Hand-related properties of polyester-viscose and polyester-cotton ring- and MJS yarn fabrics—Effects of fibre profile and finishing treatment

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The hand-related properties of polyester-viscose and polyester-cotton ring and polyester-viscose MJS yarn fabrics have been studied using FAST evaluation system. Invariably, polyester-viscose MJS yarn fabrics have higher rigidity, higher extensibility and enhanced formability but display lower shear rigidity than ring-spun yarn fabrics. The fibre profile and fibre-mix are important and critical to fabric formability and shear rigidity. When compared with the grey fabric, finished fabric compressibility and shear rigidity increase, while bending rigidity, extensibility and formability are markedly reduced. Nevertheless, polyester-cotton fabrics are more rigid, less extensible and provide higher shear rigidity and enhanced formability even for similar fibre profiles.

Keywords: Circular polyester fibre, Formability, MJS yarn, Ring-spun yarn, Wrapper fibre, Trilobal polyester fibre

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1 Introduction

Good handle and aesthetic appearance are essential quality attributes in men’s shirting fabrics. Fabric hand is basically a reflection of overall quality, and is the human response to handling a fabric. In woven fabrics, this will obviously be dependent on the mechanical and surface characteristics of the substrate. The dependence of the drapability of an apparel fabric on its bending rigidity, in addition to its shear rigidity, is well known. The colour, tone, luster and surface roughness are also important factors in pursuit of the beauty of external appearance. Other influencing variables in aesthetic appearance and the dynamic functionality of fabric used to clothe the human body are the cross-sectional shape of the fibre and the chemical finish. The cross-sectional shape of the fibre and chemical finish alter mechanical properties and degree of stiffness and hence fabric handle. The handle and mechanical properties of polyester fabrics, characterized by particular fibre forms and properties, methods of yarn processing, fabric construction and finishing procedures, have been thoroughly studied. There are occasional references to the mechanical characteristics of air-jet yarn fabrics in the literature. However, there has been no previous investigation concerning the hand-related properties of finished air-jet yarn fabrics, which is mostly related to the aesthetic comfort of clothings. The present investigation is, therefore, aimed at studying the effect of fibre profile and finishing treatment on hand-related properties, such as extensibility, bending rigidity, shear rigidity, compression and formability, of polyester-viscose (ring and MJS) and polyester-cotton (ring) yarn fabrics.

2 Materials and Methods

2.1 Preparation of Fabric Samples

The yarns used for the 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 homogeneous blend. However, for polyester-cotton yarns, the cotton was first combed and then mixed with polyester in opening room. Two different types of polyester fibres, 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

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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 rove 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 used to produce plain woven fabrics on a Texmaco shuttle loom. The construction of the twelve sets of fabrics was kept constant at 28 ends and 28 picks per centimeter (i.e 71 ends × 71 picks 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 Finishing Treatment
The fabrics were desized in 0.5 gpl non-ionic detergent (Wet Aid NI) 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 NI) 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 2 gpl sodium hydroxide and 1% non-ionic detergent (Wet Aid NI) at 100°C for 90 min.

After the treatment, the 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. All fabrics were later subjected to finishing treatment. The typical finish formulation used was: Cerapern K, 10gpl; CAN, 8gpl; Sarasoft BTM, 5gpl; and acetic acid, 2gpl.

2.3 Test Methods

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

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Table 1—Specifications of polyester, viscose rayon and cotton fibres

<table>
<thead>
<tr>
<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 Circular</td>
<td>44</td>
<td>2.22</td>
<td>45.02</td>
<td>29.20</td>
</tr>
<tr>
<td>Polyester Trilobal</td>
<td>44</td>
<td>2.22</td>
<td>40.61</td>
<td>30.00</td>
</tr>
<tr>
<td>Viscose -</td>
<td>44</td>
<td>1.66</td>
<td>24.24</td>
<td>18.25</td>
</tr>
<tr>
<td>Cotton -</td>
<td>35</td>
<td>1.52</td>
<td>30.52</td>
<td>6.30</td>
</tr>
</tbody>
</table>

*Span length, 2.5%; and bMicronaire.

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Table 2—Specifications of fabric samples

