

APPLICATION OF VIBRATION FOR REDUCTION OF RING-TRAVELLER FRICTION OF A RING SPINNING FRAME

Hosne Ara Begum¹ and Md. Maksud Helali²

¹Department of Yarn Manufacturing, Bangladesh University of Textiles, Bangladesh

²Department of Mechanical Engineering, Bangladesh University of Engineering and Technology, Bangladesh

ABSTRACT

The paper presents the effect of vibration on yarn tension as well as friction between ring and traveler and their temperature rise during spinning. With the application of vibration the variation of yarn qualities such as its strength, elongation, evenness and hairiness properties are explained also. An external vibration generating facilities is designed and placed in a miniature ring spinning frame to generate and apply vibration to ring. The miniature ring spinning frame has the facility to vary twist and count of yarn and was modified to vary the spindle speeds 6500 –13000 revolution per minute approximately. During this study the amplitude and frequency of vibration were kept almost constant. Studied have shown that ring-traveller friction is influenced by the application of vibration and the properties of cotton yarn was influenced with effect of vibration. Results are compared with and without vibration status. It was found that friction between ring and traveller was 3-12% reduced depending on the speed of the traveler. The strength, elongation and evenness properties of the cotton yarn showed improved quality. Therefore it can be concluded that application of vibration may be a way of reducing friction between ring and traveler and thus the mechanical process of twisting and winding can be done at high speed for higher productivity of ring spinning system which is a limiting factor of this system.

Keywords: Friction, Vibration, Ring, Traveller and Yarn Tension

1. INTRODUCTION

Ring spinning is an important spinning system for making spun yarn from different short to medium staple length fibers in the textile industry. As per quality concern of product, this system is best, flexible and most widely used 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. It is well known that traveler speed is limited for high friction between ring and traveler, which 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 vibration on friction between ring and traveler. Many researchers have been carried out to reduce the frictional force between ring and traveller by modifying surfaces and surface contact area of ring and traveller. Sofar knowledge goes no reported work was found which apply vibration to reduce frictional force between ring and traveller of ring spinning frame. [1-4]

2. THEORETICAL

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 are founded the following three equations:-

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

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

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

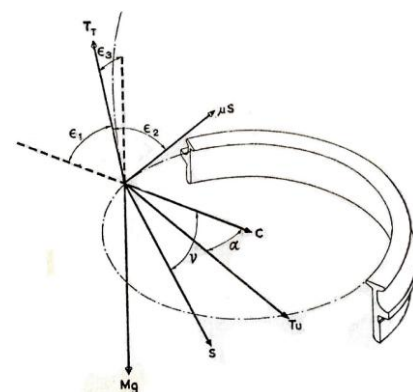


Fig 1. Forces acting on traveler

Here $C = MR\omega^2$ is the centripetal force required to keep the traveller rotating $R =$ is the radius of rotation of the center of gravity of the traveler, $M =$ mass of the traveller $T_U =$ yarn tension at traveller in the package side, $\mu =$ the co-efficient of friction between ring and traveler, $\alpha =$ the winding angle, $S =$ the normal reaction between ring and traveller

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

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

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

So it can be written

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

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

3. EXPERIMENTAL

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.

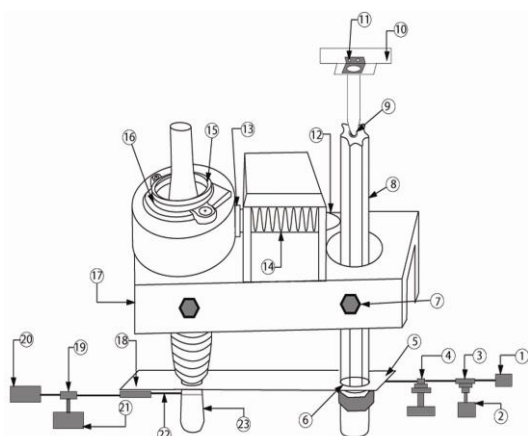


Fig 2. Schematic diagram of the experimental set-up

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.

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 a isolated 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.

To do the experiment the following parameters(table-1) are selected 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 Vibration on Yarn Tension

To compare the effect of vibration on yarn tension during spinning five different spindle speeds(13125, 11518, 9920, 8410, 6540)r.p.m and polyester multifilament are selected on the basis of experimental facilities. Amplitude and frequency of the applied vibration was 0.5mm and 375 Hz respectively.

