Cleaning Action in the Lickerin Part of a Cotton Card

Part 1: Opening Action in the Lickerin Part

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Abstract

The mechanisms of the opening action in the nose part around the lickerin and the action of removing trash and fibers from the lickerin were analyzed, and the effects of the factors affecting these actions were examined.

With a wide nose-lickerin setting, a high lap-feeding rate, a slow lickerin speed or a large tooth angle of the garnet wire, the above-mentioned opening action was low. The lickerin speed varied the centrifugal force and affected the action of removing trash and fibers from the lickerin. Therefore, raising lickerin speed improved the cleaning action, rather than reducing the lap-feeding rate. The tooth angle of the garnet wire, too, had a bearing on the above-mentioned removing action; it is not advisable to increase the tooth angle.

Introduction

The principal actions of the lickerin part of a cotton card are fiber-opening and cleaning. Good opening action in the lickerin part gives good cleaning action in the lickerin part as well as good carding and cleaning actions between the cylinder and the flats, resulting in good sliver quality.

Lap fed by the feed roller is opened by the garnet wire wound on the lickerin near the nose of the dish plate, and the trash and a part of the fibers contained in the lap get a chance to leave the lickerin surface. Trash and fibers which have left here move along their respective paths in the induced flow around the lickerin roll, as explained in the next instalment of this series of studies. In line with the respective locations of the mote knife and the lickerin screen, as well as their respective paths, trash and fibers contained in lap deposit on the floor or are collected into the lickerin screen. A part of the air flow between the lickerin and the lickerin screen passes through the perforations of the lickerin screen. The air flow is accompanied by short fibers.

Such are the opening and cleaning processes, which are classified into the following stages:

i) Opening of cotton tufts in the nose part of the dish plate.
ii) Removing trash and fibers from the surface of the lickerin.
iii) Separating trash and fibers in the air flow induced near the surface of the lickerin.
iv) Removing short fibers accompanying the air flow through the perforations of the lickerin screen.

This article deals with an analysis of factors relating to stages i and ii. In addition, the effect of fiber-opening in stage i on the cleaning action of the flats is also discussed. Stages iii and iv will be dealt with in the next instalment.

1. Opening Action in the Nose Part

1-1. Lap-feeding

The fibers constituting finisher lap fed to the card by the conventional blowing process are in the form of cotton tufts (see Photo 1). Cotton fibers instead of being separated into individual fibers are piled in fiber tufts in the layers of the lap.
The respective weights of the individual cotton fiber tufts distribute as shown in Fig. 1. The distribution curve depends on the type of the beater in the picking machine, but there are only very few individual fibers for each type.

The orientation of fibers in each of these cotton tufts is fairly good, as shown in Photo 1, but the orientation of the fibers among those in adjacent cotton tufts is bad enough to bear out Itani's finding\[1\] that the fiber orientation of finisher lap expressed by the weight mean value $E^* (\cos \theta)$ was 0.51 to 0.57.

Lap having such a structure is held between the fluted feed roller and the smooth-curved surface of the dish plate under a certain load, and is fed to the lickerin part by the revolutions of the feed roller.

Although the surface of the dish plate is smooth, lap is subjected to a shearing force due to friction on its under surface, because the dish plate is fixed. For instance, if the revolving speed of the feed roller is 1.0 rpm and lap weighs 15 oz/yd, the lap feeding rate should be 11.04 lb/h, assuming that lap is fed at the same rate as the surface speed of the roller.

However, the actual value of the lap-feeding rate calculated from the weight of the lap consumed was 10.0 lb/h, which is about 10% below the above theoretical value. It shows the presence of shearing force acting on the under layer of the lap. Therefore, some of the cotton tufts in the lower layer of the lap are rolled into a ball-like state.

1-2. Mechanism of Opening and Uncertain Lap-holding

Observe an individual fiber tuft in lap being fed by the feed roller and the dish plate. The front of the fiber tuft is combed downward by the tips of the teeth of the garnet wire mounted on the lickerin roller which are running downward. Fibers freed from their grip by the feed roller and the dish plate are carried one by one off the lickerin surface by the garnet wire.

