A Comparative Study of the Equalizing Power of Jute Breaker Cards of Different Makes

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The transfer function of a jute card has been derived under certain assumptions and then utilized to determine experimentally the quantity \( \beta \), a function of various machine parameters. \( \beta \) has been made use of for developing an expression for comparing the equalizing powers of jute cards of different makes. Giddings and Lewis-Fraser's type JF2, 3-pair breaker card has been found to have superior equalizing power compared to J.F. Low's type M, 2-pair breaker card.*

The heterogeneous character of jute fibres and the mode of feeding the breaker card invariably introduce feed variations despite utmost care taken during feeding. The variations are reflected as long term grist variations in the yarns and may often be responsible for the fluctuations in fabric weight. It is an established fact\(^1\)\(^-\)\(^3\) that carding machines have the capacity to equalize feed variations to some extent when the variations are within reasonable limits. It is also known that the equalizing power differs from card to card, depending on the basic design of the machines. In an earlier paper\(^4\), it was reported that for a jute breaker card the relative contributions of the various rollers towards equalization differ considerably and the contribution of the worker-stripper pairs is about one and a half times that of the cylinder. In this paper, an attempt has been made to compare the equalizing power of a Giddings and Lewis-Fraser's type JF2, 3-pair breaker card with that of a J.F. Low's type-M, 2-pair breaker card.

Theoretical Considerations

To derive an expression for the transfer function of the system which is subsequently utilized to find out the expression for comparing the equalizing power of two jute cards, let us consider a vertical section of the carding machine, which shows the configuration of fibre flow (Fig. 1). With reference to Fig. 1, we define the following quantities:

- \( v_f, v_c, v_d \) = speed of the fibre layer in the feed zone, on cylinder and on doffer respectively.
- \( v_{w}, v_{st} \) = speed of the worker and stripper at the \( n \)th working zone, e.g. \( P_n \).
- \( Q_i \) = weight per unit length of the fibre layer in a given \( i \)th cross-section in steady state.
- \( \Delta Q_i \) = instantaneous value of deviation from \( Q_i \).
- \( d_i' = \frac{\Delta Q_i}{Q_i} \) = normalized deviation at \( i \)th cross-section with respect to \( Q_i \), when \( i = j \), \( d_i' = d_i \).
- \( T_i = \) time for transit of fibre from \( i \)th to \( j \)th cross-section.

After the card has attained steady state, if at any instant \( t \) the deviation of linear density at the cross-section \( C \) be \( \Delta Q_i \), it will be related to the feed variation at cross-section (c. s.) \( f \) by the relation

\[
\Delta Q_f(t) = \Delta Q_i \left( t - T_i^f \right) \frac{v_f}{v_c} \quad \text{... (1)}
\]

But \( Q_f = Q_e \frac{v_f}{v_c} \). So dividing both sides of Eq. (1) by \( Q_e \), we get

\[
d_e(t) = d_f \left( t - T_i^f \right) \quad \text{... (2)}
\]

Taking the Laplace transform of Eq. (2), we get

\[
D_e(h) = D_f(h) e^{-h T_i^e} \quad \text{... (3)}
\]

where \( D(h) \) is the Laplace transform of \( d(t) \). Proceeding in this way, the corresponding equations for other cross-sections are obtained as

This does not purport that one make is superior or otherwise to the other in overall performance.
So the transfer function can be defined as

$$W(h) = \frac{D_o(h)}{D_f(h)} e^{-hT_h} \quad \cdots (10)$$

The characteristic equation corresponding to the transfer function (10), i.e.,

$$F(h) = 0 \quad \cdots (11)$$

is a complicated equation and provides an infinite number of solutions. But we are interested only in the dominant solution consistent with the physical conditions of the jute-card and at the same time accurate enough for our purpose. For this reason, we expand all the exponential quantities in $F(h)$ in the form of a Taylor series in $h$ and rewrite $F(h)$ in the form of an infinite series. Out of this infinite series, we retain only the first order term in $h$, i.e.

$$F(h) = 1 + a_1 h = 0 \quad \cdots (12)$$

where the coefficient $a_1$ is defined as

$$a_1 = \frac{1}{\epsilon_d} \left[ (1-\epsilon_d) T_h + \sum_{n=1}^{3} \frac{\tau_n}{1-\epsilon_n} \right] \quad \cdots (13)$$

Since the error incurred by the approximation (12) is very small, we can write the transfer function after neglecting the phase factor as

$$W(h) = \frac{D_o(h)}{D_f(h)} = \frac{1}{1+a_1 h} \quad \cdots (14)$$

Taking the inverse Laplace transform of Eq. (14), we get

$$d_o(t) = \int r(t_1) d_f(t-t_1) dt_1 \quad \cdots (15)$$

where

$$r(t) = \frac{1}{a_1} e^{-t/\tau} \quad \cdots (16)$$

Expressions (15) and (16) are important, for they provide a method for determining $a_1$ experimentally when a suitable form is chosen for input variation. Following Emmanuel's, we choose the feed variation in the form of a step-function, i.e.

$$d_f(t) = \begin{cases} 0 & \text{when } t < 0 \\ (d_f)_0 & \text{when } t \geq 0 \end{cases} \quad \cdots (17)$$