<table>
<thead>
<tr>
<th>Fabric ref. no.</th>
<th>Fibre composition</th>
<th>Fibre profile</th>
<th>Yarn type</th>
<th>Yarn characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₁</td>
<td>48:52 P/C</td>
<td>Circular</td>
<td>Ring</td>
<td>Diam.×10⁻³ cm: 16.98; Flexural rigidity mN.mm²: 1.20</td>
</tr>
<tr>
<td>S₂</td>
<td>48:52 P/C</td>
<td>Circular</td>
<td>Ring</td>
<td>17.08</td>
</tr>
<tr>
<td>S₃</td>
<td>65:35 P/C</td>
<td>Circular</td>
<td>Ring</td>
<td>17.22</td>
</tr>
<tr>
<td>S₄</td>
<td>65:35 P/C</td>
<td>Circular</td>
<td>Ring</td>
<td>17.66</td>
</tr>
<tr>
<td>S₅</td>
<td>48:52 P/V</td>
<td>Circular</td>
<td>Ring</td>
<td>16.64</td>
</tr>
<tr>
<td>S₆</td>
<td>48:52 P/V</td>
<td>Trilobal</td>
<td>Ring</td>
<td>16.91</td>
</tr>
<tr>
<td>S₇</td>
<td>65:35 P/V</td>
<td>Circular</td>
<td>Ring</td>
<td>16.82</td>
</tr>
<tr>
<td>S₈</td>
<td>65:35 P/V</td>
<td>Trilobal</td>
<td>Ring</td>
<td>17.45</td>
</tr>
<tr>
<td>S₉</td>
<td>48:52 P/V</td>
<td>Circular</td>
<td>MJS</td>
<td>15.70</td>
</tr>
<tr>
<td>S₁₀</td>
<td>48:52 P/V</td>
<td>Trilobal</td>
<td>MJS</td>
<td>15.99</td>
</tr>
<tr>
<td>S₁₁</td>
<td>65:35 P/V</td>
<td>Circular</td>
<td>MJS</td>
<td>16.188</td>
</tr>
<tr>
<td>S₁₂</td>
<td>65:35 P/V</td>
<td>Trilobal</td>
<td>MJS</td>
<td>16.40</td>
</tr>
</tbody>
</table>

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 polyester-viscose 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 is another factor affecting diameter and the flexural rigidity. The values of flexural rigidity and diameter are considerably higher for the 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 finished 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.

3.2.1 Compression

Comparison of thickness values under different loads provides information about the fabric compressibility. The fabric compressibility, which is a percentage change in fabric thickness at 2gfcm⁻² and 100 gfcm⁻² loads, was used for assessing fabric compression (Fig. 1). Under all experimental conditions, the finished fabrics display higher compressibility than the corresponding grey fabrics, mainly due to the development of swelling-shrinkage during finishing. The data show that the fabric compressibility is highly dependent on the yarn structure, and the polyester-viscose MJS yarn fabrics yield much higher compressibility compared to polyester-viscose ring-spun yarn fabrics. The MJS yarn fabrics, being significantly thicker, obviously display less resistance to compression than the ring-spun yarn fabrics. The results are very consistent, the influence of fibre-mix being particularly significant. In both grey and finished states, compressibility of the polyester-cotton fabrics is relatively higher than the polyester-viscose fabrics, and remains unaltered with the increase in polyester content from 48% to 65%. Fibre profile is the most significant factor in determining fabric compression. The data suggest that the fabrics made from yarns containing trilobal polyester tend to be more compressible than those made from circular polyester fibre, presumably on account of the greater bulk of the yarn structures arising from higher bending rigidity of the trilobal fibre.

3.2.2 Bending Rigidity

Figure 2 shows the bending rigidity of different fabrics. The fact that MJS yarn fabrics virtually exhibit higher bending rigidity as compared to ring

<table>
<thead>
<tr>
<th>Process variable</th>
<th>Compression</th>
<th>Bending rigidity</th>
<th>Extensibility</th>
<th>Shear rigidity</th>
<th>Formability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yarn type</td>
<td>30.7(16.26)</td>
<td>2115.9(10.59)</td>
<td>409.6(21.2)</td>
<td>232.4(11.26)</td>
<td>414.8(11.26)</td>
</tr>
<tr>
<td>Polyester content</td>
<td>7.5(16.26)</td>
<td>103.6(10.59)</td>
<td>90.0(21.2)</td>
<td>44.9(11.26)</td>
<td>010.8(11.26)</td>
</tr>
<tr>
<td>Fibre cross-section</td>
<td>10.8(16.26)</td>
<td>7.7(10.59)</td>
<td>17.6(21.2)</td>
<td>65.6(11.26)</td>
<td>129.6(11.26)</td>
</tr>
<tr>
<td>Fibre-mix</td>
<td>145.2(16.26)</td>
<td>207.2(10.59)</td>
<td>18.9(21.2)</td>
<td>231.3(11.26)</td>
<td>270.4(11.26)</td>
</tr>
<tr>
<td>Finishing treatment</td>
<td>213.6(16.26)</td>
<td>65.2(10.59)</td>
<td>3841.6(21.2)</td>
<td>2297.2(11.26)</td>
<td>033.0</td>
</tr>
</tbody>
</table>

Values in parentheses indicate table values.
Since fibre composition was the same for both types of fabrics, it may be correct to assume that the differences in the bending rigidities of ring and MJS yarn fabrics reflect the differences in the yarn structures. Also, the changes of bending rigidity related to yarn composition and polyester content are evident in all the fibre-mix. In the fibre blends tested, the data clearly indicate that the polyester-cotton fabrics are more rigid than polyester-viscose fabrics. Increasing proportion of polyester fibre in the mix increases the bending rigidity, but interestingly a significant result was not found for the relationship between fibre cross-sectional shape and bending rigidity. Doubtless, the effect of finishing treatment on the bending rigidity results from the increased pliability of the fabric structure on account of the dissipation of the internal stress after finishing.