If the fibers are held securely by the feed roller and the dish plate while any part of a fiber is placed between them, if a fiber is instantaneously accelerated by the garnet wire when the rear end of the fiber reaches a certain point, and if the rear ends of the fibers are distributed at random in their moving direction in the lap, then the fibers should be completely opened and separated.

However, the thickness of the lap is very large compared with the thickness of a fiber, and the lap is composed, as we have said, of discontinuous and separated cotton tufts. Accordingly, the change from gripped state to free state or to the accelerated state of fibers does not occur in a fixed position. In addition, since the lap bends sharply, as shown in Fig. 2, near the point where it is gripped, the actual points of gripping are sufficiently deviated.

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by the layers of lap to cause layer-by-layer differences in the combing action of the garnet wire.

An observation of the front end of lap taken out by the reverse motion of the feed roller after its stoppage indicates that the respective lengths of the parts of the fibers combed by the garnet wire are shorter in the lower layers than in the upper, as shown in Photo 2. This shows that the fibers in the lower layers are combed hardly at all by the garnet wire where the lap bends sharply. The inference, then, is that the lower layers are insecurely held by the feed roller.

These fiber tufts are held for a while under the upper layer fibers even after they have been freed from the grip of the feed roller. They are carried away by the garnet wire as they are, once a part of each fiber catches on the wire during the combing of the fibers in upper layers. These fiber tufts cannot be opened here.

Thus it is rather difficult to open fiber tufts perfectly and to separate them into individual fibers completely in the nose part with the conventional mechanism of the nose part and in the conventional state of the fiber distribution in the lap. It is desirable, however, that air flow in picking machines be controlled so as to orient fibers longitudinally in lap; and that thin lap be formed and fed to the card if the condition of the uniformity of the thickness permits.

It is also desirable to reduce the size of the cotton tufts in lap. For that purpose, we might as well use a picking machine which has a beater wound with garnet wire, shown in the right half of Fig. 1 and recommended by Narumi[2].

1-3. Size Distribution of Cotton Tufts on the Surface of the Lickerin Roller

Since it is difficult to open fibers perfectly in the conventional nose part, we might do well to measure the size distribution of cotton fiber tufts carried on the surface of the lickerin roller by using a strobo-flash camera and examine the opening action in the nose part by varying the major factors which are believed to have bearings on it.

Raising the lickerin speed improves sliver quality, because, Bogdan[3] said, a certain amount of fibers distributes on a wider surface of the lickerin roller. The same reasoning also applies if the lap feeding rate is reduced. It is also supposed that the nose-lickerin setting or the tooth angle of the garnet wire wound on the lickerin may affect sliver quality even

<table>
<thead>
<tr>
<th>Test number</th>
<th>(a) Lap-feeding rate (low)</th>
<th>(b) Lickerin speed (high)</th>
<th>(c) Lap-feeding rate (high)</th>
<th>(d) Lickerin speed (low)</th>
<th>(e) Nose-cylinder setting (wide)</th>
<th>(f) Tooth angle of wire (large)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditions</td>
<td>Normal</td>
<td>12.4</td>
<td>7.3</td>
<td>12.3</td>
<td>21.3</td>
<td>13.1</td>
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<td>Lap-feeding rate (lb/h)</td>
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<td>446</td>
<td>770</td>
<td>446</td>
<td>275</td>
<td>446</td>
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<tr>
<td>Lickerin speed (rpm)</td>
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<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>Nose-cylinder setting (10^-3 in)</td>
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<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Tooth angle of garnet wire (°)</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
</tbody>
</table>
if the amount of fibers fed to a unit area of the lickerin surface is the same.

Each time the factors believed to bear on the opening action in the nose part were varied, instantaneous photographs of the lickerin surface were taken with a strobo-flash apparatus. The conditions for varying the factors are shown in Table 1, where the variations in the lap-feeding rate and the lickerin speed are approximately 5 : 3 : 3/5. The strobo-flash bulb and the camera were placed at the lower rear of the lickerin, the mote-knife was removed, and the free space zone of the lickerin surface between the nose and the inlet of the lickerin screen was photographed.

