Effects of rotor spinning parameters on microdust accumulation from a low-middling grade cotton

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The effects of opening roller speed, rotor diameter and rotor speed on rotor deposits were studied. The mass of accumulated trash particles in the rotor groove increased with increases in these spinning parameters. Opening roller speeds which gave a calculated value of less than 1.5 mg for the fibre mass per tooth caused a marked increase in the accumulated mass of rotor deposit. Expectedly, a deterioration was observed in the yarn quality with increased trash accumulation, but this appeared to be less than that attributable to increased rotor diameter and speed.

Keywords: Cotton, Opening roller speed, Rotor deposits, Rotor diameter, Rotor speed, Rotor spinning

1 Introduction

It is well known that the accumulation of fine dust particles in the rotor groove during spinning causes increased yarn breakage rate, deterioration in the yarn properties and rapid wear of the spinning machine components. Many steps that have been suggested to alleviate these problems include the use of improved blowroom machinery, optimization of the carding and drawing operations, coating of rotor surfaces with wear-resistant finishes, application of rotors designed to have a self-cleaning action, and on-line monitoring devices which arrest the spinning action on detecting a deterioration in yarn quality. However, little work has been reported on the effects of the spinning parameters on microdust accumulation in the rotor. This paper addresses this aspect, taking into account the reported recommendations on the raw material preparation.

2 Materials and Methods

A low-middling grade cotton was used, which had the following specifications.

Effective length, 30.5 mm
Short fibres, 30%
Maturity coefficient, 0.8
Fineness, 194.6 mtex
Micronaire, 4.56 g/in
Non-lint content, 2.07% (card lap)

The cotton was obtained from a mill in card lap form of 410 g/m². The mill operated a conventional blowroom line without special dust extraction.

2.1 Carding

The cotton was processed on a high-production card, and measures were taken to produce a sliver with the lowest trash content possible from the card. In this respect, the total draft and the doffer speed were varied to determine their effects on the trash content of the resulting sliver, measured by using a Shirley analyzer and a suitable balance. The other machine variables were maintained at the manufacturer's settings. The nep count and the Uster irregularity were also measured. Table 1 shows that a low trash content and a low cage loss were obtained when a theoretical total draft of 103.3 was used to produce a sliver of 4.0 ktex. The table also shows that the reduction in the doffer speed further decreased the measured values for these two parameters. The lowest value for U% and nep count corresponded to the conditions for the lowest trash content and cage loss. These results are in agreement with the findings reported earlier.

2.2 Drawing

The card sliver of lowest trash content was given two drawframe passages and, in agreement with other reported work, a further reduction in the trash content was obtained (Table 1). In general, the results in the table show that the best of the carding operations gave a 92% reduction in the trash content of the cotton lap and that a further 2% reduction was obtained with the two drawframe passages. With regard to the cage loss, carding effected a
Table 1—Sliver preparation and trash content

<table>
<thead>
<tr>
<th>Form of fibre mass</th>
<th>Trash mg/kg</th>
<th>Cage loss %</th>
<th>Nep counta</th>
<th>U%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton lap</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Card sliver</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sliver count</td>
<td>Carding</td>
<td>Theoretical draft</td>
<td>Doffer speed revs/min</td>
<td></td>
</tr>
<tr>
<td>ktex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.4</td>
<td></td>
<td>72.9</td>
<td>30</td>
<td>1430</td>
</tr>
<tr>
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<td>4.0</td>
<td></td>
<td>103.3</td>
<td>30</td>
<td>830</td>
</tr>
<tr>
<td>4.0</td>
<td></td>
<td>103.3</td>
<td>40</td>
<td>1100</td>
</tr>
<tr>
<td>4.0</td>
<td></td>
<td>103.3</td>
<td>22</td>
<td>730</td>
</tr>
<tr>
<td>Drawn sliver</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First passage</td>
<td>630</td>
<td>0.86</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Second passage</td>
<td>540</td>
<td>0.82</td>
<td>—</td>
<td>3.5</td>
</tr>
</tbody>
</table>

aShirley template method.

