COTTON INTER-FIBER FRICTION

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Abstract

The friction and cohesion forces are some of the most important parameters that affect the yarn spinnability and tenacity. A new and simple device has been developed in order to quantify the friction forces during a quasi-static fiber slippage in a sliver under controlled normal pressure. The force-displacement curves are analyzed in order to check out the parameters which characterize the friction force during inter-fiber slippage. If the force and the load are normalized with respect to the sliver count, the frictional behavior of the fibers can be described by only two coefficients which can be used to distinguish different cottons.

This approach has been applied to a group of different cottons. The results show that the friction coefficients are different for different type of cottons. These coefficients, which are related particularly to the fiber modulus, permit to explain the yarn tenacity as depended either on the fiber tenacity, the fiber length and yarn irregularity.

Introduction

The friction and cohesion forces take an important place in fiber processing. The friction force defines the sliver and rover strength and, up to a certain level, the yarn strength also. Many works deal with the measuring of the inter-fiber friction force using different methods. Some of these studies concern the measure of the frictional force on one single fiber. Postel measured the frictional force during the withdrawing of a wool fiber from a compressed pad. Lindberg measured the frictional force between two fibers twisted together. Lord studied the frictional force developed during the relative motion of two identical fiber fringes. The El Mogahzy's method is very similar to the Lord's but his apparatus is more precise. He studied theoretically the friction phenomena and tried to explain the Howell equation.

As shown in the scientific bibliography, in order to measure the inter-fiber friction force, it is necessary to prepare carefully even single fiber and compressing pads, or identical fiber fringes. These conditions require time and may generate errors and a high variance of the measured parameter. For this reason, the present authors have tried to use an ordinary sliver in order to evaluate the inter-friction forces developed in this sliver under controlled normal load and relative fiber slippage.

Methods and material

The device used in the present work has been presented in the Cotton Beltwide Conference in January 2006 and is of two identical little carriages (see Figure 1). One of them (A) is fixed, whereas the second (B) is moving throw a linear guide (C). A piece of sliver is put down in the channel (D) of the two carriages which are initially in zero displacement position, i.e. the two carriages are in contact. The sliver is compressed with the upper carriage sides (E) where two identical weights are loaded (W). The moving one is tracked with a constant speed, whereas the fixed one is attached, by the intermediate of a force sensor, to the frame. The distance between the two carriages is measured by displacement sensor. A digital video camera records what is happening between the two clamps.

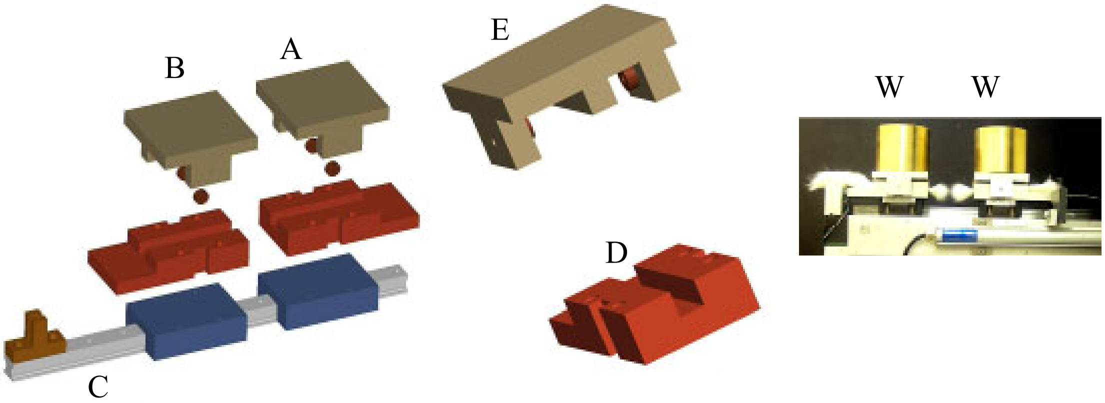


Figure 1. Static Friction Tester

Eleven different cottons have been used in the present study. They have been tested by AFIS, Spectrum, FMT3, Almeter, etc. Some of their AFIS characteristics are summarized in Table 1. These cottons have been spun in a micro-spinning line in 20, 25 and 33 tex yarns.

