Characteristics of dref-3 yarns with jute in core

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The tensile properties of jute-acrylic and jute-cotton dref-3 yarns with jute in core have been studied. The tenacity of dref-3 yarns was found to be lower but the strength translation efficiency of jute fibres was higher when used in the core of jute-acrylic dref-3 yarn as compared to that when used in the flyer yarn structure. Stick-slip pattern of failure was observed in case of dref-3 yarns, whereas catastrophic failure was observed in case of jute flyer yarn. Breaking elongation and specific work of rupture of the dref-3 yarns were higher than those of the jute flyer yarn.

Keywords: Dref-3 yarn, Jute-acrylic yarn, Jute-cotton yarn, Modulus ratio, Packing coefficient, Stick-slip pattern, Tensile properties

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1 Introduction

Dref-3 friction spinning technology has established its commercial success in the coarse and medium count range. The yarn consists of a core made of bundle of staple parallel fibres and a sheath where the staple fibres are regularly twisted in a helical fashion around the core. The strength of such a structure is largely dependent on the magnitude of radial pressure exerted by the sheath fibres on the core fibres.

Although considerable research work has been carried out to study the viability of spinning different fibres into yarn by this system of spinning, very little published work is available on the use of jute fibres and no published work is available on the use of jute fibres in the core. Jute fibre, blending of jute with finer and flexible fibres helps to improve the processing and characteristics of dref-2 yarns. Jute fibre has been used as sheath fibre in blends with other fibres in dref-3 system so as to cover it with high value fibre. There is a good effect of stronger and longer jute fibres in higher percentage, either in the core or in the sheath, on the tensile properties of dref-3 yarn.

Dref-3 yarn with jute in the intermediate layer is quite strong and has significantly lower shedding tendency during subsequent high speed weaving.

Stronger and longer fibres in the core produce stronger yarns; higher core/sheath ratio gives better strength, whereas lower core/sheath ratio gives better cover. Jute blended dref-3 yarn is being used as weft on various looms to produce denim and Oxford fabrics. Dusting of jute blended dref-3 yarn on shuttleless looms is appreciably lower as compared to similar yarn spun through the other spinning systems due to the presence of lesser jute fibres on the surface even when the jute content is around 53%. Oxford fabric with specialty finish is found to be quite comfortable and almost free from any pricking sensation.

As reported in the work carried out at Arvind Mills, the payback period is 4.5 years for a cotton/polyester mill which has to procure jute slivers from jute mills. The payback period is 6.6 years for a new dref-3 spinning plant which has to procure all the slivers from cotton/polyester/jute mills.

In the present work, the yarns have been spun by dref-3 spinning system using jute fibres in the core and acrylic as well as cotton as sheath fibres and the tensile characteristics of these yarns have been compared with those of conventional jute flyer yarns.

2 Materials and Methods

2.1 Materials

Jute fibres of Tossa-Daisee grade(TD-3), acrylic staple fibres of 3 denier and 51 mm length and cotton fibres of Digvijay grade were used. Some of the physical properties of these fibres are given in Table 1.
2.2 Methods

2.2.1 Preparation of Yarn Samples

A twenty-spindle Mackie apron-draft spinning frame was used to spin the conventional jute yarns of nominal linear density (175 tex) with four different twist multipliers (24.35, 25.56, 26.83 and 28.3) at a flyer speed of 3200 rpm.

Dref-3 machine was used to spin jute-acrylic and jute-cotton yarns of same nominal linear density at a delivery speed of 75 m/min. The speeds of spinning and carding drums were maintained at 3750 and 12000 rpm respectively. While jute sliver of 3.1 ktex was fed to the drafting unit 1, five slivers each of 3.2 ktex were fed to the drafting unit II in preparing both jute-acrylic and jute-cotton yarns. Core-sheath ratio of 70:30 was maintained to achieve stable spinning condition.

2.2.2 Evaluation of Tensile Properties

Tensile characteristics of all the fibres were tested on Zwick tensile tester (Model 1445) with a gauge length of 10 mm. Average values of tenacity, breaking elongation and initial modulus were taken for each type of fibres. Tests were carried out with cross-head speeds of 1, 5 and 10 mm/min for jute, cotton and acrylic fibres respectively.

Tensile characteristics of the yarn samples were tested on Instron tensile strength tester (Model 1195) with the gauge length of 500 mm and cross-head speed of 50 mm/min in all the cases. The average values of fifty tests were taken for each yarn sample to evaluate tenacity, elongation, specific work of rupture and initial modulus.

2.2.3 Evaluation of Packing Coefficient

The packing coefficient of each type of yarn was computed from the ratio of densities of yarn and fibre. The diameter of yarn samples was measured on a projectina microscope with the magnification of X 20. A pre-tension level of 0.025 cN/tex was used for each yarn sample. An average of thirty readings was taken for each yarn sample. Specific volume of fibre \( V_f \) in case of dref-3 yarns was calculated by taking the weighted average of specific volumes of the two component fibres using the following relationship:

\[
\text{Specific volume of fibre (} V_f = \frac{V_{f1} \times V_{f2}}{XV_{f1} + YV_{f2}}
\]

where \( V_{f1} \) and \( V_{f2} \) are the specific volumes of fibres \( f_1 \) and \( f_2 \); and \( X \) and \( Y \), the fractional presence of fibres \( f_1 \) and \( f_2 \). Specific volumes of jute, acrylic and cotton fibres were taken as 0.7, 0.85 and 0.65 cc/g respectively.

