Properties of woven fabrics containing core-sheath DREF-III yarn in weft

S M Ishiaque
Department of Textile Technology, Indian Institute of Technology, New Delhi 110 016, India

and

A Das & P Yadav
Northern India Textile Research Association, Sector 23, Raj Nagar, Ghaziabad 201 002, India

Received 21 March 2002; revised received and accepted 27 June 2002

The properties of plain woven fabrics made of DREF-III yarns having staple fibre core-sheath yarn, twistless core component and hollow sheath component in weft and 2-ply cotton ring-spun yarn in warp have been studied. Three different types of weft yarn, namely 59 tex yarn with staple viscose fibre in both core and sheath, 118 tex yarn with staple viscose fibre in core and water-soluble staple PVA fibre in sheath, and 118 tex yarn with PVA in core and viscose in sheath, were prepared on DREF-III system using 50:50 core-sheath ratio. It is observed that the fabric made from twistless core component in weft shows very good tensile strength, tear strength, crease recovery and abrasion resistance, whereas the fabric with hollow sheath component in weft shows bulky and compressible structure.

Keywords: Abrasion resistance, Cotton fibre, Crease recovery, DREF-III yarn, Tear strength, Tensile strength, Viscose fibre

1 Introduction

The fabric characteristics mainly depend on the structure and type of yarn used. The development of new yarn structures raises questions about the nature and quality of fabrics made out of it. It has been studied that different types of yarn making processes not only produce different yarn structures, but the differences are reflected in the performance of fabrics made from them. Among the different yarn structures, DREF-III yarn has got typical core-sheath structure, where core and sheath components in the yarn have completely different fibre configurations. Thus, the staple fibre core and staple sheath components contribute differently to properties of yarn. The properties of such yarn largely depend on the magnitude of radial pressure exerted by the sheath on the core, and on the frictional characteristics of both core and sheath fibres. The contribution of staple core and staple sheath components to the tensile properties of DREF-III core-sheath yarns has been studied earlier. But the behaviour of almost twistless staple fibre core and the surrounding hollow sheath components individually within the fabrics is totally unknown. There is hardly any study reported on this subject.

The present study was, therefore, undertaken to investigate the behaviour of woven fabric made out of staple twistless core component and hollow sheath component of DREF-III yarn in weft and to compare its properties with the properties of fabric made from DREF-III core-sheath type of yarn. Two-ply cotton warp was used for all the samples and viscose staple fibre was selected to produce twistless core, hollow sheath and DREF-III core-sheath type yarn.

2 Materials and Methods

2.1 Raw Materials

All the fabric samples were produced with the same warp of 2-ply cotton ring-spun yarn with resultant count of 78.73 tex, obtained from a commercial spinner. Three types of DREF-III yarns were used in weft (Table 1). The fibres used for producing DREF-III weft yarns were viscose staple fibres (44 mm long, 1.5 denier linear density, 18.8 cN/tex tenacity and 19.2% breaking elongation) and PVA staple fibres (40 mm long, 1.68 denier linear density, 41.9 cN/tex tenacity and 37.4% breaking elongation).
2.2 Sample Preparation

The DREF-III yarns for weft were made on a Fehrer AG type DREF-III (1998 model) friction spinning machine. The carded slivers of both viscose and PVA were given two passages in the draw frame to have sliver weight of 3.0 ktex. There was one sliver for core fibres and five slivers for sheath fibres. In all the DREF-III yarn samples, the core/sheath ratio was kept at 50:50. The count of DREF-III yarn with 100% viscose in both core and sheath was 59 tex. To study the behaviour of fabrics with twistless core component in weft, 100% viscose fibre sliver and 100% PVA slivers were used in core and sheath respectively. When the behaviour of fabric with hollow sheath component in weft was studied, the use of viscose and PVA slivers was just reversed, i.e. PVA sliver was used in the core and viscose slivers were used in sheath. The count of these two yarns where PVA fibres were used in sheath and core respectively was kept exactly double, i.e. 118 tex. The idea was to have exactly the same yarn count (59 tex) in weft for all the three samples when water-soluble PVA portion completely washed out. The spinning drum speed was kept constant at 4500 rpm and the yarn delivery speed was 150 m/min for all the three samples.

The single yarns in warp require sizing which may cause partial or complete removal of PVA fibres, resulting in drastic drop in yarn strength. So, the preparation of fabrics with core-sheath DREF-III single yarns both in warp and weft was not possible. To avoid any sorts of wet treatment on single DREF-III yarns containing PVA fibre prior to fabric stage, the yarns were used in weft only.

All the three fabric samples were prepared with plain weave in a rapier loom using the same warp yarn. The details of warp and weft used in fabrics are given in Table 1. All the three weft yarns were used one after another so that the three fabric samples (Fabric A, Fabric B and Fabric C) could be treated afterwards as a single piece.

