Tension in a Roving Withdrawn from a Bobbin

By Yoshito Miura and Sueo Kawabata

Member, Kyoto University of Industrial Arts and Textile Fibers

Abstract

The roving tension between a guide rod and a traverse guide is the sum of the withdrawing tension T and the frictional force between the roving and a guide rod.

The larger the withdrawing angle is, the larger the discrepancy between the observed and the calculated tension T and also the larger the variation of the observed value.

The height of the guide rod under equal tension at the top and bottom of each bobbin layer is about $\frac{1}{3}$ of the bobbin length.

The maximum values of draft of each layer of bobbin are practically the same.

So far as tension is concerned, the package can be made much larger than the present size.

Introduction

There are many published studies on the problem of irregularity of draft in the drafting and winding mechanism of spinning machines, but few on the irregularity of draft caused by the roving tension between the bobbin on the creel and the drafting roller.

From a thorough study of the irregularity of draft caused by the roving tension, we find means to fix the proper dimensions of a larger packed bobbin or determine the proper mechanism of the creel to cope with the effect of this irregularity of draft.

This article gives the measurement of the tension of the roving unwound from the package on the creel and also the measurement of the frictional force between the roving and the surface of guide rod. It also probes the irregularity of draft caused by this tension and by frictional force.

Experimental Method

As shown in Figure 1, the roving tension is picked up by a three-pulley mechanism. The middle pulley is fixed on a metallic plate which is held by a spring plate and which moves vertically.

Under this metallic plate, another metallic plate is fixed on the bed, the two plates forming an electric capacitor.

The other two pulleys are fixed on the bed. When roving passes these pulleys, the middle pulley is pushed down by the roving tension and produces a variation in the distance between the two plates, i. e., the electric capacity. The variation in the electric capacity is transformed into a vari-

ation in the electric current, and the variation in the electric current is measured by an Ammeter. Transfer circuit is shown in Figure 2

Cotton roving of 1.07 twists/inch, 155 grains/15 yd was used in our experiment.

Fig 1 *Measuring apparatus of the roving tension*

Fig 2 *Transfer circuit*

When the Roving Tension Does not Pass the Guide Rod

A packed bobbin is set on the creel. Roving is drawn from the bobbin through a guide pulley which may rotate very lightly. The guide pulley is set on the centre line of the bobbin length at a distance of 10 cm from the bobbin axis.

The unwinding speed of the roving is variable. When the resolving point of the package is above the center of bobbin length, the value of unwinding angle ϕ is defined as positive. Angle ϕ is a factor of roving tension, but the weight of the packed bobbin M and the speed of roving V are also factors concerned with the roving tension.

The weight M is calculated by the following formula:

$$dm = 2\pi r \rho H, dr = 2\pi \rho r \{H_0 - 2(r - r_0) \cot \theta\} dr \quad \dots\dots\dots (1)$$

Hence

$$M = \pi \rho \{ (H_0 + 2r_0 \cot \theta) (r^2 - r_0^2) - 4/3 (r^3 - r_0^3 \cot \theta) \} + M_0 \quad \dots\dots\dots (2)$$

$$\text{or } M = 25.75r - 1.21r^3 + 128 \quad \dots\dots\dots (2')$$

Fig. 3a Roving tension
The packed bobbin weight $M = 620$ g
The packed bobbin radius $r = 5$ cm

where ρ : density of packed roving
(0.251g/cm)

r : bobbin radius (2cm)

θ : slope angle of package (41deg)

H_0, H_r : Package lift when package radius is zero and r ($H_0 = 28$ cm)

m : packed roving weight without bobbin

M_0 : bobbin weight including the skewer (220g)

According to our experimental survey, the roving tension always varies even under a constant condition. The maximum and minimum values of the tension are shown in Figures 3a and 3b. Figure 3a shows the tension when M is constant. Figure 3b shows the tension when V is constant.

