FRICTION EVALUATION OF SOFT PAPERS FOR HUMAN SKIN INTERACTION

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Abstract: Most soft paper materials are used in the everyday life of humans in various applications, some of them in direct contact with the human skin. Therefore, the assessment of handle properties is of utmost importance as these materials contact the human skin causing several skin reactions. The objective of the work was the study of the friction behaviour of different cellulosic soft materials used for human interaction, such as toilet paper, paper towels, handkerchiefs and napkins, all black coloured, on the coefficient of friction. For all materials except paper towels a subjective evaluation was also performed which was used for a comparative study with the objective values.

Keywords - FRICTORQ, Friction coefficient, Soft papers

1. Introduction

Human senses allow the interaction with the surrounding environment. They are five, namely sight, hearing, smell, taste and touch. Several studies have been carried out in order to understand how they work and which are the variables responsible to activate them [1, 2, 3, 4]. For this reason, the touch, analysed in the handle perspective, has a huge interest due to the interacting sensation with the respective surrounding environment. This importance has already captured the interest of industrial companies in knowing more deeply the correlation of the touch sense as it is associated with the human well being. Pursuing this aim, the design and evolution of products which interact with humans can result either in the improvement of the existing products or in the design of new ones. Most soft paper materials are used in the everyday life of humans in various applications, some of them in direct contact with the human skin. Therefore, the assessment of handle properties is of utmost importance as these materials contact the human skin causing several skin reactions.

2. Objectives

The objective of the work was the study of the friction behaviour of different cellulosic soft materials used for human interaction, such as toilet paper, paper towels, handkerchiefs and napkins, all black coloured, on the coefficient of friction. For all materials except paper towels a subjective evaluation was also performed which was used for a comparative study with the objective values.

3. Methodology

An experimental procedure was designed using FRICTORQ instrument for obtaining the friction coefficient. FRICTORQ® is a laboratory equipment studied, designed and manufactured at the University of Minho based on a new method of accessing friction coefficient of 2D non-rigid surfaces [5, 6]. Regarding the subjective analysis, an inquiry was carried out that used the semantic differential [7]. This methodological tool intended to assess the perception of individuals with objects by touch feeling.

3.1 Theoretical

Friction coefficient is not an inherent characteristic of a material or surface but results from the contact between two surfaces. Unlike other methods, FRICTORQ is based on a rotary movement and therefore on the measurement of a friction reaction torque. The contact between the sample and the instrument reference surface is restricted to 3 small elements disposed in a circle at 120°. With a relative displacement of approximately 90°, it is assured that a fresh portion of the sample is always moved under these elements. Friction coefficient is computed from the friction reaction torque measured by a high sensitivity torque sensor. Figure 1 is a schematic representation of the model named FRICTORQ II.

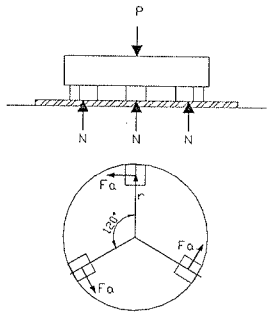


Figure 1: Model of FRICTORQ II

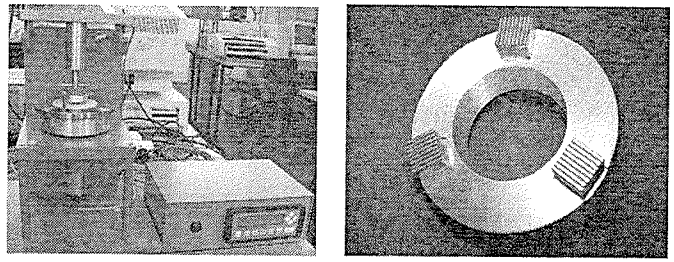
For this model, torque is given by:

$$T = 3 F_a r \quad (1)$$

where F_a is the friction force on the contact and r is the distance to the centre. Being, by definition, $F_a = \mu N$ and $N = P/3$, where P is the vertical load, the coefficient of friction is then expressed by:

$$\mu = \frac{T}{P \cdot r} \quad (2)$$

Being P and r constants, coefficient of friction is worked out as a function of friction torque T, measured by a stationary reaction torque sensor. Figure 2 shows the latest set-up, as well as a detail of the reference surface identified as NB 3.5 (for a contact pressure of 3,5 kPa) that includes 3 small pads with an approximately square shape, covered by a number of calibrated steel needles of 1 mm diameter.



