Effect of Steam-Relaxation Treatment on Characteristics of Acrylic-Viscose Rotor-spun Yarns

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The steam-relaxation treatment of acrylic-viscose rotor-spun yarns decreased their tenacity significantly but increased breaking extension. Acrylic-majority yarns exhibited higher bulk and residual shrinkage. Residual shrinkage increased slightly with increase in twist but bulk decreased.

Keywords: Acrylic-viscose rayon yarn, Molecular degradation, Residual shrinkage, Rotor-spun yarn, Shrinkage potential, Tex twist factor, Yarn bulk

1 Introduction

Rotor-spun yarns have many superior properties such as higher breaking extension, less hairiness, surface smoothness, loft, good dyeability, lesser lint-shedding, fewer knots, weak places and slubs. Hence the superior knitting performance of rotor yarns. The twist-liveliness of rotor yarns, however, leads to snarling and spirality in single jersey construction. These disadvantages more than offset the fore-mentioned merits of rotor yarns. The snarling tendency of these yarns can be reduced by using lower spinning twist and by relaxation treatment. However, these factors, when not suitably controlled, can be responsible for major problems in processing and usage. Many researchers have reported the steam-setting of rotor-spun yarns as an effective way of reducing the snarling tendency of the yarn and the spirality of the fabric. However, very little information is available on the mechanical properties of steam-relaxed rotor yarns. Though the high-bulking characteristics of acrylic fibres have made them readily adoptable for apparel applications, the addition of viscose for imparting soft silky handle, better static performance and improved hydrophilic properties made it necessary to investigate the influence of steam-relaxation treatment. The present study aims at investigating the effect of twist and steam-relaxation treatment on the physical and mechanical characteristics of acrylic-viscose rotor-spun yarns.

2 Materials and Methods

2.1 Preparation of Yarn Samples

Rotor yarns were spun from three different blends of acrylic and viscose rayon fibres on an Ingolstadt rotor spinner RU 11/RU 80 (4602). The specifications of acrylic and viscose rayon fibres used are given in Table 1. The rotor and opening roller speeds were kept constant at 40,000 rpm and 6,000 rpm respectively. The rotor diameter was 56 mm. Three twist factors, 32.15, 35.40 and 38.56, were used for 50% acrylic-50% viscose yarns and

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Table 1 - Specification of Acrylic and Viscose Rayon Fibres

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Fibre length mm</th>
<th>Fibre denier</th>
<th>Before steaming</th>
<th>After steaming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Diameter cm x 10^{-3}</td>
<td>Tenacity g/den</td>
</tr>
<tr>
<td>Acrylic</td>
<td>38</td>
<td>2.0</td>
<td>1.55</td>
<td>1.67</td>
</tr>
<tr>
<td>Viscose</td>
<td>38</td>
<td>2.0</td>
<td>1.36</td>
<td>1.57</td>
</tr>
</tbody>
</table>

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one twist factor, 35.40, for 100% viscose and 100% acrylic yarns. The blend proportions and twist factors were decided in accordance with the factorial design.

2.2 Steam-Relaxation Treatment
All the yarns were bulked with wet steam in skein form. Skeins of 300-400 m were prepared on a wrap-reel and laced at 3-4 points. The lacings were kept completely loose so as not to hinder the bulking process in the yarns during shrinkage. The skeins were then hung-up loosely in a laboratory starazar machine from a fabric covered stand and steamed at 102°C for 30 min. The starazar unit comprised a fabric covered stand, an inlet for steam and an outlet.

2.3 Tests
Yarn tenacity and breaking extension, before and after steaming, were measured on an Instron, using 100 mm test specimen and 200 mm/min extension rate. The mean yarn strength and breaking extension were calculated from 50 tests for each yarn sample. Yarn diameter was measured on a Projectina using a magnification of 50. Fifty readings of diameter were averaged for each yarn sample. The yarn bulk \( V \) was calculated by the following formula:

\[
V = \frac{\pi \times D^2 \times l}{4}
\]

where \( D \) is the mean diameter and \( l = 1 \) cm. Yarn residual shrinkage was measured by the method suggested in ASTM handbook.

3 Results and Discussion

3.1 Effect of Steam-Relaxation Treatment on Breaking Strength
Acrylic fibres taken out from loose steamed-stock, when tested on an Instron, showed a decrease in fibre tenacity and an increase in breaking extension (Table 1). On the other hand, viscose rayon fibres exhibited a decrease both in tenacity and extension. Table 2 shows a significant loss in breaking strength of 100% acrylic and 50% acrylic-50% viscose yarns when steamed under identical conditions, the loss being insignificant for 100% viscose yarn. The decrease in breaking strength is expected to be due to the molecular degradation of fibres.