Thirty to 37 pictures were taken of each condition in which the factors were varied, because the surface area photographed was small and the scene varied from picture to picture even if the condition was the same. Photo 3 gives several photos taken at random for various conditions.

A number of cotton fiber tufts of various sizes were observed in all pictures and the effects of lap-feeding rate and lickerin were seen distinctly. The

\[
\begin{align*}
(a) & \quad \text{Normal condition (lap-feeding rate: 12.4 lb/h, lickerin speed: 446 rpm; nose-lickerin setting: } 10 \times 10^{-4} \text{ in; tooth angle of garnet wire: 75°)} \\
(b) & \quad \text{Lap-feeding rate (low): 7.3 lb/h} \\
(c) & \quad \text{Lickerin speed (high): 769 rpm}
\end{align*}
\]

Photo 3  Instantaneous photographs of lickerin surface from nose part (upper end in Photo) to inlet of lickerin screen (lower end) without mote knife
(d) Lap-feeding rate (high): 21.2 lb/h

(e) Lickerin speed (low): 275 rpm

(f) Nose-lickerin setting (wide): $80 \times 10^{-3}$ in

(g) Tooth angle of garnet wire (large): 105°
area of every cotton fiber tuft was calculated from
the average width and the average length of the
tuft in every picture and then number of the tufts
was obtained for each size group classified by the
calculated area.

Fig. 3 shows the number of the cotton tufts
over an actual area of 100, 50, 25, 12, or 6mm² on
the surface of the lickerin. The number denoted
is for the total area of the lickerin surface. The
number in each size group increased, as expected,
(a) when the nose-lickerin setting increased, (b) when
the lap-feeding rate increased, (c) when the lickerin
speed decreased, or (d) when the tooth angle of
garnet wire increased.

The number of cotton fiber tufts for lap fed by
a revolution of the feed roller increased with an
increase in the lap-feeding rate or with a decrease
in the lickerin speed, as shown in Fig. 4, although
the variation was less evident.

With the nose-lickerin setting widened to 80 × 10⁻³
inches, the distance from the gripping point of
the feed roller to the tooth tips of the garnet wire on
the lickerin, which was shown in Fig. 2, widened
and the fibers, especially in the lower layers of the
lap, received less combing by the tooth tips. There-
fore, as shown in Fig. 3(a), large-size cotton fiber
tufts increased notably in number. Particularly,
cotton tufts over 50 mm² for \(80 \times 10^{-3}\) inches were twice as many as for the normal condition, \(12 \times 10^{-3}\) inches.

When the tooth angle of the garnet wire increased, the fiber-holding force of the teeth was weakened and their combing capacity was reduced. Then the number of smaller cotton tufts, especially those below 25 mm², increased, in marked contrast to the increase in the number of bigger cotton tufts when the nose setting was increased.

The number of cotton tufts on the lickerin surface has a bearing on the separation of trash around the lickerin. Increases in the size and number of cotton tufts reduce the chance of trash separation considerably.

2. Removal of Trash and Fibers from the Lickerin Surface

When the fibers in a cotton fiber tuft in lap are opened in the nose part and become separated

![Diagram showing geometry around lickerin part](image_url)

<table>
<thead>
<tr>
<th>Cylinder side</th>
<th>Partitions of lickerin floor</th>
<th>Feed roller side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partition (Feed roller under lickerin)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight percentage of lickerin waste (weight of waste×100/rap weight)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylindrical Partition (Feed roller under lickerin)</td>
<td></td>
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<tr>
<td>Weight percentage of lickerin waste (weight of waste×100/rap weight)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Normal condition</td>
<td>(c) Lap-feeding rate (low): 4.8 lb/h</td>
<td>(e) Lickerin speed (high): 761 rpm</td>
</tr>
<tr>
<td>(b) Nose-lickerin setting (wide): (80 \times 10^{-3}) in</td>
<td>(d) Lap-feeding rate (high): 23.4 lb/h</td>
<td>(f) Lickerin speed (low): 74 rpm</td>
</tr>
<tr>
<td>(h) Lap-feeding rate (low): 3.3 lb/h</td>
<td>(i) Tooth angle of garnet wire (large): 100°</td>
<td></td>
</tr>
<tr>
<td>Lickerin speed (high): 19.0 lb/h</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

