Some studies on properties of wrapped jute/acrylic (parafil) yarns

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The effects of blend composition in the core and of wrap density on the properties of parafil yarns prepared using jute/acrylic fibres as core and polyester as wrapper filaments have been studied. It is observed that the unevenness, imperfections and mechanical properties of parafil yarn are greatly influenced by both blend composition and wrap density. With increase in acrylic component at comparable wrap density, the total imperfections, CV_m%, initial modulus, strength CV% and flexural rigidity show decreasing trend but hairiness index, tenacity, breaking extension, toughness and abrasion resistance tend to increase. With increase in wrap density the breaking extension and abrasion resistance decrease, whereas hairiness index, initial modulus, toughness and flexural rigidity increase. Tenacity first increases and then decreases with increase in wrap density, whereas CV_m% does not show any trend. As compared to jute parafil yarn, the conventional jute yarn shows less CV_m%, imperfections, extension at break, toughness and flexural rigidity but higher hairiness index, tenacity and abrasion resistance.

Keywords: Abrasion resistance, Flexural rigidity, Hairiness, Imperfection, Jute/acrylic fibre, Parafil yarn, Tenacity, Toughness

1 Introduction

It has been felt necessary from a long time that a finer, uniform, and stronger jute-based yarn should be produced by economical and high productive process. With the advent of various new yarn spinning technologies the scope of using jute and jute-blended yarn has improved considerably. An indication of such attempt is available in literature using core spun, twistless, rotor, dref and wrap or cover spun (hollow-spindle technique) technology. In the hollow-spindle technology, a yarn is produced by wrapping a continuous filament around a core consisting of straight and parallel fibres. The continuous filament yarn provides radial tension and, consequently, friction between the individual fibres. As the structure of this yarn is quite different from the conventional yarns, and the fibres in the yarn are held together by the friction pressure induced by the wraps, it is expected that the properties of the wrapper filaments, core fibres and wraps per metre will have a strong influence on the mechanical properties of the yarn. Initial attempts of jute-based wrap yarn manufacture were limited to coarser count by hollow-spindle technology using HDPE or polypropylene as wrapper filaments.

In the present work, the attention is drawn towards manufacture of finer jute-based yarn using the parafil yarn technology. Keeping this in mind, an attempt has been made to see the effect of blend ratio of jute and acrylic fibres in core and of wraps/m on the physical and mechanical properties of parafil yarn.

2 Materials and Methods

2.1 Materials

Tossa-daisee jute fibres and acrylic fibres were used as core and polyester multifilament was used as wrapper to prepare jute/acrylic parafil yarns. The physical properties of the raw materials are given in Table 1.

Tossa-daisee jute (TD-3) fibre in the form of finisher card roll and six denier acrylic fibres of

<table>
<thead>
<tr>
<th>Material</th>
<th>Fiber density g/cm³</th>
<th>Linear density dtex</th>
<th>Tenacity g/tex</th>
<th>Extension at break %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jute fibre</td>
<td>1.48</td>
<td>20.2</td>
<td>39.19</td>
<td>1.19</td>
</tr>
<tr>
<td>(TD-3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrylic fibre</td>
<td>1.17</td>
<td>6.6</td>
<td>20.00</td>
<td>15.24</td>
</tr>
<tr>
<td>Polyester multifilament*</td>
<td>1.38</td>
<td>55.5</td>
<td>35.00</td>
<td>24.00</td>
</tr>
</tbody>
</table>

*Fineness, 50 denier; No. of mono filaments, 27
variable length (2 in., 4 in., 5 in.) in top form were
used either separately or in combination for
preparing parallel sliver strand of 100% jute, 100%
acrylic and different proportions of jute/acrylic
blend. Slivers of appropriate mass/unit length were
prepared using successive drawing machines with
suitable draft and doubling. The slivers (120 lb/spyd) of all jute, all acrylic and jute-acrylic
blended strands were used as feed material to wrap
spinning machine.

Approximately 140 tex (4 lb/spyd) of 100%
jute, 100% acrylic and 75/25, 50/50 and 25/75 jute-
acrylic blended yarns with polyester multifilament
yarn as wrapper (wraps/m: 280, 315 and 350) were
manufactured using a six-spindle Suessen Parafil-

For the purpose of comparison, conventional
spun (apron draft) 100% jute yam of about 140
tex/280 tpm (4 lb/spyd) was also manufactured.

2.2 Methods

2.2.1 Packing Coefficient

Packing coefficient was calculated using jute
fibre density as 1.48 g/cm³. Projectina microscope
was used for measuring yarn diameter.

2.2.2 Yarn Unevenness, Imperfections and Hairiness

Uster-3 Evenness Tester with 200 m/min yarn
speed and normal setting of imperfections was used
for the measurement of mass irregularity CV%, U%
and imperfections.

Hairiness index was estimated in Uster-3 by
measuring the total length of hair per cm of yarn,
which is an integrated average of 500 m of yarn run.

