Studies on physical properties of jute-acrylic blended bulked yarns

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Jute-shrinkable acrylic blended bulked yarns of various blend ratios have been prepared by relaxing shrinkable component of the yarns using three different methods of thermal treatments, namely dry hot air, steam and boiling water. The performance of these methods of bulking has been compared. It is observed that all the three methods produce bulked yarns having more or less same value of specific volume. Since the boiling water method is easier, convenient and economical, this method is adopted for detail study. The optimum treatment time in boiling water is found to be 30 min. Flexural rigidity of yarns decreases remarkably after bulking and shows a decreasing trend with the increase in percentage of acrylic up to 80%. Breaking strength and breaking extension of non-bulked yarn increase with the increase in percentage of acrylic. The extensibility further increases remarkably after bulking but the breaking stress of parent yarn decreases remarkably on bulking. The loss of tenacity is more when percentage of jute is more in the blends.

Keywords: Acrylic, Bulked yarn, Flexural rigidity, Jute, Tensile properties

1 Introduction

The bulking of yarn gives voluminous textile product having good thermal insulating properties as well as a fuller and agreeable handle. Bulked yarns from jute and its blends with synthetic fibres are expected to have a great demand for manufacturing diversified products like apparels including warm clothings as woven and knit wears, carpets, floor covering, etc. and also for the products where extensibility is of prime importance than strength of the fabric.

Jute fibres have been texturised chemically by treating with 18% (w/v) sodium hydroxide, but the crimps developed in fibres by this process mostly get destroyed while spinning into yarn. Later, bulking of jute-polypropylene blended yarns was done by treating the blended yarn in sodium hydroxide solution. However, the process is too lengthy and the complete removal of caustic soda from the yarn as well as the recovery of caustic soda from the spent liquor is very difficult.

The reports on texturised synthetic fibres, filaments and their blends with natural fibres are available. Turner, Knapton, Choksey and Arora et al. reported that the blends of wool with high shrinkable acrylic, texturised in the yarn stage, are suitable for knitting. Pillar discussed about the prospects of cotton-acrylic and viscose rayon-acrylic texturised high bulk yarns for fashion fabrics. However, the reports on scientific research on jute-acrylic blended bulked yarn are scanty. The bulking of acrylic blended yarns is heat provoked and can be achieved by relaxing the highly shrinkable acrylic fibres with the help of thermal treatments, viz. dry hot air, steam and boiling water. Roy et al. observed that the steam relaxation treatment on jute-highly shrinkable acrylic blended yarn helps to achieve a good quality high bulk yarn.

In the present work, all the three methods of relaxation have been used for bulking of jute-shrinkable acrylic blended yarns and the bulk properties of the treated yarns compared. On the basis of the results, plain boiling water treatment has been adopted for detail study of the properties of bulked yarns. Treatment time was optimized. The properties like specific volume, tenacity, extension and specific flexural rigidity of the yarns of various blend ratios have also been determined.

2 Materials and Methods

2.1 Materials

Jute fibre (C. capsularis) of W-2 grade having average fineness of 1.8 tex, average filament length of 110 mm at breaker card stage and tenacity of 28 g/tex, and the shrinkable acrylic (Indacrylon plus) fibre, supplied by the Indian Petrochemical Ltd, having

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fineness of 0.33 tex, average length of 100 mm and tenacity of 40 g/tex were used for the study.

2.2 Methods
2.2.1 Spinning of Blended Yarn
The jute-acrylic blended yarn samples were prepared in jute spinning system. The blending of jute finisher card sliver and acrylic sliver was done in the first drawing frame of the jute spinning system at various proportions. However, the jute-acrylic blend of 50:50 ratio was selected to study the performance of the various methods of bulking, effect of twist density on bulk property of yarn and to optimise the treatment time in boiling water. The blended sliver obtained from finisher drawing stage was spun into yarn of nominal linear density of 115 tex in Mackie apron draft jute spinning machine. The single yarns were then made 2-ply with 158 tpm.

2.2.2 Thermal Treatment of Blended Yarn
To compare the performance of different methods of bulking, the yarn samples in hank form were treated separately in dry hot air, steam and boiling water. For dry heat treatment, the yarn hanks were kept loosely in hot air chamber for 1 h at 100°C. In case of steam treatment, the yarn hanks were hung-up loosely in an autoclave and steamed at 109°C for 1 h under 0.35 kg/cm² pressure. In boiling water method, material-to-liquor (plain water) ratio was maintained at 1:20 and the boiling period was 15 - 60 min.

2.2.3 Evaluation of Physical Properties of Yarn
The testing of tensile properties of the yarns was carried out in Instron tensile tester. The specimen length under test was taken as 500 mm and the cross-head speed was maintained at 500 mm/min.

