Blend irregularity and migratory behaviour of blend constituents in AJS polyester-viscose yarns

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Image analyzer has been used to study the effect of blend percentage on blend irregularity both in the cross-section and on the surface of polyester-viscose blended air-jet spun yarn. This method is rapid and precise enough to determine zone-wise number distribution of the blend constituents in yarn cross-section. Within and between zone variance and index of blend irregularity values are derived which reflect the extent of blend irregularity for blowroom and drawframe blended yarns. The above parameters are minimum for polyester-viscose (67:33) blowroom blended yarns and higher for extreme blends. Migratory behaviour of polyester and viscose fibres with the change in blend proportion has also been studied using tracer fibres. Migratory behaviour of fibres is found to get influenced by blend proportion apart from the intrinsic characteristics of fibres. In the blended yarns, viscose component migrates from core to surface. Polyester-rich blended yarn possesses maximum wraps/mm and cork-screw type of structure.

Keywords: Air-jet spinning, Blend irregularity, Image analyzer, Polyester-viscose yarn, Tracer fibre

1 Introduction
Various blended yarns are made out of natural and man-made fibres to produce high value added textile products. The most serious problem in such cases is the blend irregularity. Considerable work has been done on blend irregularity of ring and rotor yarns, but no detailed analysis of the blend irregularity in air-jet spun yarn has been done so far.

In the present work, the effect of blend percentage on blend irregularities, both in cross-section and on yarn surface of polyester-viscose blended air-jet spun yarn has been studied using the image processing technique. The migratory behaviour of tracer fibres in a series of polyester-viscose blended air-jet spun yarns has also been studied for both blowroom and drawframe blends.

2 Materials and Methods
2.1 Preparation of Yarn Samples
Air-jet blended spun yarns of 14.76 tex (40 Ne) were produced from polyester-viscose components (51 mm, 1.5 den) with four different levels of blend proportion, viz. 20:80, 50:50, 67:33 and 80:20, in blowroom and with two different levels of blend proportion, viz. 50:50 and 67:33, in drawframe blending.

To investigate the effect of blend variation on zonal distribution of fibres (cross-sectional) and surface distribution, viscose component was dyed using direct dye (red colour).

For studying the migratory behaviour of fibres, a separate set of samples was prepared with the introduction of tracer fibre (1% by weight of the material). Direct-dyed red colour viscose and disperse dyed green colour polyester were taken as tracer fibres. In addition, 100% polyester and 100% viscose yarns were also produced adding 1% tracer fibre.

In blowroom blending, stack blending was performed, whereas in drawframe blending, the blending operation was performed on the first drawing frame. Three drawframe passages were given for both the blending methods prior to feed on Murata air-jet spinner (802 MJS).

2.2 Test Methods
The experimental set-up consisted of two parts; (i) the image processing system, and (ii) the sample mounting arrangement (Fig. 1). The image processing set-up included a stereo microscope with special incident and transmitted lighting system, a video camera, a video display unit and a storage processing unit (CPU). Two software programmes were developed for simplifying the repetitive work on cross-sectional and surface studies. For studying the migratory behaviour of fibres and blend distribution over yarn surface, the yarn was viewed with incident
light, whereas for cross-sectional study, the section of yarn was viewed under transmitted light. Before running the programme, the parameters such as area, pixel, magnification and colour mode are initialized.

2.2.1 Cross-sectional Study of Blended Yarn

For cross-sectional studies, the PVA (polyvinyl alcohol) coated and one component dyed yarn was impregnated with molten wax and paraffin mixture in a receptacle under a given tension. The mixture used should be hard after drying so that the geometrical shape of the yarn remains undisturbed during cutting. Having obtained the transverse sections of the yarn for each blend, these were converted into digital images through software programme. Fig. 2a shows the transverse cutting of polyester-viscose (80:20) blended MJS yarn at magnification 150x. The image consists of 256 × 256 pixels (1 pixel = 171 μm); each pixel is represented by an intensity value (or colour level) of the grades. The original image is captured directly by the video camera set on the microscope. This camera, coupled with storage and processing unit (CPU), permits the image to be digitized by adjusting the colour level [HSI + : 0-255 (red), 0-77 (green), 111-174 (blue)] and the results are stored in a disk file. The cross-sectional area of the yarn is divided by five concentric circles where the width of the annular zones is equal to 18 μm. The area of the inside circle and subsequent annular zones from inner (A1) to outer (A6) are 1017.83 μm², 3053.74 μm², 5089.40 μm², 7125.16 μm² and 9160.92 μm². Twenty cross-sections of each sample were taken randomly for measuring the area distribution of coloured as well as white component separately (A1/A2) in each zone of yarn cross-section. It was then converted to the number proportion \((m/n) \), \( \left( \frac{m}{n} \right) = \left( \frac{A1/A2}{A2/A1} \right) \), where \(a1\) and \(a2\) are the individual fibre cross-sectional area of dyed and undyed fibres derived from the average denier of the constituent fibres. Consequently, the weighted percentage of dyed and undyed fibres was derived (Table 1). The number distribution of dyed and undyed fibres in cross-section from computer-screen was also counted. The number distribution measurement is tedious and time-consuming. Furthermore, some difficulties are associated with the above measurement technique such as deciding about the number of fibres when fibres are partially present in a zone on the border line.