Assuming that the skewer contacts the skewerstep on a circular plane, T_0 , the minimum force to cause the packed bobbin to revolve, is shown as follows:

$$T_0 r = \frac{2\mu M}{R_0^2} \int_0^{R_0} R^2 dR \quad \dots\dots\dots (3)$$

where μ : the frictional coefficient between the skewer and the skewerstep.

R_0 : the radius of the contacting circular plane.

And when $\mu_0 = 0.25$, $R_0 = 0.1$ cm, T_0 is shown as follows:

$$T_0 = \frac{0.05}{3} \left(25.75r - 1.21r^3 + \frac{128}{r} \right) \quad \dots\dots (3')$$

Fig. 3b Roving tension
 V (The unwinding velocity) = 0.9 cm/sec

When the package weight is constant, the roving tension T is

$$T = T_0 \sec \phi \quad \dots\dots\dots (4)$$

The value of calculated T is shown by the curves in Figure 3.

As shown in Figure 3, the values of calculated T and measured T are different. This difference increases with the values of $|\phi|$ and the unwinding velocity V . When $|\phi| > 30 \sim 40$ degrees and V is larger in value, the difference between the calculated and measured values of T is remarkable. This difference between the calculated and measured values may be due to the irregularity of bobbin rotation.

Variation of the roving tension, ΔT_0 is

$$\Delta T_0 = \frac{1}{r} \dot{\omega} = I \frac{V}{r^2} \quad \dots\dots\dots (5)$$

where ω = the angular velocity of the revolving packed bobbin.

I = the moment of inertia of the packed bobbin.

$$= \pi \rho \left\{ \left(\frac{H_0}{2} + r_0 \cot \theta \right) (r^4 - r_0^4) - \frac{4}{5} (r^5 - r_0^5) \cot \theta \right\} + I_0$$

I_0 = the moment of inertia of the bobbin, including the skewer.

Fig. 4 The displacement of the resolving point

The variation of V is explained as follows:

Figure 4 shows that if the resolving point of the package is at the point O at the beginning, O moves to the point O_1 as the sticking force between the unwinding roving and the surface of the packages keeps the

roving from resolving. Afterwards, the revolutionary velocity is reduced in the time interval $(O_1O + O_1P - OP)/V_0$. And then O_1 shifts back to O again, when the revolutionary velocity of the package is accelerated suddenly.

As this process is repeated, the packed bobbin revolves intermittently.

On the other hand, when the unwinding angle $|\phi|$ increases, O is displaced to O_2 in proportion as $|\phi|$ becomes larger.

Therefore, the unwinding roving slips on the surface of the package, and then the roving tension is varied irregularly by the frictional force between the unwinding roving and the package's surface.

According to our experimental survey, the faster the unwinding velocity, the shorter the duration of the intermittent motion of the packed bobbin. At the same time, the variation of the roving tension is hardly affected by the weight of the package, because the moment of the revolution of the packed bobbin increases as its weight increases.

When Roving Tension Passes the Guide Rod

When the roving unwound from the packed bobbin is withdrawn over the guide rod, the tension, including the frictional force, is the roving tension. The following formula is used for the purpose of the investigation of the frictional force:

$$T_1 = T e^{\frac{\pi}{2} \mu} \quad \dots\dots\dots (6)$$

where T : the tension by the total load, the roving and the weight.

μ : the coefficient of the kinetic friction.

T_1 : the roving tension on the rod.

μ is seen to be changed by the temperature, the humidity and the surface condition of the rod.

In our experiment, conducted under the condition 15°C , 65% R. H, the variation of μ caused by velocity could not be observed at all, possibly because of the slowness of unwinding velocity.

However, as Figure 5 shows, the further T increases, the smaller μ becomes, until the value decreases to 0.35. The tension caused by the frictional force has a relationship with γ , the angle between the unwinding direction of the roving and the direction in which the traverse guide enters.

