Drafting of jute: Part II—Towards making regular yarns

U Datta, S C Bhadra & S Palit
Indian Jute Industries' Research Association, 17 Taratola Road, Calcutta 700 088, India
Received 17 December 1993; revised received 8 August 1994; accepted 19 October 1994

Contribution of different components to irregularity in sliver and yarn has been examined critically. It has been observed that the contribution of drawing machine to the irregularity of finisher drawing sliver and yarn is maximum. The effect of carding machines on irregularity may be reduced to minimum by repeating at least one drawing operation as a leveller at a suitable stage. The use of leveller reduces the long-term variation of yarn significantly; a minimum value of 3% could be achieved for a yarn of 278 tex. However, the use of leveller has limited effect on short-term variation, which is expected to be reduced around 13% through modification of finisher drawing machine or incorporation of other drafting system at this stage.

Keywords: Drafting, Faller bar waves, Jute yarn, Leveller, Sliver irregularity, Yarn irregularity

1 Introduction

After carding, jute slivers are subjected to three stages of drawing operation involving a total doubling of 12 and draft ranging between 204 and 278. The machine parameters of the three stages of drawing have been discussed elsewhere. During carding and drawing operations, waves (thick places) of varying length and amplitude are generated due to the action of rollers of the card and faller bars of drawing machines as well as due to irregular feeding at breaker card. The waves may be categorized as long, medium and short depending on the average length of the fibres. In carding, the waves are normally long and medium by character coupled with high amplitude. During drawing operations the waves generated due to faller bar action are short in nature with low amplitude. Another irregularity is observed at drawing and spinning stages due to random fibre arrangement. The faller waves are generated due to faults of open gill system of drafting. However, the faller waves of first and second drawing stages are levelled, to some extent, through doubling at a constant phase difference on a doubling plate. The scope of levelling the faller bar waves is not there at finisher drawing stage, where doubling precedes drafting. Hence, irregularity of a drawing sliver may be assigned due to (i) long and medium waves (carding), (ii) faller bar waves (machine faults), and (iii) random fibre arrangement (fibre properties). In short, sliver irregularity comprises of irregularities due to carding, drawing and fibre quality.

All these waves of different characters generated from feeding, roller, faller bar actions and fibre distribution are lengthened by draft and amplitudes are reduced by doubling in the subsequent processes. Ultimately, in yarn, all these waves exist superimposed one over the other along with the irregularity imposed during spinning. In other words, yarn is formed with a continuous strand of fibres having short waves superimposed on long and medium waves generated during carding, drawing, spinning as well as due to random distribution of fibres.

In the present study, the contribution of different components to irregularity has been estimated using mathematical models for slivers of different stages of drawing. An attempt has also been made to reduce the effect of the waves to produce regular sliver and yarn therefrom. For the purpose, a number of experiments were carried out in IJIRA pilot plant as well as in member mills.

2 Mathematical Models

The use of drawing process with same draft and doubling is observed in flax and cotton processing to level the slivers after carding. This process may be applicable in jute drawing also with some modification in the process of doubling of first and second drawing stages. It is due to the fact that the doubling operation of these two stages is carried out on a doubling plate after drafting operation and the number of doubling is fixed at 2 and 3 respectively for first and second
drawing stages. With a view to using same draft and doubling, first drawing may have draft and doubling 4, second drawing 6 and finisher drawing 9, within the range of draft of the machines. To use a doubling of 4 at first drawing, it is necessary to put 2 slivers together in each of the two feed slots of the machine and double the two drafted slivers on the doubling plate. Similarly, in second drawing, to obtain a doubling of 6, two slivers are to be fed together to get three drafted slivers, which may be doubled as usual. However, finisher drawing requires no such change for a doubling of 9 instead of normal 2 since it has no doubling plate for the purpose.

