Study on drafting force of roving: Part III – Effect of process parameters and roving irregularity on drafting force variability

A Das*, S M Ishtiaque & Rajesh Kumar
Department of Textile Technology, Indian Institute of Technology, New Delhi 110 016, India

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The effect of draft, drafting speed and roller setting on drafting force variability of 100% cotton roving has been studied for different levels of fibre-to-fibre friction and roving irregularity. It is observed that the drafting force variability increases with the increase in draft, drafting speed and roller setting. The drafting force variability is higher in case of rovings with lower fibre-to-fibre coefficient of friction and higher roving irregularity.

Keywords: Cotton, Drafting force, Drafting speed, Roller setting, Roving irregularity

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1 Introduction
In the earlier papers, the effect of process variables, namely draft, drafting speed and roller setting, and material variables, namely fibre-to-fibre friction, roving hank and roving twist multiplier, on drafting force has been reported. The process of attenuation of linear fibre assemblies by roller drafting causes a tension to be generated in the fibres in the drafting zone. The force necessary to give rise to the average tension in the moving fibre mass in the drafting zone is referred as drafting force.

The interaction between properties of single fibre and fibre assembly and the parameters related to drafting cause variations in inter-fibre cohesive forces acting on short fibres assembly during drafting. This variation in drafting force generates in an irregular manner in the drafting zone, which, in turn, causes a variation in mass per unit length of the drafted material. The significance of drafting force during staple fibre spinning cannot be undermined. It is, however, the variation in the drafting force which significantly affects the yarn quality. This leads to a difficult situation, as the drafting force is a highly sensitive factor which depends on various process parameters and more significantly the fibre characteristics. Thus, the relative measurement of the effect of different factors on drafting force assumes huge significance. Drafting force and its variability are important characteristics that determine the irregularity added during drafting, the number of faults generated and the drafting failures. Measurement of drafting force and its variability is therefore a useful aid in raw material selection, optimization of spray oils used in cotton, and optimization of crimp and spin finish level in synthetic fibres and other process parameters during synthetic fibre manufacturing.

Dutta et al. reported that the magnitude of drafting force is mainly dependent on the input material and constituent fibre physical properties together with the draft. Fluctuation in the input material irregularity will cause variation in the drafting force and hence it will again affect the output material variability. They also observed that there is a strong correlation between these parameters.

In the present work, the effect of process variables, namely draft, drafting speed and roller setting, on variability of drafting force has been studied. The responses of drafting force variability with process variables at different levels of fibre-to-fibre friction and variability of roving linear density have also been studied.

2 Materials and Methods

2.1 Materials
Medium grade cotton (J-34) was dyed in three different shades with natural dyes, as reported earlier.
to get different levels of friction properties. The static frictional coefficients \((\mu_s)\) of these three fibres, namely grey, dyed in linen colour and dyed in royal blue colour, were 0.3, 0.4 and 0.5 respectively. No significant difference in the properties of cotton, except in the frictional coefficient, was observed due to dyeing. The representative values of properties of cotton are given below:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5% span length</td>
<td>26.8 mm</td>
</tr>
<tr>
<td>50% span length</td>
<td>13.3 mm</td>
</tr>
<tr>
<td>Uniformity ratio</td>
<td>49.6%</td>
</tr>
<tr>
<td>Short fibre content</td>
<td>10.25%</td>
</tr>
<tr>
<td>Fibre fineness</td>
<td>3.9 µg/inch</td>
</tr>
<tr>
<td>Bundle strength</td>
<td>21.63 g/tex</td>
</tr>
</tbody>
</table>

### 2.2 Roving Preparation

The selected grey and dyed cotton fibres were processed in blow room, card and then given two passages of draw frame. The finisher draw frame slivers with three different friction levels were then processed in a simplex to produce roving, keeping both the hank and twist multiplier of roving constant at 1.0. From each of these three types of slivers, the roving bobbins with two levels \((L_1\) and \(L_2\)) of irregularity were prepared (Table 1). The higher irregularities in rovings were introduced by disturbing feed slivers. After that, all the six roving samples were taken for testing.

### 2.3 Testing of Fibres and Rovings

The grey and dyed cottons were tested for 2.5% span length, uniformity ratio and short fibre content in the Classifiber KCF/LS from Keisokki. Fibre bundle strength and micronair values were tested in Stelometer and airflow instrument respectively.

The fibre-to-fibre coefficient of friction and drafting force of roving were measured in the same way as explained earlier\(^2\). All the roving samples were tested for unevenness in Keisokki evenness tester with the running speed of 50 m/min for 2 min.

