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Effect of Frequency and Amplitude of Vibration on Ring-Traveller Friction of Ring Spinning Frame

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Abstract

The purpose of this paper is to investigate experimentally the effect of frequency and amplitude of vibration on yarn tension as well as the friction of ring-traveller. An external vibration generating facilities is created and placed in a miniature ring spinning frame to generate and apply vibration to ring. The experimental miniature ring spinning frame has the facility to vary the spindle speed, frequency and amplitude of vibration. During the experiment, the spindle speeds vary 12000 – 8000 r.p.m. The amplitude of vibration for this work was varied 0 mm to 1.25mm and frequency varied 0-800 Hz. Studied have shown that ring-traveller friction is influenced by the variation of the amplitude and frequency of vibration. Results are compared with different parameters of vibration status respective to spindle speed. It was found that yarn tension and friction between ring and traveller was depending on the parameters of vibration.

Keywords: *Friction, Vibration, Frequency, Amplitude, Ring, Traveller and Yarn tension*

1. Introduction

Ring spinning is a popular spinning system for making spun yarn from cotton, wool and different man-made staple fiber in the textile industry. According to strength of product (yarn), this system is best and this system is flexible and most widely used spun yarn manufacturing system. But low productivity is one of the remarkable limitations of this system due to the limited speed (max 40meter/sec) of traveller. Traveller speed is limited for high friction between ring and traveller, which increase the temperature of traveller and finally it breaks.[1-4]
The co-efficient of friction between the contacting surfaces depends on type of material, surface characteristics and conditions, relative motion and vibration etc.[5-8] Vibration may increase or decrease friction depending on surface characteristics, area of contact, sliding velocity, contact pressure and temperature etc. [9-15] It is known that frictional force may increases or decreases depending also on the vibration parameters. It can be noted that there are no established correlation between co-efficient of friction and vibration related parameters. Considering the above findings and lack of correlation, the present research was aimed to study the effect of frequency and amplitude of vibration on yarn tension and as well as friction between ring and traveller of a ring spinning frame.

2. Theoretical Analysis

The forces acting at the traveller on the contact of ring owing to its rotational motion with the tension of yarn is analyzed and at the condition of equilibrium in the three orthogonal directions is founded the following three equations:-

$$C = T_U \cos\alpha + S\cos\nu - T_T \cos\varepsilon_1 \qquad (1)$$

$$\mu S + T_T \cos\varepsilon_2 = T_U \sin\alpha \qquad (2)$$

$$T_T \cos\varepsilon_3 = S\sin\nu + Mg \qquad (3)$$

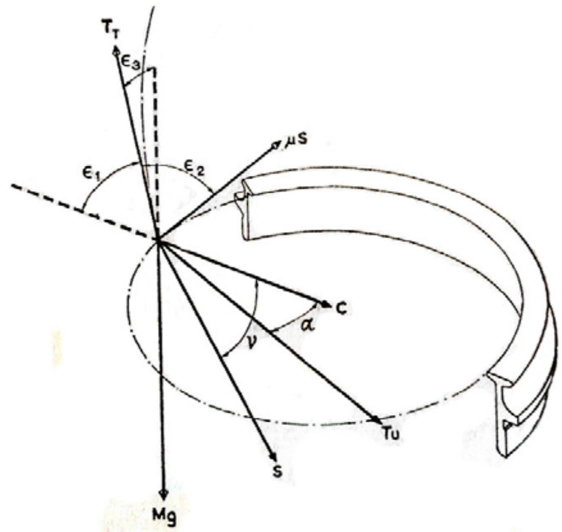

Fig. 1. Forces acting on traveller

Here C = MRω² is the centripetal force required to keep the traveller rotating R = is the radius of rotation of the center of gravity of the traveller, M = mass of the traveller

T_U = yarn tension at traveller in the package side, μ = the co-efficient of friction between ring and traveller, α = the winding angle, S = the normal reaction between ring and traveller

At equilibrium condition and simplification of equation no.1, 2 and 3 with different logical assumption, the following equation is found

$$T_T \cong a\mu C \qquad (4)$$

But C is always constant for same spindle speed and traveller weight

So it can be written

$$T_T \approx a\mu \qquad (5)$$

Now it is clear that Yarn tension depends on ring traveller and yarn traveller friction.

3. Experimental setup

An experimental set-up was designed and fabricated such that it can transmit vibration to the existing ring of a spinning frame. In this set up (Figure.2) the to and fro motion along the radial direction of an arm is used to vibrate the ring base. The construction and working principle of the set-up is given bellow.