The Eqs (4), (5) and (6), developed earlier to evaluate thickness (CV%) of first, second and finisher drawing slivers respectively for normal draft and doubling process, may be modified accordingly as above and are reduced to the following equations for repeating the drawing operations with same draft and doubling:

\[
CV_{1,i} = CV_{1,i-1} + 26.55 \quad \text{(for first drawing)} \quad \ldots (1)
\]

\[
CV_{2,i} = CV_{2,i-1} + 13.95 \quad \text{(for second drawing)} \quad \ldots (2)
\]

\[
CV_{3,i} = CV_{3,i-1} + 95.40 \quad \text{(for finisher drawing)} \quad \ldots (3)
\]

where \( i \) is the \( i \)th repeat operation of the drawing stage.

The equations reveal that if a sliver with certain irregularity (within the range of that stage) is processed with same draft and doubling at that stage repeatedly, the output irregularity approaches a minimum value. For example, applying observed irregularity of first drawing sliver as input \( (CV_{1,0}) \) in Eq. (1), the irregularity of sliver after first repeat \( (CV_{1,1}) \) can be estimated theoretically. Similarly, for second and third repeat and so on. For second and finisher drawing sliver irregularities, Eqs (2) and (3) may be applied similarly putting the observed irregularities as input \( (CV_{2,0} \text{ and } CV_{3,0}) \) respectively for first repeat. Again, putting \( CV_{1,0}, CV_{2,0} \text{ and } CV_{3,0} \) equal to zero in Eqs (1), (2) and (3), the output irregularities of first, second and finisher drawing slivers become \( 26.55 = 5.15, \sqrt{13.93} = 3.73 \text{ and } \sqrt{95.40} = 9.76 \) respectively, which may be considered as the minimum irregularities of the slivers theoretically when input slivers are totally even. From the above, it is clear that the use of leveller (drawing operation with same draft and doubling) at a suitable drawing stage may improve sliver irregularity, which may produce regular yarn. The minimum irregularities so obtained after repeat operations at each stage may be regarded as irregularity free from long and medium waves generated during carding operations.

The minimum irregularity so obtained comprises of two components, viz. irregularity imposed by processing machine and irregularity due to random distribution of fibres in silver. Banerjee observed that the contribution of random arrangement of fibres may be estimated by

\[
130/\sqrt{n} \quad \ldots (4)
\]

where \( n \) is the number of fibres in the cross-section.

The irregularity due to machine could be estimated by subtracting the value of irregularity due to fibre arrangement from the minimum irregularity after levelling the sliver. Mathematically, the total relative variance of sliver of any stage of drawing and yarn may be expressed as a sum of component relative variances as follows:

\[
(CV_T)^2 = (CV_w)^2 + (CV_M)^2 + (CV_P)^2 \quad \ldots (5)
\]

where \( CV_T = \text{Total irregularity} \)

\( CV_w = \text{Irregularity due to long and medium waves} \)

\( CV_M = \text{Irregularity due to machine} \)

\( CV_P = \text{Irregularity due to random arrangement of fibres} \).

3 Materials and Methods

For the experiments, good quality of jute (TD3 variety) was used and 4% jute batching oil was applied on it (by weight) in the form of oil-in-water emulsion. The softened material was then carded through JF2 breaker card and JF3(L) finisher card. Finisher card sliver weight was maintained around 80 ktx at 30% moisture regain. The carded sliver was processed through Lagan's Open Screw Gill first, second and finisher drawing machines with normal draft and doubling. 278 tex yarn was spun through Mackie's 4.25 in apron draft spinning frame with 16.8 twist/dm and a flyer speed of 4500 rpm.

Forty metres of first drawing sliver was collected and its irregularity was measured. After testing, it was divided into 4 equal segments of 10 m each without any strain and deformation. The segments were processed through first drawing again with draft and doubling of 4. Sliver (40m) so obtained was tested for irregularity and divided again into 4 pieces of 10 m each and processed with same draft and doubling. The process was repeated and irregularity was tested again and again till last two values of irregularity were almost same. Similarly, 60 m of sliver was collected from second drawing...
stage and divided into 6 pieces of 10 m each after measuring irregularity. The slivers were processed repeatedly with 6 draft and doubling and tested for irregularity till minimum value was attained. At finisher drawing stage, 405 m of sliver was collected and its irregularity was tested. It was divided into 9 segments of 45 m each and processed through the stage with draft and doubling of 9 repeatedly and irregularity was measured after each repeat following the above method.

