Handle Assessment of Tissue Paper

Rosa M. Vasconcelos[1], António Carneiro[2], Mário Lima[3], Luís F. Silva[3], Eurico Seabra[3]
1 University of Minho, Department of Textile Engineering, Guimarães, Portugal
2 University of Minho, MSc in Materials Engineering, Guimarães, Portugal
3University of Minho, Centre for Mechanical and Materials Technologies, Guimarães, Portugal
antoniocarneiro@portugalmail.pt, rosa@det.uminho.pt, mlima@dem.uminho.pt

Abstract: Handle has a primary influence with nearly everything surrounding us as it gives the essential information to interact with our neighbourhood. The need to know how this affects our decisions is fundamental and leads to the study and understanding of this human sense. Tissues paper is one of the most common elements of interaction in the day-to-day human life; it can be produced in various ways leading to different textures which can transmit various sensations. The FRICTORQ® is a laboratory equipment developed by the authors to measure the friction coefficient in fabrics, to enable a quantitative assessment of touch/handle, in order to predict the comfort behaviour of 2D/3D structures when used or touched by humans.In the present study the existence of a correlation between a subjective assessment and the objective measurement of different parameters analysed in paper tissues has been investigated.

Key Words: Handle, Frictorq, KES, paper Tissue, objective and subjective analysis

1. INTRODUCTION

Comfort is present in all actions in our life. Authors such as Fourt and Hollies [1] concluded that the thermal comfort involves thermal and non-thermal components that are related to the circumstances in which clothes are used, for example, at work or at critical or non-critical conditions.

For a long time it has been recognized that it is difficult to describe comfort from a positive point of view but discomfort is easily defined by terms such as: hot, cold, rough and causes skin irritation. Therefore, a definition [2, 3, 4] of comfort that is generally accepted is that it transmits freedom from pain and discomfort, in other words, it is in a neutral state.

Physiological responses of the human body to a certain combination of clothing and the ambient conditions are predictable when it reaches an equilibrium state with the textile. There are measurable factors that help to predict textile comfort both in physiological and environmental levels, such as heat resistance, moisture recovery, weather conditions and the level of physical activity, etc. As these assessments can be made in two ways, they will be addressed separately, by a subjective and an objective analysis.

Subjective Evaluation

Sensory analysis is a subjective evaluation [5] which is reflected in an action of all the experiences assimilated over a lifetime. This directly measures the person's opinion through surveys in order to analyze preferences. Urdapilleta [6] in the Treaty of Sensory Evaluation written by defines two concepts to take into account when designing an evaluation:

- Feeling "is the state resulting from the entry into receptors activity after sensory stimulation of one sense."
- Perception: "the cognitive process of recognition, identification, organization and interpretation of sensory information."

In 1968 Kawabata [7] placed two hypotheses for the concept of handle:

(1) One person thinks the touch sensation by proving the mechanical properties of tissues, and

(2) the criterion of judgment is based on the possibility of having or not the fabric suitable to be used as clothing.

To define handle Kawabata [7] selected several expressions that relate the transmitted sensations with the mechanical properties; these expressions describe a set of primary sensations which provides a good touch and they are:

Smoothness (Numeri): mixed feeling of softness, flexibility and soft. A fabric of cashmere represents that feeling;

Stiffness (Koshi): Feeling connected to the rigidity when subjected to curvature. The elasticity promotes this feeling. Tissues, such as compact meshes and fabrics with high resilience and elasticity represent that feeling;

Fullness and Softness (Fukurami): Feeling of volume. The resilience after compression and thickness

connected to a hot "touch" is closely linked to this feeling;
Crispness (Shari): Feeling that comes from a grim and rough surface, obtained by the use of many hard twisted wires. Displays a sense of cold;
Anti-drape stiffness (Hari): refers to the stiffness that opposes the fall, whether or not the elasticity of the tissue.
To evaluate the subjectivity of fabric hand and then compare with objective data surveys were carried out. It became necessary to use psychometric scales in which the set of descriptors attributes or qualifying adjectives is to convey the every day experience.
The method adopted in this study uses an observer’s panel to measure subjectively the different samples. An exhaustive list of possible adjectives to be used in the description of the ring was formulated. The groups of adjectives used in the study of handle evaluation were proposed by North Carolina State University (NCSU) [8] and are shown in Table 1