During spinning, ring rail always traverse up and down along a certain length of bobbin and consequently yarn is wound on that place of bobbin. At the time of spinning, different types of forces act on the yarn e.g friction with lappet and traveller, resistant of air drag and winding tension etc. These forces are variable due to different type of variable speed acts on yarn. Such as (i)one is traveling lengthwise(variable) from nip point of front drafting roller to winding point of bobbin through lappet and traveller (ii)another one is rotating with traveller. As a result variable tension is developed at yarn, due to variable forces. These variable forces generate variable tension in yarn, which are measured by the tension meter with the name of average, minimum, maximum and peak-value. Yarn tension meter can capture 60 readings per second and during each measured data was recorded for one minute. Similarly reading are taken in five times at particular spindle speed and presented in mean result.

Average value of yarn tension: Figure 3(a) shows the average value of yarn tension at five different spindle

speed (different velocity of traveller) with and without application of vibration and it is seen that, at every steps of spindle speed the average value of yarn tension is lower due to effect of vibration on ring. From this study, it is seen that the value of yarn tension directly proportional to the value of co-efficient of friction between ring and traveller. So the lower value of yarn tension means lower co-efficient of friction between ring and traveller.[equation no-5]

Figure 3(b) shows the percent reduction of average value of yarn tension for five different spindle speeds and this reduction varies from 4.25% to 9.75%. The reduction of average yarn tension is high at high spindle speed than low speed. Higher sliding velocity of traveller responds more by the effects of vibration than lower velocity.

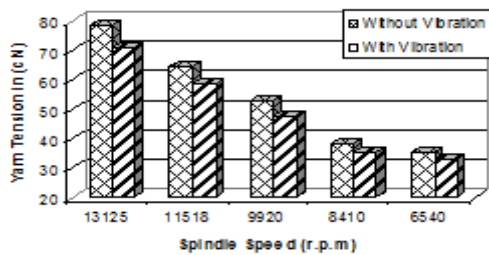


Fig 3(a). Average value of yarn tension with and without application of vibration.

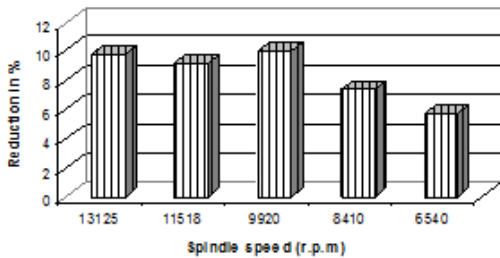


Fig 3 (b). Percentage reduction of average value of yarn tension with application of vibration.

Minimum value of yarn tension: Figure 4(a) represents the comparison of minimum value of yarn tension at five different spindle speeds. These values of yarn tension decreases at each spindle speed due to the vibration of the ring. The amount of percent reduction of minimum value of yarn tension is presented in figure 4(b) and from this figure it is also clear that percent reduction of minimum value of yarn tension is varied from 2% - 8% and maximum reduction was found at 9920 r.p.m of spindle speed.

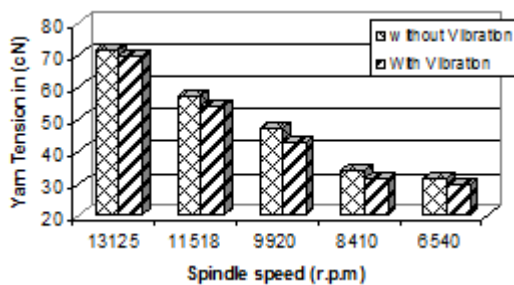


Fig 4(a). Minimum value of yarn tension with and without application of vibration.

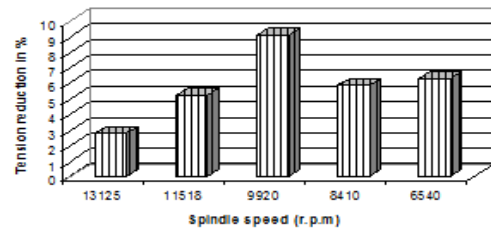


Fig 4(b). Percentage reduction of minimum value of yarn tension with application of vibration.

Maximum value of yarn tension: These maximum values of yarn tension reduce with the effect of vibration at each spindle speed (6540 to 13125 r.p.m) which is shown at figure 5(a).

Figure 5(b) shows the reduction percent of maximum value of yarn tension at the condition of vibration. This value reduces at 10% at the spindle speed of 13125r.p.m and it reduces 7% at the spindle speed of 6540r.p.m. The effect of vibration is more prominent on high spindle speed than low spindle speed.

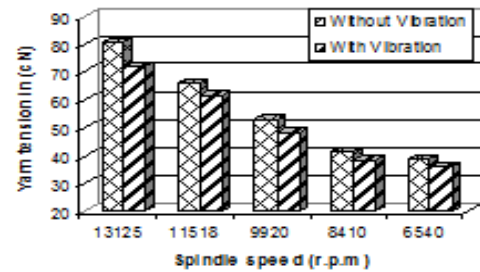


Fig 5 (a).Maximum value of yarn tension with and without application of vibration.