### Table 1 — Details of roving samples

<table>
<thead>
<tr>
<th>Frictional coefficient of fibre</th>
<th>Irregularity of roving, U%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>5.50 6.73</td>
</tr>
<tr>
<td>0.4</td>
<td>6.02 6.98</td>
</tr>
<tr>
<td>0.5</td>
<td>6.21 7.21</td>
</tr>
</tbody>
</table>

\(L_1\) and \(L_2\) denote two levels of irregularity.
The variability of drafting force was obtained by taking into account the individual drafting force data in computer and then calculating the coefficient of variation. For each sample, twenty readings of drafting force variability were taken to get the average drafting force CV%.

3 Results and Discussion

Table 2 shows the drafting force and drafting force CV% for two levels (L1 and L2) of roving irregularity with different levels of fibre-to-fibre frictional coefficient and process variables (draft, drafting speed and roller setting). It is observed that there is no significant difference in the drafting force of roving at both the levels of roving irregularity. This phenomenon is valid for all the friction levels of fibres. It is also observed that keeping all other parameters same, the drafting force increases with the increase in the level of fibre friction. The variability of drafting force is always higher in case of rovings with higher irregularity (L2) for all the levels of fibre-to-fibre friction. The effect is more prominent in case of rovings with lower fibre-to-fibre friction.

The drafting force of any fibre strand depends mainly on two parameters, namely the number of fibres in the cross-section and fibre-to-fibre friction. At a lower level of fibre-to-fibre friction, the interfibre cohesion is less which results in lower drafting force. Also, at lower level of fibre friction, the number of fibres in the cross-section dominates in generating drafting force. For this reason, the higher unevenness of roving (i.e. higher variability in the number of fibres in the roving cross-section) at lower fibre friction results in higher variability of drafting force. On the other hand, the higher fibre friction dominates over the number of fibres in the cross-section. Therefore, at higher level of fibre friction, even if the number of fibres in the cross-section of roving varies widely (in case of change in irregularity), the drafting force variability is less influenced.

The effect of process variables, fibre-to-fibre friction and level of roving irregularity on drafting force and drafting force CV% is shown in Figs 1-3. As there is no significant difference in the drafting force of roving with two levels of irregularity (L1 and L2), the drafting force values for rovings with L1 level irregularity are shown in the Figs 1-3.

3.1 Effect of Draft

Fig. 1 shows that as the draft increases, the drafting force value initially increases and then drops. It is observed that the drafting force CV % of rovings for both the levels of roving irregularity increases with the increase in draft. The same trend is observed for
all the levels of fibre friction. The increase in variability of drafting force with the increase in draft is due to the fact that the sudden increase in fibre speed due to higher draft causes uncontrolled stretching of fibre strand which results in increase in drafting force variability. The rovings with high irregularity cause more erratic movement of fibres, resulting in more drafting force variability. Table 2 and the Fig. 1 also show that the increase in fibre friction results in reduction in the drafting force variability at all the levels of draft. The reason for this has already been discussed.

![Fig. 2](image1.png)  
**Fig. 2**—Effect of drafting speed on drafting force and its variability

![Fig. 3](image2.png)  
**Fig. 3**—Effect of roller setting on drafting force and its variability
3.2 Effect of Drafting Speed

It is observed from Fig. 2 that with the increase in drafting speed the drafting force value increases for rovings with both the levels of irregularity at different levels of fibre-to-fibre friction. The similar trend has been reported earlier. The increase in drafting speed results in increase in the drafting force variability. The increase in the drafting force CV % with the increase in drafting speed is because of the fact that with the increase in drafting speed the fibre tension increases and also causes some erratic movement of fibres which generates drafting waves. Therefore, the amplitude increases with the increases in drafting speed and hence the drafting force variability increases.

3.3 Effect of Roller Setting

Fig. 3 shows that with the increase in roller setting the drafting force values for both the levels of irregularity of rovings reduce at different levels of fibre-to-fibre friction. The similar trend has been reported earlier. It is also evident from the figure that the variability in drafting force increases with the increase in roller setting. This may be due to the fact that at lower roller setting, there is more frictional field (more fibre cohesion) and hence the fibre movement occurs in a controlled manner. But when the roller setting is increased the frictional field sharply goes down (reduction in fibre cohesion) and fibre movement becomes very much irregular, thereby increasing the drafting force variability. This trend is more prone to the more irregular roving because there are chances of more uncontrolled movement of fibres.

4 Conclusions

4.1 The mean drafting force of rovings is not affected significantly by the irregularity but the variability of drafting force is always higher in case of rovings with higher irregularity.

4.2 The rovings with higher fibre-to-fibre friction result in higher drafting force but the variability in drafting force is always found to be lesser in case of rovings with higher fibre-to-fibre friction.

4.3 The variability in drafting force always increases with the increase in draft, drafting speed and roller setting. This trend is valid for all levels of fibre-to-fibre friction and roving irregularity.

References