_Lickerin waste_ — _Fibers_ — _Trash_ — _waste_ — _trash_ — _fibers_ — _in up_ — _in up_ — _in up_ — _in up_ — _in up_ — _in up_

Fig. 6 Weight distribution of lickerin waste on floor from cylinder side to feed roller side

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into individual fibers or into smaller fiber tufts, trash and short fibers included in the tuft get a chance to leave the lickerin surface. The more opened fibers are, the better this chance is.

For trash or short fibers held by the garnet wire or adhering to fibers on the lickerin to be removed against the holding or adhering force, there must be sufficient centrifugal force acting on trash or short fibers.

Since, therefore, out of the four factors affecting the opening action, only the increase of the lickerin speed increases also the centrifugal force, it should be more effective for removing trash and short fibers than the decrease of the lap-feeding rate.

3. Amount of Waste under Lickerin

By varying factors relating to the opening action in the nose part i and relating to the removal of the trash and short fibers from the lickerin surface ii, cotton lap blended for 40's yarn was fed to a card. The weight of the lickerin waste for each varied factor is shown in Figs. 6 and 7. The floor under the lickerin was divided into 10 sections, as shown in Fig. 5.

The waste depositing on each section was classified into trash and fibers. The fibers were classified by their staple lengths into units of 3/4 inch and each unit was weighed. Fig. 6 shows the respective weights of fibers of the various length units and the weight of trash deposited on each section, the weights being expressed in the weight percentage of lap. Fig. 7 gives the integrated values of the weights throughout the 10 sections.

3-1. Effects of Nose-Lickerin Setting and of Lap Feeding Rate

As shown in Fig. 6(a), the weight of trash deposited under the lickerin under normal condition showed a peak in section 6 and distributed symmetrically on both sides of the section. The amount of fibers deposited was large on the cylinder side and decreased gradually as it went to the rear.
With a wider nose-lickerin setting (Fig. 6(b)) and a higher lap-feeding rate (Fig. 6(d)), the distributions of trash and fibers are nearly the same. Compared with normal condition (Fig. 6(a)), the shape of the distributions was similar and the weight decreased in all sections. The integrated values varied as shown in Figs. 7(a) and (b).

Figs. 3(a) and (b) indicate that, with a wider nose-lickerin setting or a higher lap-feeding rate, cotton fiber tufts per unit area of the the lickerin surface increased in number, tufts over 50 mm², in particular, being twice as many as under normal condition. The decrease in the weight of the deposit can be explained by poor fiber-opening action in the nose part.

The lickerin speed being constant under the two conditions and also under normal condition, there could be no difference in the conditions of the removal of trash and fibers from the lickerin and of the air flow under the lickerin. This explains why there was no difference in the shape of the distribution curve of the deposits for the three conditions.

At a lower lap feeding rate, the weight increased as shown in Fig. 6(c), although the shape of the distribution appears similar.

### 3-2. Effects of Lickerin Speed

With the lickerin speed lowered without changing the lap-feeding rate and various other conditions, an increase in the number of cotton fiber tufts reduced the removal of trash and fibers, as shown in Fig. 3(c), and the weight of the deposit under the lickerin decreased, as shown in Fig. 7(c). The shape of the distribution of the deposit under the lickerin was different from normal condition, as shown in Fig. 6(f), unlike Figs. 6(b) and (d).

A raise in the lickerin speed increased the weight of the deposit considerably. Especially, it increased the weight of fibers or longer fibers markedly. This tendency suggests an improvement in the opening action in the nose part i and an increase in the number of particles leaving the lickerin surface due to increased centrifugal force ii. Furthermore, an improved circulation of air flow under the lickerin distributed the fibers over all sections, while an increased speed of the downward stream along the rear surface of the mote-knife allowed trash to travel straight and shifted the peak of the deposit toward the rear.

