EXPERIMENTAL DETERMINATION OF THE FRICTIONAL CHARACTERISTICS OF FABRICS MADE OF WOOL

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Abstract *In the present work the frictional characteristics of fabrics made of 100% wool and woolen fabrics with admixtures of polyamide and polyester are determined. The test was performed in different directions of the woven textiles and at different compressive force. With friction of surface textile materials, the compressive force affects the coefficient of friction at rest and the coefficient of friction at sliding. This is due to the increase in the actual contact area of the friction surfaces. For accurate study of the frictional behavior of textile products, formulas for friction characteristics are used, derived specifically for fabrics - friction index, friction parameter and friction factor.*

Keywords: *friction index, friction parameter, friction factor.*

1 INTRODUCTION

The frictional characteristics of fabrics are of great importance in the field of technologies available to the sewing industry, in the technologies for textile weaving, as well as in the subjective assessment of it when wearing ready-made clothing and contact with woven surfaces (blankets, upholstery, etc.). In the technology field for sewing industry, friction is carried out during the layering of the fabrics, cutting of many layers of fabric and its subsequent separation. Friction is observed when sewing clothes (with the metal parts of the sewing machines), when packing and storing the finished clothes, etc.

The user's subjective perception of fabric friction is important, but not a method for quantifying the process. For textile technologies, it is important to assess the quantitative parameters of fabric friction, as well as the influencing factors.

It is known that the friction force in textile materials depends on a number of test factors - normal load, contact area, test speed, as well as the nature of the textile surface and the direction of friction - warp by warp, warp by weft. There are numerous publications in the scientific literature related to tissue friction and determination of friction coefficients [1-3, 5-7].

The present paper focuses on the frictional characteristics of fabrics made of wool - friction index, friction parameter and friction factor. The development is part of a larger study of the frictional characteristics of fabrics made of natural materials. The aim of the present study is to investigate the frictional characteristics in different directions of the fabric, as well as the influence on the frictional characteristics of the content of additional impurities to the wool.

2 EXPERIMENTAL

The experimental studies for this working paper are made with textile fabrics containing wool (pure wool and woolen fabrics mixed with polyamide, polyester and elastane). The studied textiles have different characteristics. They are produced in textile factory Mirolio, Bulgaria. The following four types of fabric with different composition, weave, content, surface area, etc., were examined. The characteristics of these fabrics (Figure 1) are presented in Table 1.

a) Delia b) Miss c) Rexos d) Oreste

Figure1 Structure of studied fabrics

Table 1 Characteristics of the studied wool fabrics

№	Item	Weave	Surface area [g/m^2]	Linear density [tex]		Density [thread number/dm]		Composition [%]	Fabric width [cm]
				Warp	Weft	Warp	Weft		
1	Delia	Sn1/4Z	380	105	105	171	160	PA/virgin wool 20/80	150/145
2	Miss	reps trame: 2-2	153	16.7x2	29.4x1	236	215	PE/virgin woo/E 54/44/2	150/145
3	Rexos	Se2/2Z	196	16.7x2	16.7x2	275	270	PE/virgin wool 55/45	153/148
4	Oreste	reps trame: 2-2-1-1	190	21x2	25x1	266	265	virgin wool 100	151/153

Note: PA - polyamide, PE - polyester, E - elastane

Results obtained through experimental studies of the static and dynamic friction coefficients, determined with the use of MXD-02 tribometer from Labthink, China (Figure 2), are used to determine the friction parameter as well as the friction coefficient and the friction index.

