Effect of fibre cross-sectional shape on handle characteristics of polyester-viscose and polyester-cotton ring and MJS yarn fabrics

G K Tyagi & P Madhusoodhanan
The Technological Institute of Textile & Sciences, Bhiwani 127 021, India

Received 5 July 2005; revised received and accepted 19 December 2005

The relationships between handle characteristics of polyester-viscose and polyester-cotton ring and MJS yarn fabrics and yarn bulk and rigidity have been studied using FAST evaluation system. Generally, MJS yarn fabrics are relatively thicker, more rigid and provide a lower shear rigidity and enhanced formability. There are significant changes in the compression, shear rigidity and formability with variation in fibre profile, and a marked improvement in these characteristics is obtained with trilobal polyester fibre. Increased polyester component leads to a noticeable increase in bending and shear rigidities. A polyester-cotton fabric has been found preferable to a polyester-viscose fabric in respect of fabric handle.

Keywords: Circular polyester fibre, Formability, MJS yarn, Ring-spun yarn, Trilobal polyester fibre, Wrapper fibres
IPC Code: Int. CI 8 D02G3/00

1 Introduction
The comfort performance of shirt fabrics has long been of great concern to consumers, even more so in recent years. The aesthetic comfort, which depends upon the mechanical and surface characteristics of the substrate, includes such aspects as handle, softness, drape, colour, style, fashion, compatibility and other similar characteristics. The permeabilities to air, water, and heat are also the major factors governing thermal comfort. For these reasons, the measurement and understanding of handle and comfort are required to specify the performance of fabric to be used in clothing. In producing textile substrates, materials such as cotton yarns with various linear densities, twists and ply are used for warp and weft ends of fabric. Besides, polyester fibre yarns in blends with cotton and viscose fibres are also in extensive use for dress materials. In such fabrics, the coarse and fine polyester fibres are mixed with cellulosic fibres and spun. There have also been a trend towards the use of trilobal polyester fibre over recent years, and consequently many polyester fibres with irregular shaped cross-sections have been developed. Studies on the handle and mechanical properties of woven polyester fabrics have already been published by various authors. However, the studies on contribution of fibre cross-sectional shape to various fabric characteristics are rare, and there is only a limited amount of literature on thermal studies of MJS yarn fabrics. The present work is aimed at investigating the role of polyester fibre profile in influencing the handle characteristics of light weight polyester-viscose and polyester-cotton ring and MJS yarn fabrics. Such a detailed knowledge is not only imperative for establishing processing guidelines but also essential for realizing the effectiveness and limitations of a given fibre cross-section.

2 Materials and Methods
2.1 Preparation of Fabric Samples
The yarns used in this study were made from blends of polyester, viscose and cotton fibres on ring and air-jet spinning machines. The specifications of polyester, viscose and cotton 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 homogenous blend.

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Fibre profile</th>
<th>Length (mm)</th>
<th>Linear density (dtex)</th>
<th>Tenacity (cN/tex)</th>
<th>Breaking extension (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyester</td>
<td>Circular</td>
<td>44</td>
<td>2.22</td>
<td>45.02</td>
<td>29.20</td>
</tr>
<tr>
<td>Polyester</td>
<td>Trilobal</td>
<td>44</td>
<td>2.22</td>
<td>40.61</td>
<td>30.00</td>
</tr>
<tr>
<td>Viscose</td>
<td>-</td>
<td>44</td>
<td>1.66</td>
<td>24.24</td>
<td>18.25</td>
</tr>
<tr>
<td>Cotton</td>
<td>-</td>
<td>35</td>
<td>1.52 (3.9b)</td>
<td>30.52</td>
<td>6.30</td>
</tr>
</tbody>
</table>

*Span length, 2.5% ; and bMicronaire.
However, for polyester-cotton yarns, the cotton was first combed and then mixed with polyester in opening room. Two different types of polyester fibre, viz. circular and trilobal, were used. The conversion to drawn sliver was carried out by using a MMC carding machine and a Lakshmi Rieters’ draw frame DO/2S. Three drawing passages were given to card slivers, the linear density of finisher sliver being adjusted to 2.93 ktex. The drawn slivers were spun into yarns on Murata air-jet spinners (802 MJS). The machine parameters used to produce these yarns were: spinning speed 200 m/min, feed ratio 0.98, first nozzle pressure 2.5 kg/cm², second nozzle jet pressure 4.5 kg/cm², and condenser width 4 mm. For ring spinning, the drawn slivers were converted into suitable row using OKK roving frame. Equivalent ring yarns were spun on Lakshmi Rieters’ ring frame G5/1 using a spindle speed of 14000 rpm.

Experimental ring and MJS yarns were separately woven into plain fabric on a Texmaco loom. The construction of the twelve sets of fabrics was kept constant at 28 ends and 28 picks per centimetre (i.e. 72×72 per inch) for single 16.8 tex yarns. For a given set of fabric, the warp used was the same as filling yarn. The details of the fabrics are given in Table 2.