1= variable frequency drive, 2 = Motor, 3,4 = Step pulley , 5= Bobbin rail, 6 = Bolt, 7= Nut, 8 = Fluted spindle, 9 = Fluted spindle supporter, 10= Connector with frame, 11= Supporter attachment, 12= To and fro motion transferring arm, 13= Nut, 14= Helical Spring, 15= Ring 16= Ring fitting frame, 17 = Ring rail, 18 =Bobbin rail, 19= Motor pulley, 20= Variable frequency drive, 21= Motor.

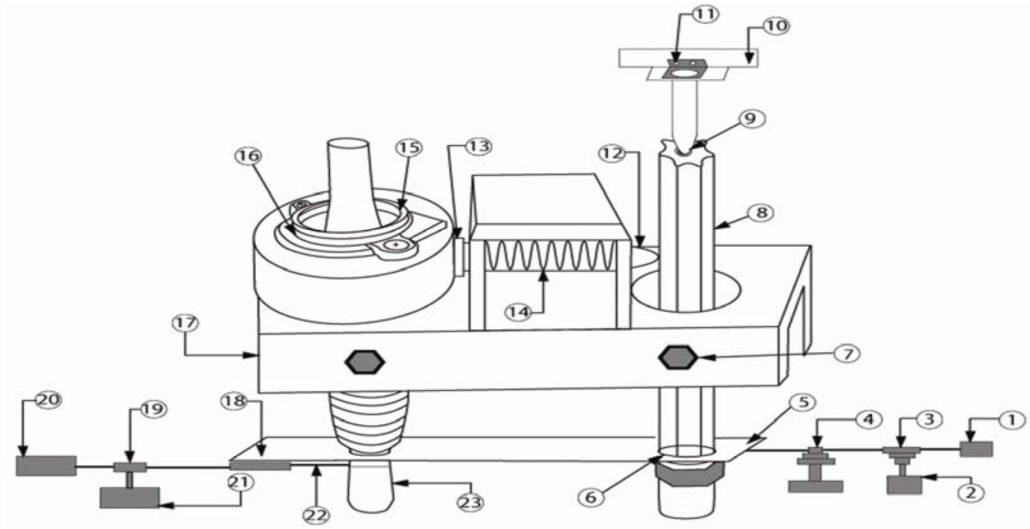

Fig. 2. Schematic diagram of the experimental set-up [16]

A spindle with corrugated surface (fluted spindle) is designed and fabricated in such a way, that it can be placed at the normal position of the spindle with existing facilities. To rotate this fluted spindle, power is transferred through flexible belt from step pulley arrangement of a motor. The motor is mounted vertically on an isolated place having rubber damper. In addition to step pulley, a variable frequency drive (an electronic speed control unit) is used to vary the speed of the motor as required.

A to and fro motion transmitting arm is placed between fluted spindle and the ring base. During rotation of the fluted spindle, to and fro motion is created to the contacting arm which finally becomes a vibration to the ring base.

The Spindle of the ring spinning machine rotates from the power of main drive through belt. A variable frequency drive is also connected with this main motor to rotate the spindle at variable speed.

The parameters of spinning are taken, which are mention in. (table-1) and during experiment the following measurements (table-2) are recorded:-

Table. 1 Experimental condition

Name of the Parameter	**Selected material and value for experiment**
Type of fiber	Polyester multifilament and cotton fiber
Yarn count (Ne)	10 and 20
Twist per inch	14 and 18
Ring diameter(mm)	45
Traveller weight	0.045- 0.049 gm

Table. 2 Measuring instrument and measurement

Name of the Measuring Instrument	**Parameters measured/Calculate**
Vibration Measuring Meter METRIX Instrument Co	Displacement and Velocity of vibration
Yarn Tension Measuring Meter SCHMIDT, Germany	Yarn Tension (Average, Minimum, Maximum and Peak value)
Digital Tachometer	Spindle speed

4. Results and Discussions

4.1 Effect of Frequency of Vibration on Yarn Tension

To identify the effect of frequency of vibration on ring; the amplitude of vibration is 0.5mm and frequency 200, 400, 600 and 800 Hz selected. Experiments are being done with the spindle speed of 8000, 10000 and 12000 r.p.m.

