FRICTORQ, FABRIC FRICTION TESTER: A COMPARATIVE STUDY WITH KES

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Abstract

Coefficient of Friction is one of the factors involved in the so-called parameter fabric hand and its importance justifies the number of contributions given in the past to this problem. More recently, a new laboratory instrument was proposed by the authors for the assessment of this property. A comparative study with another widely respected instrument, the KES-friction, is the main purpose of this research.

Key Words, FRICTORQ, Friction Coefficient, Torque, Fabric Hand, KES

1. INTRODUCTION

Most textile materials are used near humans and frequently touched by the human skin and by the human hand in particular, namely clothing, home furnishings and automotive fabrics. Interaction with the human senses is therefore an essential performance property (Kawabata et al., 1994) and (Gupta, Mogahazy, 1991). Friction coefficient is one of the factors contributing for the so-called parameter *fabric hand* and its importance justifies the number of contributions given in the past to this problem (Kawabata, 1980) and (Bueno et al., 1998). More recently, a novel laboratory equipment was proposed for a new method of accessing the friction coefficient of fabrics. The development and validation of FRICTORQ justifies a comparative study with another widely respected instrument, the KES-friction, which was the main purpose of this research.

2. THE CONCEPT

Friction Coefficient is not an inherent characteristic of a material or surface, but results from the contact between two surfaces (Nosek, 1993). Unlikely other methods, FRICTORQ is based on a rotary movement and therefore on the measurement of a friction reaction torque. In the original model, the principle is based on an annular shaped upper body rubbing against a flat lower fabric. The fabric sample is forced to rotate around a vertical axis at a constant angular velocity. Friction coefficient is then proportional to the torque measured by means of a high precision torque sensor. A general view of the FRICTORQ I instrument on a fabric-to-fabric situation is represented in figure 1 (Lima et al., 2003). This model went through various development stages, and some of the detected weaknesses suggested that a different approach should be explored (Lima et al., 2004-a) and (Lima et al., 2004-b). Figure 2 is a schematic representation of the new model. The rotary action remains, but the contact is now restricted to 3 small special sensors at 120°. Providing a relative displacement of approximately 90°, it is assured that a new portion of fabric is always moved under the sensors. For this model, Torque is given by

$$T = 3\,F_a\,r \qquad (1)$$

Being, by definition, $F_a = \mu N$ and from Fig.2, $N = P/3$, where P is the vertical load, the coefficient of friction is expressed by,

$$\mu = \frac{T}{P \times r} \qquad (2)$$

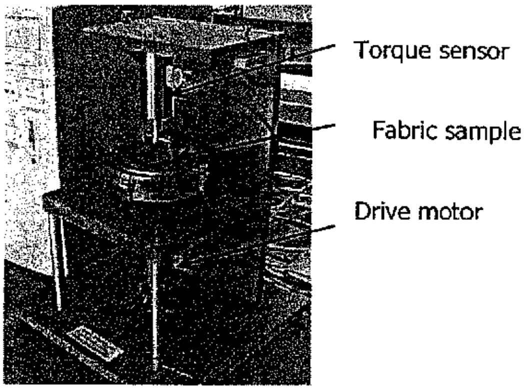

Figure 1 FRICTORQ I prototype

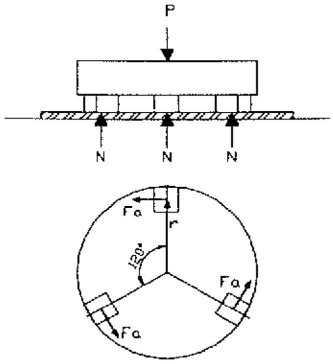

Figure 2 FRICTORQ II model

Previous exploratory work led to the establishment of some design parameters, namely contact pressure and linear velocity in the geometric centre of each contact foot, the latter set to approximately 1,57 mm/s.

3. EXPERIMENTAL

In this study, a comparison between FRICTORQ II and KES-FB4 friction has been carried out: A set of experiments was designed using cotton woven fabrics where parameters such as Yarn Count, Structure and Finishing could be differentiated. For this comparative analysis, friction tests were made in samples of the same fabric using KES (ref. KES) (Cunha, 2003), FRICTORQ at 3,5 kPa, (ref. NAB) and FRICTORQ at 10 kPa, (ref. NSB). All tests were carried out under controlled atmosphere.