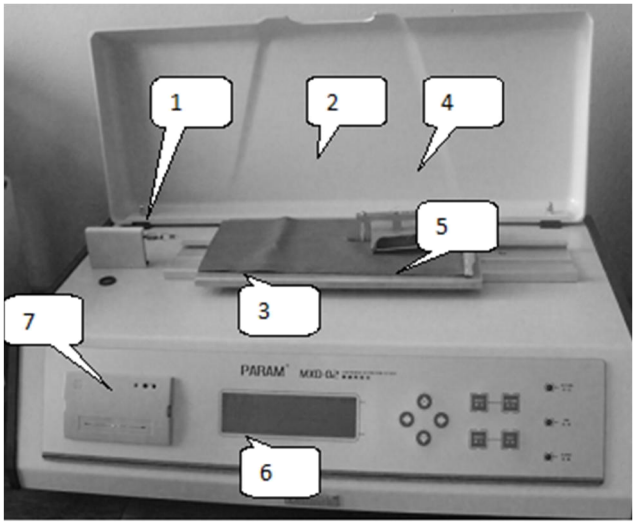

Figure 2 Overall appearance of appliance MXD-02

Force meter (1) measures the friction force that occurs when sled (2) slides on platform (3). The platform moves on guide rail (4) (Figure 2). The change in friction force is shown graphically on display (6). The display shows calculated values of the friction coefficient at rest and of the friction coefficient during sliding. Appliance MXD-02 can work in accordance with different standards. The standard can be selected through control panel (5). The experimental studies in this work paper are performed according to BDS EN ISO 8295: 2006.

The test is performed by placing one layer of the test fabric on sled (2) so that the direction of the warp threads coincides with the direction of movement of the platform. Another layer of fabric is then placed on the sled. The layer of fabric placed on the sled is placed either is in the direction of the warp threads or in the direction of the weft threads.

3 RESULTS AND DISCUSSION

Friction coefficient at rest *μ0* is determined at the moment when the metal thread connecting the force meter and the sled is stretched. When the slide starts sliding on the platform, the tribometer calculates the average value of sliding friction coefficient *μ*, as well as the standard deviations for *μ0* and *μ*. Sliding friction coefficient values as well as standard deviation values *μ0* and *μ*, are visible on the screen and can be printed on paper through mini printer (7).

The results for *μ0* and *μ* are given in Tables 2 and 3.

Table 2 Values of coefficients of friction at rest

Item	Load [g]	Static coefficient of friction	
		Warp FS - Warp FS[1]	Warp FS – Weft FS[2]
Delia	200	1.164	1.149
	300	1.286	1.487
	400	1.694	1.697
Miss	200	0.590	0.634
	300	0.828	0.885
	400	0.966	1.111
Rexos	200	0.672	0.596
	300	0.876	0.836
	400	1.072	1.060
Oreste	200	1.010	0.924
	300	1.368	1.225
	400	1.497	1.487

Note: Warp FS[1] – Warp face side; Weft FS[2] – weft face side.

Table 3 Values of coefficients of friction at sliding

Item	Load [g]	Dynamic coefficient of friction	
		Warp FS - Warp FS[1]	Warp FS – Weft FS[2]
Delia	200	1.164	1.149
	300	1.286	1.487
	400	1.694	1.697
Miss	200	0.590	0.634
	300	0.828	0.885
	400	0.966	1.111
Rexos	200	0.672	0.596
	300	0.876	0.836
	400	1.072	1.060
Oreste	200	1.010	0.924
	300	1.368	1.225
	400	1.497	1.487

A study of the available literature shows that no significant differences in friction force are reported [1, 4] when experimenting with low sliding speeds in the range of 10 to 500 mm/min.

The main factor influencing the friction characteristics of the fabric is the actual contact area of friction between fabrics [2]. The actual contact area increases with increased pressure due to flattening of the threads. Due to the insignificant influence of the friction speed of the fabric layers relative to each other, this study is performed at a sliding speed of 100 mm/min. The relationship between friction force and normal load [2, 8-10] is a logarithmic dependence:

$$\frac{F_i}{B} = C.\left(\frac{N_i}{B}\right)^n \quad \text{or} \quad log\left(\frac{F_i}{B}\right) = logC + n.lpg\left(\frac{N_i}{B}\right) \tag{1}$$

where: i = 1, 2,…m; B - contact area [m^2]; C - friction parameter [Pa^{1-n}]; n - friction index; N - normal pressure [N]; F - friction force [N]; m - number of experimental observations.

The studies of Das, Sular et al [4, 5, 6] for a mixture of cotton and polyester in different ratios, show that the normal load and the frictional force follow the logarithmic relationship for all the fabrics.