2.2.3 Tensile Properties

Instron Tensile Tester (model 1122) was used for
tensile tests of yarn using 50 cm gauge length, 20
cm/min cross-head speed and 20 cm/min chart
speed. An average of 50 observations was taken for
each sample.

Uster Tensorapid was used to obtain the work of
rupture values (toughness). An average of 30 tests
was taken for each sample. Initial modulus values
(modulus at 1% extension) were obtained from the
same instrument for each sample.

2.2.4 Flexural Rigidity

The flexural rigidity of yarn was measured using
‘Ring Loop’ method as suggested by Peirce and
modified by Owen. It is calculated on the basis of
measurement of small deflection of the loop under a
known weight. Twenty readings were taken for each
sample.

2.2.5 Abrasion Resistance

CSI Flex Abrasion Tester was used to measure
abrasion resistance of yarn samples. Twenty
observations were taken and the average number of
cycles required to break the specimen was taken as a
measure of abrasion resistance.

3 Results and Discussion

3.1 Uster Results for Jute/Acrylic Blended Wrap Spun Yarn

3.1.1 Mass Irregularity

It is observed from Table 2 that the mass CV%
and U% of 100% wrap spun jute yarn are in the
range of 30.7-32.6% and 24.6-26.1% respectively
while the mass CV% and U% of 100% wrap spun
acrylic yarn are 20-23% and 16-18% respectively
for all the three wrap density (280, 315 and 350
wraps/m) of polyester multifilament wrapper used.

With the increase in the proportion of acrylic fibre
in the blend, the mass CV% and U% gradually
reduce up to 100% wrap spun acrylic yarn. Higher
proportion of jute in the blend, therefore, causes
higher mass CV% and U%. The above phenomenon
may be due to the higher mass irregularity of jute
fibre, as compared to that of acrylic fibre. Again,
with increase in acrylic content, the total number of
fibres in the yarn cross-section increases because of
the use of finer acrylic fibres, resulting into better
mass regularity. The overall irregularity of all types
of yarn is higher which may be due to the poor
control of fibre during processing. Mass irregularity
does not show any trend with wrap density for all
types of yarn.

3.1.2 Imperfections

From Table 2 it may be seen that 100% jute wrap
spun yarn shows large number of thick and thin
places and neps/slubs. With the increase in the
proportion of acrylic fibres in the wrap spun yarn of
same wrap density, imperfections (thick places, thin
places and neps) per km decrease. But with the
increase in wrap density from 280 wraps/m to 250
wraps/m, the thick places, thin places, neps and the
total imperfections do not exhibit any common trend
considering all types of yarn.

3.1.3 Hairiness

It is observed from Table 2 that in almost all the
cases as the proportion of acrylic fibres increases,
the hairiness index increases at all levels of
wraps/m. This is attributed to the relatively longer
hairs of acrylic component. Also, the number of hairs is higher due to acrylic component as the number of fibres in the yarn increases with the increase of acrylic component (also confirmed by projectina microscope).

Further, for a particular jute/acrylic blended wrap spun yarn with the increase in wrap density, the Uster hairiness index decreases which is due to decrease in average hair length. However, 100% jute wrap spun yarn shows less hairiness than 100% jute conventional spun yarn due to wrapping of relatively straight core fibres by multifilament yarn.

### 3.2 Mechanical Properties

#### 3.2.1 Tenacity and Strength CV%

It is seen from Table 3 that 100% jute wrap yarn
exhibits lowest tenacity amongst yarns of comparable count and wrap density. With increase in acrylic component in jute/acrylic blended wrap spun yarn, the tenacity increases at comparable wrap density. The above phenomenon may be attributed to less proportion of short fibres and higher uniformity of yarn structure with increase in acrylic component in the yarn. Again, the higher extensibility of acrylic fibre helps wrapper filament to orient along the yarn axis with increased radial packing, resulting into greater strength. Apart from this, the increase in tenacity may also be attributed to the increase in the number of fibres in the yarn cross-section because of the use of finer acrylic fibres. Hence, in this case, decrease in stronger jute component and packing coefficient (Table 2) with the increase in acrylic fibres in blend does not have much bearing on the tenacity of parafil yarn.

However, with the increase in wrap density at a fixed blend ratio in jute/acrylic blended wrap spun yarn, the tenacity increases up to 315 wraps/m and then decreases with further increase in wrap density. The observed results may be viewed under the effect of two opposing influences: (i) with increase in wraps/m, the yarn becomes more compact, i.e. fibres in the yarn pack more closely (Table 2), resulting in higher inter-fibre friction due to higher radial compressive force by higher number of wraps/m, ultimately causing increase in tenacity, and (ii) with a very large number of wraps/m, the contribution in tensile load sharing by the wrapper filament in the parallel direction of yarn axis reduces, which results in the above phenomenon.

Table 3 shows that the conventional spun 100% jute yarn possesses higher strength than 100% jute wrapped spun yarn which may be due to the difference in their structures. With the increase in acrylic fibre component in the blend, the strength CV% decreases to a noticeable extent and becomes lowest in case of 100% acrylic spun yarn.