3.2.3 Extensibility

Fabric extensibility indicates the extent of increase in fabric dimensions during loading. A large value means that it is easy to alter the dimensions. Figure 3 clearly shows a significant decrease in fabric extensibility on finishing, in conformity with the results reported by Wang et al. The effect could conceivably be due to the shrinkage during finishing as a result of disorientation and folding of molecular chain in thermoplastic polymer fibres. The results of variance analysis reveal that the extensibility of trilobal polyester blended fabrics is not significantly different from the equivalent circular polyester blended ones. Moreover, the extensibility of fabrics made from polyester-viscose MJS yarns is significantly higher as compared to the fabrics made from equivalent ring-spun yarns, and among ring yarn fabrics of identical construction, polyester-cotton fabrics display lower extensibility both in warp and weft directions on account of the lower breaking extension of cotton fibre.

3.2.4 Shear Rigidity

The shear rigidity provides a measure of the resistance to rotational movement of the warp and weft threads within a fabric when subjected to low levels of shear deformation. A low value means that the fabric more readily conforms to the intended shape. Results for the shear rigidity of polyester-cotton and polyester-viscose ring and polyester-viscose MJS yarn fabrics with varying blend ratio and polyester profiles are shown in Fig. 4. It is found that the shear rigidities of fabrics from ring-spun yarns are

Fig. 2—Variation in bending rigidity of ring and MJS yarn fabrics [(a) warp-way; and (b) weft-way]

Fig. 3—Variation in extensibility of ring and MJS yarn fabrics [(a) warp-way; and (b) weft-way]
relatively higher than the values of fabrics from MJS yarns, indicating better tailorability of the former. An obvious reason for the higher shear rigidity is the higher bulk and more hairiness of ring-spun yarns which lead to an increase in the resistance to the movement of warp and weft threads within the fabric and hence low structural mobility, the latter being inversely proportional to shear rigidity. Furthermore, the polyester-cotton fabrics exhibit higher shear rigidity amongst the fabrics made from ring-spun yarns. Increasing polyester content increases shear rigidity. Differences become apparent in shear rigidity values of fabrics differing in polyester fibre profile. The data reveal that the trilobal polyester fabrics show higher shear rigidity than the circular polyester blended fabrics, regardless of the fibre composition and yarn structure. This implies that the fibre cross-sectional shape influences structural stability. It is worth noting that the shear rigidity of the finished fabrics is consistently higher than that of the grey fabrics, the differences being significant at 1% probability level. This is a reflection of the increased compactness of the structure on finishing. Analysis of variance results verify that the effects of fibre profile, yarn type and raw material on the shear rigidity are significant.

3.2.5 Formability

Fundamentally, fabric formability is a measure of the extent to which a fabric can be compressed in its own plane before it will buckle. It is defined as the product of its longitudinal compressibility and bending rigidity. Figure 5 presents the formability data for different fabrics. In general, polyester-viscose MJS yarn fabrics have significantly higher formability than the ring yarn fabrics. These differences in formability may be attributed to differences in fabric extensibility and bending rigidity, as mentioned above. The formability measurements differ significantly for circular and trilobal polyester fabrics, circular polyester fabrics giving lower formability values than their trilobal polyester counterparts. In the case of ring yarn fabrics, the higher formability corresponds to polyester-cotton fabrics. The fact that widely differing viscose and cotton fibres in blends with polyester produce fabrics with different extensibilities and bending rigidities explains the observed trends. With regard to the effect of polyester content, the results for polyester-viscose and polyester-cotton fabrics are consistent. Moreover, formability differs for 48:52 polyester-cotton and 65:35 polyester-cotton fabrics, and for 48:52 polyester-viscose and 65:35 polyester-viscose fabrics. Interestingly, no significant relationship between polyester content and fabric formability has been found. In comparison with the grey fabrics, the finished fabrics have much lower formability, mainly due to the low bending rigidity and the decreased extensibility.
4 Conclusions

4.1 The fibre cross-sectional shape, blend ratio and yarn structure are important factors in determining fabric handle. Fabrics woven from polyester-viscose MJS yarns are more compressible and more rigid but display lower shear rigidity as compared with equivalent ring-spun yarn fabrics. As the polyester content is increased, there is a tendency of decreasing the fabric extensibility. The reduction in fabric extensibility is accompanied by a simultaneous increase in bending and shears rigidities. A non-circular polyester fibre produces fabrics with higher compressibility and higher shear rigidity. Nevertheless, polyester-cotton fabrics are relatively more compressible, more rigid, and less extensible and provide higher shear rigidity.

4.2 The polyester-viscose MJS yarn fabrics provide higher formability than the equivalent ring yarn fabrics. The fibre profile is important and critical to the fabric formability, and a non-circular fibre is preferable. Amongst polyester-viscose and polyester-cotton fabrics, the former have lower formability even for similar fibre profiles. When compared with the grey fabric, finished fabric compressibility and shear rigidity increase, while its bending rigidity, extensibility and formability are markedly reduced.

Industrial Importance: This study provides useful information about unacceptable level of deterioration in handle parameters, which, in turn, help engineer fabrics for a particular end-use.

References