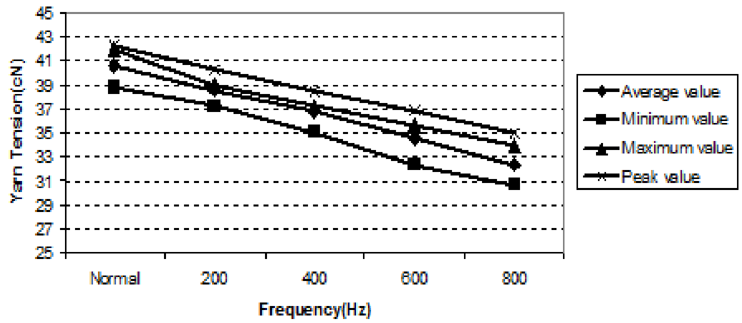

Fig. 3. Yarn Tension at different frequency of vibration at ring. (spindle speed 8000 r.p.m., amplitude 0.5mm)

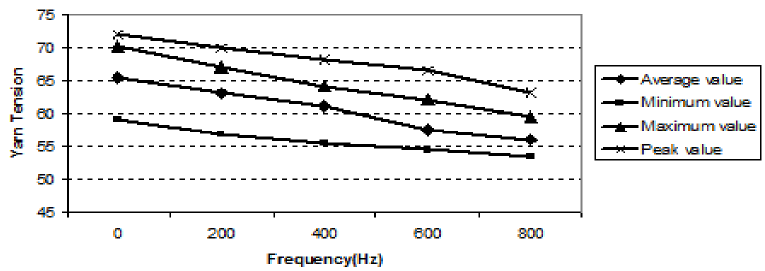

Fig. 4. Yarn Tension at different frequency of vibration at ring. (spindle speed 10000 r.p.m., amplitude 0.5mm)

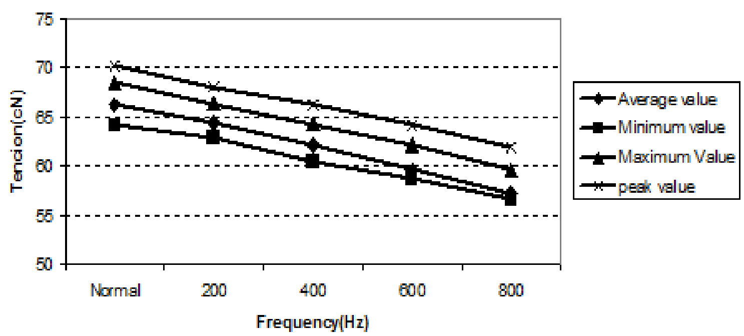

Fig. 5. Yarn Tension at different frequency of vibration at ring.(spindle speed 12000 r.p.m., amplitude 0.5mm)

The effects of frequency of vibration are displayed in Figures 3, 4 and 5. From the three figures it is seen that all the values of yarn tension (average, min, max, peak) decrease clearly with increasing the frequency of vibration. The tendency of tension decrease rate is almost linear for the three different spindle speeds. Frequency is an important parameter of vibration, which makes the repetition of oscillating motion per second of a vibratory body. Higher frequency ensures higher times of oscillation motion per second, which has strong effect on yarn tension. Yarn tension or friction between the ring and the traveller is inversely proportional to the frequency of vibration. It is very difficult to generate more than 800 Hz frequencies of vibration due to the system limitation. The system of vibration generation could not be more stable with too high frequency.

High frequency of vibration means more number of separations between vibration bodies and at the same time lower time for contacting surfaces, that is lower area of contact. This procedure reduces the resistance against the running of the traveller, causing the reduced tension. Therefore, the reduction of yarn tension for the increase of frequency of vibration is due to more separation of the contact surfaces. In fact the higher the separation, lower the time of contact between the frictional surfaces. As the frequency increases, keeping the amplitude of vibration constant, the acceleration of vibration will also increase that might cause momentary vertical load reduction, which causes the reduction of effective normal force resulting reduction of tension with the increase of frequency of vibration. The factors may be responsible for the momentary load reductions are:

- Superposition of static and dynamic force generated during vibration.
- Reversal of the friction vector
- Load transformation of vibration energy into heat energy
- Approaching excitation frequency to resonance frequency

Therefore it can be concluded that with the increase of frequency of vibration decreases the value of yarn tension as well as the friction.

4.2 Effect of Amplitude of Vibration on Yarn Tension

To verify the effect of amplitude of vibration on the ring; the frequency of vibration is 400 Hz and amplitude 0.25, 0.5, 0.75, 1 and 1.25 mm selected. Experiments are being done with the spindle speed of 8000, 10000 and 12000 r.p.m and other parameters of spinning are taken the same as given in Table 1.1.