Yarn count: In order to test the capability of assessing the influence of yarn type in the friction properties, tests were carried out, using three different yarns. A description of the tested materials is given in table 1.

Table 1 Identification of tested fabrics for yarn count

	J	Q	R
Yarn count (Ne)	100/2	36	50
Fabric structure	Plain	Plain	Plain
Weight (g/m^2)	106,6	127,0	114,1
Processing stage	No iron	No iron	No iron
Warp density (ends/cm)	53.0	40,5	53.1
Weft density (picks/cm)	29.9	29.0	29.7
Thickness (mm)	0,387	0,500	0,434

Structure: To test the capability of assessing the influence of weave structure in the friction properties, tests were carried out using three different weaves. Table 2 presents a summary description of the tested materials.

Table 2 Identification of tested fabrics for structure

	J	M	N
Yarn count (Ne)	100/2	100/2	100/2
Fabric structure	Plain	Twill 2x2	Basket weave
Weight (g/m^2)	106,6	123,86	134,50
Processing stage	No iron	No iron	No iron
Warp density (ends/cm)	53.0	53.9	54.4
Weft density (picks/cm)	29.9	41.7	50.0
Thickness (mm)	0,387	0,431	0,447

Finishing: To assess the influence of finishing treatments in the friction properties, tests were made using three different processing stages, using only FRICTORQ (NAB) and KES. A description of the tested materials is given in table 3.

Table 3 Identification of tested fabrics for finishing

	C	J	U
Yarn count (Ne)	100/2	100/2	100/2
Fabric structure	Plain	Plain	Plain
Weight (g/m^2)	109,4	106,6	113,0
Processing stage	Wash	No iron	No iron++
Warp density (ends/cm)	52.8	53.0	53.5
Weft density (picks/cm)	30.3	29.9	29.9
Thickness (mm)	0,529	0,387	0,391

4. RESULTS AND DISCUSSION

The results of all the tests were analysed using various tools, including SPSS12.0® statistical package.

Yarn Count: A comparison between the values obtained with NAB (FRICTORQ at 3.5 kPa), with NSB (FRICTORQ at 10 kPa) and with KES, for samples J, Q and R, is done in order to establish the differences or similarities between the three different tests.

Figure 3 is the graphical representation of the box-plots obtained for the analysed samples. In this figure it can be seen that the dispersion of the box-plot for the sample NAB-Q is bigger than for samples NAB-R and NAB-J, being the dispersion of NAB-R bigger than that of NAB-J. For the KES samples the dispersion obtained for KES-Q is bigger than for KES-R and KES-J, while for NSB there is nearly no difference in the dispersion for the three samples being the variation on samples NSB-J, Q and R very similar.

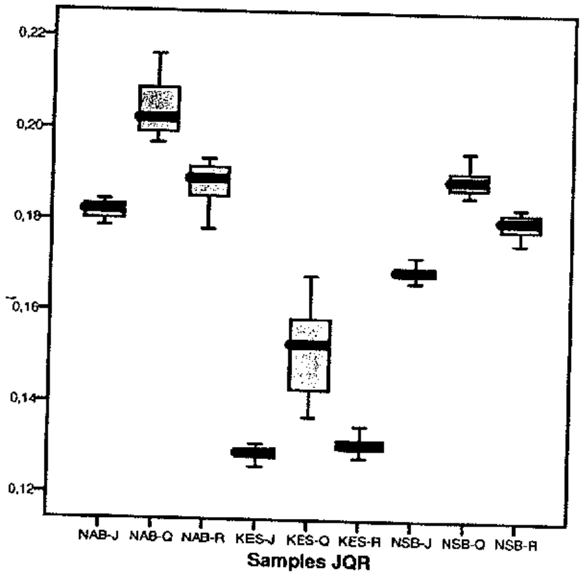

Figure 3 Box-plot for samples J, Q &R

Table 4 Means for yarn count in homogeneous subsets

Samples J, R, Q	N	Subset for alpha = .05					
		1	2	3	4	5	6
KES-J	20	,1296					
KES-R	20	,1311					
KES-Q	20		,1512				
NSB-J	12			,1695			
NSB-R	12				,1799		
NAB-J	12				,1828	,1828	
NAB-R	12				,1877	,1877	
NSB-Q	12					,1893	
NAB-Q	12						,2040
Sig.		1,000	1,000	1,000	,053	,203	1,000

Table 5(a) represents the statistical differences (X) found between the different measurements. It is clear a significant difference between sample Q and the other two, but not between samples J and R. The exact same results are obtained for KES, as shown in table 5(b). However, for NSB, table 5(c), there is a statistical difference between the values obtained for all the tree cases. Therefore, NSB appears to be more sensitive to changes in yarn configuration.