Five experiments were carried out to simulate the above experiments as per plan in Table 1. In the plan, experiment no. 1 is the normal sequence, experiment nos 2, 3 and 4 involve one leveller each at first, second and finisher drawing stages respectively. Experiment no. 5 involves one leveller at each stage of drawing. Yarns were spun and tested for linear density, irregularity, long-term variation and tenacity.

Semi-bulk trials were conducted in two member mills using second drawing as a leveller to confirm the findings of the above experiments. In these trials, yarns of 278-600 tex were spun and the properties mentioned above were tested.

The irregularity of first and second drawing slivers was determined on the basis of 300 thickness readings using ST1 and ST2 (Sliver Irregularity Testers) developed by UIIRA and thickness CV% was calculated. Irregularity of finisher drawing sliver and yarn was measured through Uster Evenness Tester at a speed of 8 and 25 m/min respectively for 5 min. U% was converted to CV% by using the equation CV% = 1.25 U%.

The linear density (tex) of the yarns was measured on the basis of weights of 25 hanks of 67.5 m each. The hanks were collected from randomly selected 5 bobbins and 5 hanks from each bobbin. CV% of the hank weights was calculated to determine the long-term variation of the yarns.

Single yarn strength was tested using Goodbrands Yarn Strength Tester at a gauge length of 60 cm and traverse rate of 30 cm/min. The average of 200 tests from the selected 5 bobbins was calculated. The average strength (g) was divided by the tex of the yarn to calculate tenacity. Fibre fineness of finisher card sliver was determined following the air flow method.

<table>
<thead>
<tr>
<th>Process</th>
<th>1 (Normal sequence)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draft/Doubling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First drawing leveller</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draft/Doubling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second drawing</td>
<td>6/3</td>
<td>6/3</td>
<td>6/3</td>
<td>6/3</td>
<td>6/3</td>
</tr>
<tr>
<td>Draft/Doubling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second drawing leveller</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draft/Doubling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draft/Doubling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finisher drawing leveller</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draft/Doubling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of passages of drawing</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Total draft/doubling</td>
<td>216</td>
<td>864</td>
<td>1296</td>
<td>1944</td>
<td>4665</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>48</td>
<td>72</td>
<td>108</td>
<td>2592</td>
</tr>
<tr>
<td>Spinning draft</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

*Experiment nos 2, 3 and 4 involve one leveller each at first, second and finisher drawing stages respectively and experiment no. 5 involves one leveller at each stage of drawing.

4 Results and Discussion

Three different methods were used to determine the irregularity of slivers and yarns. It was due to the fact that shorter test lengths were preferred to conduct repeat operations at the drawing stages for easy handling of the samples and testing after each repeat. However, compatibility of the different test methods was verified by measuring the irregularity of slivers. Among these methods, it was observed that thick sliver of first drawing stage was difficult to run through Uster at a speed of 25 m/min and so it was tested at a speed of 8 m/min for comparison with ST1. However, second drawing slivers were tested at both the speeds of 8 m/min and 25 m/min in Uster to compare the values with ST2 as well as among themselves. The results are given in Table 2, which reveal that the irregularity values of the slivers of different stages of drawing, evaluated by different test methods, have practically no difference.

Irregularity of the slivers of different stages of drawing after levelling (applying 1-4 repeat operations) has been shown in Table 3 along with the theoretical values following Eqs (1), (2) and (3) and using the observed values of irregularity as input for first repeat. It is observed from the table that the theoretical values are in good agreement with the observed values and almost stable after
second repeat at first drawing and after first repeat at second and finisher drawing. However, the rate of decrease in irregularity of finisher drawing sliver, applying repeat operation, is much less than that observed in first and second drawing slivers. It is due to the fact that finisher drawing sliver contains less variation due to long and medium waves.