Table 1. Afis Characteristics for the 11 cottons used.

Cotton	Neps	L(w) mm	CVL(w) %	SFC(w) mm	UQL(w) mm	L(n) mm	CVL(n) %	SFC(n) %	Fineness mtex	Maturity
1	103,3	26,0	33,1	6,2	31,4	21,5	46,1	19,5	178,5	0,9
7	136,0	28,9	32,0	4,4	34,5	24,0	45,2	16,2	161,3	0,9
11	36,5	24,7	32,1	6,0	29,3	20,7	44,0	18,6	178,3	0,9
15	95,3	26,7	33,6	5,6	32,1	21,9	46,8	18,9	163,5	0,9
17	77,5	26,6	31,8	4,9	31,7	22,4	43,5	16,4	185,0	1,0
21	68,0	27,2	30,9	4,3	32,4	23,1	41,9	14,4	186,3	1,0
26	92,5	26,2	32,2	5,7	31,5	21,8	45,1	18,5	174,8	0,9
30	60,8	25,5	32,5	5,4	30,3	21,6	43,0	16,7	181,8	0,9
50	39,5	26,0	30,4	4,5	30,8	22,0	42,4	15,8	185,5	0,9
51	106,3	25,7	33,0	5,4	30,6	21,1	46,8	19,2	170,3	0,9
52	32,3	28,3	28,2	2,7	32,6	24,9	37,4	10,3	188,5	1,0

The yarns have been tested by UT3, 4 cops with 5 repetitions of 50m for each cops, and by Tensorapid, 60 tests per cops. One part of the results is summarized in Table 2.

Tableau 2. Some results of yarn testing.

Cotton	Tenacity 20tex (cN/tex)	Tenacity 25tex (cN/tex)	Tenacity 30tex (cN/tex)	CVm, 33tex (%)	Thin-40% 33tex	Hairiness, 33tex
1	10,44	11,95	12,40	19,40	56,2	6,11
7	15,69	16,00	16,19	16,77	14,9	5,69
11	12,88	13,71	13,51	17,81	38,3	6,43
15	15,82	16,60	16,20	17,09	23,1	6,25
17	13,35	13,92	14,22	18,10	32,5	6,35
21	12,77	13,36	13,60	18,81	39,7	6,26
26	13,25	13,57	13,70	18,18	41,45	6,21
30	12,24	13,17	13,44	18,32	40,95	6,09
50	13,06	13,52	14,52	17,07	30,15	6,04
51	14,32	14,29	15,34	17,83	28,3	5,78
52	16,10	17,33	16,73	15,50	12,55	5,61

As shown by the authors in a previous study, the speed effect seems to be not significant in the experimental domain we use i.e. that this test characterize what is happening during a quasi-static test. The force-displacement curves are similar, as shown in Figure 2. In order to characterize the frictional force, we have chosen the force at point B, where all the fibers participate to the friction force.

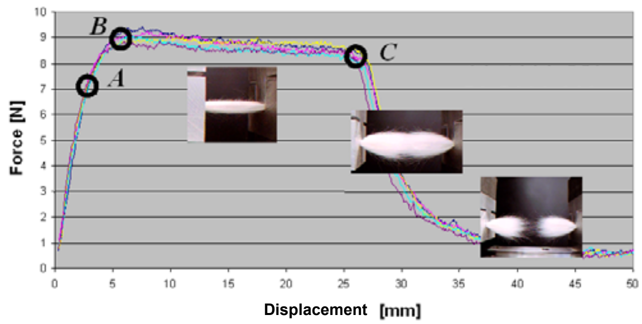


Figure 2. Typical force-displacement curves

Results and discussion

As shown by the authors in a previous study, the frictional force can be described by the following equation:

$$\frac{F}{T} = K\left(\frac{W}{T}\right)^n$$

where F is the friction force at point B, W is the normal load, T is either the sliver count or the number of the fibers in the sliver cross-section. The coefficients K and n can be used to characterize the inter-fiber frictional behavior. Table 3 gives the values of these coefficients for the 11 cottons used.