The linear regression equation was fitted between the number of fibres measured by the two different techniques, taking the whole yarn section under consideration. The results, based on 120 observations, are given below:

Regression equation: \( Y = 0.981X - 1.962 \)

where \(X\) is the number of fibres (range, 78-84) measured using Leica Q 500 MC image analyser; and \(Y\) the number of fibres (range 81-85) counted using computer screen.

F-ratio (1,118) : 1857
Correlation coefficient : 0.97
Standard error of Y-estimate : 1.26
Standard error of X-coefficient : 0.023

These results conclusively show that the image analyser can be used for conducting cross-sectional studies on blended yarns with high reliability. It is observed that the number measurement through software programme is more than actual counting the number of fibres in cross-section. This may be due to the fact that the twisted structure of core fibres results in higher cross-sectional area after transverse sectional cutting of yarns. Apart from this, the object boundaries of the digitized images are not always very well defined, particularly when the fibres of similar type form clusters. Therefore, the derived number measurement became higher than actual counting.

2.2.2 Surface Study of Blended Yarn

In surface study using image analyser Leica Q 500 MC, the image of the yarn surface is captured by video camera as an analogue output which is proportional to the amount of light incident on the camera. The analogue video signal is digitized into 256x256 pixels by adjusting the colour level [RGB :
Fig. 2—Polyester viscose blend yarns: (a) cross-sectional view, (b) cork-screw type structure, and (c) class III type structure
3.1 Cross-sectional Study of Blend

The mean values of the zonal distribution of viscose component (by weight) in cross-section for blowroom and drawframe polyester-viscose blended yarns are given in Table 1. It is observed that the viscose component in cross-section gradually decreases from outermost zone (A4) to innermost (A1) concentric circles of zone from outermost (A4) to innermost (A1), concentric circle (A5) in all polyester-viscose blowroom and drawframe blends. This may be explained through air-jet spinning mechanism. The air jet introduces tension to the twisting strand by exhausting down stream air at front roller during air-jet spinning. The twisting strand is at its highest tension before entering the first jet. The next highest tension is being in the region between two jets and the lowest tension in the region after second jet. The fibre strand, after emerging from front roller nip, enters high tension and low twisting zone. During twisting of fibres strand, higher modulus polyester fibres develop higher tension and hence more likely to be pushed towards yarn axis, resulting in greater proportion of viscose component towards the outer zone. No difference was observed in the migratory behaviour of viscose component in between blowroom and drawframe blends.

3.1.1 Effect of Blend Proportion on Blend Homogeneity

Blend proportion influences blend homogeneity which is investigated through between and within zone variance and index of blend irregularity (IBI).

3.1.1.1 Between Zone Variance of the Blend Constituent

Table 1 shows that with the increase in viscose percentage from 20% to 80%, the between zone variance first decreases to minimum for the blend with 33% viscose component and thereafter it increases. Balanced blends show lower variance than
extreme blends (20:80 and 80:20). It is further observed that the drawframe blended AJS yarn possesses higher variance than the blowroom blended yarn.

3.1.1.2 Within Zone Variance of the Blend Constituent

Table 1 shows that within zone variance is minimum in the inner zones (A4 and A5) for polyester-viscose (67:33) blend as compared to that for unbalanced blend (80:20). It is also observed that as regard to within zone variance, there is no significant difference in between blowroom and drawframe blends.

3.1.1.3 Index of Blend Irregularity of the Blend Constituent

It is observed from Table 1 that IBI is lowest for blend having 33% viscose and is higher in extreme blends (20:80 and 80:20). AJS yarn produced with drawframe blend possesses higher IBI, i.e. longitudinal irregularity is higher as compared to that in blowroom blend.

