

RESEARCH OF SOME PHYSICAL AND MECHANICAL CHARACTERISTICS OF SUITING FABRICS FOR DESIGNING THE CLOTHES

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Abstract: *The main physical and mechanical characteristics that have an effect on the shape and design of the clothes are thickness, surface density, rigidity and drapeability of the fabric. Experimentally, according to the standardized methods, were identified the main physical and mechanical characteristics of fabrics of the suiting group. Using the selected parameters, the comparative analysis of fabrics samples was conducted and dependencies between them were determined. Analysis of experimental data showed that the raw components of fabrics do not affect significantly on their properties (drapeability, rigidity). Fabrics with the different raw components can have the same or close values of these parameters. More significant is the weave of fabric, which has an effect on the rigidity characteristics of fabric in the longitudinal and transverse directions. Conducted experimental researches are the basis for development of the suiting group fabrics classification in terms of flexural rigidity for the purpose of developing the recommendations for designing the clothes of different three-dimensional forms.*

Key words: *thickness, drapeability coefficient, surface density, warp and weft rigidity, correlations.*

1 INTRODUCTION

In the design of the clothes in the garment industry a wide range of fabrics is used. The development of the textile industry and the emergence of fabrics with new structural characteristics at the market force the workers of the garment industry to find new solutions for arising problems, which are connected with the provision of the necessary constructive form to the products, retention of the shape during the use of the products.

As a result of analysis of fabric classifications, provided by different sources [1-4], it was determined that the main fabric classification for the purpose of clothes designing was expedient to consider the assortment of clothes and division of fabrics on linen, clothes, suits etc. Exactly the characteristics of fabrics by the assortment and not, for example, by the surface density or thickness makes it possible to provide recommendations on the selection of methods of forming and on techniques of constructive modeling in the design of the clothes.

The aim of the research is determination of parameters of physical and mechanical properties of fabrics of the suiting group, estimation of linkages between them for scientifically grounded selection of fabrics with the purpose of creation the specified three-dimensional form of sewn product.

2 EXPERIMENTAL

It is known that the main elements which characterize the form of the clothes are design, material, size, weight, structure and so on. Materials, in turn, have an effect on the form of the clothes with their aesthetic parameters (appearance of the fabric, surface characteristics, color, decoration etc.) and with their physical and mechanical characteristics. The following characteristics have the biggest impact on the form of clothes: raw components, weave, thickness, surface density, rigidity, drapeability, crease coefficient [5, 12]. Depending on the values of these parameters product designation, its model and design features, technology of its production can be determined.

The rigidity of the fabrics depends on the raw components, fiber structure, structure and degree of twist of the yarn (fiber), on the type of weave, density and decoration of the fabrics. The rigidity of the fabrics increases with increasing of twist of the yarns, their thickness and density. The weave of the yarn in the fabrics structure also significantly affects the rigidity of the fabrics. With increasing length of overlaps and a decrease in the number of connections between yarn systems the rigidity of the fabrics decreases. Increase of the number of filling of the weaves in the material structure leads to the increase of the fabrics rigidity. Configuration of the sectional view of the fabrics also has a significant effect on the rigidity of the

fabrics. Sectional view of the round shape has a greater resistance to the flexural efforts, rigidity increases with the thickness of the fabrics. Drapeability of the textile materials closely connected with the same structural parameters, which determine the flexural rigidity.

To achieve the goal, about thirty samples of the suiting fabrics with the different raw components were analyzed, which differ in appearance and physical and mechanical parameters. Were determined such parameters of fabrics as thickness, surface density, flexural rigidity, drapeability coefficient. All tests were conducted under the current regulations [6, 7], in compliance with requirements to the objects of experimental research. The processing of the results of experiments was made by using the mathematical tool for statistical data analysis.

Material thickness was determined by using the manual thickness tool of indicative type TP 10-1 [6], was calculated the surface density of the suiting fabrics M_s [g/m^2]. During the analysis of fabric rigidity by console contactless method [10], was used the device, type ПТ-2 (Figure 1).

