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Studies on Carding Force between Cylinder and Flats in a Card: Part III—Carding Parameters, Sliver Quality and Carding Force

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Changes in the carding parameters leading to an increase in the load on the operational layer of the cylinder are detrimental to the quality of carded sliver with regard to neps and regularity. The ratio between the mean carding force and the load on the operational layer of the cylinder or the mean carding force/unit load of fibre on the operational layer is a reliable index of the carding quality. Increase in carding force/unit load decreases both the nep content and the Uster U% of the sliver.

The quality of the carded sliver is normally assessed through the estimation of nep content, sliver irregularity and the arrangement of fibres in a sliver. Considerable work has been reported in literature on the factors influencing the various aspects of sliver quality. However, no work has been reported so far on the possible relationship between the carding force and the quality of the carded sliver in a revolving flat card.

The present investigation, while generally confirming the earlier findings regarding the effect of carding variables on sliver quality, attempts to draw out a relationship between the carding force and the sliver quality *vis-à-vis* the load on the operational layer of the cylinder.

Materials and Methods

Egyptian cotton (fibre length, 1.25 in; and fibre fineness, 3.15 μ) was used in all the experiments. Laps were processed on a semi-high production card equipped with metallic fillets.

Fibre disorder—The fibre disorder in the card sliver was determined using Lindsley's technique[1]. The proportion of curved fibre ends (ρ) and the coefficient of relative fibre parallelization (K_{rp}) were calculated from the following equations suggested by Leont'eva[2]:

$$\rho = \frac{E}{N + E} \qquad \dots (1)$$

$$K_{rp} = \left(1 - \frac{C}{C + N + E}\right) \qquad \dots (2)$$

where C is the weight of combed out fibres; E, the weight of fibre ends projecting over the line of cut after combing; and N, the weight of sliver portion clamped under the cutting plate after combing.

Nep content—The nep counting in the card web was done using the Shirley nep counting plates. From the values of neps/100 sq in, the neps/g of sliver was estimated.

Evenness—The evenness of the sliver was measured using the Uster evenness tester. The conditions of the test room were maintained at 65% RH and 80°F.

Results and Discussion

The effect of various process factors is shown in Tables 1-4. The results with regard to fibre disorder, neps and evenness of sliver are interpreted below.

Factors influencing fibre disorder—It is observed that the fibre disorder is influenced by the cylinder-doffer speed ratio, carding rate and cylinder-doffer setting. The licker-in speed and the cylinder-flats setting have no influence on fibre disorder.

Increase in carding rate through sliver weight, at constant cylinder and doffer speeds, decreases the fibre parallelization and increases the proportion of curved fibre ends in the reverse direction (Table 1). The total proportion of curved fibre ends decreases with increase in the carding rate. Increase in carding rate through increase in doffer speed decreases the proportion of curved fibre ends in the reverse direction and increases the proportion in the forward direction (Table 2). The total proportion of curved fibre ends remains unchanged and no trend is observed between fibre parallelization and carding rate. Increase in cylinder speed, at a constant doffer speed, increases the proportion of curved fibre ends in the reverse direction as well as the coefficient of relative fibre parallelization. The total proportion of curved fibre ends decreases with increase in the cylinder speed (Table 3). Increase in cylinder-doffer setting decreases the fibre parallelization and increases the total proportion of curved fibre ends (Table 4). The proportion of curved fibre ends increases in the reverse direction and decreases in the forward direction. No definite trend is observed between the cylinder load and the sliver disorder. The results are in close agreement with the findings of Bhaduri[3], who did not observe any definite association between the load and the pattern of hooking.