Table 5 Statistical difference for yarn count between friction values obtained by different methods

NAB (Frictorq 3.5 kPa)

	NAB-J	NAB-Q	NAB-R
NAB-J			
NAB-Q	X		
NAB-R	–	X	

(a)

KES

	KES-J	KES-Q	KES-R
KES-J			
KES-Q	X		
KES-R	–	X	

(b)

NSB (Frictorq 10 kPa)

	NSB-J	NSB-Q	NSB-R
NSB-J			
NSB-Q	X		
NSB-R	X	X	

(c)

(X) – statistically significant (--) – non statistically significant

Structure: A comparison between the values obtained for coefficient of friction for samples J, M and N, which differ in terms of their structure, measured with NAB (FRICTORQ at 3.5 kPa), NSB (FRICTORQ at 10 kPa) and KES, is done in order to establish the differences or similarities between them.

Figure 4 is a graphical representation of the box-plots obtained for the analysed samples. In this figure it can be seen that the dispersion of the box-plot for sample NAB-J is slightly smaller than for samples NAB-M and NAB-N. For KES values, the dispersion obtained for sample KES-N (basket weave) is bigger than the other two.

As for the graphical representation of the NSB measurements, the bigger dispersion is for the twill sample (NSB-M) while the lower dispersion value is for the plain weave (NSB-J).

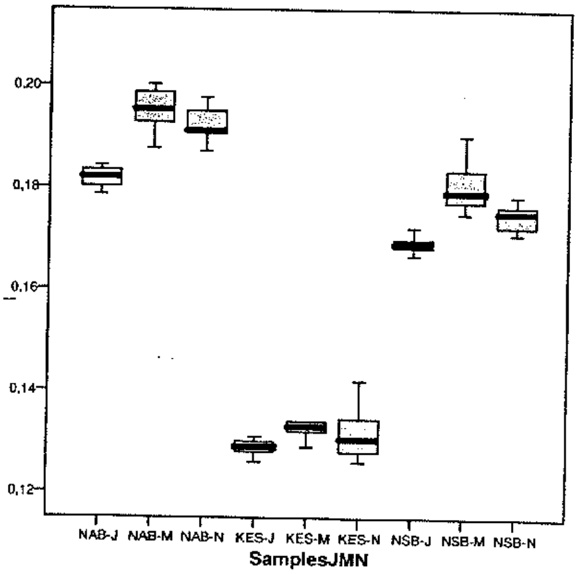

Figure 4 Box-plot for samples J, M &N

The smaller dispersion in all J samples is probably due to the structure being plain weave, which is the most simple and regular one, thus conferring less irregularities to the fabric surface.

Table 6 Means for structure in homogeneous subsets

Samples JMN	N	Subset for alpha = .05				
		1	2	3	4	5
KES-J	20	,1296				
KES-N	20	,1315				
KES-M	20	,1348				
NSB-J	12		,1695			
NSB-N	12		,1748	,1748		
NSB-M	12			,1805	,1805	
NAB-J	12				,1828	
NAB-N	12					,1923
NAB-M	12					,1955
Sig.		,216	,195	,114	,977	,850

When values of table 7 are analyzed for the statistical difference between samples with different structures we can see that for NAB the obtained values are only statistically different for the plain weave (sample J) when compared with the other two structures. For KES, there is no significant difference in the obtained values for the different samples. Regarding NSB, table 7(c), there is a statistical difference only between values obtained for the plain and twill weave. Therefore NAB appears to be more sensitive to changes in weave structure.

