Analysis of spinning tension in ring spinning

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The fluctuation in spinning tension in ring spinning at different time scales, viz. long term (beginning to end of the cop build up), medium term (for winding a chase) and short term (for one revolution of a traveller) has been studied using Rothschild Tensiometer 2000 and a customized software. It is observed that the spinning tension decreases from the beginning to the end of the cop build up. Traverse of the ring rail and rotation of the traveller introduce periodicity to the spinning tension over which fluctuations arising out of the vibrations from the spindle are superimposed.

Keywords: Cotton, Ring spinning, Spinning tension

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1 Introduction

The performance of a ring spinning machine is evaluated by productivity, end breakage rate and quality of yarn produced. Limitations of traveller speed and end breaks due to tension peaks on the yarn in the spinning zone are the major constraints in enhancing productivity of the ring spinning. The end breakage rate rises steeply with increasing spinning tension and its variation. In this respect, the peak value of spinning tension is more important than the average value and for a better performance of ring frame, the peak value of spinning tension should be lower. Because when the peak tension exceeds the strength of the weak places in the yarn, it leads to end break. In addition, a very high spinning tension results in the deterioration of yarn quality parameters, such as elongation, unevenness and imperfections. The spinning tension therefore plays a crucial role in evaluating the performance of a ring spinning machine.

During the ring spinning process, the rotation of traveller over the ring and the ring-rail movement cause the spinning tension to fluctuate periodically. Further, the vibration of different elements of the ring spinning machine due to the rotation of spindle, traveller and drafting rollers causes the spinning tension to vary. Among these, the spindle is the major source to cause tension fluctuations, as it is not supported at the top and rotates at a very high speed. The study of spinning tension has been the subject of a number of investigations. Lünenschloß and Bünger measured the winding and spinning tensions and found that the amplitude and frequency of the tension fluctuations in the winding zone are higher than those in the spinning zone. Sonntag reported that the spinning tension increases with the increase in traveller velocity and ring-traveller frictional force. An eccentric yarn guide does not change the average spinning tension significantly but the tension distribution becomes wider and peak tension increases. He also observed a cross correlation between the spindle vibration and the spinning tension. Stalder reported that the spinning tension is a function of spindle speed, traveller mass, ring diameter, coefficient of friction between ring and traveller, and the angle between the connecting line from the traveller-spindle axis and the piece of yarn between the traveller and the cop.

In this study, the fluctuation of spinning tension has been measured using a tension meter at different response time and duration of the measurement. These are classified as long-, medium- and short-term variations.

2 Materials and Methods

Rothschild Tensiometer 2000 was used to measure the spinning tension. This instrument works on the principle of differential capacitor. The tension probe was positioned in the spinning zone 5 cm below the front roller nip. When yarn passes over the movable
pin of the probe, the pressure applied by the yarn causes a change in the voltage which is proportional to the yarn tension. The two fixed pins of the probe were removed to avoid twist blockage to the spinning zone and consequently thread breaks. A Teflon rod was placed just above the top most position of the lappet to avoid the swinging of the yarn in the spinning zone. This keeps a constant angle of wrap of the yarn over the movable pin at 150°. The instrument was interfaced with a computer. A software process the output from the instrument, plots the variation in spinning tension and gives statistical parameters. With a response time of 1 ms, it is possible to observe the variation in spinning tension during one revolution of traveller. To analyze the variation in spinning tension and its periodicity at different time periods, the measuring system response times were selected as 1 s and 1 ms. For the purpose of simplification and analysis, the variation in spinning tension from the beginning to the end of the cop is termed as long-term variation; for a chase (one traverse of ring rail) it is termed as medium-term variation; and for one revolution of the traveller it is termed as short-term variation. For the experiments, a 20s Ne cotton yarn was spun at a spindle speed of 16000 rpm by using ICI MMUDR traveller. A schematic diagram of the testing of spinning tension and measuring unit is shown in Fig. 1.