Table 1 – Parameters proposed for the assessment of fabric hand

Parameters	
Hard/Soft	Damp/Dry
Stiff/Flexible	Thick/Thin
Rough/Smooth	Warm/Cool
Heavy/Light	Loose/Dense
Nonstretchy/Very Stretchy	

Typically the panel consists of 30 to 40 observers, with men, women or both sexes depending on the purpose of the analysis [8]. NCSU submits to these studies healthy individuals, non-smokers, aged between 18 and 35 years, being first considered those who already have some experience. The observers come in a temperature controlled environment where they wait 30 minutes to stabilize. All test samples were placed in a conditioned atmosphere for the required humidity and temperature before each test.
The questionnaire consisted of two parts: the first refers to the social characterization of the inquired being composed of four issues: gender, age, experience in sensory analysis and profession. These questions allow an exchange of data between the social characterization and professional activity, with the sensory analysis. The second part refers to the sensory analysis of samples, consisting of thirty-six sets of questions and each question consists of 9 pairs of adjectives.
At the beginning of the survey the inquired were asked whether they were familiar with the terms used; after their positive answer they would move to the next phase. If they were unaware of the terms used the respondents were eliminated. Before starting the process the respondents were asked to wash their hands to remove as many impurities as possible to improve test performance.

Objective Analysis

Expressions like "good touch" or "bad touch", which are generally used to analyze the quality of fabric, have different meanings when talking to an expert. For the expert "good touch" represents a fabric with high softness and a moderate stiffness, smoothness, and voluminosity, because, for him/her, the interaction of this entire core values of "handle" transits a clear total value of handle
Kawabata [7] proposed the use of the total value of handle (Total Hand Value - THV) as an indicator of "touch". The good "touch" THV value is the sum of the primary qualities evaluations of fabrics and they are taking into account the comfort, appearance and function of the garment.
The devices that are used to determine the properties are: the KES-FB System (Kawabata Evaluation System) [7], the SiroFAST System [9] and the FRICTORQ System [10].
Excluding the SiroFAST System since it is only used in woolen fabrics, the other textile equipments evaluate various types of textile materials [11,12,13] and also nontextile materials [10,14,15].
The KES-FB system [7,11] includes a set of measurements that compose the analysis of fabric hand, consisting of six parameters of properties, which are: tensile, bending, surface, thickness, weight and compression.
Surface properties, thickness and weight are not mechanical properties but physical, although they are indirectly related to the mechanical properties. The KES-FB system consists of four blocks,
Each block measuring a certain set of properties present in the total final handle by the values previously determined.
KES-FB1 determines mechanical characteristics; it measures tensile and shearing properties.
KES-FB2 evaluates the properties of curvature in a pure bending state.
KES-FB3 analyzes compression.
KES-FB4 examines surface properties. This analysis includes the study of surface roughness and surface friction.

FRICTORQ

Developed in the University of Minho, FRICTORQ [10] aims at measuring the coefficient of friction of fabrics and other planar soft surfaces such as papers and nonwovens, to be used in their characterization. It comprises three blocks, namely: (1) the torque sensor with the respective data acquisition system; (2) the direct current motor and the mechanical transmission, and (3) the control of the entire system with a software application. The principle of operation [14] of the first model, designed for fabric-to-fabric tests, is based on the dry disk clutch principle, where an annular flat body is rotary drawn in contact on a flat surface under the action of a specified normal force, which results in a uniformly distributed contact pressure. Figure 1 is a general view of the FRICTORQ I instrument at the textile physics laboratory of University of Minho.

Fig.1 - FRICTORQ I System

The coefficient of friction, μ, is determined through the relative displacement of two surfaces, one above the other, in a relative sliding rotational very low constant speed [10, 14].