When the driving direction of the roving which passes more than one rod is as in Figure 6a, the tension T is as follows:

Fig. 5 Variation of the coefficient of the friction

Fig. 6 The driving direction of the roving over two rods

$$T_1 = T e^{(\pi - \gamma) \mu} \quad (7a)$$

as Figure 6b $T_1 = T e^{(\pi - \cos^{-1} \frac{R_1 + R_2}{l} - \frac{\gamma}{2}) \mu}$ (7b)

If the traverse guide and the guide rod have exactly the same surface condition, the formula (7) can be arrived at once, assuming that μ is constant.

Draft caused by Tension

Although the draft of the roving caused by the tension is theoretically measured as described in the following paragraphs, in actual practice the increase of the draft due to various kinds of vibration on the machine must be taken into consideration.

The roving is twisted gently by hand in order to change the number of twists. Although there is the mitigation of the stress by time, here we use about 30 seconds for one measurement.

Figure 7 shows the relation between the elongation and the load. The difference in the number of twists, though small, has a big influence upon the load-elongation diagram, and the roving breaks down between 2.3~2.7% in the elongation.

The roving tension varies with the number and the positions of the guide rods which roving passes. For example, Figure 8 shows

Fig. 7 Load-elongation curve of the roving

Fig. 8 The rod passing over rods

the method of withdrawing roving through two rods, as in A; through one rod, as in B; and without a rod, as in C.

Given in Table 1 is the draft when the unwinding velocity in the three cases A, B and C above is 0.9cm/sec.

The coefficient of friction is given the value according to the tension in Figure 5, not according to the formula (7).

Apparently, the value of the draft is about

Table 1. Draft of the Roving (%)

M(g)	r(cm)		ϕ (deg)										
			(+) 54	(+) 47	(+) 39	(+) 28	(+) 15	0	(-) 15	(-) 28	(-) 39	(-) 47	(-) 54
900	6.6	{ A			1.22	1.20	1.20	1.20	1.24	1.45	1.54		
		{ B			0.94	0.90	0.93	0.94	1.00	1.18	1.25		
		{ C			0.89	0.80	0.76	0.70	0.76	0.90	0.96		
790	6.0	{ A		1.38	1.20	1.22	1.20	1.24	1.30	1.38	1.50	1.60	
		{ B		1.02	0.90	0.96	0.94	0.96	1.02	1.06	1.24	1.32	
		{ C		1.00	0.80	0.80	0.76	0.76	0.78	0.81	0.92	1.02	
620	5.0	{ A		1.27	1.21	1.20	1.22	1.24	1.24	1.34	1.42	1.50	
		{ B		1.02	0.92	0.83	0.94	0.97	0.96	1.05	1.12	1.23	
		{ C		0.97	0.86	0.80	0.80	0.75	0.71	0.74	0.83	0.89	
460	4.0	{ A		1.22	1.17	1.17	1.20	1.20	1.25	1.33	1.42	1.50	
		{ B		0.93	0.81	0.83	0.86	0.85	0.96	1.05	1.15	1.22	
		{ C		0.89	0.83	0.80	0.80	0.70	0.70	0.80	0.84	0.89	
270	2.5	{ A	1.21	1.16	1.16	1.10	1.14	1.19	1.23	1.34	1.44	1.50	1.53
		{ B	0.92	0.84	0.84	0.80	0.84	0.88	0.99	1.04	1.16	1.21	1.24
		{ C	0.90	0.83	0.80	0.70	0.70	0.70	0.73	0.77	0.85	0.88	0.89

1.1~1.6% in case A, 0.8~1.3% in case B, and 0.7~1.0% in case C. Each of the these values is sufficiently strong against cutting off.

The Position of the Guide Rod

The draft of the roving is different at each unwinding angle ϕ , as Table 1 shows, and is therefore, larger in the negative direction than in the positive.

If the rod is at the point where both tensions at the positive and negative maximum unwinding angles ϕ_1 , ϕ_2 , are equal, the irregularity of draft in one layer of the package will, at least, be decreased.