For each of the studied textile products, three experiments were made, and the arithmetic mean value was determined. *Log(Fi/B)* and *log(Ni/B)* are determined in different directions and when the pressure changes. Normal pressure is changed by placing additional weights on the sled. Additional weights are added to the sled's own weight of 200 g. The mass of the test piece mounted on the sled is not taken into account as it is negligibly small. The tests were performed at an average air temperature of about 22°C and humidity ≈70%. The determination of the two parameters - friction index and friction factor is performed and after calculating the normal compressive forces *Ni* and friction forces *Fi*, *log*(*Fi/B)* and *log(Ni/B)* are calculated.

The following linear regression equation is determined:

$$y=a+x.b \tag{2}$$

$x = log(N_i/B);\ y = log(F_i/B);\ a = logC;\ b=n$

Friction parameter and friction index are used to determine the friction factor *R*, also called composite friction coefficient or correlation coefficient of friction [3], the value of which is determined by the dependence:

$$R = \frac{C}{n} \tag{3}$$

The results of the friction parameter, friction factor and friction index for friction at rest and at sliding, are listed in Table 4.

Figures 3-6 show the experimental results for the friction index and the friction parameter depending on the test direction.

Table 4 Values of frictional characteristics at rest and at sliding

Item	Direction of the fabric	Frictional characteristics at rest			Frictional characteristics at sliding		
		Index n	Parameter C [Pa^{1-n}]	Factor R [Pa^{1-n}]	Index n	Parameter C [Pa^{1-n}]	Factor R [Pa^{1-n}]
Delia	Warp FS- Warp FS	0.907	0.716	0.789	0.830	0.684	0.824
	Warp FS - Weft FS	0.905	0.709	0.783	0.820	0.682	0.832
Miss	Warp FS- Warp FS	0.654	0.679	1.038	0.618	0.676	1.094
	Warp FS - Weft FS	0.615	0.676	1.099	0.599	0.674	1.125
Rexos	Warp FS- Warp FS	0.702	0.683	0.973	0.579	0.676	1.168
	Warp FS - Weft FS	0.580	0.674	1.162	0.592	0.676	1.142
Oreste	Warp FS- Warp FS	0.864	0.703	0.814	0.757	0.682	0.901
	Warp FS - Weft FS	0.784	0.688	0.878	0.772	0.685	0.887

