

Variation Flow Analysis in the Preparation of Jute Yarn

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The variation flow analysis technique for determining the added irregularity at any stage of jute processing is described and results of experiments conducted recently at the pilot mill of the Indian Jute Industries' Research Association (IJIRA) and in a number of mills applying this technique are reported. Some studies on short-term irregularity are also reported from which the flow of short-term irregularity from the breaker card through third drawing stages has been established.

Variation flow analysis helps in comparing the actual and the expected irregularities at various processing stages and thus in determining the amount of extra irregularity, if any, contributed by any particular manufacturing stage. Considerable work¹⁻⁴ has been done on cotton and other textile fibres applying this technique. In jute, not much work has been done in this area. Banerjee⁵ developed a method for determining the irregularity indices for jute yarn which have been defined, following Huberty, as the ratio of the actual irregularity to the irregularity at the Martindale limit. The values of these indices specify the overall performance of the preparatory and spinning operations in a mill. Similar work has also been reported by Bandyopadhyay⁶, who used Spencer-Smith and Todd's expression for the CV% of the linear density of an ideal sliver to derive the expression for random irregularity of jute yarn. Uranowicz⁷ also determined the machine irregularity in jute spinning process from the relation

$$V_m^2 = V_f^2 - V_t^2$$

where V_m is the CV caused by machine; V_f , the CV of sliver or yarn from the machine; and V_t , the theoretical CV of sliver or yarn.

Theoretical CV was assessed using Martindale's formula

$$V_t^2 = \frac{1}{n}(1 + V_f^2)$$

where V_f is the CV of fibre area of cross-section in sliver or yarn and n , the number of fibres in the area of cross-section of sliver or yarn.

The values of V_f were determined on the basis of test length of constant sliver weight at each stage and also on the basis of test length of 5 cm for the feed end at each stage and $\left(5 \times \frac{\text{draft}}{\text{doubling}}\right)$ cm for the delivery end.

This paper describes a simplified method for determining the added irregularity at any stage of jute processing, and reports the results of experiments conducted recently at the pilot mill of this institute and in a number of mills applying this technique.

Besides determining the added irregularity, the nature of $B(L)$ curves and the flow of short-term irregularity from breaker card to finisher drawing stage have also been studied.

Experimental Procedure

Methods used for determining weight CV%—To assess the addition of irregularity at any stage of processing, the weight CV was determined at different stages. The 'unit' of test length for determining CV% at a particular stage was obtained by multiplying the test length for the immediately previous stage by the draft values of the stage concerned. The extra irregularity added by a stage was determined from the formula

$$\begin{aligned} I &= CV_0^2(D.L) - \frac{CV_1^2(L)}{n} \\ &= B_0(D.L) - \frac{B_1(L)}{n} \end{aligned}$$

where I is the added irregularity; $CV_0(D.L)$, weight CV% of output sliver determined between weights of length $D.L$; $B_0(D.L) = CV_0^2(D.L)$, standardized variance; $CV_1(L)$, weight CV% of input sliver determined between weights of length L ; $B_1(L) = CV_1^2(L)$; n is the number of doubling between them; and D , the Draft applied.

The types of machines used and machine particulars are given in Table 1.

Experiments at IJIRA pilot mill—At IJIRA pilot mill, the small scale spinning technique^{8,9} was employed, using staggered diagonal feeding to the breaker card so as to have the minimum possible CV at

Table 1—Type of Machines and Processing Parameters

Stages	IJIRA			A			B			C			D		
	Type & make	Draft	Doub-ling	Type & make	Draft	Doub-ling	Type & make	Draft	Doub-ling	Type & make	Draft	Doub-ling	Type & make	Draft	Doub-ling
Breaker card	JF ₂	16.2	—	JF ₂	15.3	—	Mackie	11.5	—	Low	12.76	—	Low half circular	14.42	—
Finisher card	JF ₂	12.0	10	JF ₄	14.3	11	Mackie 4½ pair	11.7	11	Low	13.5	11	Fair ba-irn full circular	13.14	11
1st Drawing	Mackie screw gill	3.8	2	Mackie screw gill	3.8	2	Mackie high	3.5	2	Mackie screw gill	4.0	2	do	3.4	2
2nd Drawing	do	6.0	3	do	6.0	3	Mackie screw gill	6.0	3	do	6.8	4	Mackie screw gill	6.0	3
3rd Drawing	do	8.5	2	do	9.0	2	do	10.0	2	do	9	2	do	9.0	2
Spinning	Slip draft	17.0	1	Apron draft	14.63	1	Apron draft	18.75	1	Apron draft	17.44	1	Slip draft	13.95	1

the initial stage. Jute of White Middle variety (W_4) from which the roots had been cut off was used. Several equivalent morahs of 1.5 kg were prepared from a lot. The fibre lots were then passed through the softener machine where oil-in-water emulsion was applied and the fibres were kept in an insulated bin for one day. These softened fibres were next passed through the breaker card machine. To avoid introduction of irregularity due to irregular feeding at the breaker card, the arrangement of fibre morahs on the feed table following mini-spinning technique was modified slightly. This involved dividing the feed apron table (which was extended) into several rectangles and placing the fibre morahs with crop end over the root portion along the diagonal line of the rectangles (Fig. 1). In the breaker card, 7.5 kg (1.5×5) of fibre was used each time. The fibre was wound into a roll after discarding the non-uniform parts from the initial and the end portions. For certain operational reasons, the same breaker card was used as finisher card with ten doublings. Three passages of drawing were used and the third drawing sliver was spun on the slip draft frame.

