fifty
Table 1 — Processing parameters for MJS yarns

<table>
<thead>
<tr>
<th>Yarn ref. no.</th>
<th>Yarn linear density, tex</th>
<th>Yarn type</th>
<th>Fibre composition (Polyester: Viscose)</th>
<th>Feed ratio</th>
<th>Main draft</th>
<th>Spinning speed m/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>18.4</td>
<td>Filament core</td>
<td>30:70</td>
<td>0.96/0.97/0.98</td>
<td>30.91</td>
<td>180</td>
</tr>
<tr>
<td>S2</td>
<td>18.4</td>
<td>Filament core</td>
<td>30:70</td>
<td>0.96</td>
<td>30.91/35.77/41.55</td>
<td>180/190/200</td>
</tr>
<tr>
<td>S3</td>
<td>18.4</td>
<td>Filament core</td>
<td>30:70</td>
<td>0.96</td>
<td>30.91</td>
<td>180</td>
</tr>
<tr>
<td>S4</td>
<td>11.8</td>
<td>Filament core</td>
<td>47.53</td>
<td>0.96/0.97/0.98</td>
<td>30.91</td>
<td>180</td>
</tr>
<tr>
<td>S5</td>
<td>11.8</td>
<td>Filament core</td>
<td>47.53</td>
<td>0.96</td>
<td>30.91/35.77/41.55</td>
<td>180/190/200</td>
</tr>
<tr>
<td>S6</td>
<td>11.8</td>
<td>Filament core</td>
<td>47.53</td>
<td>0.96</td>
<td>30.91</td>
<td>180</td>
</tr>
<tr>
<td>S7</td>
<td>11.8</td>
<td>Viscose</td>
<td>0.100</td>
<td>0.96/0.97/0.98</td>
<td>30.91</td>
<td>180</td>
</tr>
<tr>
<td>S8</td>
<td>11.8</td>
<td>Viscose</td>
<td>0.100</td>
<td>0.96</td>
<td>30.91/35.77/41.55</td>
<td>180/190/200</td>
</tr>
<tr>
<td>S9</td>
<td>11.8</td>
<td>Viscose</td>
<td>0.100</td>
<td>0.96</td>
<td>30.91</td>
<td>180</td>
</tr>
</tbody>
</table>

NP1 – First nozzle pressure; and NP2 – Second nozzle pressure.

Table 2 — ANOVA test results

<table>
<thead>
<tr>
<th>Process variable</th>
<th>Yarn property</th>
<th>Tenacity</th>
<th>Breaking extension</th>
<th>Initial modulus</th>
<th>Energy -to- break</th>
<th>Flexural rigidity</th>
<th>Elastic recovery</th>
<th>Strength loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yarn type</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
</tr>
<tr>
<td>Yarn tex</td>
<td>s</td>
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<td>s</td>
<td>s</td>
<td>s</td>
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<tr>
<td>Feed ratio</td>
<td>ns</td>
<td>ns</td>
<td>s</td>
<td>s</td>
<td>ns</td>
<td>s</td>
<td>s</td>
<td>s</td>
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<tr>
<td>Main draft</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>ns</td>
<td>ns</td>
<td>s</td>
<td>s</td>
</tr>
<tr>
<td>Spinning speed</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
</tr>
</tbody>
</table>

s – Significant at 99% confidence level, and ns – Non-significant at 99% confidence level.

Fig. 1 — Variation in tenacity of core-spun yarns with feed ratio, main draft and spinning speed [S1 – 18.4 tex MJS core yarn; S2 – 11.8 tex MJS core yarn; S3 – 11.8 tex MJS viscose yarn; and S4 – 11.8 tex ring-spun core yarn]

3 Results and Discussion

The effect of processing conditions on the yarn properties was assessed for significance using analysis of variance (Table 2). Only first order interactions were considered.

3.1 Tensile Properties

Figures 1-4 show the tensile characteristics of polyester-viscose core-spun yarns in relation to spinning system and some process parameters. Since the fibre composition and yarn linear densities were the same for core-spun yarns, it may be correct to assume that the differences in the tenacities of ring
and MJS yarns reflect the differences in the spinning processes. On comparing the tenacities of all the MJS yarns, the viscose-covered polyester filament yarns are found to be stronger than 100% viscose yarns. The statistical analysis of the data indicates that the yarn linear density is a major contributor to the core yarn tenacity. The tenacity increases considerably with the decrease in yarn linear density. The change in yarn tenacity is associated with the increased influence of edge fibres. The air flow at the nip of the front roller causes the edge fibres to move away from the fibre bundle and thus helps to produce long wrappings. The effect of main draft is along the predictable lines, a higher main draft results in a higher yarn tenacity. Spinning speed also has a significant effect on tenacity, and the core yarns spun at 200 m/min
Spinning speed register higher tenacity than those spun with lower values of spinning speed due to longer wrapped length.