3.2 Surface Study of Blend

Table 1 shows the viscose area proportion on yarn surface for different polyester-viscose blended AJS yarns. Cork-screw type structure (Class 1 type according to Grosberg et al.) i.e. crimped yarn core and tensioned, regular helical wrapping was viewed frequently in 80:20 polyester-viscose blend (Fig. 2b). On the other hand, straight yarn core with wrapper fibre type structure (Class III) was predominant in 20:80 polyester-viscose blended yarn (Fig. 2c). This phenomenon may be explained on the basis of fibre torsional rigidity. As the polyester fibres have lower torsional rigidity than viscose fibres, the twist transference from core to surface is more in case of polyester yarn than viscose AJS yarn. So, polyester-majority yarn shows more tighter surface-wrapped structure than viscose-majority yarn. This is also supported by Chasmawala et al.

Table 1 also shows the variance of area distribution of viscose component over the surface of polyester-viscose blends. It is observed that variance is minimum for 67:33 polyester-viscose blowroom blend and maximum for extreme blends. Blowroom blended yarns show lower variance over yarn surface compared to drawframe blended yarn.

<table>
<thead>
<tr>
<th>Blend composition (Polyester/viscose)</th>
<th>Percentage of fibre configuration</th>
<th>Percentage of fibre configuration</th>
<th>Percentage of fibre configuration</th>
<th>Percentage of fibre configuration</th>
<th>Percentage of fibre configuration</th>
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<tbody>
<tr>
<td></td>
<td>Belt</td>
<td>Wrapper</td>
<td>Migrated core fibre</td>
<td>Core fibre</td>
<td>Wrap/mm</td>
</tr>
<tr>
<td></td>
<td>P-V</td>
<td>P-V</td>
<td>P-V</td>
<td>P-V</td>
<td></td>
</tr>
<tr>
<td>100:0</td>
<td>3-21</td>
<td>9-32.0</td>
<td>67-36.9</td>
<td>0.78</td>
<td></td>
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<tr>
<td>0:100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Blowroom</td>
<td>20:80</td>
<td>4-21</td>
<td></td>
<td></td>
<td>0.72</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50:50</td>
<td>1-2</td>
<td>2-8</td>
<td>30-36.8</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>67:33</td>
<td>1-15</td>
<td>12-32.1</td>
<td>41-36.9</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>80:20</td>
<td>1-19</td>
<td>10-32.4</td>
<td>50-37.0</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>Drawframe</td>
<td>50:50</td>
<td>3-16</td>
<td>35-37.1</td>
<td>0.71</td>
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<tr>
<td>67:33</td>
<td>5-11</td>
<td>7-32.8</td>
<td>43-36.9</td>
<td>0.75</td>
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</tr>
</tbody>
</table>

The values in parentheses indicate fibre extent in mm

P—Polyester and V—Viscose
3.3 Migratory Behaviour of Fibres

It is observed from Table 2 that with the change in blend ratio, there is no statistically significant change in fibre extent, belts and viscose migrated core fibres. However, when yarns of extreme blends are compared, polyester wrapper and migrated core fibres are higher but viscose wrapper is lower for polyester-rich blends. Wrapes/mm is higher for polyester-rich blends as compared to that for viscose-rich blends. No significant difference in the migratory behaviour of fibres is observed between blowroom and drawframe blended yarns.

4 Conclusions

4.1 In polyester-viscose blended AJIS yarn, the viscose component migrates from core to surface in all blends.

4.2 Between zone variance and IBI values are minimum for polyester-viscose (67:33) blowroom blend and higher for extreme blends. Drawframe blended yarns show higher values than blowroom blended yarns.

4.3 Cork-screw type structure is viewed frequently in polyester-rich blend, whereas straight yarn core with wrapper fibres is observed in viscose-rich blend.

4.4 The variance of area distribution of blends is minimum for polyester-viscose (67:33) blowroom blend and higher for extreme blends. The variance is more in drawframe blended yarns than in blowroom blended yarns for the same blend ratio.

4.5 Except fibre extent, belts and viscose migrated core fibre, all the other migration related parameters are different for extreme blends. Maximum wrapes/mm is observed in polyester-rich blend and vice-versa. Regarding migratory behaviour of fibres for the yarn produced with different blending methods, there is no significant difference in between blowroom and drawframe blending.

References