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DYNAMIC FRICTION MEASUREMENTS OF EGYPTIAN COTTON YARNS

Part 2: Study of frictional behaviour of plyed yarns

by

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Abstract:

In this work, the frictional properties of single and plyed yarns were studied. The yarn coefficient of friction was found to be affected by the sliding speed over guides, yarn count and guide diameter. The method of twisting (ring or two-for-one) was also found to have a substantial influence on the friction behaviour of plyed yarns.

1. Intoduction:

Friction is the force opposing the relative motion between two bodies in contact, with direction tangent to the surface of contact. Its effect is extending to any situation involving a contact between two distinct surfaces.

Textiles are no exception to the rule. Friction is one of the most important characteristics determining intermediate and final product quality and processing behaviour. This appl es, in the staple fiber spinning systems, to the strength of the picker lap and card web, the drafting process, the strength of the final yarn and subsequent yarn tension as it is wound in packages suiatable for further processing.

The main characteristics of a modern textile machinary is high speed. This requires a high load capacity of the material being processed. Higher material loading means higher thread speeds, greater thread tensile forces and severer friction stressing. The friction stress acts directly on the yarn surface may cause abrasion and hence dust and possibly serious deterioration of the yarn properties.

As important as frictin is, however, it is very difficult to characterize quantitatively, due primarily to the complex and variable physical behaviour of textile materials, predicated by such properties as viscoelasticity, anisotropy, etc. The most successful theory of friction, is the one developed by Bowden and Tabor, the adhession shearing mechanism. According to the them, two surfaces are in contact only at the tips of

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their asperities. At these contacts strong adhession takes place, somewhat like a cold welding effect. Friction represents the force necessary to shear these junctions. Thus

$$F = S \, . \, A + P$$

where

F = friction force
S = shear strength of junctions
A = true area of contact
P = ploughing force required for the asperities of the harder surface to plough or groove the other surface.

The problem is to determine A. For materials, it is straight forward because A is proportional to the load since the deformation is plastic. For viscoelastic materials (e.g. textile fibers), the problem is more complex and A is given by:

$$A = k \, . \, W^{n}$$

where

W = normal load
K = constant
n = friction index $2/3 < n < 1$

This theory has been successfully applied to the friction of textile fibers and plastics involving both points and line contacts.

For the friction of fibers around cylindrical guides, assuming :

$$F = \mu \, . \, W$$

$$T_2 / T_1 = e^{\mu\theta}$$

since $$F = K \, . \, W$$

Then $$T_2^{1-n} - T_1^{1-n} = K \, (n-1) \, \theta \, R^{1-n}$$

where

T_1 = initial tension
T_2 = final tension
θ = angle of contact
R = cylinderical radius

The effects of lubrication in friction is very important. In fact there are two distinguish types as follows:

i- boundary lubrication in which, only a few molecular layers of lubricant between surfaces. This condition exists at low speeds and high loads.

ii- hydrodynamic lubrication in which, theoretically no contact between the surfaces. This condition exists at high speeds and light loads.

Experiments /2 & 3 / have shown that fibers, running over cylinderical surfaces reflect hydrodynamic conditions at high speeds. This means is single valued function of Z V / N . where

Z = viscosity of lubricant
V = speed of sliding
N = normal load

For lower values of Z V / N , boundary conditions apply, as shown in figure (1).

The objective of this work is to study some factors affecting yarn friction. These factors are :

1- yarn count
2- twist and type of twisting
3- guid diameter , and
4- sliding speed

II. Experimental Work:

Cotton spun yarns, single and plyed, according to table (1) were tested on F-Meter.

Cotton	Single	Plyed Ne	
	Ne	ring	Two for one
Giza 75 carded	20	20/2	20/2
Giza 75 carded	30	30/2	30/2
Giza 75 carded	40	40/2	40/2
Giza 70 combed	50	50/2	---

The pre-tension was fixed at a constant value of 5 and the angle of wrap around to the cylindrical guide was 180 ,during the course of this work. The coefficient of friction and output tension were recorded at different sliding speeds. To overcome the high level of variation in the recorded values of coefficient of friction and output tension, the F-Meter was set on inert during this experiment.
To study effect of guide diameter, it was necessery to make two steel guides of different diameter (8) and (20) mm.

III. Experimental results and discussions:

Figures (2 to 9) show the results obtained for coefficient of friction and output tension at sliding speeds of 20, 50, 100, 200 and 300 m/min. The results show that the friction properties of yarn is highly affected by yarn thickness (diameter), twisting method, sliding speed and guide diameter.