14.5% reduction and drawing an additional reduction of 14.7%.

2.3 Spinning

A second passage drawn sliver was used to spin yarns of 40, 60 and 80 tex on a six-position, Rieter rotor spintester. The rotor diameter, rotor speed, opening-roller speed and twist factor were varied to determine their effect on the amount of accumulated trash particles within the rotor. At each setting, spinning occurred for 4 h without an end break. At the end of this period the trash particles accumulated within all six rotors were removed with a vacuum device, similar to that reported by Nield and Abadeer, and weighed on a micro-balance. The calculated average values per kg of yarn spun were then compared to determine the trends associated with the changes in the machine parameters.

The tensile properties, irregularity and hairiness were measured for the yarns spun. The effect of rotor deposits on the measured properties was compared with the effect of increased opening-roller speed, rotor speed and rotor diameter.

3 Results and Discussion

3.1 Effect of Opening Roller Speed on Rotor Deposits

Fig. 1 shows that the amount of accumulated trash particles in the rotor increased with opening roller speed, the increase in accumulation being significantly smaller for 5000-7000 revs/min as compared to that for speeds above 7000 revs/min.

Simpson and Murray suggested that increased opening roller speed can lead to increased rotor accumulations and attributed this to two factors: (i) an increased freeing of trash particles through better fibre individualization, and (ii) the greater impact of the opening-roller wire clothing causing fibre breakage, where the length of fibres is shortened by up to 6% and the broken-off ends become rotor accumulations. Rakshit and Balasubramanian and Hunter have also reportedly observed fibre breakage at high opening roller speeds. However, during the work reported in this paper no indication of fibre breakage was observed. For each of the five opening roller speeds, a comb-sorter diagram was prepared from the fibres collected in the grooves of the six rotor units used. No significant change in either the effective-fibre length or the percentage of short fibres was evident from these diagrams. Microscopic analysis of the rotor accumulations did not reveal the presence of broken-off fibre ends. The
work was carried out with a pin-type opening roller clothing, having a 88° working angle (rake) and a teeth-density of 10.6/cm². Vigo and Barella have reported that pin-type clothing is less likely to cause fibre damage than saw-tooth type clothing. It would seem reasonable to assume, then, that the increase in accumulated trash (Fig. 1) was more likely the result of increased fibre individualization than of fibre breakage. Following this assumption, an important parameter would be the average mass of fibre per tooth of the opening roller and in this respect, Fig. 1 also shows that the more significant increases in accumulated deposits correspond to the calculated averages of mass per tooth less than 1.5 mg.

Because of the significance of fibre individualization, the fibre mass per tooth was kept constant when the effects of varying the other machine parameters were studied.

3.2 Effect of Rotor Diameter on Rotor Deposits

The effect of increased rotor diameter on the mass of accumulated rotor deposit is shown in Fig. 2. Referring to Neild and Abadeer's study, trash particles enter the rotor groove each time the gap behind the peel-off point coincides with the exit of the transfer channel. Accordingly, for a given groove geometry, rotor speed and yarn delivery speed, the mass of deposited trash should be greater for smaller rotor diameters. However, the figure shows the mass of accumulated deposits to have increased with rotor diameter. A possible reason for this may be the difference in the self-cleaning effect of the rotors. The rotors used had a groove angle of 45°. This angle enables the yarn to give the rotors, through the propagation of peripheral twist, the self-cleaning effect. Clearly, the effectiveness of this action will be dependent on the force pressing the mass of trash particles into the groove and the magnitude of the torque producing the peripheral twist, the former opposing the action and the latter enhancing it. Both should increase with increased rotor diameter. From Fig. 2 it may, therefore, be assumed that all other factors being equal, a larger rotor diameter has less effective self-cleaning.

It may be further reasoned that for each rotor used, the deposited mass and the accumulated mass differed, the latter being lower because of the self-cleaning effect. The difference would be lower the larger the rotor diameter, and this would give rise to the trend seen in Fig. 2.