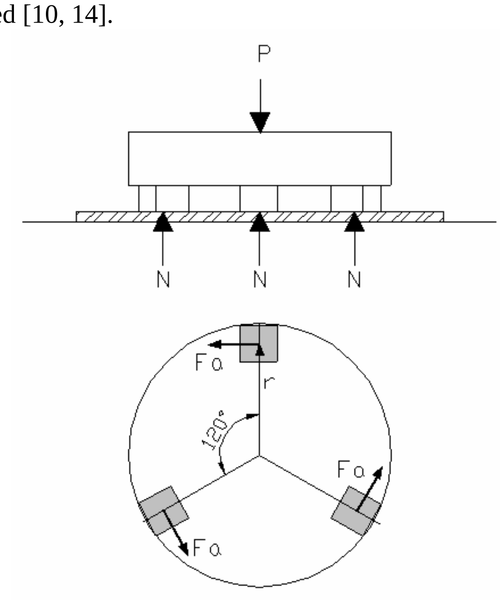

Fig. 2 - Geometry of FRICTORQ II model

On a second phase, FRICTORQ II was developed. The upper body has now 3 small square areas of contact at 120° as seen in figure 2. The own weight P of this upper body is standardized in order that a constant pressure of 3,5 kPa is exerted at the contact areas.
This device has demonstrated readiness for evaluation of the coefficient of friction for various textile and non-textile materials [10, 14].

2. METHODOLOGY

Samples that were studied are described in Table 2

Table. 2 - Tissue Paper

Nº	Materials	Nº of Sheets	Fragrant	Colour
1	L1_3F_Black	3	No	Black
2	L2_3F_Orange	3	No	Orange
3	L3_3F_Green	3	No	Green
4	L4_3F_Red	3	No	Red
5	L5_4F_Citrus	4	Yes	Orange
6	L6_4F_Mint	4	Yes	White
7	L7_2F_Plenitude	2	No	
8	L8_2F_Renova	2	No	
9	L9_3F_Active	3	No	
10	L10_3F_Magic	3	No	
11	L11_2F_Sensitive	2	No	

Friction tests were carried out using the instrument FRICTORQ with contact probe NB3.5 (3,5 kPa of contact pressure) in a set of 11 paper samples of tissue paper produced by the Portuguese RENOVA company.Table 2 summarizes company references of all tested materials. For each of the materials, samples with 11,3 cm diameter (100 cm2) were cut, and 13 samples were tested. The obtained results were analyzed using SPSS18® statistical package.
KES tests were performed according to the procedure given in the manual provided by the manufacturer. Specimens were cut square with 20 cm side, and placed in Module 4 of the KES-FB4. The samples were fixed to the module through a system integrated in it, and the tests were carried out on all samples and repeated five times. The sample handling required latex gloves to prevent contamination; then the values were transferred to an SPSS16® spreadsheet for analysis.
All objective tests were carried out under a standard atmosphere (of 20 ±2 °C and 65 ±5% RH), and all fabrics were conditioned for a time period over 48 hours.
In order to achieve Qualitative parameters it was necessary to select the tool to be used for the collection of the qualitative data. This choice was a research already used by Martins [6] in the study on the "Contribution to the objective measurement and subjective handle mesh fabric." This survey contains a questionnaire of closed questions divided into two parts: the first part appears the general characterization of the sample and the second consists of an attitude scale to

describe the material under study. To determine whether the use of a conditioned atmosphere is a parameter that must be considered, the observers were arranged into two groups of respondents:

Group A: survey carried out in a space with no standard atmosphere.

Group B: survey carried out in a space with standard atmosphere

The standard atmosphere is characterised by a temperature of 20 ±2 °C and humidity of 65 ±5%.