2.3 Fabric Treatment

To have the staple viscose twistless core component and hollow sheath component individually in weft, the PVA fibres must be removed from the sheath and core portions respectively from the weft yarn. PVA is soluble in water at 60°C and dissolves completely from fabric properly. All the three fabric samples were used as single piece and treated with hot water using laboratory jigger at 90°C for 120 min. Care was taken to remove the PVA portion completely. The Fabric A, in which the weft yarn consists of 100% viscose staple fibres, was also treated with boiling water along with Fabrics B and C. After the treatment, the Fabrics B and C contained twistless viscose core and hollow viscose sheath respectively in the weft. The details of finished fabrics are also given in Table 1.

2.4 Testing Procedure

The denier and tensile properties of single fibre were measured by Lenzing Vibroskop-400 and Vibrodyn-400 respectively. The end and pick densities were measured with a pick glass at 10 randomly selected positions for each sample. The count of weft yarns from finished fabric was measured by electronic balance. Tensile strength of
warp and weft yarns and fabrics was measured by SDL Tensile Tester. Tensile strength of fabric was measured according to IS: 1969 method. Tear strength was determined using the ASTM D1424 method. Flexural rigidity was determined on a Shirley stiffness tester according to ASTM D1388. Crease recovery was measured according to ISO 2337 method. Compression was measured using a thickness tester. The initial and final thickness values were the fabric thickness at pressure levels of 20 g/cm² and 300 g/cm² respectively. The compression is the difference between initial and final thickness values, expressed as % of initial thickness. Flex abrasion resistance was measured with a Universal wear tester according to ASTM D3885.

3 Results and Discussion
3.1 Tensile Properties

Tensile properties of warp and weft yarns, taken out from finished fabrics, are given in Table 2. As the warp is same in all the three fabrics, the average tensile properties from three fabrics are taken. So far as the weft yarns are concerned, the core-sheath DREF-III yarn of Fabric A shows maximum strength and elongation whereas the twistless staple core portion of Fabric B shows minimum strength and elongation. The hollow sheath component in weft yarn of Fabric C shows intermediate strength and elongation. The similar results have already been reported earlier. Bearing in mind that the yarns with different structures were used only in the weft direction, one might expect that the weft-wise fabric strength would be roughly in proportion to yarn strength. But this is not true as can be observed from Table 3. With twistless staple core in weft (Fabric B), the tensile strength in the weft direction is maximum. This may be due to the fact that the compacting forces created in fabric structure itself result in higher interfibre frictional force. Also, the parallel laying of fibres in weft yarn along the load direction results in uniform and maximum load sharing by all the component fibres in weft direction of the fabric. The minimum tensile strength in weft direction of Fabric C may be due to the fact that the weft yarn consists of hollow sheath component, where most of the fibres are not aligned to the axis of yarn. The hollow sheath component is made of wrapper fibres which wrap around the core component. The effective length of fibres along the yarn axis of sheath component is very small and also the fibre migration within the sheath structure is almost negligible, which result in poor strength of Fabric C in weft direction. Although the breaking elongation of weft yarn from Fabric B (Table 2) is very low, the breaking elongation of fabrics in weft direction shows completely different trend. The typical load-elongation behaviour in weft

<table>
<thead>
<tr>
<th>Yarn source</th>
<th>Yarn type</th>
<th>Tenacity cN/tex</th>
<th>Breaking elongation, %</th>
<th>Initial modulus cN/tex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warp yarn</td>
<td>2-Ply ring</td>
<td>10.61</td>
<td>5.70</td>
<td>213.19</td>
</tr>
<tr>
<td>Weft yarn from Fabric A</td>
<td>DREF-3 yarn</td>
<td>7.80</td>
<td>10.56</td>
<td>54.35</td>
</tr>
<tr>
<td>Weft yarn from Fabric B</td>
<td>Only core</td>
<td>0.41</td>
<td>0.74</td>
<td>86.35</td>
</tr>
<tr>
<td>Weft yarn from Fabric C</td>
<td>Only sheath</td>
<td>3.82</td>
<td>9.98</td>
<td>25.22</td>
</tr>
</tbody>
</table>

Table 3—Properties of finished fabrics

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Tensile strength N</th>
<th>Breaking elongation %</th>
<th>Tear strength* N</th>
<th>Flexural rigidity mN.mm²/mm</th>
<th>Crease recovery deg</th>
<th>Compression, %</th>
<th>Abrasion resistance cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warp</td>
<td>Weft</td>
<td>Warp</td>
<td>Weft</td>
<td>Warp</td>
<td>Weft</td>
<td>Warp</td>
<td>Weft</td>
</tr>
<tr>
<td>Fabric A</td>
<td>593.6</td>
<td>382.9</td>
<td>17.83</td>
<td>22.48</td>
<td>39.59</td>
<td>30.64</td>
<td>18.39</td>
</tr>
<tr>
<td>Fabric B</td>
<td>583.5</td>
<td>439.2</td>
<td>16.87</td>
<td>24.30</td>
<td>47.58</td>
<td>36.77</td>
<td>18.46</td>
</tr>
<tr>
<td>Fabric C</td>
<td>570.2</td>
<td>146.6</td>
<td>15.36</td>
<td>17.64</td>
<td>16.73</td>
<td>18.52</td>
<td>6.67</td>
</tr>
</tbody>
</table>

*Warp — Warp being broken; Weft — Weft being broken.
direction of three types of fabric is shown in Fig. 1. Fabric C with hollow sheath component in weft shows the multi-stage breakage. After reaching maximum load value, the structural reorientation in weft yarns inside the fabric takes place which results in more than one peak. The warp yarns were common to all the three kinds of weft yarns, but Table 3 shows that there are variation in tensile strength and breaking elongation in warp direction also which may be due to the presence of different weft yarn structures.

