Hairiness of Jute Yarn: Part II—Effects of Linear Density, Twist Multiplier, Spinning Draft and Piling Period

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The effects of variation of linear density, twist multiplier, spinning frame draft and piling period on the hairiness of jute yarn were examined. With increase in linear density and twist multiplier the hairiness decreased significantly. Increase in spinning frame draft caused a significant increase in hairiness. A piling period of 3 days produced a minimum number of hairs, and with increase in piling period the hairiness increased.

Keywords: Bulk density, Jute yarn, Packing coefficient, Piling period, Singeing, Spinning draft, Yarn hairiness

1 Introduction

Jute yarn is excessively hairy owing to some of the inherent fibre properties and a number of processing factors. In the normal use of jute fibre as a packaging material, hairiness may not be so important, but in diversifying the use of jute to high-value decoratives, hairiness will be a major shortcoming. Unless the hairiness is controlled suitably, diversification in use cannot be fully realized. Apart from other disadvantages of hairiness of jute yarn to be used for upholsteries and other decoratives, high dust pick-up and shredding loss are the most important ones. Factors responsible for hairiness of many natural and manmade fibres have been studied extensively, but no published data for jute yarn are available.

The effects of on-line spinning tensions on hairiness of jute yarn have been studied and the data published1. The influence of some of the processing factors, viz. linear density, twist multiplier, spinning draft and piling period were studied in this work.

2 Materials and Methods

After proper sampling, W-2 grade white jute fibres were sprayed with 30% oil-in-water emulsion (20 : 80) on the weight of the fibre, and passed through 63 pairs of softener rollers and binned for 72 h except in the case of the fourth set of yarns. The softened fibres were processed through standard jute machinery following the small-scale spinning technique2. The sequence of machinery was: JF3 breaker card, JF4 finisher card, three passages of Mackie screw-gill drawing frames and 4.25 in Mackie slip draft spinning frame. Four sets of yarns were spun. In the first set the twist multiplier was kept constant at 25 (tex$^{1/2}$ × tpc) and the yarns were spun with different tex values—217, 263, 324, 385 and 407. The second set of yarns was spun with a constant linear density of 276 tex, while the twist multiplier was varied to get 3.0, 3.6, 4.0, 4.5, 5.0 and 6.0 twists per inch. In the third set, both the linear density and twist density of all the yarns were kept constant but yarns were spun with variable spinning drafts of 12.5, 16.0, 17.6 and 18.2, by using back stuff of different linear densities. The piling or binning period, after the application of the oil-in-water emulsion, was varied, the other parameters being kept constant to spin yarns of the fourth set. The piling period was varied from 0 to 4 days with a day's interval.

The JTRL jute yarn hairiness meter3 was used to count the number of hairs per unit length of 230 cm measured at a distance of 2.3 mm from the surface of the yarn.

The loss in weight due to singeing in all the cases was also studied by the method developed in this laboratory1 and expressed as a percentage of the actual weight of the yarn. This was considered as the index of hairiness.

The diameter of all the parent yarns was measured in a Projectina microscope (× 20). The bulk density and packing coefficient were calculated by the relationship:

Packing coefficient = Bulk density/Fibre density

where, bulk density = 1/specific volume, and specific volume = $\pi d^2.10^5/4 T$, $d$ being the diameter of yarn in cm and $T$ being the linear density of the yarn in tex.

The results are given in Tables 1 and 2 and in Figs 1 and 2.
3 Results and Discussion

Variations in the number of hairs in the yarns of different linear densities are shown in Table 1. The respective diameters (in microns), specific volumes, bulk densities and packing coefficients of the yarns are also given in the table. The table shows that the hairiness of jute yarn sharply decreases with increase in the linear density. The number of fibres per cross-section and, hence, the diameter and bulk of the yarn, increases with increase in the tex value. Coarser yarns, being less packed and more bulky, will minimize the chance of the drafted fibres to let their ends outwards, whereas in the case of finer yarns, with higher packing density and lower bulkiness, the fibres in the drafted strand will have a tendency to eject out their ends. Pillay\textsuperscript{5} reported that the hairiness increased with the increase in count. Barella\textsuperscript{6} also reported that increase in yarn diameter decreased the hairiness (with a correlation coefficient of 0.6 to 0.8) of worsted yarn. It is also reported in the same review that Hunter and his coworker, and Hunter, Barella and Manich, worked with mohair and wool-worsted spun yarns using a Shirley hairiness meter and a digital apparatus. They also found that linear density and hairiness were highly inter-related with a positive significant correlation coefficient. In our present study with jute fibres, the correlation coefficient is (-0.9591) and statistically significant at 99\% confidence interval.