RESULTS AND DISCUSSION

The results are graphically displayed in figures 3 and 4. The samples reaching the highest coefficient of friction with FRICTORQ are L8_2F_Renova_I on the Outer-face and L7_2F_Plenitude_O in the Inner-face. When accessed by KES-MIU, the friction coefficient of sample L1_3F_Black reaches the maximum on both faces. For the standard deviation, it is greater for sample L1_3F_Black to the Outer-face and to L7_2F_Plenitude Inner-face when referring to values obtained by FRICTORQ. But when examining the values obtained by KES-MIU, L3_3F_Green samples are those that reach the maximum values to the Outer-face and L2_3F_Orange in the Inner-face

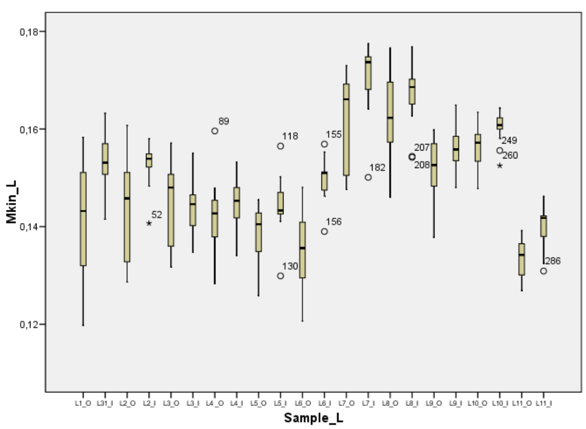

Figure 3 - Kinetic Friction Coefficient by FRICTORQ

The lower values of coefficient of friction by FRICTORQ are obtained for sample L11_2F_Sensitive on both faces, which also happens in the KES-MIU for the sample L4_3F_Red. There is lower amplitude of values for sample L11_2F_Sensitive to the Outer-face and for the sample L10_3F_Magic to the Inner-face in relation to the two instruments

Figure 5 shows the average roughness of the samples. The higher value is for L7_2F_Plenitude to the Outer-face and L9_3F_Active to the Inner-face, the last sample also has the highest dispersion values. The sample having the largest dispersion to the Outer-face is L11_2F_Sensitive. The lowest average in deviation to the Outer-face is obtained by sample L2_3F_Orange, and to the Inner-face the lowest average belongs to sample L1_3F_Black and the smallest deviation to sample L4_3F_Red.

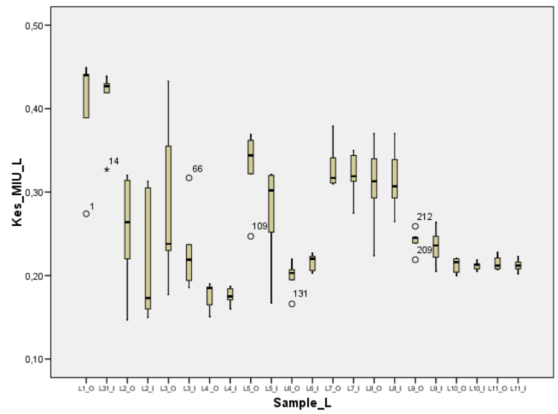

Fig.4 - Kinetic Coefficient of Friction by KES-MIU

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Figure 6 shows the parameters of analysis carried out, respecting the scale stipulated in the development of the survey. The scale has values from 1 to 7 which corresponds to the range of sensations of the different parameters. The first value corresponds to the maximum initial adjective sensation of each of the sets of parameters, the latter corresponds to the respective opposite. At the interior of the graph there are two lines, at 3.5 and 4.5, defining the zone of "no opinion", i.e., the area where the responders had more difficulty in deciding a sensation.

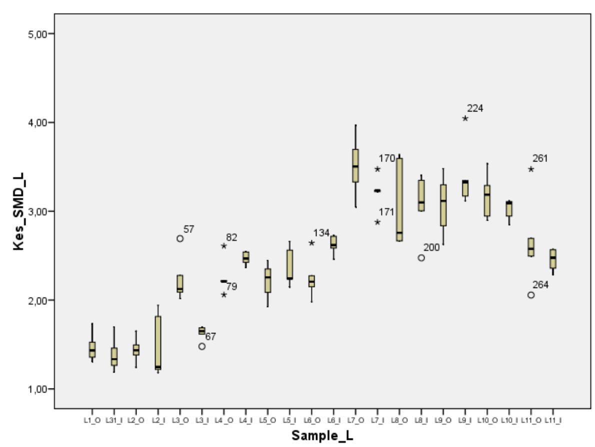

Fig.5 - Values of Roughness by KES-SMD

As seen in figure 6 Parameters Elastic-Hard, Warm-Cool and Loose-Compact do not have any statistical significance in all samples.