Putting Eq. (17) in Eq. (15), we get

$$d_o(t) = (d_f)_0 \left( 1 - e^{-t/\tau} \right) \quad \cdots (18)$$

If the sliver weight variation is plotted with time following the deviation in the feed zone (Figs. 2 and 3), it is observed that the mass of fibre required for...
levelling the weight deviations is given by the area

\[ A' = \oint [d_0(t) Q_0 v_0 - (d_f) Q_f v_f] \, dt \]  

(19)

Combining Eqs. (18) and (19), we get

\[ A' = \frac{a_1 Q_0 v_0}{(d_f)_0} \]

But in actual experiments, \( (d_f)_0 = - \frac{1}{2} \frac{d_0}{v_0} \). So we neglect the sign and introduce a parameter \( \beta \) defined by

\[ \beta = \frac{a_1 v_0}{(d_f)_0} = - \frac{A'}{Q_0 v_0} \]

(20)

To find the criteria for comparing the equalizing power of jute cards, we make the assumption that the weight fluctuations in the feed zone take place in the form of periodic variations. In that case:

\[ d_f(t) = (d_f)_0 \cos(w_f t) \]

(21)

Putting it in Eq. (15) and assuming that the steady state condition has reached, i.e. \( t \) is large, the output deviation is given by

\[ d_0(t) = \frac{(d_f)_0}{1 + (w_f v_0)^2} \times (w_f a_1 \sin w_f t + \cos w_f t) \]

(22)

So the steady state amplitude of output variation is given by

\[ (d_0)_M = \frac{(d_f)_0}{1 + (w_f v_0)^2} \cdot \sqrt{(w_f v_0)^2 + 1} \]

Thus, the amplitude characteristic which is defined as the ratio of output and input amplitudes at steady state is given by

\[ A = \frac{(d_0)_M}{(d_f)_0} = \frac{1}{\sqrt{1 + (w_f v_0)^2}} \]

(23)

But with textile materials it is more conventional to express the characteristics of the irregularity in terms of wavelength rather than frequency. So we put \( w_f = \frac{2 \pi v_0}{\lambda_0} = \frac{2 \pi v_0}{\lambda_0} \), where \( \lambda_0 \) is the wavelength of output variations. Thus, we get from Eqs. (23) and (20):

\[ A = \frac{1}{\sqrt{1 + (\frac{2 \pi v_0}{\lambda_0})^2}} \]

(24)

Eq. (24) can be used for comparing the equalizing powers of two jute cards.

**Experimental Procedure**

From a lot of commercial tossa middle fibres, several 5 kg representative samples were made by random sampling. The hard root portion and the entangled crop ends were removed to ensure better uniformity of the samples.

In feeding the cards, the method employed in the small-scale spinning technique developed at this institute was followed. The fibres, after emulsification, softening and binning for 72 hr were fed in the card in two distinct steps. The first 2 m of the feed apron had a fibre layer density of 2.6 kg (at 20\% moisture regain) per metre and the next 2 m had a fibre layer density of 1.3 kg (at 20\% moisture regain) per metre. The card was then run and all the slivers were collected in a sliver can. The sliver was then cut to 1 m long pieces, maintaining the order of emergence from the card. The weight of the cut pieces and the corresponding moisture regain values were recorded accurately. For both the cards, two sets of experiments were conducted.

**Results and Discussion**

The patterns of sliver weight decay due to the stepwise fall in feed weight at a given instant of time for JF2, breaker card and JF. Low's breaker card are shown in Figs. 2 and 3 respectively for two sets of observations. The shaded area in the figures is proportional to the mass of fibres required for levelling the feed weight variation. It is seen that for both the variants, the shaded area for JF2 breaker card is greater than that for JF. Low's breaker card.

The machine particulars and \( \beta \) values for both the cards are given in Table 1. It is seen that input varia-

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**Table 1 — Machine Particulars and Experimental Data for the Calculation of \( \beta \)**

<table>
<thead>
<tr>
<th>Type of</th>
<th>No. of</th>
<th>Doffer</th>
<th>Draft</th>
<th>((d_f)_0)</th>
<th>(\beta = \frac{a_1 v_0}{(d_f)_0})</th>
</tr>
</thead>
<tbody>
<tr>
<td>machine</td>
<td>worker</td>
<td>surface</td>
<td>Draft</td>
<td>((d_f)_0)</td>
<td>(\beta = \frac{a_1 v_0}{(d_f)_0})</td>
</tr>
<tr>
<td>JF2</td>
<td>breaker card</td>
<td>3</td>
<td>46.02</td>
<td>15.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Low's type M breaker card</td>
<td>2</td>
<td>31.69</td>
<td>15.4</td>
<td>0.5</td>
<td>7.98</td>
</tr>
</tbody>
</table>
tion and machine draft remaining the same, for both the variants, the mass of fibres required for levelling the input variation is greater for JF2 breaker card, and $\beta$ value, which is a vital criterion for determining the equalizing power, is also greater for JF2 breaker card.

The variation in amplitude characteristics with the wavelength of sliver weight variation for both the cards is shown in Fig. 4. It is seen that for any given wavelength, the corresponding amplitude characteristic value is lower for JF2 breaker card, indicating better equalization.

Conclusion

A method for comparing the equalizing action of jute cards has been developed and two jute breaker cards of different makes have been compared with respect to equalizing power with identical feed weight variation and machine draft. It is observed that Giddings and Lewis-Fraser's type JF2, 3-pair breaker card has better equalizing power compared to J. F. Low's type M, 2-pair breaker card.

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References