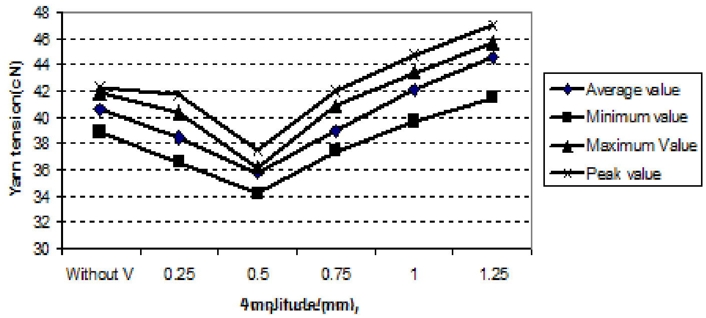

Fig. 6. Yarn Tension at different amplitude of vibration at ring. (spindle speed 8000 r.p.m., frequency 400 Hz)

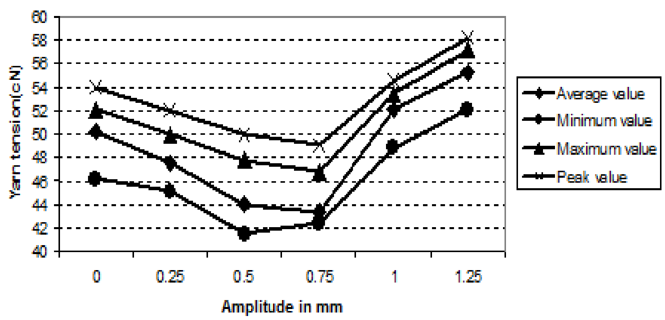

Fig. 7. Yarn Tension at different amplitude of vibration at ring. (spindle speed 10000 r.p.m., frequency 400 Hz)

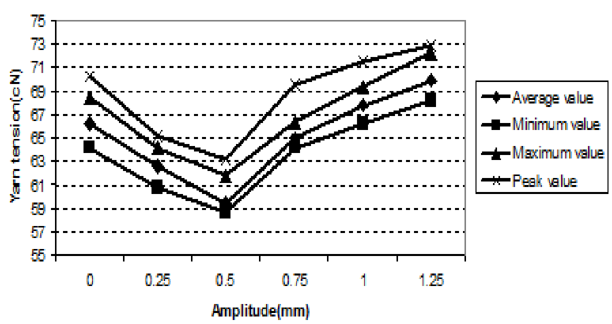

Fig. 8. Yarn Tension at different amplitude of vibration at ring. (spindle speed 12000 r.p.m., frequency 400Hz)

Amplitude is also an important parameter for generation of effective vibration at the ring for the reduction of friction between ring and traveller. Figure 6, 7 and 8 show the effect of different amplitude of vibration on yarn tension. At first yarn tension is reduced up to 0.5 mm of amplitude but after 0.7 mm of amplitude, yarn tension is going to increase at upward direction. It may happen, high amount of amplitude creates some new problem to traveller, which makes large displacement from the surface of the ring and dropped again ring contact with additional load. When the traveller is going to drop at the surface of the ring at running condition from a long distance, suddenly a strong pressure arises between the ring and the traveller. This makes a serious problem to traveller and consequently deformed itself on ring surface and fly out.

Therefore it can be concluded that with the increase of amplitude of vibration, the value of yarn tension as well as the friction decreases. This may happen up to certain limit, for the increase of amplitude friction and consequently the yarn tension start to decrease. It can happen for the increase of mechanical interlocking that result increase of tension. The factors may be responsible for the momentary increase of load for the following reason:

- Addition of the friction vector
- Load transformation of vibrational energy into high heat energy, which deform the surface of comparative softer material (traveller) and increase frictional force.

Amplitude is an important factor for effective generation of vibration. Appropriate amplitude might help to reduce friction between the ring and the traveller of the ring spinning frame.

Vibration is one kind of oscillating motion and this oscillating motion of ring induces the traveller to maintain intermitted contact with ring. This reduction of contact time and area of contact has influence on the reduction of temperature of the meeting surface of ring and traveller and hence the rise of temperature is decreased. The same reason may be valid to the reduction of yarn tension.

Now it can be summarized that application of vibration is a new way, which can assist the traveller to run with intermittently contact on the ring. This process reduces yarn tension, temperature of meeting surface between ring and traveller and as well as its friction. To maintain the present running condition i.e the same friction, about 10% spindle speed can increased with the application of vibration. This will increase the production of a spinning machine.

5. Conclusion

Amplitude and frequency are two important parameters for generation of effective vibration at the ring for the reduction of friction between ring and traveller. Co-efficient of friction between ring and traveller decreases with increase of frequency of vibration but with the increase of amplitude of vibration, the value of yarn tension as well as the friction decreases, which happen up to certain limit and then it shows opposite character.

Selection of appropriate frequency and amplitude of vibration is very important for generation of effective vibration, which helps to reduce friction between ring and traveller of a ring spinning frame.

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