A raise in the lickerin speed at a constant lap-feeding rate improves not only the effect of stage i (opening) but also the effect of stage ii (removing trash and fibers). A reduction in the lap-feeding rate at a constant lickerin speed improves the effect of only stage i.

Therefore, if the integrated weights of deposits under the lickerin, when the lickerin speed is varied with a constant lap-feeding rate (ordinate of Fig. 7(c)) and when the lap-feeding rate is varied with a constant lickerin speed (ordinate of Fig. 7(b)), are plotted as ordinates against the weight of lap fed to the lickerin per revolution of the lickerin as abscissa, as shown in Fig. 8, the difference in the integrated weights of the two cases indicates the removing effect of the stage ii.

Figs. 6(g) and (h) and Fig. 7(d) show the experimental value when the lap-feeding rate and the lickerin speed were proportionally increased to keep the weight of lap fed per revolution of lickerin constant. In this case, the effect of stage i should be constant all the time and the effect of stage ii can and should be demonstrated by these figures.
Fig. 7(d) shows an improved effect of removal in stage \(ii\) due to increased centrifugal force. It indicates an increase in the deposit of longer fibers and trash. The shape of the distribution curve in Fig. 6 (g) or (h) can be explained as a combination of (d) and (e) or of (c) and (f).

3-3. Effects of Tooth Angle of Garnet Wire

When the tooth angle of the garnet wire was large, cotton fiber tufts, especially those of medium and small sizes, increased considerably in number, as shown in Fig. 4 (d). Presumably, a poor opening effect in stage \(i\) increased the amount of trash in fiber tufts. As if to bear out this assumption, a reduced trash deposit was observed.

At the same time, the fiber retention force of the garnet wire decreased and the deposit of the fibers longer than \(\frac{1}{2}\) inch increased, although there was only a slight difference in the deposit of fibers shorter than \(\frac{1}{2}\) inch from normal condition.

Thus, a 100° tooth angle of the garnet wire spoils the cleaning action in the lickerin part by the inferior opening effect at stage \(i\) and by the removal of longer fibers due to the removal effect at stage \(ii\).

4. Effects of the Opening at the Lickerin on Sliver Quality

Good opening action in the nose part around the lickerin improves the cleaning action at the lickerin and, consequently, sliver quality. Good opening action does more than that. Since fibers transferred to the cylinder contain a smaller number of tufts, fewer fibers are deposited on the flats and on the cylinder, thus reducing the weight of flat strips, the fiber density on the cylinder and nep formation. Trash and fragments are apt to be absorbed by flat clothing. Therefore, sliver quality tends to be improved also by these advantages.
Fig. 8 shows the impurity density in sliver when the nose setting, lap feeding rate, or lickerin speed was changed. The wider the nose-lickerin setting, the higher the lap-feeding rate and the lower the lickerin speed, the larger the amount of neps, seed-fragments and leaf-fragments in sliver.

5. Conclusions

By examining cleaning action due to fiber-opening in the nose part and due to centrifugal force from the surface of the lickerin, the effects of these actions on the sliver quality was investigated.

An increased lap feeding rate, a reduced lickerin speed, or an increased nose-lickerin setting made the fiber-opening action in the lickerin part poor, reduced the depositing of trash and short fibers under the lickerin, spoiled the carding action between the flats and the cylinder and, therefore, lowered sliver quality.

Not only the opening action but also centrifugal force affect considerably the amount of lickerin waste if the lickerin speed is varied. With a 75° tooth angle of the garnet wire and with a lickerin speed above 450 rpm (30 g of centrifugal force), the deposit of longer fibers increased, while a considerable effect of centrifugal force was noticed on the deposit of medium-size seed-fragments when the lickerin speed was varied not only above 450 rpm but also below 450 rpm. With a 100° of tooth angle of the garnet wire, retention force was so slight that the deposit of longer fibers increased even at 450 rpm, because of the greater effect of centrifugal force.

References