Spinnability of Jute Fibres with Special Reference to Bleached Jute

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The changes in jute fibre properties at various degrees of bleaching are reported. The changes in processing parameters, found necessary during semi-bulk and bulk trials in the mills, along with the limitation in spinnability of jute, are discussed. Up to 3% concentration of $\text{H}_2\text{O}_2$, there was no problem in spinning, only higher twist was necessary. Above this, the bundle tenacity of fibre decreased rapidly and hence adjustments in carding and spinning were essential. For efficient spinning the limiting value of bundle tenacity was 13 g/tex.

Keywords: Bleaching, Jute fibre, Spinning

1 Introduction

Bleaching of jute is one of the important means of diversifying jute goods so as to promote its uses in decorative and furnishing materials such as wall covers, curtains and upholstery. The conventional bleaching process involves bleaching at fabric stage with wet-processing machinery. The drawbacks are high processing cost, high capital investment in the setting up of a plant and loss in weight and shrinkage of fabric width. As a result, it prevents many mills from entering into this field.

With a view to overcoming these drawbacks to a large extent, IJIRA developed a simple and economic process of bleaching jute fibres at the fibre preparation stage (batching). Any mill can adopt the process as it dispenses with wet-processing machinery. The bleached fibres are processed through the normal sequence of carding, drawing, spinning and weaving through the conventional machinery.

The process consists in incorporating a bleaching agent and auxiliary chemicals with a jute batching oil (JBO) emulsion and its application of fibres in such concentrations as to achieve the desired degree of whiteness.

In this process, the fibre properties change owing to the application of the bleaching agent. The degree of change depends on the concentration of the bleaching agent. Because of the change in fibre properties, the spinnability of the fibres also changes. Hence processing parameters of carding and spinning require some changes in order to achieve satisfactory spinning efficiency and yarn quality.

In this paper, the changes in fibre properties at various degrees of bleaching are reported. The changes in processing parameters found necessary during semi-bulk and bulk trials in mills are discussed along with some experiments to achieve the optimum values of the parameters. An attempt has also been made to find out the limitations in spinnability of jute with respect to spinning performance and yarn tenacity against fibre tenacity, which is the most important criterion of the fibre properties. Further, the twist factor for processing weak fibres has been optimized to achieve optimum yarn tenacity.

2 Materials and Methods

Standard grades of TD 3 and W3 jute were used in the proportion 7:3, and hydrogen peroxide was used as a bleaching agent. The dry-cut jute was processed through a dry softener machine to free the fibres from foreign matters like dirt, dust and specks, and to soften the fibres mechanically so that the chemicals can easily penetrate into the fibres. The chemicals were sprayed over the fibres along with the jute batching oil (JBO) emulsion in proportion to the weight of jute. The application was restricted to between 20 and 30% depending upon RH of the atmosphere. The application of JBO was maintained at 2%, the application of $\text{H}_2\text{O}_2$ being varied up to 6%. The fibres were later piled for 48-72 h depending on the concentration of $\text{H}_2\text{O}_2$ applied.

The bundle tenacity (g/tex) of raw jute was determined before and after the treatment for each quality of jute on a Scott fabric strength tester at a gauge length of 5 cm with a constant rate of traverse (30 cm/min). The average of 30 measurements was calculated. Fineness was determined by the air flow method and the average fibre length in the breaker card sliver was determined according to the method developed by Mukhopadhyay and Bhattacharyya.

During carding, droppings beneath the cards were weighed and expressed as percentage of the total weight of jute processed for different types of cards available in the industry. The carding intensity was
Table 1—Fibre Fineness (denier) at Various Degrees of Bleaching TD3 and W3 Grades of Jute

<table>
<thead>
<tr>
<th>Grade of jute</th>
<th>Fibre fineness at different conc. of H$_2$O$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
</tr>
<tr>
<td>TD3</td>
<td>22±1.1</td>
</tr>
<tr>
<td>W3</td>
<td>17±1.2</td>
</tr>
</tbody>
</table>

The value of fibre fineness is average value ± standard error.

changed by changing draft and cylinder speed of the cards to optimize it with a view to achieving optimum yarn tenacity of bleached jute.

The unevenness of the finisher drawing sliver was determined with an Uster evenness tester at a speed of 25 m/min for 5 min after properly conditioning the material. The value of unevenness (U%) was converted to CV% (CV% = 1.25 U%) in accordance with the Uster Manual.