It is also observed from Table 3 that the achievable irregularity of slivers is 6.3%, 5.3% and 10.4% respectively for first, second and finisher drawing stages.

Irregularity due to random arrangement of fibres in the slivers of drawing stages and yarn (Table 4) reveals that its effect is considerable in finisher drawing sliver and yarn. It is due to less number of fibres in their cross-sections.

The results of the experiments 1-5 (Table 5) show that experiment nos 3, 4 & 5 produced regular yarns with around 17% irregularity and 3% long-term variation (weight CV%). This may be regarded as the optimum irregularity for this quality of yarn using the fibre and the processes mentioned. Among the processes, use of a leveller at second drawing is most convenient for production purpose. Use of finisher drawing as a leveller has practical problems which are discussed later. The process of using leveller at each stage of drawing is expensive and cannot be considered useful in practice since using one of the other two processes similar yarn quality can be obtained. However, it may be mentioned here that in the experiments 1-5 (Table 1), the total doubling at the drawing stages ranges between 12 and 2592 of which 72 appears to be optimum beyond which further improvement in yarn quality is not observed.

During mill trials, leveller was used to produce regular yarns using normal fibres used by the respective mills. The yarn test results (Table 6) corroborate with the findings of the experiments. It is interesting to note that both in the experiments and bulk trials in the mills, decrease in irregularity of slivers has marginal effect on the irregularity of yarns but has considerable effect on long-term variation (weight CV%). It is mainly due to the presence of faller bar waves in finisher drawing sliver and irregularity imposed by spinning machine.

The contribution of different components to sliver and yarn irregularity was calculated separately applying Eq. 5 and using observed minimum sliver and yarn irregularity values. The results are
shown graphically in Fig. 1 in terms of relative variance. It is observed that the effect of irregularity due to long- and medium-term waves is maximum in first drawing sliver and it gradually reduces with minimum being in finisher drawing sliver and yarn. Contribution of machine is minimum in second drawing sliver and it increases rapidly in finisher drawing sliver and yarn due to obvious reasons of drafting faults of finisher drawing machine and high draft in spinning. The effect of fibre distribution is also maximum in yarn due to the same reason.

The relative contribution of the different components as a percentage to total relative variance is shown in Table 7 separately for different stages of drawing and spinning. It is clear from Table 7 that the contribution of machine in finisher drawing sliver and yarn is maximum and almost same while draft of spinning is much longer than that of finisher drawing. It is obvious that apron draft system of spinning has better control on fibres than gill drafting system of the drawing machine. Moreover, the faller bar waves in finisher drawing sliver has no chance of reduction by way of doubling at this stage. These are the reason for maximum machine contribution in finisher drawing sliver. It is perhaps worthwhile to mention here that if drafting system of finisher drawing is changed or a proper doubling system is adopted to reduce faller bar waves, machine contribution may be reduced to half, similar to as observed in the other stages of drawing. This indicates that through modification, finisher drawing sliver irregularity may be as low as 8% and in yarn therefore, 13%.

5 Conclusion

Regular jute yarns may be produced through the use of leveller, which reduces sliver irregularity, resulting in reduction in long-term variation of yarns. A leveller may be used at second or finisher drawing stage with same draft and doubling. However, practical experience reveals that use of leveller at second drawing stage is more convenient due to the fact that it does not require any change of the machine. On the other hand, use of leveller at finisher drawing has practical problems like frequent breakage of thin sliver, leading to missing ends and longer creel to accommodate 9 doubling at the back of the machine, which requires modification. However, use of leveller has marginal effect on yarn irregularity, mainly due to the presence of faller bar waves in finisher draw-
ing sliver which are lengthened by draft during spinning operation. To reduce yarn irregularity further, it is necessary to change the drafting and doubling system of the finisher drawing machine so that formation of faller bar waves is reduced.

Acknowledgement
The authors are thankful to the management of Champdany and Gondalpara mills for extending cooperation in conducting the trials.

References