3.2.2 Extension at Break

It is observed from Table 3 that with the increase in proportion of acrylic fibre in jute/acrylic blended wrap yarn, the extension at break increases continuously showing highest breaking extension for 100% acrylic wrap yarn. This may be due to the increase in proportion of higher extensible acrylic fibre in the core material. However, this must be carefully examined that the variation of wrap density for any wrap yarn does not have much bearing on breaking extension.

From Table 3, it is also observed that the breaking extension of 100% conventional jute yarn is less as compared to that of wrapped jute yarn which can be explained as fibres form helix which possesses interlocking structure in ring-spun yarn contrary to wrap yarn counterpart.

3.2.3 Initial Modulus

It is observed from Table 3 that with the variation of blend ratio the initial modulus does not show any definite trend, but 100% jute wrapped yarn exhibits higher initial modulus than that of 100% acrylic yarn. The above phenomenon may be due to the higher initial modulus of jute fibre as compared to acrylic fibre. Again, a gradual decrease in initial modulus is noticed with increase in wrap density for all types of yarn.

3.2.4 Toughness and Flexural Rigidity

It is seen from Table 4 that with the increase in acrylic content in the yarn with definite wrap density, the toughness increases which is expected due to the greater extensibility of acrylic fibre. It is also noticed that with the increase in wraps/m for a yarn of same blend ratio, the toughness index increases.

The specific flexural rigidity decreases with the increase in acrylic component at all levels of wrap density (Table 4). This may be due to the less rigidity of acrylic fibre as compared to jute fibre.

Table 4—Toughness, specific flexural rigidity and abrasion resistance of jute/acrylic blended wrap spun yarn

<table>
<thead>
<tr>
<th>Blend ratio</th>
<th>Wraps/m</th>
<th>Toughness</th>
<th>Flexural rigidity x 10⁴</th>
<th>Abrasion resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>kgf-cm</td>
<td>g-cm²</td>
<td>cycles</td>
</tr>
<tr>
<td>100:0</td>
<td>280</td>
<td>0.69</td>
<td>0.430</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>315</td>
<td>0.83</td>
<td>0.457</td>
<td>112</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>1.00</td>
<td>0.443</td>
<td>95</td>
</tr>
<tr>
<td>75:25</td>
<td>280</td>
<td>1.05</td>
<td>0.419</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>315</td>
<td>1.09</td>
<td>0.435</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>1.12</td>
<td>0.326</td>
<td>122</td>
</tr>
<tr>
<td>50:50</td>
<td>280</td>
<td>6.05</td>
<td>0.236</td>
<td>233</td>
</tr>
<tr>
<td></td>
<td>315</td>
<td>6.31</td>
<td>0.259</td>
<td>204</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>6.62</td>
<td>0.248</td>
<td>195</td>
</tr>
<tr>
<td>25:75</td>
<td>280</td>
<td>13.05</td>
<td>0.191</td>
<td>278</td>
</tr>
<tr>
<td></td>
<td>315</td>
<td>13.19</td>
<td>0.208</td>
<td>268</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>13.86</td>
<td>0.175</td>
<td>245</td>
</tr>
<tr>
<td>0:100</td>
<td>280</td>
<td>17.00</td>
<td>0.103</td>
<td>464</td>
</tr>
<tr>
<td></td>
<td>315</td>
<td>17.45</td>
<td>0.114</td>
<td>439</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>17.80</td>
<td>0.104</td>
<td>369</td>
</tr>
<tr>
<td>Conventional spun</td>
<td>0.50</td>
<td>0.400</td>
<td>156</td>
<td></td>
</tr>
<tr>
<td>100% jute yarn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Interestingly, with the increase in wraps/m, the specific flexural rigidity first increases and then decreases. It is also observed from Table 4 that the conventional jute yarn shows lower flexural rigidity as compared to wrapped jute yarn which may be due to the migratory fibre structure of conventional jute yarn.

3.2.5 Abrasion Resistance

It is seen from Table 4 that the flex abrasion resistance increases with the increase in acrylic content in the yarn at comparable wrap density. The above phenomenon may be due to the inherent property of the acrylic fibre. Again, with the increase in wrap density the abrasion resistance shows decreasing trend for all types of yarn. The above trend may be due to greater cutting effect because of increased yarn packing.

4 Conclusions

4.1 With increase in acrylic component, the packing coefficient, CVm%, total imperfections, initial modulus, strength CV% and flexural rigidity tend to decrease but hairiness index, tenacity, breaking extension, yarn toughness and abrasion resistance show increasing trend.

4.2 With increase in wraps/m on any parafil yarn, the packing coefficient, breaking extension and abrasion resistance show decreasing trend but hairiness index, initial modulus, yarn toughness and flexural rigidity increase. Tenacity first increases and then decreases with increase in wrap density whereas CVm% does not show any trend.

4.3 As compared to jute parafil yarn, the conventional spun jute yarn shows less CVm%, imperfections, extension at break, toughness and flexural rigidity but it exhibits higher hairiness index, tenacity and abrasion resistance.

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References