Influence of Fibre Length and Yarn Twist Multiplier on Fabric Characteristics

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The characteristics of a fabric depend mainly on yarn and fabric construction, and if the yarn count and yarn and fabric constructions are identical, then the fabric characteristics are determined by the type and length of fibre. When technology has advanced to the level of producing regenerated and synthetic fibres with any staple length it becomes necessary to study the influence of fibre length on the fabric characteristics, which would help design a fabric for a specific end-use.

The aim of the present work was to ascertain the effect of fibre length on the tensile strength, abrasion resistance, breaking extension, and flexural rigidity of fabrics, the final count of weft and the quality of warp and weave being kept identical in all cases.

Several researchers have studied the effect of fibre dimensions on fabric characteristics using different fibres alone or in blends but little information is available on the use of cotton warp and viscose weft—an acceptable method of producing cheap and economical fabrics.

Materials and Methods

Warp—Using J-34 cotton, single 24s cotton count yarn was spun on a ring frame and the single yarn was then doubled on a doubling frame to obtain 2/24s yarn, which was used as warp. Single yarn was Z-twisted to 24.5 turns/in, while 2-fold yarn was S-twisted to 18.2 turns/in.

Weft—An attempt was made to produce nine yarn samples using 27, 44 and 60 mm staple length viscose fibres, each with 2.5, 4.5 and 6.5 twist multipliers but only 8 yarn samples could be prepared. With a 2.5 twist multiplier and a 27 mm staple length viscose fibre, yarn could not be spun because of the very poor spinning performance on a miniature plant.

Fabrics—Eight fabric samples of 56 × 48 nominal fabric construction were prepared using 2/24s warp. All the fabric samples were produced on the same loom under identical conditions. They were wet-relaxed in an open trough containing 0.5% Lissapol-D solution at 40°C for 30 min, rinsed twice, and dried in relaxed state by spreading on a clean floor.

Before testing, the fibre, yarn and fabric samples were conditioned in standard atmosphere (65 ± 2% RH and 27 ± 2°C) for 12, 24 and 48 hr respectively. The breaking strength and breaking extension of the fibres were tested on an Instron tensile tester. The tenacity of the fibre was calculated by dividing the breaking strength of fibre by its denier.

The count of the yarn samples was measured on a Knowle's balance and the breaking strength and breaking extension were measured on an Instron tensile tester. The tenacity of each yarn sample was calculated as for fibre.

The number of threads/in in warp and weft directions was determined in the usual way by counting with the help of a standard 1-in pick glass. Eureka crimp tester (Shirley type) was used for measuring the warp and weft crimps of the fabric samples. The value of total crimp was obtained by adding the square roots of warp and weft crimps. Fabric weight was determined by using threads/in., crimp and count of warp and weft.

The warp and weft direction tensile strength and breaking extension of each fabric sample were measured on an Instron tensile tester. The ravelled strips (20 × 5 cm) of different fabric samples were prepared by the standard procedure.

The bending length of fabrics was measured on a
Shirley stiffness tester. The warp and weft flexural rigidities of fabrics were calculated by the relationship:

\[
\text{Flexural rigidity (mg-cm)} = \frac{W L}{L^3}
\]

where \(W\) is the weight of the fabric in mg/cm\(^2\) and \(L\), the bending length in cm.

The flex abrasion in warp and weft directions of each fabric sample was measured on a Stoll abrasion tester.

**Results and Discussion**

**Fibre Characteristics**

Table 1 shows that except for staple length all other characteristics of viscose fibres, i.e. fibre denier, breaking strength, breaking extension and tenacity, are nearly of the same magnitude. This may be because all the fibres were supplied by the same manufacturer and belong to the same lot.

**Yarn Characteristics**

The values of yarn breaking strength, breaking extension and tenacity (Table 2) show that the yarn prepared from the longer staple length fibre is stronger, more extensible and more tenacious. As the fibre strength increases, the length of fibre involved in slippage proportionately reduces owing to better gripping, allowing the tension to build up. As a result, breaking strength and yarn tenacity increase. On the other hand, the reduction in the chances of fibre slippage makes the yarn more extensible although the limit of yarn extensibility is decided by the fibre extensibility and obliquity effect on fibre behaviour.

Table 2 also shows that increase in twist multiplier increases the strength, extensibility and tenacity of yarns. This is because increase in twist not only increases the fibre-to-fibre cohesion but makes the tips or ends of the fibres protruding from the surface of the yarn to contribute to yarn cohesion. Thus, within the limits of twist, an increase in strength, extension and tenacity may be observed.

**Fabric Characteristics**

The physical and mechanical characteristics of fabric samples are given in Tables 3 and 4 respectively.

*Threads per inch*—Table 3 shows that the use of longer fibres has no significant effect on the number of threads per inch. However, a slight increase in the number of threads per inch is observed in both directions. Increase in yarn twist multiplier also results in an insignificant increase in the number of threads per inch. The reason for this may be that a higher twist yarn results in greater shrinkage, thereby causing a slightly higher number of threads per inch.

*Crimp*—The values of warp and weft crimps individually do not follow any trend, but a slight increase in the value of total crimp is observed as a result of the use of longer fibres and increase in yarn twist multiplier. The reason for this is the higher number of threads per inch, which, in turn, crimps the yarns more.