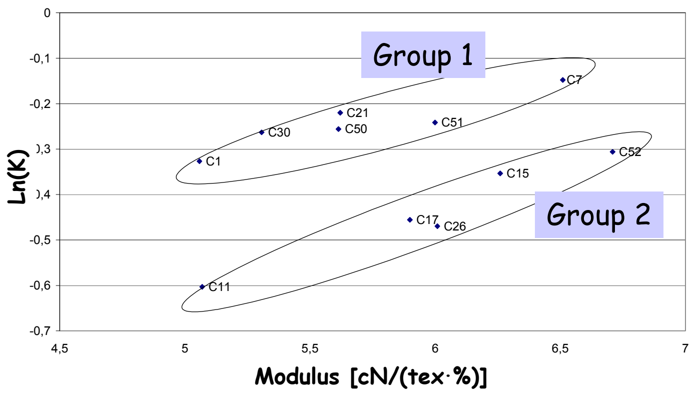
Table 3. Values of *ln(K)* et de *n* calculated by normalizing the load and the force by the number of the fibers in the sliver cross-section.

Cotton	*Ln(K)*	*n*
1	-0,326	1,004
7	-0,148	1,020
11	-0,603	0,958
15	-0,354	1,008
17	-0,455	0,984
21	-0,220	1,016
26	-0,470	0,984
30	-0,263	1,011
50	-0,256	1,005
51	-0,242	1,015
52	-0,306	1,012

4 charge levels, 6 repetitions = 24 measures by cotton

The correlation between all the fiber and yarn parameters does not give clear and significant tendencies concerning the effect of the friction on the yarn characteristics. Nevertheless, if we plot the Ln(K) versus the fiber modulus, we observe that the 11 cottons seem to be separated in two groups (see Figure 3). Even if the number of the cottons in each group (6 and 5 respectively) is not sufficient to carry out highly significant correlation coefficients within the first or the second group separately, same very interesting, tendencies become evident, as show in Tables 4 and 5.

Figure 3. Ln(K) VS. The fiber modulus cN×tex^{-1}/%.



Concerning the effect of the inter fiber friction on the yarn quality, it can be observed that the cottons which present a higher friction coefficient K give more regular yarns with less thin and thick places. In Tables 4 and 5, the correlation coefficients between the thin places (thin-40%) and the yarn tenacity are of –0.979 and –0.959 for the group 1 and 2 respectively, whereas this correlation coefficients between the fiber and yarn tenacity are 0.959 and 0.702. The yarn tenacity seems to be more affected by the thin places than by the fiber tenacity in the case of cottons with higher friction coefficient. On the other hand, we can observe the same influence of the friction on the thin places. These observations seem to confirm the fact that the friction does not affect the yarn tenacity directly, it affects the yarn irregularity and imperfections directly and there are these parameters, particularly the thin places, which affect the yarn tenacity.

For higher frictional cottons (group 1), where the fiber tenacity affect the yarn tenacity more, the fiber length (Lw) seems to be less important vis-à-vis to the yarn tenacity with a correlation of 0.724, whereas for the 2nd group –lower levels of K and lower correlation between fiber and yarn tenacity- the effect of the length seems to be more important with a correlation coefficient of 0.783 between the yarn tenacity and the fiber length Lw.

Table 4. Some correlation within the group 1 vis-à-vis to the yarn tenacity

	Ln(K)	n	Fiber tenacity	Yarn tenacity,20tex
Fiber tenacity	0,8052	0,6186	1	0,9590
Yarn tenacity,20tex	0,9145	0,8070	0,9590	1
CVm%, 20tex	-0,8559	-0,5827	-0,9536	-0,9228
Thin-40%, 20tex	-0,9024	-0,7098	-0,9766	-0,9791

Table 5. Some correlation within the group 2 vis-à-vis to the yarn tenacity

	Ln(K)	n	Fiber tenacity	Yarn tenacity,20tex
Fiber tenacity	0,8734	0,8496	1	0,7016
Yarn tenacity,20tex	0,9118	0,9192	0,7016	1
CVm%, 20tex	-0,7999	-0,7724	-0,7842	-0,8775
Thin-40%, 20tex	-0,9008	-0,8846	-0,7902	-0,9591

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