The spinning performance was studied by counting end-breaks for 10 doffs, the average breakage rate being expressed as number of breaks per 100 spindle-hours. To improve the spinning performance, various twists per decimetre were tried during mill trials and from the corresponding yarn test results, the optimum twist was determined for bleached jute.

The tensile strength of yarn was determined by breaking 100 pieces of single yarn on a Goodbrand’s yarn strength tester at a gauge length of 60cm with a constant rate of traverse (30 cm/min). The linear density (tex) of the yarn was determined on the basis of 5 hanks of 67.5 m each from 5 different bobbins. The yarn tenacity (g/tex) was calculated by dividing the average yarn strength by its linear density.

The degree of whiteness was determined by measuring brightness index by using a reflection meter (Model No. CG-60 of Canadian Research Institute) with Tristimulus blue filters.

3 Results and Discussion

The relationship between bundle tenacity of fibres and concentration of H$_2$O$_2$ (Fig. 1) shows that the bundle tenacity decreases with increase in H$_2$O$_2$ concentration. This is because the process reduces the amount of lignin, the main cementing agent for the constituents. As a result, during carding, the weaker fibres break and the average fibre length decreases with increase in the concentration of H$_2$O$_2$ (Fig. 2). But fibre fineness does not change (Table 1) and this implies that H$_2$O$_2$ does not act uniformly on the fibres along its length. The comparatively weak portion of it, where H$_2$O$_2$ acts directly, breaks during carding and turns into short fibres. The strong portion remains intact, resulting in the reduction in the average fibre length but of the same fineness. The short fibres and dust thus generated during carding drop under the cards as droppings which increase with increase in the concentration of H$_2$O$_2$ (Table 2). The dust and short fibres should be dropped to the extent possible, otherwise there would be a disturbance in the subsequent processing, resulting in excessive slub in sliver and yarn. In this regard, open cards (half circular finisher card) appear to be better than closed cards (full circular finisher card).

Table 2—Card Dropping (%)

<table>
<thead>
<tr>
<th>Card droppings at different conc. of H$_2$O$_2$</th>
<th>0%</th>
<th>2%</th>
<th>4%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breaker card</td>
<td>0.59</td>
<td>0.76</td>
<td>1.19</td>
</tr>
<tr>
<td>Finisher card</td>
<td>1.21</td>
<td>1.29</td>
<td>1.43</td>
</tr>
<tr>
<td>Half-circular (open)</td>
<td>1.06</td>
<td>1.12</td>
<td>1.28</td>
</tr>
<tr>
<td>Full circular (closed)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
With a view to achieving a gentler mechanical treatment of the tender bleached fibres during mill trials, carding intensity was gradually reduced from $4 \times 10^3$ to $2.4 \times 10^3$ by reducing the draft as well as cylinder speed of a breaker card machine. The corresponding yarn tenacity values (Table 3) show that a carding intensity of less than $3 \times 10^3$ improves yarn tenacity. Normally, carding intensity for jute cards varies between $4 \times 10^3$ and $5 \times 10^3$.

Owing to the generation of short fibres during carding, the finisher drawing sliver unevenness (CV%) increases with increase in the concentration of $H_2O_2$ (Table 4). These results show that spinning performance deteriorates with increase in the concentration of $H_2O_2$. A few changes in the spinning parameters, specially in speed (flyer rpm) and twist, were, therefore, found essential during trials. The spinning breaks per 100 spindle-hours at various speeds ranging from 3600 to 4200 rpm of slip draft (SD) spinning frames and from 4000 to 4400 rpm of apron draft (AD) spinning frames for yarns of tex 235 to 345 against 0 to 4% concentration of $H_2O_2$ are shown in Fig. 3. Up to 4% concentration of $H_2O_2$, AD frames with 4400 rpm and SD frames with 3600 rpm pose no problem for a paired frame spinner (one spinner looks after two frames), since the breakage rate though higher remains within his piecing capacity. A higher twist was essential (discussed later). The problem starts with the high speed (4200 rpm) SD frames for 278 tex yarn at higher (above 3%) concentrations of $H_2O_2$. The high speed SD frames are single frames (one spinner looks after one frame) and the spinner has the scope of managing a higher number of end-breaks per 100 spindle-hours. Fig. 3 shows that up to 3% concentration of $H_2O_2$ end-breakage rate is within the piecing capacity of the spinner but above 3%, the end-breaks go beyond the control in spite of a higher twist being used. In this case a speed of 3800 rpm was found optimum at 4% concentration of $H_2O_2$ for 278 tex yarn. Bleached jute of these grades above 4% concentration of $H_2O_2$ loses strength substantially and fails to achieve a satisfactory spinning performance at the normal speeds of the spinning frames mentioned above, i.e. fibre strength goes below the spinnability limit. A higher grade of jute (TD2) was spinnable at 6% concentration of $H_2O_2$.