Experiments at mills—Experiments were also carried out in four mills, A, B, C and D. In each mill, eleven rolls of breaker card sliver were first prepared with 100% TD2 quality, following the mill practice of dollop feeding and these were processed up to yarn stage using one set of machines.

Selection of samples—Samples were selected from different rolls or cans* of different deliveries and from

*Rolls are close-packed dense spirals of sliver about 3 ft in diam. and 4-5 in in width (as against loose packed 40 in wide scutcher lap in cotton). Slivers are collected in roll form at the breaker and finisher card stages and sometimes in first drawing also. In drawing stages, slivers are collected in cans and fed to spinning.

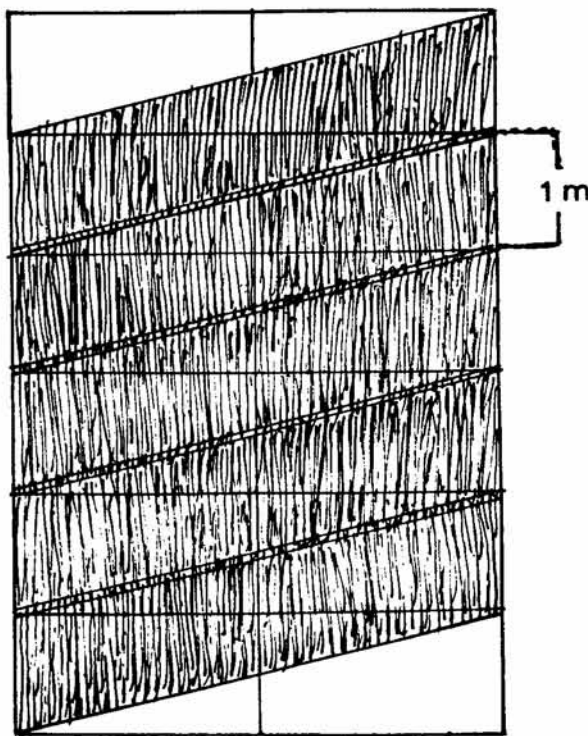


Fig. 1—Arrangement of fibre morahs on the feed apron of the breaker card machine

each roll or delivery several metre lengths were selected.

Tests—In the case of IJIRA pilot mill and also for mill A, taking 1.25 cm as the 'unit' of test length at breaker card stage, the 'unit' of test length for determining weight CV at any other stage was determined from the draft used at that stage. The weight CV at breaker card stage was, however, not determined because of the difficulty of cutting the sliver into such small pieces. Later, a sliver cutting machine

was fabricated and with the help of this machine, the breaker card sliver in the case of mill D was cut into 1 cm pieces. This length was chosen as the unit of test length at this stage. The unit of test length for determining weight CV at the subsequent stages for this mill was selected following the method described earlier.

Apart from the determination of added irregularity, weight CV was also calculated in the case of the pilot mill samples at different test lengths for constructing $B(L)$ curves. In the case of samples collected from mill A, thickness CV was determined within 10 m lengths from the irregularity charts obtained from a mechanical tongue and groove type irregularity tester besides determining the added irregularity at different stages, while for mills B and C, only thickness CV was determined from the irregularity charts.

Results and Discussion

Added irregularity (pilot mill results vs mill results)—The results presented in Table 2 show the expected irregularity along with the irregularity actually obtained at different stages of processing. In the case of pilot mill experiment, the observed and the expected irregularities show good correspondence, indicating that the machines are in good condition. The input CV at the breaker card for the pilot mill experiment has been made as low as possible by adopting a special technique of feeding to the breaker card. In the case of mills A and D, at the first drawing and spinning stages, the observed irregularity is significantly greater than the expected CV. The difference between the two CVs is also found to be pronounced at finisher and second drawing stages for mill D. In the case of second drawing, however, the observed CV for this mill is less than the expected value which is not theoretically expected.