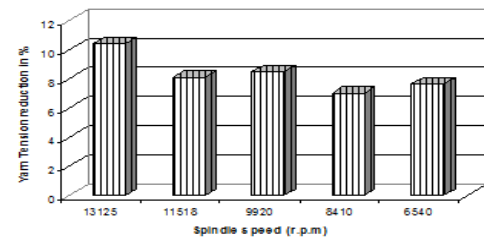


Fig 5(b). Percentage reduction of maximum value of yarn tension with application of vibration.

Peak value of yarn tension: Application of vibration at ring also affects at the peak value of yarn tension. At every steps peak value of yarn tension reduces, which is shown in figures 6(a) and from figure, it is seen that without vibration yarn tension is 80 cN and with application of vibration it is only 72 cN at the spindle speed of 13125 r.p.m. The percent reduction of yarn tension shows in figure no. 6(b) and these are 5.9 % to 9.2 % at different spindle speed. Decrease rate of peak value of yarn tension is high at high speed than low speed.

To compare figures 3(b), 4(b), 5(b) and 6(b), it is seen that decrease rate of peak value of yarn tension is higher than average, minimum and maximum value. Peak value of yarn tension is an important value, which has strong effect on end breaks.

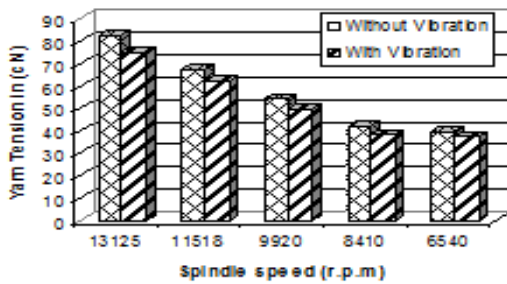


Fig 6(a). Peak value of yarn tension with and without application of vibration.

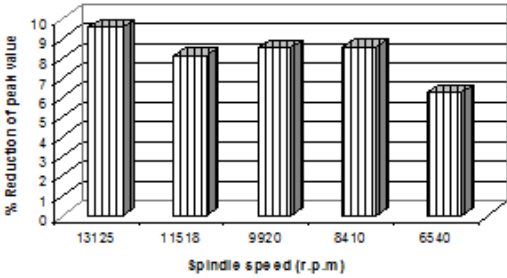


Fig 6 (b). Percentage reduction of peak value of yarn tension with application of vibration.

speed of 6540- 13125 rpm. This reduction of ring temperature indicates the reduction of frictional force for application of vibration at ring.

Vibration is one kind of oscillating motion and this oscillating motion of ring induces the traveler to maintain intermittent contact with ring. This reduction of contact time and area of contact has influence on 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 reduced yarn tension, 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.

4.2 Effect of Vibration on Ring Temperature

During running of traveller on ring rail, temperature generates at the meeting surface of ring and traveler due to friction. K-type thermocouple is used to measure ring temperature as possible as close the meeting surface. Temperature of ring is measured continuous 16 minutes from start. Due to high rotational speed of traveler, its temperature measurement could not be done to the lack of facilities.

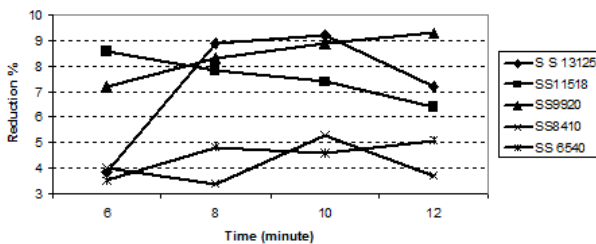


Fig 7. Percentage reduction of ring temperature at different spindle speed with application of vibration

Figure 7 shows the percent reduction of ring temperature at five different spindle speed with application of vibration during spinning. This reduction of rise ring temperature maintains approximate similar tendency as tension reduction value. Percentage reduction of ring temperature is varied also 3-10 due to spindle speed of 6540- 13125 rpm. This reduction of ring temperature indicates the reduction of frictional force for application of vibration at ring.

Vibration is one kind of oscillating motion and this oscillating motion of ring induces the traveler to maintain intermittent 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 traveler 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 reduced yarn tension, rises 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.

4.3 Effect of Vibration on Yarn Properties

To observe whether vibration has any adverse effect on the yarn quality of the produced yarn the following properties of yarn assessed and compared.(table-3) 10 and 20Ne of cotton spun yarn are manufactured from cotton fiber(length= 24mm, fineness= 4.2 micronaire and maturity= 90%) with and without application of vibration at 10000 rpm of spindle speed with 14 and 18 T.P.I. respectively at same environment condition. Strength, elongation and parameters of evenness are measured by Titan universal strength tester and Uster tester4 respectively.