3.3 Effect of Rotor Speed on Rotor Deposits

Fig. 3 shows that increased rotor speed results in increased trash accumulation in the rotor groove. Based on the above discussion in respect of the trash particle deposition into rotors and the self-cleaning effect of rotors, it can be assumed that more trash will be deposited with increased rotor speed and that the force compressing the trash particles into the rotor groove will become greater and reduce the self-cleaning effect.

3.4 Effect of Twist on Rotor Deposits

To maintain a constant fibre mass per tooth while studying the influence of twist, the twist level was changed by increasing the rotor speed. Fig. 4 shows that the mass of accumulated deposit initially decreased with increases in twist and then increased. This trend may be attributed to the self-cleaning action of the rotor. It can be reasoned that the initial increase in twist enhanced this action sufficiently to
overcome the opposing effect of the associated increase in rotor speed. Further increases in twist were not as effective because the related rotor speeds were significantly higher. However, on comparing the values corresponding to 60,000 revs/min in Figs 3 and 4, both obtained with the same degree of fibre separation, it can be seen that the increased twist had reduced the mass of accumulated trash particles by 33%.

3.5 Effect of Yarn Count on Rotor Deposits

Yarn counts of 40, 60 and 80 tex were spun, keeping the degree of fibre separation and level of twist constant. Fig. 5 shows that the mass of accumulated deposit decreased significantly with increases in yarn count. Neild and Abadeer\(^8\) have reported that the width of the fibre ring in the rotor groove increases with yarn tex. This facilitates the incorporation of trash particles in the body of the yarn and enhances the self-cleaning action of the rotor, resulting in the trend shown in Fig. 5.

![Graph showing the effect of yarn count on rotor deposits](image)

**Fig. 5**: Effect of yarn count on rotor deposits

3.6 Comparison of the Effects of Machine Variables and Rotor Deposit on Yarn Properties

In agreement with the reported studies\(^{16-18}\), the measured tensile properties decreased and the irregularity and hairiness increased with increases in rotor deposits, rotor diameter and rotor speed (Table 2). It may, however, be observed that, in general, other factors being equal, the changes in the measured yarn properties due to increased rotor deposits were not as large as those caused by increased rotor diameter and rotor speed.

4 Conclusions

The results reported pertain to a low-middling grade cotton and, therefore, conclusions drawn may not strictly apply to other cottons. However, the following points contribute to the general understanding of rotor sedimentation.

It is understood that the mass of trash particles accumulated within the rotor groove in a given time will be less than the actual mass deposited in the groove\(^{6,8,13}\), but the results of the present work show that for a given yarn count and production speed, the size of the difference would depend on the degree of fibre individualization and the effectiveness of the rotor's self-cleaning action.

With the pin-type opening roller used, increases in opening roller speed reduced the fibre mass per tooth without fibre breakage and increased the freed micro-trash particles, resulting in increased rotor accumulation. Below 1.5 mg fibre mass per tooth, the release of trash particles is more prominent.

Increased twist enhances the rotor's self-cleaning action. However, increased rotor diameter and

<table>
<thead>
<tr>
<th>Rotor diam. mm</th>
<th>Rotor deposit mg/kg of yarn</th>
<th>Rotor speed revs/min</th>
<th>Tenacity cN/tex</th>
<th>Ext %</th>
<th>U%</th>
<th>Hairs/m</th>
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<td>11.9</td>
<td>9.7</td>
<td>13.2</td>
<td>28</td>
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</table>
speed oppose the self-cleaning action through the forces compressing the trash particles into the rotor groove; and as a result, the accumulated mass is increased.

The deterioration in the measured yarn properties due to increased trash accumulation is less than that caused by increased rotor diameter and speed.

References
10 Rakshit A K & Balasubramanian N, Influence of opening roller speed, rotor speed and rotor diameter on open-end yarn quality; paper presented at the 40th all India textile conference, Ahmedabad, December 1983.
11 Hunter L, Text Prog, 10 (1978) 12.