Table 2 shows that the hairiness decreases with increase in twist density of the yarn. The index of hairiness, measured by an electronic hairiness meter as well as by singeing, shows a clear downward trend with increase in the twist. Higher twists always generate a higher twist angle in the structure of the yarn, which resists the fibre ends to migrate outwards. It may rather help shorten the length of the protruding fibre ends with a tendency of the fibre ends to migrate inward. Barella\textsuperscript{6}, Vila et al.\textsuperscript{8} and Pillay\textsuperscript{5} observed an inverse relationship between hairiness and twist in yarn, though Boswell and Townend\textsuperscript{9} could not confirm this relationship using the gravimetric measuring technique. Barella\textsuperscript{6}, however, confirmed a significant difference in hairiness at different twist densities of the yarns of the same count.

Table 2 shows that the yarn diameter and the specific volume of the yarn are inversely, and the packing factor is directly, proportional to twist factors of the yarns.

### Table 1 — Linear Density versus Hairiness

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Linear density (tex)</th>
<th>Mean no. of hairs per 230 cm of yarn</th>
<th>CV of no. of hairs (%)</th>
<th>Hair loss by singeing (%)</th>
<th>Yarn diameter ((\mu))</th>
<th>Specific volume (cm^3/g)</th>
<th>Bulk density (g/cm^3)</th>
<th>Packing coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>217</td>
<td>321</td>
<td>22.0</td>
<td>9.70</td>
<td>639</td>
<td>1.4778</td>
<td>0.6766</td>
<td>0.4666</td>
</tr>
<tr>
<td>2</td>
<td>263</td>
<td>296</td>
<td>18.5</td>
<td>9.70</td>
<td>721</td>
<td>1.5524</td>
<td>0.6442</td>
<td>0.4442</td>
</tr>
<tr>
<td>3</td>
<td>324</td>
<td>289</td>
<td>18.0</td>
<td>2.52</td>
<td>808</td>
<td>1.5826</td>
<td>0.6319</td>
<td>0.4358</td>
</tr>
<tr>
<td>4</td>
<td>385</td>
<td>267</td>
<td>17.0</td>
<td>2.04</td>
<td>890</td>
<td>1.6158</td>
<td>0.6188</td>
<td>0.4267</td>
</tr>
<tr>
<td>5</td>
<td>407</td>
<td>240</td>
<td>12.0</td>
<td>3.09</td>
<td>980</td>
<td>1.8533</td>
<td>0.5396</td>
<td>0.3721</td>
</tr>
</tbody>
</table>

The difference in values of hairiness by number is significant at 99\% confidence limit in all the cases except between the samples 2 and 3. Correlation coefficient of linear density and hairiness is (-0.9591) and is significant at 99\% confidence limit.