Parameters Rough-Soft, Thick-Thin, Light-Heavy, Flexible-Firm, Soft-Hard and Wet-Dry tend toward the more extreme values in the semantic differential antonyms. Sample L8_2F_Renova was simpler to define, because values tend to one of the parameters; the more difficult was L5_4F_Citrus, because values tend to the “not know” area.

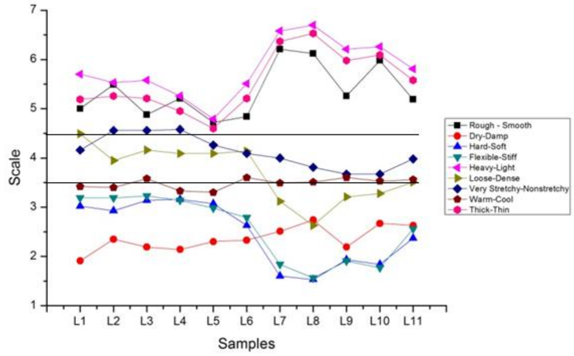

Fig.6 - Average values of the Subjective Analysis of Tissue Papers

Data Correlation of Objectives with Subjective Data

Table 3 shows all the parameters, both objective and subjective, as well as the statistically significant correlations. It is observed the existence of a statistically significant correlation (p=0.01) between parameters Rough-Soft and Thick-Thin with FRICTORQ and a statistically significant correlation (p=0.05) between FRICTORQ and Heavy-Light parameter.

Table 3 – Correlation between the analyzed Objective and Subjective parameters

L	Rough/ Smooth	Dry/ Damp	Soft/ Hard	Flexible/ Stiff	Heavy/ Light
Mkin	**				*
KES MIU					
KES SMD					
L	Dense/ Loose	very stretchy / nonstretchy	Warm/ Cool	Thick /Thin	
Mkin				**	
KES MIU					
KES SMD					

** Significant correlation = 0.01
* Significant correlation = 0.05

CONCLUSIONS

The behaviour of paper tissues regarding the coefficient of friction leads to the formation of the 10 groups by FRICTORQ with sample L11_2F_Sensitive_O to produce the different performance at lower values and sample L7_2F_Plenitude_I at higher values. The number of groups is reduced to three in the analysis by KES-MIU and many samples have different performance at lower values, namely: L4_3F_Red_O, L4_3F_Red_I, L42_4F_Min_O, L10_3F_Magic_I, L10_3F_Magic_O, L11_2F_Sensitive_I, L11_2F_Sensitive_O, L42_4F_Min_I and L2_3F_Orange_I. For higher values, only sample L1_3F_Black_I presents distinct behaviour. Regarding roughness the number of groups formed is six, and sample L1_3F_Black_I a different behaviour in the sample below (??? não entendo isto aqui) and the higher values L7_2F_Plenitude_O.

In order to evaluate the accuracy of the experimental results an ANOVA test was performed. The behaviour obtained for the samples demonstrates, in general, that FRICTORQ instrument can obtain a greater accuracy in the analysis, as the number of groups formed is higher than by KES-FB4. Samples that have the lower and higher values are in the same groups when the analysis is performed by FRICTORQ or KES-FB4.

Parameters Elastic-Rigid, Warm-Cold and Loose-Compact present values, defined by the semantic differential scale, closer to four (not know). It can be concluded that these parameters do not contribute to defining their characteristics.

Correlations between subjective and objective parameters in Tissue Papers had a significant one of 0.05 and two of 0.01. In correlation with significance of 0.01, the first one was between FRICTORQ and Rough-Soft in value of -0.154 and the second between FRICTORQ and Thin-Thick in value of -0.155. Thus, there is an inverse relationship between the parameters, i.e., with the increasing of the value it decreased the sensation in the respective analysis.

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