3.1. Effect of yarn diameter on coefficient of friction:

Figure (2) shows the relationship between yarn coefficient of friction and sliding speed for both, single and plyed yarns. The yarn was sliding over a cylinderical guide made of ceramic.
Generally, the coefficient of friction increased as the sliding speed was increased for both , single and plyed yarns. The rate at to which the coefficient of friction increased was high at speeds up 100 m/min. At speeds higher than 100 m/min, the rate of increase in the coefficient of friction was low. This agrees to a large extend with the general frictional behaviour of liquid-lubricanted textile yarns/1/.The yarns sliding over cylinderical surfaces reflect a hydrodynamic conditions at higher speeds.
For viscoelastic materials,the true area of contact with surfaces playes an important role in their frictional behaviour / 1 / . The increase in area of contact causes an increase in friction force and thus, coefficient of friction is increased (for a constnt normal load). The experimental results shown in figure (2) agree with this, yarns with large diameters showed higher coefficient of friction compared to those of small diameters. This also, explaines why the coefficient of friction for plyed yarns is higher than that of single yarns.

3.2. Effect of twisting method on yarn friction:

Figures (2 & 3) show the results obtained for the coefficient of friction between plyed yarns and ceramic guides at different sliding speeds for ring twisting and two-for-one twisting systems, respectively.
The plyed yarns produced on two-for-one twisting machine showed a relatively low coefficient of friction compared to those produced on ring twisting machines. This is attributed to the fact of using lubricant during yarn twisting on two-for-one machine. The lubricant is basically used to reduce friction between yarn and guides, and thus the yarn tension during twisting is reduced. In spite of this, the yarn is still subjected to high abrasion during twisting compared to yarns produced on ring twisting machines. The matter which made the twisted yarns produced on two-for-one twisting machine to have a relatively more hairness than those produced on ring twisting machine. This is attributed to the fact of using lubricant during yarn twisting on two-for-one machine. The lubricant is basically used to reduce friction between yarn and guides, and thus the yarn tension during twisting iS reduced. In spite of this, the yarn still subjected to high abresion during twisting compared to yarns produced on ring twisting machine. The matter which made the twisred yarn produced on two-for-one machine to have a relatively more hairness than those produced on ring twisting machines.

The yarn to yarn friction was measured by twist mehood on F-meter at one , two and three turns of twist. Figures (4 to 7) show the relationship between the output tension and sliding speed for both types of twisted yarns. The twisted yarns produced on two-for-one machines, showed a higher friction than those produced on ring twisting machine. This is because the yarns on two-for-one twisting machine have more hairness, the matter which caused an entalgement between fibers when yarn slides over yarn.

3.3. Effect of guide diameter on coefficient of friction:

Figures (8 &9) show the relationship between yarn coefficient of friction and sliding speed over (8 mm) and (20 mm) steel guides for yarn count Ne 20 and Ne 50, respectively. The coefficient of friction between yarn and guide increased as the guide diameter was increased. This is because the area of contact between the yarn and guide increases when large guide diameter is used. This resulted in an increase in the friction force and concequently, the coefficient of friction was increased. The results agree with the work done by / 2 / agd / 3 /. Figure (9) shows that the effect of guide diameter on coefficient of friction was diminshing at high sliding speeds. This is attributed to the effect of hydrodynamic conditions at high sliding speeds when the area of contact is small i.e. fine yarn.

IV. Conclusions:

From the previous results and discussions, the following conclusions can be drawn:

1- The coefficient offriction between yarn and guide increased when, both the sliding speed and yarn diameter (count) were increased.

2- The plyed yarns produced on two-for-one twisting machine show a low coefficient of friction compared to that produced on ring twisting machine. On the other hand yarn to yarn friction was high for plyed yarn produced on two-for-one twisting machine.

3- Using a large guide diameter caused an increase in yarn coefficient of friction. This effect diminished when fine counts (Ne 50) was sliding at high speeds.