The specific volume of the yarns was determined from the diameter of the yarn by the expression as depicted by Sinha et al.10

For evaluation of specific flexural rigidity, a mandrel was used for the preparation of yarn rings of 3.121 cm diameter. The yarn ring was supported on a hook and the undistorted diameter was measured. Now, a load of 0.455 g was suspended on the yarn ring to give a distortion of the ring of about 20%. The loading time of 60 s was allowed and the new position of the ring was determined. The calculation of flexural rigidity of yarns was carried out by the method given by Beevers11 and the specific flexural rigidity of yarns was calculated by the method given by Morton and Hearle.12

The shrinkage of yarn samples was measured in hank form as per the ASTM method13.

3 Results and Discussion
3.1 Comparison between Three Methods of Bulking
Table 1 shows that the specific volume of bulked yarn is more or less same in all the three methods of bulking. Moreover, it is also found from the visual observation that the steam bulked jute-acrylic blended yarn sheds more fibres from the yarn surface than the other two types of yarn samples. Boiling water method is very simple, convenient and economical. Therefore, in the present work, only plain boiling water treatment for bulking the jute-shrinkable acrylic blended yarns was adopted for detail study of the properties of bulked yarn.

3.2 Effect of Treatment Time on Properties of Bulked Yarn
3.2.1 Effect on Specific Volume, Shrinkage and Diameter Irregularity
Fig. 1 shows that there is a substantial amount of shrinkage of yarn, ranging between 32% and 34%, after bulking in boiling water. This has been reflected in the yarn twist per unit length, showing approximately 32% increase in the twist per unit length in the bulked yarns. However, the difference in the shrinkage percentage among the yarns treated for different durations is marginal.

The increase in specific volume of the yarn is appreciable at 15 min treatment time and it increases

<table>
<thead>
<tr>
<th>Method of bulking</th>
<th>Specific volume, cm³/g</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Single</td>
</tr>
<tr>
<td>Dry hot air</td>
<td>4.39</td>
</tr>
<tr>
<td>Steam</td>
<td>4.35</td>
</tr>
<tr>
<td>Boiling water</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Fig. 1 — Effect of treatment time on specific volume and shrinkage of blended yarn
Table 2 — Effect of treatment time on specific volume and diameter CV % of jute:shrinkable acrylic (50:50) 2-ply yarn

<table>
<thead>
<tr>
<th>Time min</th>
<th>Specific volume cm$^3$/g</th>
<th>Diameter CV %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2.39</td>
<td>18.6</td>
</tr>
<tr>
<td>15</td>
<td>10.85</td>
<td>28.7</td>
</tr>
<tr>
<td>30</td>
<td>14.72</td>
<td>23.6</td>
</tr>
<tr>
<td>40</td>
<td>14.73</td>
<td>25.3</td>
</tr>
<tr>
<td>50</td>
<td>14.24</td>
<td>27.5</td>
</tr>
<tr>
<td>60</td>
<td>15.38</td>
<td>23.4</td>
</tr>
</tbody>
</table>

Table 3 — Effect of treatment time on tensile properties of jute:shrinkable acrylic (50:50) 2-ply yarn

<table>
<thead>
<tr>
<th>Time min</th>
<th>Tenacity cN/tex</th>
<th>Extension %</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>7.1</td>
<td>36.5</td>
</tr>
<tr>
<td>30</td>
<td>7.4</td>
<td>39.7</td>
</tr>
<tr>
<td>40</td>
<td>7.4</td>
<td>35.9</td>
</tr>
<tr>
<td>50</td>
<td>6.6</td>
<td>37.9</td>
</tr>
<tr>
<td>60</td>
<td>7.4</td>
<td>38.5</td>
</tr>
</tbody>
</table>

Further with the increase in treatment time (Fig. 1), however, it is apparent from the figure that this trend of increase in specific volume of the yarn almost levels off after 30 min of treatment while considering both specific volume (Table 2) and percentage increase in specific volume of the yarn samples.

Table 2 also shows that the irregularity of the yarn increases after bulking. This may be due to the reorientation of component fibres in the yarn matrix. It, however, appears that there does not exist any clear relationship between treatment time and yarn diameter irregularity.

3.2.2 Effect on Tensile Properties

Table 3 shows that the treatment time does not have appreciable effect on tenacity and extension of the bulked yarns.

From the results on the effect of treatment time on shrinkage, specific volume and tensile properties of bulked yarns, it may be concluded that 30 min is the optimum treatment time for boiling water method of bulking.