Yarn tenacity reduces gradually with increase in the concentration of $H_2O_2$ up to 3% and above this there is a rapid fall (Fig. 4). This trend accords with the spinning performance (Fig. 3). Hence it is clear that the bleached jute starts losing its spinnability rapidly above 3% concentration of $H_2O_2$, which corresponds to a bundle tenacity of 14 g/tex (Fig. 1) and completely loses spinnability above 4% concentration of $H_2O_2$, corresponding to a bundle tenacity of 13 g/tex. This

### Table 3—Effect of Carding Intensity on Yarn Tenacity of 276 tex Yarn at 4% Conc. of $H_2O_2$

<table>
<thead>
<tr>
<th>Carding intensity</th>
<th>Yarn tenacity, g/tex</th>
</tr>
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<tbody>
<tr>
<td>$2.4 \times 10^3$</td>
<td>9.23 ± 0.16</td>
</tr>
<tr>
<td>$2.7 \times 10^3$</td>
<td>9.10 ± 0.15</td>
</tr>
<tr>
<td>$3 \times 10^3$</td>
<td>8.45 ± 0.20</td>
</tr>
<tr>
<td>$4 \times 10^3$</td>
<td>8.39 ± 0.17</td>
</tr>
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</table>

The value of yarn tenacity is average value ± standard error.

### Table 4—Effect of Conc. of $H_2O_2$ on Finisher Drawing Sliver Unevenness

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conc. of $H_2O_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear density of sliver, ktex</td>
<td>0%</td>
</tr>
<tr>
<td>Uster CV%</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Fig. 3—Relationship between spinning breaks and concentration of $H_2O_2$ (a—278 tex yarn through SD frames at 4200 rpm; b—345 tex yarn through SD frames at 4200 rpm; c—278 tex yarn through AD frames at 4400 rpm (X—through SD frames at 3600 rpm); and d—235 tex yarn through AD frames at 4000 rpm)

Fig. 4—Relationship between yarn tenacity and concentration of $H_2O_2$ (x—x—x) 345 tex; (○—○—○) 278 tex; and (●●●) 235 tex]
indicates that jute fibres of tenacity below 13 g/tex cannot be spun with the conventional speed of the spinning frames under the paired and single frame operation systems of the industry.

As mentioned earlier, a higher twist was found necessary to improve the spinning performance during trials. This is because of the fact that shorter fibres require a greater cohesive force to achieve a higher yarn tenacity. In order to optimise the twist of 278 tex yarn with 4% concentration of H₂O₂, yarn tenacity was evaluated for twists ranging from 17.6 to 20.8 per dm; the results are shown in Fig. 5. The normal value of twist is 16.8/dm. The figure shows that yarn tenacity attains its maximum value corresponding to 18.4 twist/dm. For a lower degree of bleached jute a proportionately lower twist was found optimum for practical purposes, namely 18 for 3%, 17.6 for 2%, and so on.

Measurements of the brightness index of raw jute and fabrics with 4% bleached jute have shown that the brightness index of raw jute varies between 25 and 27 and that of fabrics between 45 and 52.

4 Conclusion

Up to 3% concentration of H₂O₂ there is no problem in spinning; only a higher twist is necessary. Above this, a gentler carding is desirable and carding intensity of less than 3 x 10³ produces a stronger yarn. At this stage, open finisher cards are preferable to closed cards to reduce short fibres (%) in the sliver. Optimum flyer speeds are 3600 rpm and 3800 rpm for paired frame and single frame operations of SD frames.

The loss in spinning productivity gradually increases with increase in concentration of H₂O₂. In spite of this loss in productivity, the process is economical because of its advantages like (i) minimum weight loss, (ii) no capital investment for wet-processing machinery, (iii) no restriction on fabric width, and (iv) no extra labour/inputs of electricity/water and steam as required in wet-processing.

The spinnability of jute depends mainly upon the bundle tenacity of fibre and the limiting value is 13 g/tex.

Efficient spinning of weak fibres requires a higher twist and for 278 tex yarn from fibres of bundle tenacity of as low as 13 g/tex, a twist of 18.4/dm is optimum.

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