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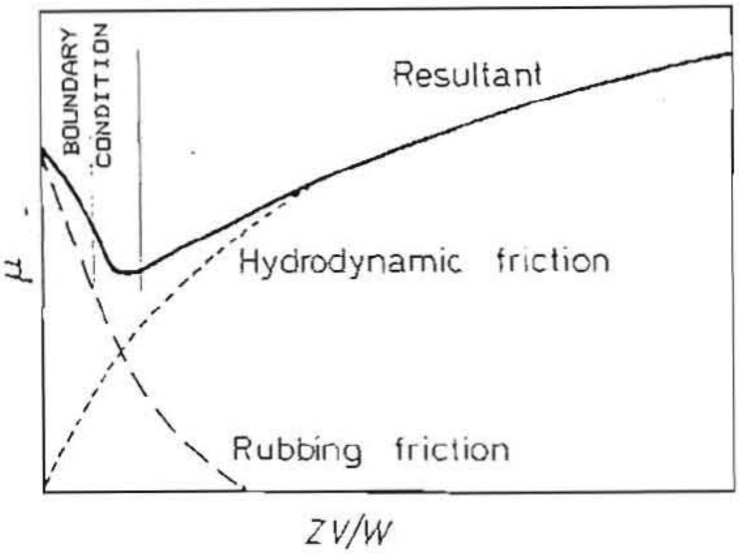

Fig.(1) Frictional behaviour of visco-elastic materials.

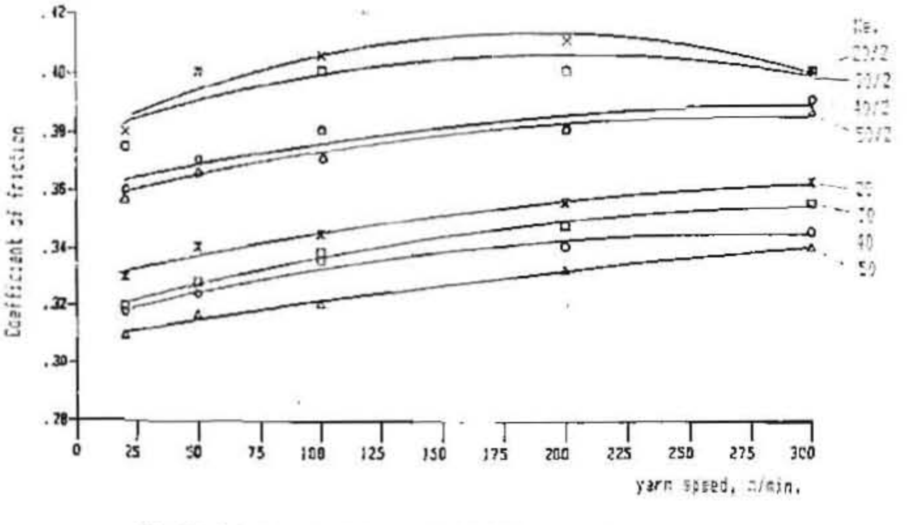

Fig (2) Relationship between coefficient of friction and sliding speed for single and plyed ring twisting yarns

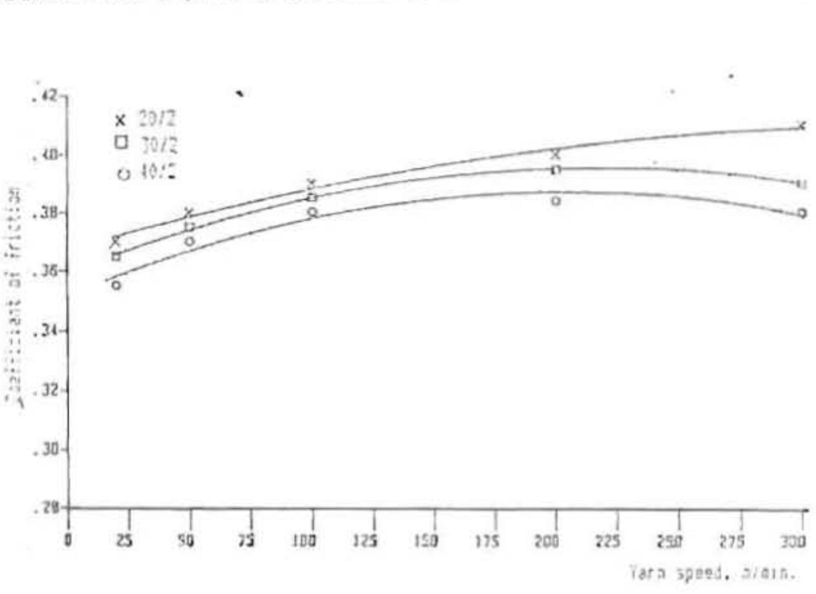

Fig. (3) Relationship between coefficient of friction and sliding speed for plyed yarns "two-for-one"