3 Results and Discussion

3.1 Tensile Characteristics of Jute Flyer Yarns

The twist-tenacity relationship is shown in Fig. 1. The optimum tenacity value is observed at a twist multiplier of 25.56. The increase in strength at low twist level is due to the increase in cohesive force and fall in strength after optimum twist multiplier is due to the obliquity effect.

3.2 Tensile Characteristics of Jute Blended Dref-3 Yarns

3.2.1 Tenacity

The characteristics of jute, acrylic and cotton fibres are shown in Table 1. Much lower value for elongation is observed in case of cotton fibres when compared with the normal values. This may be due to the short and coarser variety as lower elongation values are generally observed in shorter and coarser varieties.

The tensile characteristics of jute-acrylic and jute-cotton dref-3 yarns are given in Table 2 along with the tensile characteristics of jute flyer yarn at the optimum twist multiplier of 25.56. Tenacity values of both jute-acrylic and jute-cotton dref-3 yarns are found to be lower as compared to that of jute flyer-spun yarn. Jute flyer yarn shows the highest and jute-cotton dref-3 yarn shows the lowest tenacity values.

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**Fig. 1** Effect of twist multiplier on tenacity of twisted jute yarn

<table>
<thead>
<tr>
<th>Twist multiplier, turns/cm</th>
<th>24.35</th>
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<td>Specific Stress, cN/tex</td>
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while jute-acrylic dref-3 yarn occupies the intermediate position. However, the tenacity of jute-acrylic dref-3 yarn is found to have higher value than that of jute flyer yarn when the tenacity is calculated on the basis of linear density of jute fibres at the core. This indicates higher strength translation efficiency of jute fibres at the core. Tenacity of jute-cotton dref-3 yarn is found to be still lower than that of jute flyer yarn even when calculated on the same basis. It is evident from these results that the transverse pressure developed by surface acrylic fibres on the core structure comprising the jute fibres is more during straining of the yarn as compared to that developed by the twisted structure in case of jute flyer yarn. The transverse pressure generated by the surface cotton fibres is lower than that generated by the acrylic fibres. The less initial transverse pressure provided by cotton sheath is also evident from the lower packing coefficient value (Table 2). A marginally lower packing coefficient value of jute-acrylic dref-3 yarn is observed as compared to that of jute flyer yarn.

3.2.2 Initial Modulus

The initial modulus values of both jute-acrylic and jute-cotton dref-3 yarns are lower than that of jute flyer yarn. But considering the linear density of jute fibres in the core, the initial modulus is found to be higher for both jute-acrylic and jute-cotton dref-3 yarns. Table 2 also shows the ratio of yarn modulus and fibre (jute) modulus. The ratio is lower in case of dref-3 yarns than that in case of jute flyer yarn when the count of the whole yarn is considered. But when linear density of jute fibres in the core is considered, both jute-acrylic and jute-cotton dref-3 yarns show higher values of modulus ratio than that of jute flyer yarn. This essentially shows higher effective utilization of fibre tensile characteristics in the elastic deformation part of dref-3 yarn due to the development of more transverse pressure on the core structure by the surface fibres.

3.2.3 Elongation and Specific Work of Rupture

Elongation at maximum load for the dref-3 yarns is found to be higher than the elongation at failure of the jute flyer yarn. This may be due to the slipping and gripping phenomenon of the dref-3 yarns, thus delaying the failure to occur, as compared to the catastrophic failure in case of jute flyer yarn. Specific work of rupture values of dref-3 yarns are found to be remarkably higher than that of jute flyer yarn, which is due to the step-wise failure of the dref-3 yarns, resulting in the failure to occur over a longer time as compared to the catastrophic failure of jute flyer yarn.

3.3 Failure Mechanism

The failure mechanism of jute flyer yarn and jute-acrylic and jute-cotton dref-3 yarns can be explained from their stress-strain curves (Fig. 2). As compared to the catastrophic failure in case of jute flyer yarn, a stick-slip pattern due to the alternate slipping and gripping phenomenon of the dref-3 yarns, thus delaying the failure to occur, as compared to the catastrophic failure in case of jute flyer yarn. Specific work of rupture values of dref-3 yarns are found to be remarkably higher than that of jute flyer yarn, which is due to the step-wise failure of the dref-3 yarns, resulting in the failure to occur over a longer time as compared to the catastrophic failure of jute flyer yarn.
gripping of core and sheath fibres is observed in case of dref-3 yarns. A phenomenon of multiple breakage of core fibres is possibly the reason of such behaviour for dref-3 yarns, which is due to the continual development of transverse pressure by the sheath fibres as the yarn is strained.

4 Conclusions

4.1 Jute can be used successfully in the core of dref-3 friction yarn. Core-sheath ratio of 70 : 30 for both jute-cotton and jute-acrylic is found to be the most suitable from the spinning point of view. Maximum speed of 75 m/min is also found to be possible for stable spinning.

4.2 Jute-acrylic and jute-cotton dref-3 yarns with jute in the core show considerable strength but lower than that of jute flyer yarns. The strength translation efficiency of the jute fibres in the core is higher for jute-acrylic dref-3 yarns than for the corresponding flyer yarn.

4.3 The elongation at maximum load for jute-acrylic and jute-cotton dref-3 yarns is higher than the breaking elongation of jute flyer yarn, resulting in higher specific work of rupture of these yarns. The initial modulus of jute-acrylic and jute-cotton dref-3 spun yarns is comparable with that of jute flyer yarn.

4.4 The spinning of jute-cotton and jute-acrylic dref-3 yarn and making fabrics from such yarns shall be commercially viable and can be used for the production of diversified value-added products, like furnishings, decorative fabrics and blankets.

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References