*The factorial design has three variables, viz. blend proportion, twist factor and tightness factor (knitting). The effect of these variables will be reported in a subsequent paper.*
Moncrieff reported 51% loss in the strength of acrylic fibre after exposure to a temperature of 140°C or above. He also reported that viscose rayon fibres also suffered swelling and molecular disorientation and became soft and less elastic on wetting.

Further, Table 2 also shows a greater loss in the breaking strength of low-twisted yarns than high-twisted yarns after steaming. Since the packing of fibres is low in low-twisted yarns, the fibres do not impose much resistance to the penetration of steam, causing a drop in tenacity owing to the molecular degradation of fibre components and change in the structural order of the bulked yarn matrix.

3.2 Effect of Steam-Relaxation Treatment on Breaking Extension

Table 2 shows that all yarns, except 100% viscose yarn, register a significant increase in breaking extension after steaming. The increment may be due to the rearrangement of molecular structure and yarn shrinkage. In the case of 100% viscose yarn, there is a decrease in breaking extension which could be attributed to the molecular disorientation of fibres, which affects both the breaking extension and tenacity. An increase in twist factor from 32.15 to 38.56 leads to an increase in the breaking extension of steamed yarns, probably due to an increase in inter-fibre friction owing to the swelling and shrinkage of fibres within the yarn.

3.3 Effect of Steam-Relaxation Treatment on Yarn Linear Density

Table 3 shows increase in yarn linear density with increasing twist. This may be attributed to the reduction in segment length arising from increased contraction, which, in turn, increases with twist. However, the high extension of fibre components at very high twist may cause an additional extension of yarn segment. Steam-relaxation of acrylic-viscose yarns leads to an increase in linear density which is expected to be due to the shortening of fibre length brought about by the alteration in the structural arrangement of fibres in the yarn. Further, the increase in linear density is more marked in acrylic-majority and low-twisted yarns, which can be assigned to the higher shrinkage potential of acrylic fibres and easier penetration of steam molecules into the yarn core, resulting in more yarn contraction, which ultimately causes an increase in linear density.

3.4 Effect of Steam-Relaxation Treatment on Yarn Bulk

Table 3 shows yarn diameter and bulk as influenced by twist and steam-relaxation treatment. Yarns spun from higher proportions of acrylic fibre exhibit a bigger diameter, the latter decreases with increase in twist factor, as can be seen from the test results for 50% acrylic-50% viscose blend. The decrease in yarn diameter occurs because high twist causes an increase in packing density, which, in turn, decreases the yarn diameter.

The diameter and bulk of all the yarns tend to increase after steaming because steaming causes the fibre components to bend and buckle, resulting in loosening of the structural matrix of yarn. Further, the increase in yarn diameter is less marked in 100% viscose and high-twist yarns, which can be attributed to the lower shrinkage potential of viscose rayon fibre and increased frictional hold on fibres, preventing them from bending and buckling. However, the change in diameter of steamed fibre components is also expected to cause an increase in yarn diameter, as can be seen from the results for 100% acrylic fibre (Table 1).

3.5 Yarn Residual Shrinkage

As may be seen from Table 3, yarn residual shrinkage appears to be considerably higher in 100% acrylic and 50% acrylic-50% viscose yarns owing to the higher shrinkage potential of acrylic fibres. An increase in twist factor from 32.15 to 38.56 leads to an increase in yarn residual shrinkage. This may be attributed to the decreased resistance to buckling owing to an increase in the incidence of wrapper f-
bres, the latter increases with increasing twist. Hari et al.\textsuperscript{14}, who studied the effect of mercerization on the tensile properties of rotor-spun yarns, also reported an increase in yarn residual shrinkage with increase in twist.

4 Conclusions

4.1 Steam-relaxation treatment decreases the breaking strength of acrylic-viscose rotor yarns, the decrease being less in 100% viscose and high-twisted yarns.

4.2 Acrylic-majority yarns exhibit higher breaking extension, which increases with an increase in twist and decreases thereafter with further increase in twist. All the yarns, except 100% viscose, exhibit a higher breaking extension after steaming treatment irrespective of twists.

4.3 Yarn diameter and bulk decrease with increase in twist factor, but increase after steam-relaxation treatment.

4.4 Acrylic-majority yarns exhibit a higher residual shrinkage, which increases with increasing twist factor for 50% acrylic-50% viscose yarns.

References