3.2 Tear Strength

It is also clear from Table 3 that the weft tear strength of Fabric B is higher than that of Fabric A, whereas Fabric C shows the lowest weft tear strength. The tear strength mainly depends on the yarn strength, fabric structure and surface characteristics of yarn. Apart from these, the alignment of fibres in yarn also plays an important role. Yarns bridge the delta zone at the point of tear, and the tightness of the fabric structure determines how many yarns carry the load. A tight fabric allows only one yarn to break at a time as the tear propagates. A loose fabric allows more yarns to carry the load at any one time. In the present study, we have compared the fabrics of same structure with yarns that only varied in respect to the kind of weft. The higher tear strength of Fabric B with twistless core component in weft is mainly due to the two factors: (i) the smooth surface of twistless core component allows to slide within delta zone and thus more than one yarn carry the load at one time, and (ii) the alignment of fibres along the axis of yarn results in maximum sharing of load. The weft yarn of Fabric C lacks the above two qualities, thereby results in poor weft tear strength. The hollow bulky structure of weft yarn does not allow to slide within the delta zone and also the angle of orientation of fibres with the yarn axis is very high.

The warp tear strength of Fabric B is higher than that of Fabric A. This is mainly due to the surface characterization of weft yarn of Fabric B, which allows to slide the warp yarn within the delta zone. We could not get the warp tear strength of Fabric C due to the large difference in tear strength of warp and weft; tearing was always taking place in weft direction instead of warp direction.

3.3 Flexural Rigidity

Table 3 shows that the weft flexural rigidity of Fabric B is higher than that of Fabric C. The result would seem to be odd as the hollow structure of sheath component in weft of Fabric C is expected to show higher flexural rigidity. The deviation from what might be expected can be related to the partial flattening of hollow sheath component and also the alignment of fibres. Moreover, the parallel alignment of fibres in twistless core component in weft of Fabric B develops some restrictive force during bending. The maximum weft flexural rigidity of Fabric A is due to the compact weft yarn structure as compared to Fabrics B and C. The warp flexural rigidity does not show any significant change with the change in weft yarn.

3.4 Crease Recovery

It is evident from Table 3 that the weft crease recovery of Fabrics B and C is higher than that of Fabric A. The reason may be that the bulky and flatten weft yarns of Fabrics B and C cause more contact area that results in less inter-yarn movement during creasing. The axial alignment of fibres in weft yarn of Fabric B results in further increase in crease recovery. The warp crease recovery also shows the similar trend.

3.5 Compression

It is observed from Table 3 that the compression of Fabric C is maximum, followed by Fabric B and Fabric A. The difference in compressibility of these fabrics is mainly due to the different structures of weft yarns. The high initial thickness of Fabric C (Table 1) is due to the relatively hollow and bulky sheath structure. When higher pressure is applied, the compression takes place due to the flattening of hollow sheath structure in weft. Also, fibre-to-fibre slippage and bending of fibres in bulky weft yarn help compression. In case of Fabric A, the compressibility is comparatively low as the weft yarn has compact structure.
3.6 Abrasion Resistance

Abrasion resistance of Fabric B is higher than that of Fabric A (Table 3). As in all the fabrics the warps are same, the difference in abrasion resistance is mainly due to the variation in weft yarn structures. The twistless core portion in weft of Fabric B results in higher abrasion resistance. The similar observation has also been reported earlier. The lowest abrasion resistance in Fabric C may be due to the particular wrap structure of sheath component in weft yarn.

4 Conclusions

4.1 The effects of fabric assistance are more evident in the tensile strength in weft direction of fabric with twistless staple core in weft. In spite of very poor strength of twistless core component, the weft tensile strength of fabric is maximum. The weft tensile strength of fabric with hollow staple sheath component is very poor. A similar trend is also observed in tear strength.

4.2 Weft flexural rigidity of fabric with twistless core component is higher than that of the fabric with hollow sheath component in weft. The weft crease recovery of fabric with twistless core component is maximum.

4.3 Fabric with hollow sheath component shows maximum compression but very poor abrasion resistance. The abrasion resistance of fabric with twistless core component is higher than that of other two types of fabric.

4.4 The warp-wise properties in terms of tensile strength, tear strength and crease recovery are affected by making substitution in the type of weft yarn. No significant change in warp-wise flexural rigidity is observed.

4.5 Fabric made out of hollow sheath component is not suitable for those applications where strength and other mechanical properties are important. But, as the fabric is softer and bulkier, it can be used for baby clothing, ladies wear or in those applications where softness and warmth are important.

References