(a) (b)

Figure 2: (a) FRICTORQ II; (b) Reference surface

3.2 Experimental

Friction tests were carried out using instrument FRICTORQ II with reference surface NB 3.5 in a set of 4 paper samples produced by the Portuguese company RENOVA, namely, toilet paper (TP), paper towels (PT), handkerchiefs (H) and napkins (N), all black coloured. Table 1 summarises the company references of the tested materials. For each of the materials, samples with 11,3 cm diameter were cut. All tests were carried out under a standard atmosphere (20° C and 65% RH), and all the materials were conditioned for a time period over 24 hours. For each material 13 samples were tested. The obtained results were analysed using SPSS16® statistical package.

An experimental inquiry was carried out in order to determine the correlation between friction coefficient and subjective response of human subjects as they touch using parameters such as rough/smooth and hard/soft.

Table 1 Identification of materials and samples

Sample	Material	Sheets
TP_3F_black_OF	Toilet Paper	3
TP_3F_black_IF		
PT_2F_black_OF	Paper Towels	2
PT_2F_black_IF		
N_2F_black_OF	Napkins	2
N_2F_black_IF		
H_3F_black_OF	Handkerchiefs	3
H_3F_black_IF		

4. Results

For an easy visualization, the results for the analyzed groups are presented in a graphical form using the

box-plot representation in figure 3. In the identification of the samples, **OF** means outer-face while **IF** means inner-face.

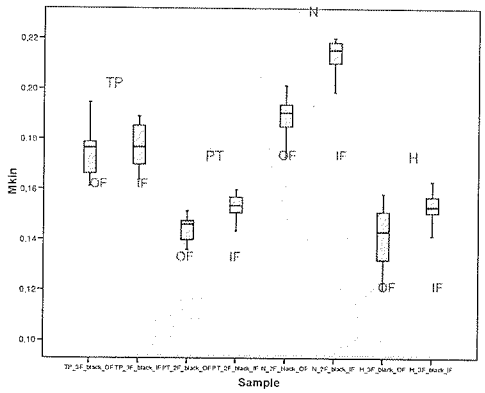


Figure 3: Box-plot representation of the results

As can be seen in figure 3 the values obtained in the inner faces are higher than those obtained in the outer faces in all the types of samples. A Scheffe analysis was done in order to compare the results obtained from the four tested materials. The results are shown in table 2.

Table 2 Homogeneous subsets for black cellulosic papers

Sample	Subset for alpha = 0,05					
	N°.	1	2	3	4	5
H_3F_black_OF	13	0,141				
PT_2F_black_OF	13	0,144	0,144			
PT_2F_black_IF	13		0,154			
H_3F_black_IF	13		0,154			
TP_3F_black_OF	13			0,174		
TP_3F_black_IF	13			0,177		
N_2F_black_OF	13				0,190	
N_2F_black_IF	13					0,214
Sig.		0,995	0,259	0,999	1,000	1,000

The correlations obtained between the friction coefficient and the subjective parameters were -0,195 for Rough-Smooth and 0,212 for Soft-Hard, for a 0,05 significant level.

5. Conclusions

The results obtained show that FRICTORQ is technically simple and a reliable instrument to access surface frictional properties of soft papers.
From the analysis of the obtained results it is possible to draw the following main conclusions:
Napkins and toilet paper have different friction behaviour when comparing with handkerchiefs and paper towels despite friction coefficient for the outer and inner faces are different for napkins.

Paper towels and handkerchiefs show similar statistical friction behaviour in both faces.
As to the preliminary subjective evaluation, high values of friction coefficient produce a *rough* and *hard* sensation in the individual meaning that Napkins are the roughest and handkerchiefs the smoothest papers.

6. References

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