*Fabric weight*—The values of fabric weight (Table 3) reveal that both factors, viz. the use of longer fibres and increase in yarn twist multiplier, independently increase the fabric weight, which is the result of increased thread density and total crimp.

*Tensile strength*—The values of warp and weft tensile strengths for various fabrics (Table 4) reveal that the use of longer fibres in the preparation of yarn and use of the latter as weft result in a fabric stronger in...
Table 4—Mechanical Characteristics of Fabrics

<table>
<thead>
<tr>
<th>Fabric ref. No.*</th>
<th>Tensile strength, kg</th>
<th>Breaking extension, %</th>
<th>Flexural rigidity, mg-cm</th>
<th>Flex abrasion, cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warp</td>
<td>Weft</td>
<td>Warp</td>
<td>Weft</td>
</tr>
<tr>
<td>27/3.5</td>
<td>24.9</td>
<td>14.3</td>
<td>14.3</td>
<td>23.8</td>
</tr>
<tr>
<td>27/4.5</td>
<td>26.6</td>
<td>18.7</td>
<td>15.8</td>
<td>26.8</td>
</tr>
<tr>
<td>44/2.5</td>
<td>26.3</td>
<td>22.0</td>
<td>14.6</td>
<td>23.7</td>
</tr>
<tr>
<td>44/3.5</td>
<td>27.1</td>
<td>24.1</td>
<td>15.7</td>
<td>26.3</td>
</tr>
<tr>
<td>44/4.5</td>
<td>27.7</td>
<td>25.3</td>
<td>15.9</td>
<td>28.4</td>
</tr>
<tr>
<td>60/2.5</td>
<td>26.4</td>
<td>24.0</td>
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<td>24.1</td>
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<tr>
<td>60/3.5</td>
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<td>25.2</td>
<td>15.8</td>
<td>26.8</td>
</tr>
<tr>
<td>60/4.5</td>
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<td>43.67</td>
<td>18.18</td>
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<td>52.73</td>
<td>22.55</td>
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<td></td>
<td>67.04</td>
<td>35.72</td>
<td>410</td>
<td>361</td>
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</tbody>
</table>

*Fabric reference number is based on the yarn reference number which has been used in the preparation of fabric.

It is further observed that increase in yarn twist multiplier also increases the warp and weft tensile strengths. The reason for a trend may be the improved yarn strength and tenacity as a result of using longer fibres or a higher yarn twist multiplier. Another reason may be higher thread density, which also contributes to the tensile strength of fabric.

Breaking extension—The values of breaking extension for warp and weft directions (Table 4) indicate that the use of longer fibres in the preparation of yarn produces a fabric with higher extensibility. This is due to the higher extensibility of yarn as a result of an increase in fibre length. It is interesting to note that this happens when the breaking extension of all the fibres is more or less the same. Further, it is observed that increase in yarn twist multiplier increases the extensibility of the yarn and the trend is similar to that for fabrics. Another reason for this may be the higher crimp in the fabrics with longer staple length fibres and higher twist multiplier yarns. This is in agreement with the findings of Pierce and Taylor, who observed that the extensibility of a fabric is determined by the extensibility of yarn used and the crimp level in the fabric.

Flexural rigidity—The values of flexural rigidity for warp and weft directions of various fabrics (Table 4) show that the use of longer fibres in the preparation of yarn results in a fabric with improved flexural rigidity in both the warp and weft directions. The reason for an increase in flexural rigidity due to the use of longer fibres may be the increased support given by neighbouring fibres during bending. The reason for an increase in flexural rigidity due to increases in yarn twist multiplier may be the increased fibre-to-fibre cohesion, which, in turn, increases the yarn tenacity (Table 2) and contributes to fabric stiffness. According to various researchers, higher-tenacity fibre and yarn produce stiffer fabrics. The tenacity of yarn increases by using longer fibres and a higher twist multiplier.

Flex abrasion—The values of flex abrasion for warp and weft directions of various fabrics (Table 4) show that the use of longer fibres in the preparation of yarn and the use of the latter in fabric improve the abrasion resistance of the fabric in both warp and weft directions. The reason for an increase in flex abrasion with the use of longer fibres may be the improved tenacity of the yarn, which slows down the damage of the fabric. It is an established fact that a high-tenacity yarn produces a fabric with improved abrasion resistance. It is also observed that increase in yarn twist multiplier also increases flex abrasion. The reason for this may be that increase in twist improves the tenacity of a yarn due to increase in fibre-to-fibre cohesion, which, in turn, improves the abrasion resistance of a fabric. According to McNally and MacCord, the relationship between abrasion resistance and twist is similar to that between tensile strength and twist. Further, both the use of longer fibres and an increase in twist restrict the removal or displacement of fibres from the yarn, thereby improving the abrasion resistance of the fabric.

Conclusions

For preparing a yarn with a low level of twist, fibre length is of utmost importance to obtain better spinning performance and quality yarn.

The use of longer fibres in the preparation of a yarn and the latter's use in the fabric result in a stronger, more extensible, less flexible and more abrasion-resistant fabric.

Insertion of higher twist in the yarn improves the fabric strength, extensibility and abrasion resistance but reduces the flexibility of the fabric.

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References

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