Factors influencing nep formation—To understand the process of nep formation, Suzuki *et al.*[4] carried out some model experiments using a Mason type machine. Their experimental studies and analysis of the mechanism of nep formation showed that the higher the sliver density, the larger is the number of inter-fibre contacts as also the force of inter-fibre friction. The force needed to draw a fibre out of a fibre mass makes the carding action difficult and is conducive to nep formation. They further observed that the rate of nep formation per revolution of cylinder decreases with increase in the number of cylinder revolutions. The experimental results obtained in the present investigation closely conform to the mechanism suggested by Suzuki *et al.*[4]. When the sliver weight or the doffer speed is increased to step up production, the neps/g increase. This is due to the increase in fibre load on the operational layer, i.e. increase in material density between the flats and the cylinder. Increase in

Table 1—Effect of Production Rate (through Sliver wt/yd) on Sliver Quality

[Cylinder speed, 200 rpm; lap wt/yd, 13.6 oz; doffer speed, 12.5 rpm; RH, 56%; licker-in speed, 600 rpm; and flat setting, 12/100 in]

Sliver wt/yd (grains)	Mean carding force, g (A)	Operational layer, grains (B)	Ratio A/B	ρ			K_{rp}	Neps/g	U%
				Forward	Reverse	Total			
50	3.20	78.0	0.0410	0.089	0.113	0.202	0.452	71	3.3
62	3.68	98.0	0.0375	0.077	0.117	0.194	0.431	82	3.5
68	3.87	109.0	0.0355	0.067	0.122	0.189	0.406	101	4.2
75	4.13	121.5	0.0340	0.053	0.128	0.181	0.385	113	5.4

Table 2—Effect of Production Rate (through Doffer Speed) on Sliver Quality

[Cylinder speed, 200 rpm; lap wt/yd, 13.6 oz; licker-in speed, 600 rpm; sliver wt/yd, 62 grains; flat setting, 12/1000 in; and RH, 56%]

Doffer speed rpm	Mean carding force, g (A)	Operational layer, grains (B)	Ratio A/B	ρ			K_{rp}	Neps/g	U%
				Forward	Reverse	Total			
8	2.88	75	0.0384	0.067	0.123	0.190	0.466	72	3.4
12.5	3.68	98	0.0375	0.077	0.117	0.194	0.431	82	3.5
18.5	4.06	109.5	0.0370	0.084	0.109	0.193	0.450	98	3.7
24	4.44	126	0.0352	0.090	0.102	0.192	0.450	108	3.9

Table 3—Effect of Cylinder Speed on Sliver Quality

[Doffer speed, 12.5 rpm; lap wt/yd, 13.6 oz; licker-in speed, 600 rpm; sliver wt/yd, 62 grains; flat setting, 12/1000 in; and RH, 56%]

Cylinder speed rpm	Mean carding force, g (A)	Operational layer, grains (B)	Ratio A/B	ρ			K_{rp}	Neps/g	U%
				Forward	Reverse	Total			
200	3.68	98	0.0375	0.077	0.117	0.194	0.431	82	3.5
240	4.42	69	0.0640	0.068	0.120	0.188	0.450	68	3.3
280	5.16	49.5	0.1042	0.055	0.121	0.176	0.500	58	3.2
320	5.62	31.5	0.1784	0.047	0.123	0.170	0.532	43	3.0

Table 4—Effect of Cylinder-Doffer Setting on Sliver Quality

[Cylinder speed, 200 rpm; lap wt/yd, 13.6 oz; doffer speed, 12.5 rpm; sliver wt/yd, 62 grains; licker-in speed, 600 rpm; RH, 56%; and flat setting, 12/1000 in]

Cylinder-doffer setting (1/1000 in)	Mean carding force, g (A)	Operational layer, grains (B)	Ratio A/B	ρ			K_{rp}	Neps/g	U%
				Forward	Reverse	Total			
5	3.68	98	0.0375	0.077	0.117	0.194	0.431	82	3.5
7	4.39	128.5	0.0341	0.071	0.186	0.257	0.317	108	4.8

the cylinder-doffer setting increases the load on the operational layer and, as a consequence, there is an increase in neps. Increase in cylinder speed shows a considerable reduction in neps. This is associated with two reasons: (i) reduction in the load on the operational layer, and (ii) increase in the carding force because of the higher cylinder speed.