3.3 Effect of Density of Ply Twist on Bulk of Yarn

Fig. 2 shows that an increase in ply twist in the parent yarn results in the decrease in specific volume of the bulked yarn and also that the percentage increase in specific volume on bulking decreases remarkably. An increase in twist means an increase in the packing of yarn structure which apparently inhibits the bulking of fibres in the yarn matrix during shrinking process in the water medium. Similar trend was also observed by Roy et al. for jute-shrinkable acrylic blended yarn bulked by steam relaxation method.

3.4 Effect of Blend Composition on Properties of Yarn

To study the effect of blend composition on the bulked yarn properties, the jute:shrinkable acrylic yarns of different proportions (100:0, 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80 and 0:100) were prepared. The treatment time in boiling water was maintained at 30 min. So, an effort has been made to find out suitable blend compositions which would give better yarn property at a satisfactory level to suit the various end uses.

3.4.1 Effect on Specific Volume and Shrinkage Behaviour

It is evident from Figs 3 and 4 that the jute:shrinkable acrylic yarn of 60:40 composition gives an optimum value of specific volume as well as per cent increase in specific volume from parent yarn and this is true for both single and plied yarns. This corroborates the findings of Singh et al. 14.

It is observed from Fig. 5 that the shrinkage percentage on bulking increases with the increase in percentage of acrylic up to a particular blend composition and then almost levels off. For single yarn, the maximum shrinkage occurs at the blend composition of 20:80 (jute:acrylic) and for 2-ply yarn it is 40:60 (jute:acrylic).

3.4.2 Effect on Specific Flexural Rigidity

In general, the yarns are often subjected to bending in weaving and knitting processes, even sometimes
through sharp angles, and, therefore, the flexural rigidity of the yarn plays an important role in the process of manufacturing as well as in the fabric for maintaining the equilibrium in the final structure.

It has been observed that the blending of shrinkable acrylic with jute reduces the flexural rigidity of the yarn. The flexural rigidity further reduces on bulking of the blended yarn (Fig. 6). The specific flexural rigidity values of 100% jute single and double yarns are 148 and 82 (mN. mm²/tex²) x 10⁴ and that for jute-acrylic 50:50 blended non-bulked yarns are 109 and 76 (mN. mm²/tex²) x 10⁴ respectively. After bulking of the blended yarn, the specific flexural rigidity decreases to 69 and 30 (mN. mm²/tex²) x 10⁴ respectively. This may be due to the reduction in compactness of fibrous assembly after bulking which helps in relatively easier movement of the individual fibres in the bulked yarn during bending or flexing of the yarn. It may also be observed that the plying of single yarns, whether non-bulked or bulked, reduces the specific flexural rigidity of the yarn. This is, however, due to the fact that S-twist is imparted during spinning of single yarns while Z-twist is imparted during plying. Thus, the actual twist in the resultant yarn reduces. Further, the increase in the proportion of acrylic in the blend decreases the specific flexural rigidity of the bulked yarns. However, the flexural rigidity increases in case of above 70% acrylic in the blend, particularly in case of plied yarns.

It is also important to note that the specific flexural rigidity of jute-acrylic bulked yarns of any proportion is much lower than that of the all-acrylic bulked yarns. This is true for both single and plied yarns.

3.4.3 Effect on Tensile Properties

Figs 7 and 8 show that an increase in the percentage of shrinkable acrylic in the blended yarn results in an increase in the extensibility of the yarn for both parent and bulked single and 2-ply yarns. It is noteworthy that the increase in the percentage of

Fig. 3 — Effect of blend composition on specific volume of parent and bulked yarns

Fig. 4 — Effect of blend composition on specific volume of bulked yarn

Fig. 5 — Effect of blend composition on shrinkage behaviour of treated yarn

Fig. 6 — Effect of blend composition on flexural rigidity of bulked yarn

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tenacity and increase in the extension of the bulked yarn. But after bulking, they show a different pattern. In static migration of fibres as well as kinks and loop formation by the fibres on bulking might have resulted in the substantial drop in the breaking tenacity and increase in the extension of the bulked yarn as compared to their parent yarns.

4 Conclusions

4.1 The specific volume of jute-shrinkable acrylic blended yarn is found to be the same in case of all the three methods of thermal relaxation.

4.2 The optimum treatment time in boiling water is 30 min.

4.3 An increase in ply twist results in the decrease in specific volume of the bulked yarn.

4.4 The flexural rigidity of bulked yarns is lower than that of parent yarns.

4.5 Sensibility of yarn increases remarkably after bulking but tenacity decreases to a considerable extent.

4.6 The blend composition greatly affects the specific volume, specific flexural rigidity and tensile properties of the yarns.

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References