Assuming that there is no cohesion between the unwinding roving and the package, the position of the rod can easily be found out by calculation.

Assuming that μ is constant,

$$\frac{\cos \phi_2}{\cos \phi_1} = e^{\mu(\phi_1 + \phi_2)} \dots \dots \dots (8)$$

Assuming that μ is 0.4 and the distance between the bobbin axis and the rod is 10cm, the height of the rod from the bottom of the bobbin is 4/3th~2/7th of the height of the lift, and increases in proportion to the outer side of the packed bobbin, but the average value is 0.25 of the height of the lift.

However, as has been experimentally shown, the larger ϕ is, the larger the tension. Therefore, compared with the calculated value, actual value is 0.3~0.35 of the height of the lift.

The Maximum Limit to Making Larger Package from the Standpoint of the Tension

The maximum limit to the larger package has been surveyed from the standpoint of the unwinding tension. The unwinding tension must be of such a value as does not make the irregularity of draft excessive or cut off roving.

If the limit of the draft is set at 2%, the tension ought to be 36g. The package becomes larger if r and H_0 are enlarged. The calculated tension T_0 is 2.36g, 2.395g and 2.45g when r is 7cm, 7.5cm and 8cm.

However, the maximum value of the unwinding angle decreases in consequence of the increase of r .

After all, judging from Figure 3b, the maximum tension on the maximum radius of the packed bobbin is almost equal to the maximum tension on the minimum radius, and the draft, as shown in Table 1, varies slightly. It may be possible, therefore, to make the package larger only by increasing the radius of the packed bobbin. Conceivably, it is also possible to make the lift large.

If the distance between the bobbin and the guide rod is constant, H is shown by ϕ . Assuming that $V=0.9$ cm/sec, $M=250$ g, the distance between the guide pulley and bobbin=10cm, $\phi=70^\circ$, the tension is 7g.

If the height of the first rod in Figure 8 is increased to the extent where $\phi=-70^\circ$, tension T which passes the second rod is 34.3g, which is a strong enough tension to cut off roving.

If the first rod is set in the center of bobbin's height and the tension from the bobbin to the first rod shows 7g, the bobbin length is about 55cm. This means that the bobbin can be lifted to twice its present height. If this is done, the weight of the packed bobbin will be about 500g, but what the maximum tension will be is uncertain, although there will be no big difference in tension.

In short, it may be said from the standpoint of the unwinding tension that it is not difficult to make the package larger.

Conclusion

The authors investigated the draft after measuring the tension of the roving withdrawn

from the packed bobbin and the load-elongation of the roving. However, the measuring value described in the following paragraphs may not be taken as a general rule, because the measuring value is, after all, the result of a test of only one kind of material.

When the guide rod is placed in the middle of the bobbin's height, and the resolving point is moving upwards or downwards from the center, the tension grows larger than the calculated tension. This tendency becomes noticeable at an unwinding angle above $30\sim 40^\circ$, where the unwinding velocity becomes larger. It is caused mostly by the irregularity of the bobbin's revolution.

The maximum draft in radius of each layer varies hardly at all. When the roving passes two guide rods, the maximum elongation is 1.6%. On the other hand, the broken elongation is 2.1%, which is sufficiently strong against

cutting off by tension. It is, therefore, possible to make the lift longer, the radius of the layer larger, and the package larger.

To reduce the irregularity of draft in the layer, the rod must be placed at a point one-third of the bobbin's length measured from its bottom.

The coefficient of the kinetic friction between the rod and the roving is not changed by the variation of the velocity, if the unwinding velocity is $0.6\sim 1.6$ cm/sec, but it is changed to a value of $0.65\sim 0.35$ by the tension and becomes constant in value at 0.35 under tension above 6g.

We thank Prof. K. Fujino of Kyoto University for his helpful suggestions. We also acknowledge indebtedness to Messrs. S. Tanaka and D. Suhara, of the Toyo Cotton Spinning Co., for the facilities they have given us.