Factors influencing regularity of sliver—Karasev[5] observed that as a result of the decrease in the residual layer on the cylinder and the fibre throw (fibre delivered after the feed has been discontinued) from the flats, increase in cylinder speed leads to degradation of the regularity indices of the sliver and lowering of the degree of relative fibre parallelization and straightness. The results of the present investigation do not confirm Karasev's findings. It is observed that increase in cylinder speed, at constant carding rate, not only improves the regularity of the sliver, but also causes a marked improvement in the degree of fibre parallelization. Baturin[6] observed that the number of carding passes has a direct bearing on the web quality. He determined the number of carding passes from the following relation:

$$\text{carding passes, } K_p = \frac{Vc + Vd\,K}{Vd.K}$$

where Vc is the linear cylinder speed in m/min; Vd, the linear doffer speed in m/min; and K, the coefficient which characterizes the ratio of cylinder and doffer loads.

The results of the present investigation are in close agreement with the findings of Baturin[6]. The number of carding passes increases when the cylinder speed is increased at a constant doffer speed and decreases when the doffer speed is increased at a constant cylinder speed. Thus, the regularity of the card sliver improves with increase in cylinder speed, while a reverse trend is observed with increase in doffer speed. When the sliver weight is increased at constant cylinder and doffer speeds, the load on the carding surfaces increases, resulting in a poor quality web. Increase in cylinder-doffer setting also increases irregularity for the same reason. The results of the present investigation thus fully substantiate the observation of Bhaduri[3] that the cylinder loading can be considered to be an inverse index of carding quality.

Carding Force and the Quality of Carded Sliver

The intensity of carding depends on the carding force per fibre. If the carding force per fibre is increased, the conditions for separating the fibre tufts into single fibres are improved. The calculation of carding force per fibre is difficult as the carding state cannot be defined precisely. Moreover, it is impossible to measure the exact quantity of fibres in operation under actual working conditions. Even so, a qualitative assessment of the carding intensity is possible from the consideration of the ratio between the carding force and the experimentally determined load on the operational layer of the cylinder. It has been observed that the carding force increases with increase in load on the operational layer. If the increase in load on the operational layer results in an equivalent increase in the carding force, the carding force per fibre is likely to remain unaffected. However, if the rate of increase in the carding force is less than the rate of increase in the load on the operational layer, the net result would be a decrease in the carding force per fibre which should affect the quality of the carded sliver adversely. Values of ratio between the mean carding force and the load on the operational layer in increasing order along with the corresponding values of sliver quality indices are listed in Table 5. It is observed that both U% and neps decrease progressively with increase in this ratio. No definite trend is observed between the carding force per fibre and the coefficient of fibre parallelization. This is an expected result, as no definite trend was observed between the fibre disorder in sliver and the load on the operational layer.

Table 5—Unit Carding Force and Sliver Quality

Mean carding force, g / Operational layer, grains	Neps/g	U%	K_{rp}
0.0340	113	5.4	0.385
0.0341	108	4.8	0.317
0.0352	108	3.9	0.450
0.0355	101	4.2	0.406
0.0370	98	3.7	0.450
0.0375	82	3.5	0.431
0.0384	72	3.4	0.466
0.0410	71	3.3	0.452
0.0640	68	3.3	0.450
0.1040	58	3.2	0.500
0.1784	43	3.0	0.532

Thus, there appears to be a distinct relationship between the carding force and the quality of the carded sliver *vis-à-vis* the load on the operational layer. Increase in load on the operational layer increases the carding force, but if the ratio between the carding force and the load on the operational layer decreases as a consequence, a poor sliver quality results. Alternatively, a situation which gives rise to a higher value of this ratio results in an improved sliver quality.

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