2.2 Fabric Treatment

The fabrics were desized in 0.5 gpl non-ionic detergent (Wet Aid N1) at boiling temperature for 30 min and rinsed in hot water for 5 min. After desizing, the polyester- viscose fabrics were scoured using 2gpl sodium carbonate and 0.5 gpl non-ionic detergent (Wet Aid N1) at 60° C for 90 min and rinsed in hot water for 5 min. The polyester-cotton fabrics, on the other hand, were immersed in a solution containing sodium hydroxide and 1% non-ionic detergent (Wet Aid N1) at 100° C for 90 min.

After the treatment, samples were thoroughly washed with cold and hot water for 15 min each to remove adhered chemicals completely from the fabrics, neutralized with 2 gpl acetic acid, washed thoroughly and dried at 90° C.

2.3 Tests

2.3.1 Yarn Properties

All the yarns were tested for flexural rigidity on weighted ring yarn stiffness tester by ring loop method. The yarn diameter was measured by Leica Q500 MC at 100 randomly selected places along the length of the yarn. A sufficient length of yarn was covered to take care of any variation.

2.3.2 Fabric Properties

All the light weight polyester-viscose and polyester-cotton fabrics were tested for their extensibility, bending rigidity, shear rigidity, compression and formability using FAST evaluation system. Fabric areal density was determined according to BS 2471-1971 procedure. All the tests were carried out in an atmosphere of 27±2° C and 65±2% RH.

3 Results and Discussion

3.1 Yarn Characteristics

Table 2 shows the diameter and flexural rigidity of experimental yarns with respect to different process parameters. Interestingly, all data for diameter and flexural rigidity relative to spinning system lie in a wide range. The MJS yarns are less bulky and more rigid than the ring-spun yarns, owing to the presence of wrapper fibres, which compress the core and impede the freedom of fibre movement. The fibre profile also affects the flexural rigidity and diameter. The values of flexural rigidity and diameter are considerably higher for yarns spun with a trilobal fibre and increase with the increase in polyester content in the fibre-mix. However, the increase in these characteristics is more marked in polyester-cotton yarns. Such an increase arises due to the higher short fibre content and stiffness of cotton fibre.

3.2 Fabric Handle

The influence of process variables on the handle characteristics of polyester- viscose and polyester-cotton ring and MJS yarn fabrics was assessed for significance using Analysis of Variance (Table 3). Only first order interactions were considered.
Table 3—ANOVA test results

<table>
<thead>
<tr>
<th>Process variable</th>
<th>Fabric property</th>
<th>Compression rigidity</th>
<th>Extensibility</th>
<th>Shear rigidity</th>
<th>Formability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yarn type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyester content</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td>s</td>
</tr>
<tr>
<td>Fibre cross-section</td>
<td>s</td>
<td>ns</td>
<td>ns</td>
<td>s</td>
<td>ns</td>
</tr>
<tr>
<td>Fibre-mix</td>
<td>s</td>
<td>s</td>
<td>ns</td>
<td>s</td>
<td>s</td>
</tr>
</tbody>
</table>

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

### 3.2.1 Compression

Information on fabric compression under different loading conditions is provided in Fig. 1. The surface layer thickness, which is the difference between thickness at 2gfcm⁻² and 100 gfcm⁻² loads, was used as a measure for evaluating fabric compression. The surface layer thickness of 48:52 polyester-viscose and 65:35 polyester-viscose ring-spun yarn fabrics for circular and trilobal polyester fibres are 0.102 and 0.117 mm and 0.112 and 0.125 mm respectively. The MJS yarn fabrics, being significantly more thicker, obviously display more resistance to compression than the ring-spun yarn fabrics (F-ratio, 352.7). The thickness results for polyester-cotton and polyester-viscose ring-spun yarn fabrics are also shown in Fig. 1. The data show that the values are relatively higher for polyester-cotton fabrics. Bulk variation between two sets of yarns could explain this difference. The polyester-cotton yarns have higher bulk due to higher bending rigidity of cotton fibre. Furthermore, the comparisons of fabrics produced with trilobal and circular polyester fibres confirm the influence of fibre profile on fabric compression; the former seems to withstand more compression. The greater bulk of the yarn structures arising from higher bending rigidity of trilobal polyester fibre is believed to be responsible for resulting compression.

### 3.2.2 Bending Rigidity

Figure 2 shows the values of bending rigidity with respect to different process parameters. The bending length is highly dependent on the weight of the fabric when it hangs under its own weight. Figure 2 shows that virtually all the data for bending rigidity relative to spinning system lie in a wide range. Invariably, the MJS yarn fabrics display markedly higher bending rigidity than the fabrics woven from equivalent ring-spun yarns. In MJS yarns, the clustering effect of the core fibres due to their parallel arrangement and winding by tight wrapper fibres allows little freedom of movement of fibres during bending. In the case of ring-spun yarn fabrics, the bending rigidity is substantially higher for polyester-cotton fabrics and it increases with the increase in polyester content in the fibre-mix. Higher bending rigidity of polyester fibre results in reasonably higher bending rigidity values for the 65:35 polyester-cotton fibre-mix, which are significantly different from those for the 48:52 polyester-cotton mix. The intriguing aspect of these data is that bending rigidity values for the trilobal polyester fabrics are no different than those for the circular polyester fabrics. This suggests that the fibre cross-sectional shape does not contribute to the bending rigidity of the final fabric.