B-L Curve and flow of short-term irregularity (for pilot mill results)—The weight CV values at different test lengths for IJIRA samples for breaker card to third

drawing slivers are presented in Fig. 2. It is seen that $\log \{B(L)\}$ - $\log L$ plot is almost linear, as in the case of other textile fibres. The trend of variation in short-term irregularity (wt CV determined from the weights of 0.05 m lengths of sliver at different stages of processing) is evident from Fig. 3. A decreasing trend is observed

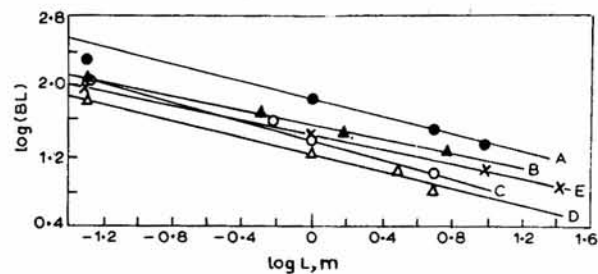


Fig. 2—B-L Curves at different stages of processing [(A) breaker card, (B) finisher card, (C) first drawing, (D) second drawing, and (E) third drawing]

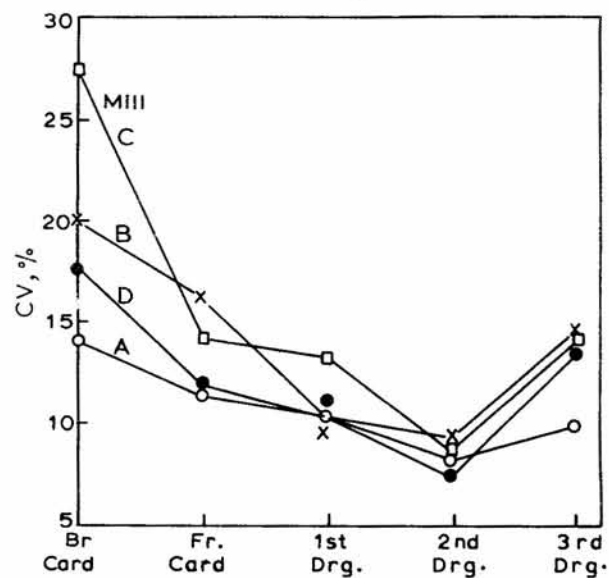


Fig. 3—Trend of short-term irregularity from breaker card to third drawing stage

Table 2—Observed and Expected Irregularities

Stages	IJIRA			Mill A			Mill D		
	Test length (m)	Observed CV%	Expected CV% $= \frac{CV_I}{\sqrt{n}}$	Test length (m)	Observed CV%	Expected CV% $= \frac{CV_I}{\sqrt{n}}$	Test length (m)	Observed CV%	Expected CV% $= \frac{CV_I}{\sqrt{n}}$
Breaker card	—	—	—	—	—	—	.01	18.56	—
Finisher card	0.15	10.1	—	0.18	6.96	—	0.14	7.18	5.60
1st Drawing	0.60	6.8	7.1	0.61	6.71	4.92	0.45	6.89	5.08
2nd Drawing	3.50	3.5	3.9	3.66	4.16	3.87	3	2.94	3.98
3rd Drawing	29	2.7	2.5	29.26	2.91	2.94	27.4	2.43	2.08
Spinning	4.94	2.9	2.7	466	4.09	2.91	379	4.25	2.43

Table 3—Contributions of Different Components of Variation to Total Irregularity

Stages	Mill B, CV%				Mill C, CV%			
	Within 10 yds (CV_W)	Between 10 yds (CV_{BT})	Between rolls/cans (CV_{BR})	Overall CV (CV_T)	Within 10 yds (CV_W)	Between 10 yds (CV_{BT})	Between rolls/cans (CV_{BR})	Overall CV (CV_T)
Breaker card	12.7	11.7	10.3	20.0	17.1	14.6	15.9	27.5
Finisher card	15.4	4.1	2.7	16.2	13.0	4.2	3.6	14.1
1st Drawing	9.8	1.7	2.7	10.3	11.8	3.7	4.2	13.1
2nd Drawing	8.1	4.2	0.6	9.2	7.9	3.6	0.6	8.7
3rd Drawing	12.6	3.9	5.8	14.4	9.7	9.5	2.5	13.8

up to the second drawing stage and thereafter CV% increases.

Analysis of mill results—The same trend of variation in short-term irregularity (thickness CV) determined from the irregularity charts is evident for mill samples (Fig. 3). The total CV determined from the irregularity charts in the case of mills B & C is made up of the following components. (1) CV% within 10 m samples, (2) CV% between 10 m samples, and (3) CV% between rolls/cans.

It is observed (Table 3) that barring breaker card stages, in all other stages, generally the within component variation accounts for 80-90% of the total variation. At the breaker card stage, CV% within 10 m, between 10 m and between rolls is found to be of the same order.

Summary and Conclusion

The extra irregularity added by any particular stage of jute processing has been determined from the relation

$$I = B_0(DL) - \frac{B_1(L)}{n}$$

Besides determining the added irregularity, some studies on short-term irregularity have also been conducted.

A decreasing trend in short-term CV from breaker card to second drawing stage has been observed and

thereafter CV% is found to increase. The total CV (thickness) within a machine, determined from the irregularity charts, has been broken into different components to find out their relative contributions. It has been found that barring the breaker card stages, in all other stages, generally the within component variation accounts for 80-90% of the total variation.

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