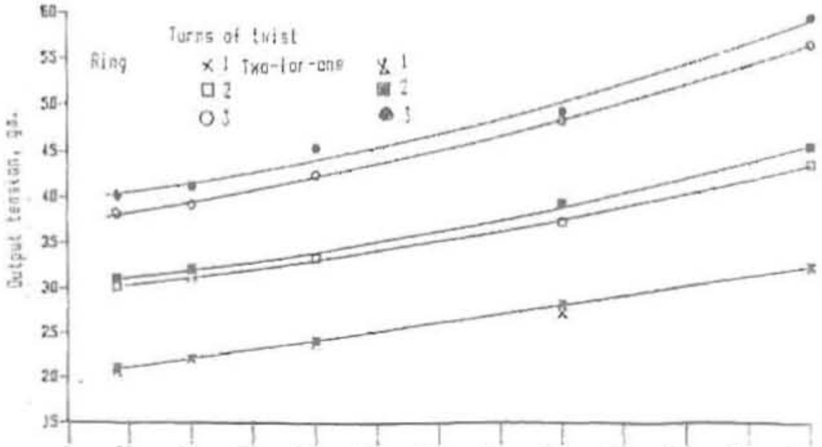

Fig. (4) Effect of sliding speed on yarn to yarn friction, Ne. 20/2

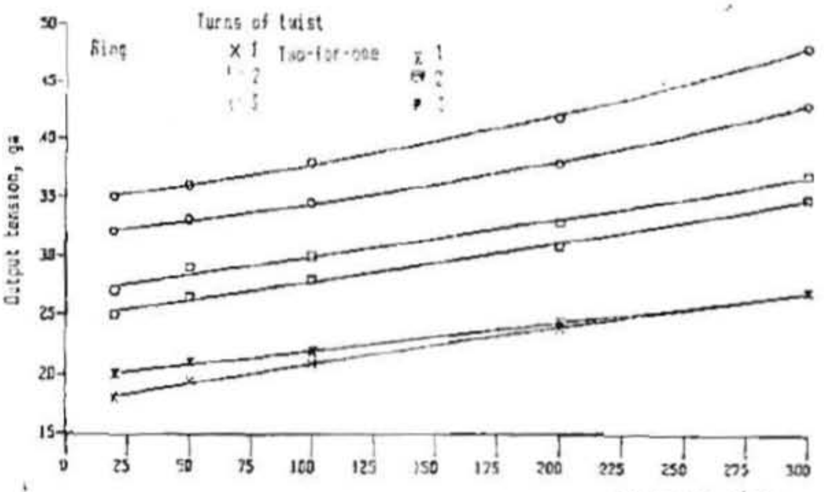

Fig.(5) Effect of sliding speed on yarn to yarn friction, Ne. 30/2

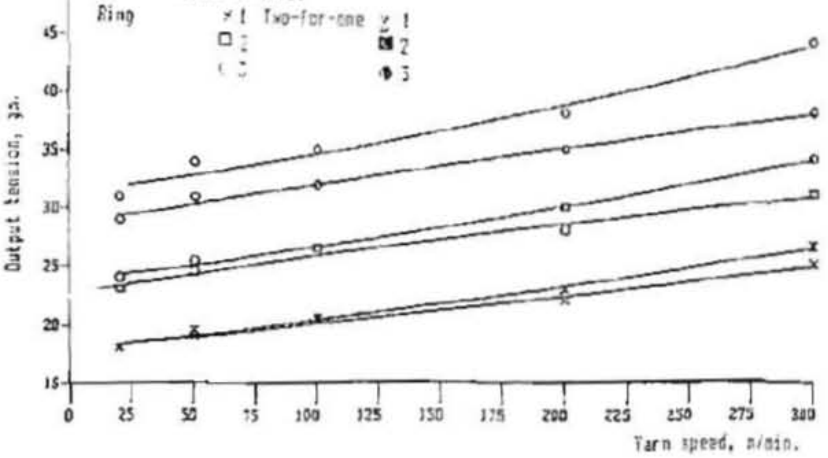

Fig.(6) Effect of sliding speed on yarn to yarn friction, Ne. 40/2