### 3.2.3 Extensibility

Fabric extensibility is an indicative of the increase in fabric dimensions during loading and is of marked significance in garment manufacturing. Figure 3 compares the extensibility of woven fabrics made from polyester-viscose and polyester-cotton ring and
MJS yarns with ratio of 48:52 and 65:35. It is observed that the extensibility of MJS yarn fabrics is considerably higher than that of the equivalent fabrics made from ring-spun yarns. The breaking extension of both ring and MJS yarns could help explain this behaviour. In ring-spun yarn fabrics, the extensibility of polyester-cotton and polyester-viscose fabrics varies from 4.3% to 5.3%, and 5.1% to 6.2% respectively. The lower extensibility of polyester-cotton ring-spun yarn fabrics is a direct result of the lower breaking extension of cotton fibre. The cross-sectional shape of polyester fibre, on the other hand, seems to exert a little influence on fabric extensibility. Under all weaving conditions, the fabrics woven from a yarn having non-round polyester fibre possess slightly lower extensibility compared to its circular polyester fibre counterparts. Similar trends are observed in respect of increased polyester content. Such a behaviour can again be attributed to aforementioned factors.

3.2.4 Shear Rigidity

Figure 4 presents shear rigidity data for woven polyester-cotton and polyester-viscose ring and MJS yarn fabrics, clearly indicating that the shear rigidity of a woven fabric is influenced by the cross-sectional shape of fibre, and the composition of the fibre-mix. The yarn structure also plays an important role in determining fabric shear rigidity. Generally, the ring-spun yarn fabrics display much higher shear rigidity. This suggests better tailorability as compared to their MJS counterparts. This implies that the shear rigidity of the specimen does not conclusively depend on its bending rigidity, but is also influenced by the surface characteristics of the substrate. In fact, higher bulk and more hairiness of ring-spun yarns produce a greater resistance to the movement of warp/weft threads over each other and consequently lower bias extensibility, the latter being inversely proportional to shear rigidity. The statistical analysis of the data indicates that the fibre profile and the composition of the fibre-mix have a significant effect on fabric shear rigidity, with F-ratios of 27.7 and 129.6 respectively. The use of trilobal polyester leads to an increase in the shear rigidity because stiffer and bulkier fibres yarns reduce yarn mobility. Among ring-spun yarn fabrics, the shear rigidity of polyester-cotton fabrics is much higher than that of polyester-viscose fabrics, as expected. This is obviously a reflection of different properties of the constituent yarns. An increase in polyester content in the fibre-mix also has a similar effect.

3.2.5 Formability

Formability determines the degree of compression in the fabric plane sustainable by it before buckling occurs. In a woven fabric, the formability is established from the longitudinal compressibility and bending rigidity. Figure 5 presents the formability data for different fabrics. An interesting point to
observe is that the formability of MJS yarn fabric is significantly higher than those of general men’s light weight shirting (0.25 mm²). This suggests that the MJS yarn fabrics do not pucker and thus maintain their intensity when made into a cuff or collar. On the other hand, a higher polyester content offers no significant advantage in respect of formability of the fabrics. However, the effect of yarn composition on fabric formability is significant. The results show that the fabrics containing polyester-cotton yarns show better formability than those in which polyester-viscose yarns are substituted. This is quite understandable and arises due to higher bending stiffness of polyester-cotton fibre-mix. Change in fibre profile significantly improves fabric formability, and a non-circular cross-section is preferable. This is behaved to correspond to higher bending stiffness of trilobal fibre, causing improvement in fabric formability.

4 Conclusions

4.1 Under all experimental conditions, MJS yarn fabrics exhibit higher thickness and higher bending rigidity as compared to ring-spun yarn fabrics. Incorporation of non-circular polyester in the fibre-mix causes an increase in fabric thickness, whereas increased polyester content brings about a noticeable increase in bending rigidity. Furthermore, the fabrics containing polyester-cotton yarns are more rigid and have higher thickness than those in which polyester-viscose yarns are substituted.

4.2 MJS yarn fabrics provide a lower shear rigidity, and enhanced extensibility and formability. Increased shear rigidity is obtained with polyester-rich fibre-mix. There are also significant changes in the formability and shear rigidity with variation in fibre profile, and the highest formability and shear rigidity are obtained with trilobal polyester fibre. Compared to polyester-viscose fabrics, polyester-cotton fabrics display relatively higher shear rigidity, higher formability and lower extensibility.

References