**Observed \(t\) value (1\% level) = 5.868 (D.F. = 3)**

**Tabulated \(t\) value (1\% level) = 5.841 (D.F. = 3)**

### Table 2 — Twist Density versus Hairiness

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Nominal TPI</th>
<th>Actual TPI</th>
<th>Mean no. of hairs per 230 cm of yarn</th>
<th>CV of no. of hairs (%)</th>
<th>Hair loss by singeing (%)</th>
<th>Yarn diameter ((\mu))</th>
<th>Specific volume (cm^3/g)</th>
<th>Bulk density (g/cm^3)</th>
<th>Packing coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.00</td>
<td>2.8</td>
<td>542</td>
<td>18.1</td>
<td>3.93</td>
<td>852</td>
<td>2.0656</td>
<td>0.4841</td>
<td>0.3339</td>
</tr>
<tr>
<td>2</td>
<td>3.60</td>
<td>3.5</td>
<td>377</td>
<td>20.5</td>
<td>3.70</td>
<td>805</td>
<td>1.8440</td>
<td>0.5423</td>
<td>0.3739</td>
</tr>
<tr>
<td>3</td>
<td>4.00</td>
<td>3.8</td>
<td>334</td>
<td>18.8</td>
<td>3.08</td>
<td>737</td>
<td>1.5457</td>
<td>0.6469</td>
<td>0.4462</td>
</tr>
<tr>
<td>4</td>
<td>4.50</td>
<td>4.4</td>
<td>284</td>
<td>18.0</td>
<td>2.91</td>
<td>713</td>
<td>1.4466</td>
<td>0.6913</td>
<td>0.4767</td>
</tr>
<tr>
<td>5</td>
<td>5.00</td>
<td>4.8</td>
<td>281</td>
<td>18.0</td>
<td>2.58</td>
<td>692</td>
<td>1.3627</td>
<td>0.7338</td>
<td>0.5061</td>
</tr>
<tr>
<td>6</td>
<td>6.00</td>
<td>5.8</td>
<td>230</td>
<td>17.8</td>
<td>1.85</td>
<td>657</td>
<td>1.2283</td>
<td>0.8141</td>
<td>0.5615</td>
</tr>
</tbody>
</table>

The difference in values of hairiness by number is significant at 99\% confidence limit in all cases except between samples 4 and 5. Correlation coefficient of twist density and hairiness is (-0.90) and is significant at 95\% confidence limit.

**Observed \(t\) value (5\% level) = 4.129 (D.F. = 4)**

**Tabulated \(t\) value (5\% level) = 2.78 (D.F. = 4)**

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jute yarn of 276 tex. The twist factor always maintains an inverse relationship with the yarn hairiness with a correlation coefficient of (-)0.9. The result is statistically significant at 99% confidence interval, except in one case.

The relationship between draft and hairiness measured by both the electronic meter and singeing is shown in Fig. 1. The figure shows that the spinning draft has a direct impact on the hairiness. Hairiness increases gradually with increase in spinning draft. Pillay\textsuperscript{10} observed similar trends while spinning cotton yarns of different counts with different varieties of cotton in the cotton machinery. A higher draft requires thicker jute drawing sliver for spinning yam of the same count, and it is also known that thicker sliver gives rise to a wider spread of fibre in the nip of the drafting rollers. Consequently, as the pressure on the fibres is released, the fibres of the ribbons are carried by inter-fibre friction only. But as the inter-fibre friction at both the fringes of the ribbon is remarkably less, the movement of these fibres is somewhat uncontrolled and during twisting they are likely to protrude from the periphery of the yarn. Cavaney and Foster\textsuperscript{11} explained this trend in terms of yarn irregularity. They found that irregularity arising out of drafting waves increased with increasing draft. Yarn hairiness may be expected to increase with yarn irregularity, because fibres protruding from the yarn surface are greater in number at the thickest and less twisted part of the yarn\textsuperscript{4}.

In the present study, the correlation coefficient between spinning draft and hairiness was 0.9944, with the statistical significance at 99% limit.

Fig. 2 shows that the least number of hairs is generated when piling or binning period is kept at 3 days. Bandyopadhyay \textit{et al.}\textsuperscript{12} observed that with 3 days' piling period the yarn tenacity improves considerably with the reduction in strength CV\% and weight CV\%. In normal industrial practice also, a good-quality jute fibre is piled for 3 days after emulsification and before further processing. It may be presumed that 72 h is the optimum time for proper spread of emulsion and subsequent softening of fibres. With increase in piling period, evaporation may take place, which might cause the drying of fibres, generation of shorter fibres in carding and production of an irregular sliver. The net effect may be the production of more number of hairs as observed on raising the piling period to 4 days.

\section*{4 Conclusions}

4.1 The hairiness of jute yarn decreases with increase in the count of the yarn in the direct system.

4.2 With increase in twist the hairiness of the yarn decreases.

4.3 Increase in spinning draft increases the hairiness of jute yarn.

4.4 Three days' piling period produces a minimum number of hairs in jute yarn.

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\section*{References}