Table 7 Statistical difference for structure between friction values obtained by different methods

NAB (Frictorq 3.5 kPa)

	NAB-J	NAB-M	NAB-N
NAB-J			
NAB-M	X		
NAB-N	X	--	

(a)

KES

	KES-J	KES-M	KES-N
KES-J			
KES-M	--		
KES-N	--	--	

(b)

NSB (Frictorq 10 kPa)

	NSB-J	NSB-M	NSB-N
NSB-J			
NSB-M	X		
NSB-N	--	--	

(c)

(X) – statistically significant (--) – non statistically significant

Finishing: To assess the influence of the finishing process in the friction properties measured by KES and NAB, a comparison between samples C, J and U was carried out.

A graphical representation of the box-plots obtained for the analysed samples is presented in figure 5. It can be seen that the dispersion of values obtained for sample NAB-U (no iron + resin) is bigger than that for the other two. As for the graphical representation of KES values, the dispersion of the box-plots shows small differences between the three KES samples.

From the analysis of tables 8 and 9 we can see that for NAB the obtained values are statistically different for all three cases. As to the KES there is only a significant difference between the values obtained for the finishing type washed, therefore the KES is not sensitive to the difference between the "no iron" and the "no iron + resins". Changes in finishing type seem to be more effectively detected using NAB (FRICTORQ at 3.5 kPa).

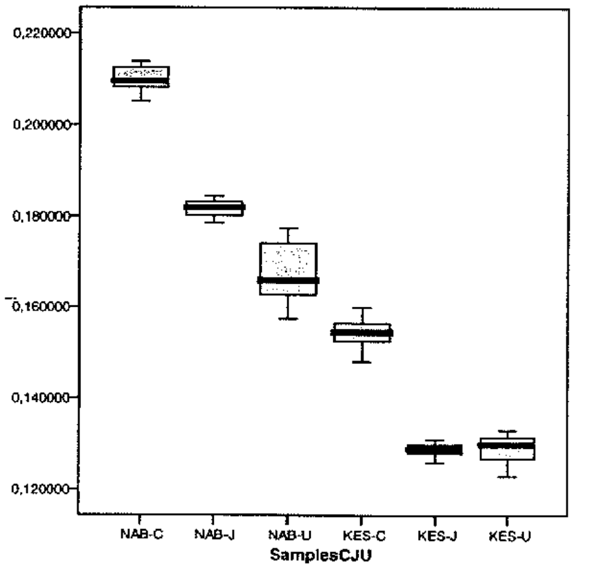

Figure 5 Box-plot for samples C, J &U

Table 8 Means for finishing in homogeneous subsets

Samples UJC	N	Subset for alpha = .05				
		1	2	3	4	5
KES-U	20	,128950				
KES-J	20	,129600				
KES-C	20		,154550			
NAB-U	12			,167083		
NAB-J	12				,182758	
NAB-C	12					,210133
Sig.		,999	1,000	1,000	1,000	1,000

Table 9 Statistical differences for finishing between friction values obtained by different methods

NAB (Frictorq 3.5 kPa)

	NAB-C	NAB-J	NAB-U
NAB-C			
NAB-J	X		
NAB-U	X	X	

(a)

KES

	KES-C	KES-J	KES-U
KES-C			
KES-J	X		
KES-U	X	--	

(b)

(X) – statistically significant (--) – non statistically significant

5. CONCLUSIONS

The main conclusions of this research work are as follows:
Regarding the comparison between FRICTORQ and KES, they both show a similar behaviour in all the used 9 samples.
KES values are always smaller than those obtained with FRICTORQ in both configurations NAB or NSB.
For FRICTORQ, values with NAB (3,5 kPa) are always higher than with NSB (10 kPa). This takes us to the conclusion that contact pressure influences friction in FRICTORQ, as it was expected.
Results with FRICTORQ NAB (3,5 kPa) could statistically differentiate almost all the parameters used in the experiments. However, in the study of the influence of yarn count, FRICTORQ NSB (10 kPa) could distinguish not only the yarn count as well as the yarn type (spun yarn-sample R versus plied yarn, sample J).
Based on these results, it is clear that FRICTORQ shows good capabilities of accessing friction in fabrics.
Future work will focus on the study of the influence of contact pressure and relative velocity of contact sensor.
This work is already a new contribution to the objective characterization of fabric surface properties. Patent protection of this new measuring method is now granted (Lima et al., 2002).

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