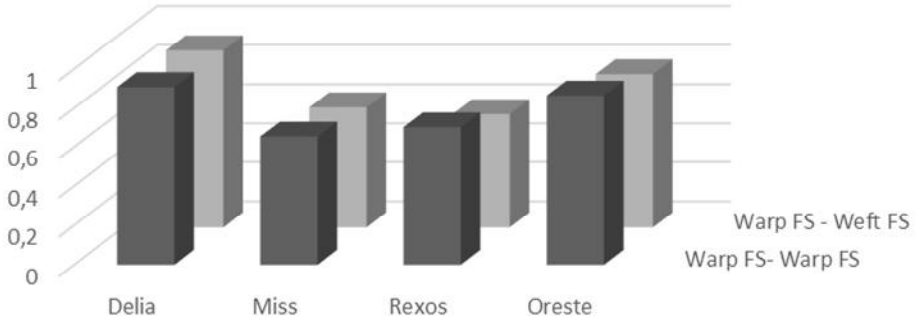

Figure 3 Influence of test direction on friction index at rest

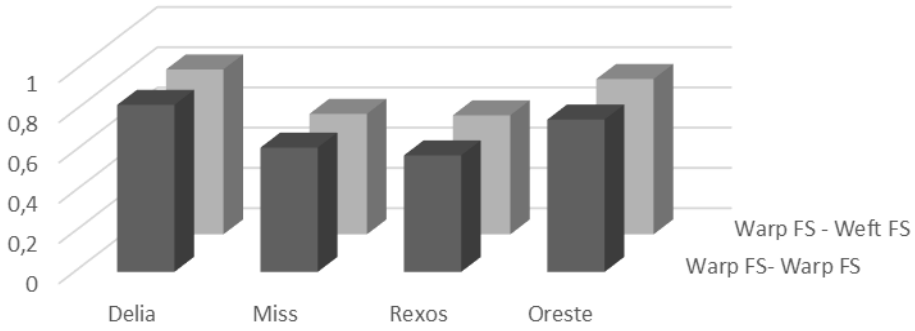

Figure 4 Influence of test direction on friction index at sliding

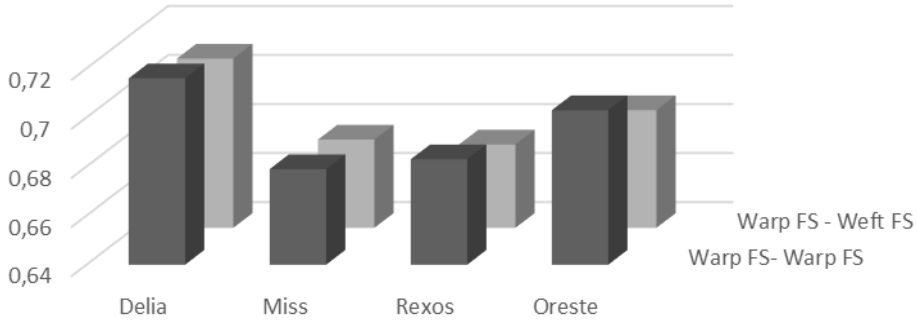

Figure 5 Influence of test direction on friction parameter at rest

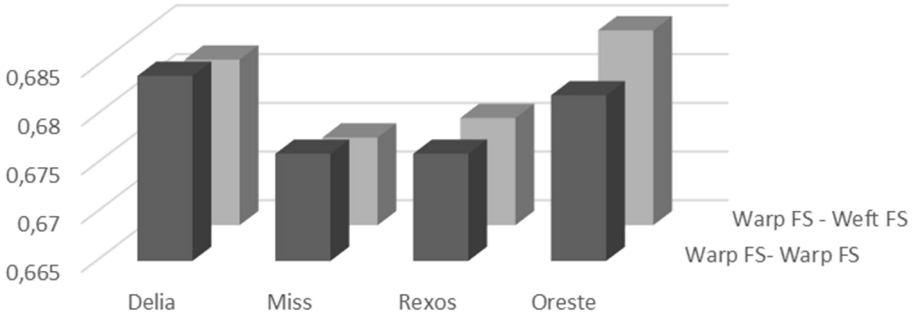

Figure 6 Influence of test direction on friction parameter at sliding

4 ANALYSIS OF THE OBTAINED RESULTS

As a result of the conducted study, the following conclusions can be drawn:

1. Friction indices, parameters and factors at rest and at sliding, for fabrics made of wool and of wool fabrics with admixture of polyamide and polyester are determined. Depending on the structure and direction of friction, the friction index varies from 0.580 to 0.907 at rest and from 0.579 to 0.830 at sliding.
2. The friction index for friction at sliding is lower than the friction index at rest.
3. In terms of arrangement of the threads, the friction index is higher when rubbing with a parallel arrangement of the warp threads of one fabric compared to the weft threads of the other fabric.
4. As expected, higher friction parameters are observed for the Delia item, which has a 20% polyamide content and 80% wool content, as well as for the Oreste article, which is made of 100% wool. Their friction parameters are larger when the warp threads of one fabric are parallel to the weft threads of the other fabric. These two items of woolen fabrics have the highest wool content out of the four studied items, which provides volume and increased resistance.
5. Friction parameters for both slide and rest for Miss and Rexos items which are high in polyester and below 50% wool are expected to be lower than the other two items higher in wool content.

5 CONCLUSION

New data has been obtained on the frictional characteristics of wool and wool fabrics with admixture of polyamide and polyester. Trends for the influence of the direction of friction, established for fabrics with other structures and composition, have been confirmed. It was found that the studied woolen fabrics increase the friction factor with an increase in the composition of the woolen content of the fabric. Influence of the test direction on the friction index and the friction factor was established, as the friction index is higher at friction with parallel arrangement of the warp threads of one fabric compared to the weft threads of the other fabric. The friction index at friction at rest is lower than the friction index at sliding.

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