Relationships between the processing factors and the breaking extension of MJS core yarns are shown in Fig. 2. Generally, the higher the spinning speed, the higher is the breaking extension. As regards the breaking extension of core yarns at different levels of main draft, it is observed that a higher main draft results in a markedly higher breaking extension. Increase in feed ratio produces a minimal effect on breaking extension. Moreover, the values of breaking extension are much higher for MJS core yarns than for 100% viscose and ring-spun core yarns, and these further increase significantly when yarn linear density decreases and, at the same time when spinning speed increases.

Figures 3 and 4 reveal the initial modulus and energy-to-break under various processing conditions. Invariably, MJS core yarn records lower initial modulus and lower energy-to-break than the ring-spun core yarn. Of the MJS yarns, those with a polyester filament core yield higher initial modulus and energy-to-break than a pure viscose yarn. The statistical analysis of the data indicates that the spinning speed and feed ratio have a significant influence on initial modulus with F-ratios of 117.6 and 134.9 respectively. The results are similar for energy-to-break. High feed ratio and spinning speed tend to increase the initial modulus and energy-to-break; this is generally true for core as well as pure viscose yarns. Both initial modulus and energy-to-break increase with increasing main draft, which is reasonable since higher main draft would tend to increase the wrapper fibres which effectively bind the core. On increasing yarn linear density, however, both initial modulus and energy-to-break decrease due to decreased edge fibres.

3.2 Flexural Rigidity

The flexural rigidity values for ring and MJS core yarns are shown in Fig. 5. The common observation that MJS yarns are more rigid than ring-spun yarns holds true for core yarns too. In MJS core yarns, the parallel polyester filaments bind by tight wrapper fibres allow little freedom of their movement during bending. An increase either in feed ratio or in main draft does not cause a significant increase in the flexural rigidity; the latter, however, decreases when both yarn linear density and spinning speed decrease. This is because slower speed leads to a reduction in wrapper fibres.

3.3 Abrasion Resistance

The flex abrasion resistance measured in terms of strength loss after 1000 rubs is shown in Fig. 6. The abrasion resistance of MJS core yarn is lower than the ring-spun core yarn. While the strength loss of 11.8 tex ring core yarn is about 18.8%, it is 40.0-45.2% for 11.8 tex MJS core yarns and 41.4-46.3% for 11.8 tex pure viscose yarns. The microscopical examination of the photographs of the yarns produced with coloured filament shows that the core surface is almost totally covered with viscose staple and shows no sign of interplying between the polyester core and the viscose sheath, indicating that the yarn can be effectively processed and utilized. However, 18.4 tex polyester-viscose MJS core yarn produced with 30/70 core-sheath ratio exhibits the highest cover factor. A statistical analysis of the data reveals that the feed ratio and spinning speed improve the abrasion resistance. The improvement is the consequence of
the increased number of wrapper fibres and wrapped-in length which effectively shield the core, leading to higher abrasion resistance. There is also a marked improvement in abrasion resistance with the increase in yarn linear density. This can again be attributed to the above-mentioned factors.

3.4 Elastic Recovery

Figure 7 depicts the elastic recovery values of polyester-viscose MJS core yarns produced under different processing conditions. Expectedly, coarse core yarns display lower elastic recovery. However, the mean elastic recovery increases significantly with the increasing spinning speed. This increase in elastic recovery is associated with higher transverse force arising out of increased wrapped-in length. Further, all MJS core yarns register a substantial increase in elastic recovery with the increase in feed ratio which can be attributed to the improved propagation of strain arising from improved alignment of fibres in the yarn. The effect of main draft on elastic recovery is minimal. Nevertheless, MJS core yarns have lower elastic recovery than the ring-spun core yarns owing to the shorter length of the fibre available per unit length in the former.

4 Conclusions

4.1 The most influencing factor is yarn linear density in all fibre compositions. Higher main draft has a potential for a marked increase in the tensile characteristics. Higher spinning speed is also of marked significance from aspects of tenacity and breaking extension.

4.2 The change in feed ratio and main draft has a little effect on flexural rigidity, although the core yarns spun with higher feed ratio and main draft are more rigid. Flexural rigidity and elastic recovery increase significantly with the increase in both spinning speed and yarn linear density. Flexural rigidity also gets increased on increasing feed ratio.

4.3 MJS core yarns exhibit lower abrasion resistance than the equivalent ring-spun yarns, which, however, improves with the increase in yarn linear density. An increase in feed ratio also increases the abrasion resistance. Spinning speed and main draft are prime factors in controlling abrasion resistance, and...
higher spinning speed and higher main draft are needed to improve abrasion resistance.

References