The properties of both yarns (10 and 20 Ne) are slightly affected by vibration. The breaking strength of both yarns, which are produced with effect of vibration increase 4-6% and elongation properties increase negligible amount. Mainly the structure of yarn formation is being begun at spinning triangle and the newly formed yarn is going forward through lappet and traveller at the direction of winding point. Yarn is running and moving with high tension at its path and vibration help to reduce the surface scraping of yarn. This may a reason to increase strength few percentages. Normally the scrapping fibers are agglomerated at the inner side of traveller and sometimes come out with yarn at the formation of yarn fault. But with effect of vibration, there is no chance to remain the scrapping fiber between yarn and traveller. The value of U%, thick, thin and hairiness remain almost same. Neps are increased few percentages; also lies at normal range

Table 3: Properties of spun cotton yarns

Sample and Experimental condition	Breaking Strength(cN)	Elongation%	U%	Index	Thick 50%	Thin 50%	Neps 200%	Hairiness Co-efficient
A	783	7.26	10.14	2.37	28	0	843	1.24
B	818	7.28	10.04	2.35	25	0	875	1.24
A	249	5.82	12.14	--	168	5	1690	3.92
B	265	5.96	12.49	--	174	9	2173	3.91

** A= Without Vibration B = With Vibration

5. CONCLUSION

The application of vibration at ring and traveller indeed affects the frictional force of ring-traveller or co-efficient of friction between ring and traveller. Co-efficient of friction between ring and traveller decreases with increase of spindle speed with effect of vibration. It is found that the percentage variation of friction co-efficient does not maintain any fixed correlation with spindle speed due to variation of vibration generation. The properties of yarn show better results due to vibration.

6. REFERENCES

1. Barr, De and Catling, H, The Principles and Theory of Ring Spinning, Manual of Cotton Spinning, Volume 5 (1965), The Textile Institute Butterworths Press, London, 1965.
2. Klein, W, A Practical Guide to Ring Spinning, Manual of Textile Technology, Volume 4, (1995)The Textile Institute, MFP Design and Print, Manchester, UK.
3. Grosberg, P and Iype, C, Yarn Production (Theoretical Aspects), (1999)The Textile Institute International, Biddles, UK.
4. Lord, P R, Yarn Production (Science Technology and economics), (2003) The Textile Institute, Woodhead Publishing Limited, Cambridge England.
5. Archard, J.F. (1980), "Wear theory and mechanism",

in Peterson, M.B. and Winer, W.O.(Eds), Wear Control Handbook, ASME, New York, NY, pp. 35-80.

6. Arnov, V., D' Souza, A.F., Kalpakjian, S. and Shareef, I.(1984a), "Interactions among friction, wear, and system stiffness- Part 1 : "Effect of normal load and system stiffness", ASME Journal of Tribology, Vol. 106, pp 54-58.
7. Arnov, V., D' Souza, A.F., Kalpakjian, S. and Shareef, I.(1984b), "Interactions among friction, wear, and system stiffness- Part 2 ." Vibration induced by dry friction", ASME Journal of Tribology, Vol. 106, pp 59-64.
8. Bushan, B., 1999, Principle and Applications of Tribology, John Wiley & Sons, Inc., New York, pp. 344-430, Chap. 6.
9. Bushan, B. and Gupta, B.K. (1991), Handbook of Tribology Materials, Coatings, and Surface Treatment, Mc-Graw-Hill, New-work,NY9reprint with corrections, Krieger, Malabar, FL(1997)
10. Godfrey, D., 1967, "Vibration Reduces Metal to Metal Contact and Causes an Apparent Reduction in Friction," ASME Transactions, 10, pp. 183-192.
11. Skare, T. and Stahl, J. (1992), "Static and dynamic friction processes under the influence of external vibrations", Wear, Vol. 154, pp. 177-92.
12. Chowdhury, M. A. and Helali, M. M. September (2006), " The Effect of Frequency of Vibration and Humidity on the Co-efficient of Friction" , Tribology International, 39, pp, 958-962.
13. Chowdhury, M. A. and Helali, M. M. (2007) , " The Effect of Frequency of Vibration and Humidity on Wear Rate" Wear, Vol. 262, pp. 198-203.
14. Chowdhury, M. A. and Helali, M. M. (2008) , " The Effect of Amplitude of Vibration on the Co-efficient of Friction", Tribology International, Vol41, pp. 307-314.
15. Lenkiewicz, W., 1969, "The sliding friction process-effect of external vibrations,' Wear, 13, pp. 99-108.

7. MAILING ADDRESS

Hosne Ara Begum

Assistant Professor
Department of Yarn Manufacturing,
Bangladesh University of Textiles,
Tejgaon, Dhaka-1208, Bangladesh.