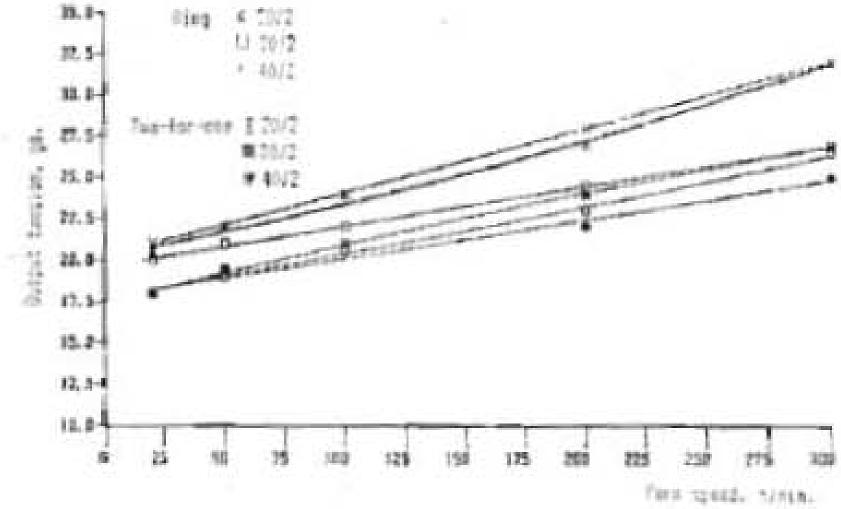

Fig.(7) Effect of sliding speed on yarn to yarn friction, one turn of twist.

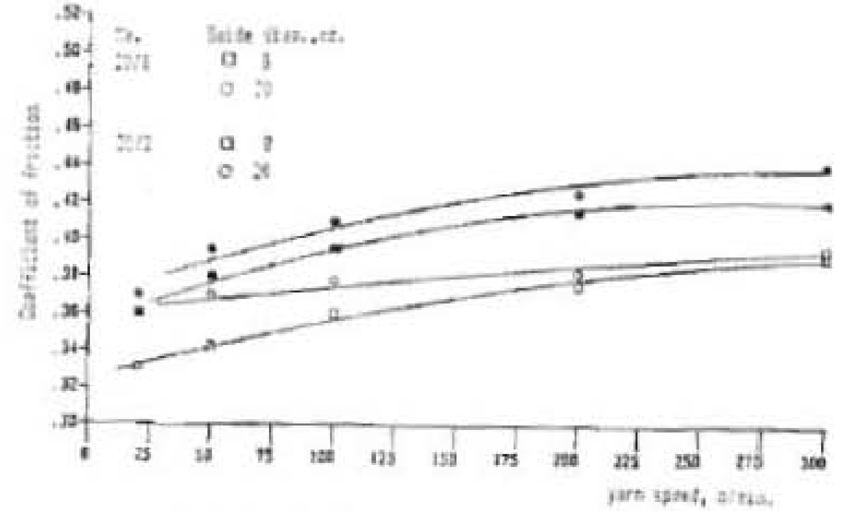

Fig.(8) Effect of guide diameter on yarn coefficient of friction, Tex. 20/1, 20/2

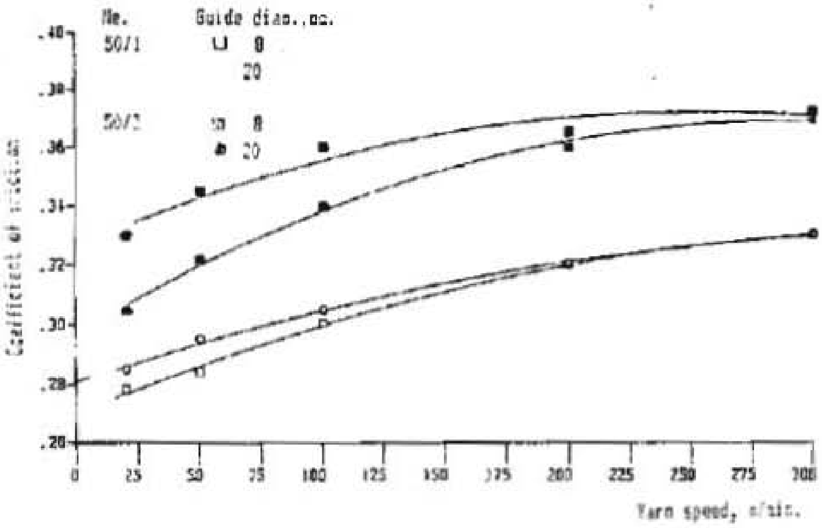

Fig.(7) Effect of guide diameter on yarn coefficient of friction, Ne. 50/1, 50/2