3 Results and Discussion

The long-term variation in spinning tension, starting from beginning to the end of the cop build, is given in Fig. 2. It is observed that the average value of spinning tension is higher at the base of the cop and it declines during the course of cop build, as evidenced from the previous studies1. This can be explained on the basis of the following two reasons. Firstly, the angle of lead, i.e. the angle between the connecting line from the traveller-spindle axis and the piece of yarn between the traveller and the cop, is lower at the base of the cop. The winding tension is a function of angle of lead and it is indirectly proportional to this angle. Secondly, the high air drag forces on the longer balloon while winding the yarn at the base of the cop are also responsible for the higher balloon tension. Due to the dynamic loading of yarn during spinning, tension amplitudes from the winding and balloon regions are propagated to the spinning region and reflected back as the forming yarn is held by the nip of the front drafting rollers. These tension amplitudes override the yarn withdrawal force in the spinning region and result in high spinning tension. High spinning tension while winding the yarn at the base of the cop is the result of the high winding and balloon tensions.

The CV% of spinning tension was also calculated at different positions of cop build. The corresponding CV% values for bottom, middle and top positions of cop are 18.7%, 23.1% and 24.5% respectively. The higher CV% of spinning tension at the end position of the cop build can be attributed to two factors. A statically balanced spindle (spindle axis and the principal mass axis coinciding) may develop quasi-static unbalance as the yarn is wound over the bobbin. At any instant while winding the yarn on the bobbin, the mass distribution around the spindle axis is never uniform. This shifts the principal mass axis of the spindle-bobbin unit continuously with the presence of excess mass always at one side of the spindle. When more and more yarn is wound from the base to the top of the bobbin, the mass distribution around the spindle axis becomes more uneven. This leads to more
vibration in the rotating spindle, resulting in high fluctuations in the spinning tension. Further, while winding the yarn on the top of the bobbin, the size of the balloon is small. With the short yarn length available in the balloon region, the damping of the vibrations transmitted from the winding region is less effective as the ballooning yarn has less energy of absorption and hence causes transfer of more tension fluctuations to the spinning zone.

The medium-term variations in spinning tension for a full traverse of ring-rail movement are given in Figs 3 and 4. A progressive decrease in spinning tension is observed while the ring rail moves downward. The spinning tension approaches the peak value at top position of the ring-rail movement. This can be ascribed to the progressive decrease in angle of lead and transfer of more yarn from the balloon region to be wound onto the bobbin as the ring rail traverse upwards. It is also observed from Fig. 3 that the time required to obtain the lower minima from higher maxima value of spinning tension is half of that required to reach the maxima from the minima. This is due to the faster traverse of the ring rail during downward movement than that during upward movement.

While measuring the spinning tension at 1 ms time of response for very short interval, the short-term variation in spinning tension is observed (Fig. 5). It is observed that, on an average, for every 4 ms one peak amplitude is generated which implies that each revolution of traveller produces at least one peak value of spinning tension. In fact, in each rotation of the traveller, there are five peak tensions. The observation of only one tension peak in each rotation of traveller is due to the limitation of response time of the measuring system, the minimum value being 1 ms. As the traveller rotates around the ring, the angle of wrap of the yarn over the lappet changes periodically. This angle of contact is low while the traveller is away from the machine (towards the operator) and it is high when traveller moves towards the machine. The periodic change of this angle influences the transfer of tension amplitudes to the spinning zone from the winding zone, resulting in spinning tension.

4 Conclusions
The average value of spinning tension is high while winding the yarn onto the base of the cop and it declines during the course of cop build, whereas the tension fluctuations are low at the base of the cop and increase as winding proceeds. For one traverse of the ring rail, the spinning tension reaches maximum and minimum when the ring rail is at the top and bottom respectively. The rotation of traveller over the ring and traverse of the ring rail introduce periodic fluctuations in spinning tension.

References
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