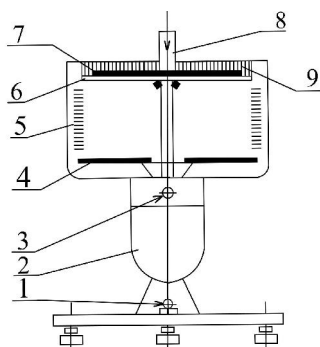


Figure 1 Scheme of device, type ПТ-2 for determination of fabric rigidity by console method:

1 - tumbler; 2 - moving mechanism; 3 - screw; 4 - crippling marker; 5 - scale of absolute crippling; 6 - horizontal plane; 7 - sample; 8 - weight; 9 - scale of symmetry checking

The methodology of experiments is as following. Five elementary samples in longitudinal and transverse directions, size 160×30 mm, are cut out. The prepared tested strips should be kept in climatic conditions not less than 23 hours before testing [11]. Test should be conducted at the same conditions.

Elementary samples of each direction (5 samples of each direction) weigh on the scales with the error no higher than 0.01 g and determine the total weight m [g] of the samples of longitudinal and transverse directions separately.

Elementary sample is placed on the supporting horizontal plane 6 face up and symmetrically to the midline, combine the outer edge of the sample and the plane. At the middle of the sample the weight

is set with a width of 20 ± 1 mm, weighing 500 ± 5 g and using a tumbler 1 switch on the mechanism of lowering the lateral sides of the supporting plane. After one minute from the moment of separation of elementary sample from the surface of the plane 6 the ends crippling f of the sample are measured using the crippling markers 4. As the final crippling taken the arithmetic average of 10 measurement results of each direction with the error no higher than 0.01 mm.

Conventional value of rigidity EI [$\mu\text{N} \cdot \text{cm}^2$] has been calculated separately for longitudinal and transverse directions by the formula:

$$EI = 42046.m/A \quad (1)$$

where m – total weight of all five elementary samples of fabric [g], size of every sample is 160×30 mm; A – function of relative crippling f_0 , which is determined from the table in the regulatory documents [10] according to the value f_0 :

$$f_0 = f/l = f/7 \quad (2)$$

where f – value of the arithmetic average of crippling of the samples [cm]; l – length of the sample that is weighted [cm], equal to $l = (L - 2)/2 = 7$ cm, where L – the length of elementary sample [cm].

Rigidity coefficient of material was calculated as the ratio of rigidity values in longitudinal and transverse directions:

$$C_{EI} = EI_{\text{longitudinal}} / EI_{\text{transverse}} \quad [\%] \quad (3)$$

Recommended values of surface density and conventional rigidity of fabrics of the suiting group presented in Table 1 [2, 8-10].

Table 1 Oriented values of surface density and flexural rigidity of fabrics of the suiting group

Group of fabrics	Surface density [g/m^2]	Flexural rigidity [$\mu\text{N} \cdot \text{cm}^2$]
cotton	180–300	4000–9000
linen	200–400	
woolen	220–360	
silk	150–230	

The research of drapeability of the samples of the suiting fabrics was performed on the device for determination of drape by the disk method [8], because it was necessary to evaluate the drapeability of fabrics in longitudinal and transverse directions at the same time. This method is not standardized, but it is used very often in the garment industry because of its simplicity. The scheme of the device is given on Figure 2.

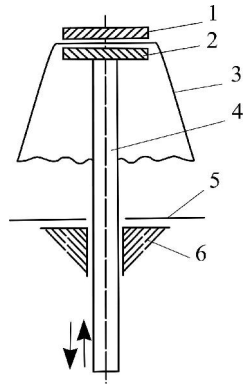


Figure 2 Scheme of device for determination the drapability of fabric by disc method: 1 – pressed disc; 2 – table; 3 – sample of fabric; 4 – rod; 5 – paper circle; 6 – horizontal plane

Fabric sample 3 that was cut as a circle with a diameter 200 ± 1 mm is put on the Table 2 with the diameter 50 ± 1 mm, which has a needle for fixing the sample. On the top of the sample the pressed disc 1 is placed, the size and shape of which match the size and shape of the Table 2. The table is lifted; the edges of the sample are hanging down. In order to provide the sample with constant natural form, disc with the sample is lifted up and moved down 5 times and after 3 min outline the projection of sample 3 on a paper circle with a diameter 200 ± 1 mm, which can be obtaining by lighting from the top by parallel rays of the light perpendicular to the plate of the sample. Then determine the projection area of the material.

During the research of fabrics of the samples the drapability coefficient (C_d) was calculated using the results of weighing of the paper (with an error no more than 0.001 g) that was cut in accordance with the projections of undraped sample (mass m)

and draped (mass m_d) by the formula:

$$C_d = 100 \cdot (m - m_d) / m \tag{4}$$

where m – projection area of original undraped sample [g]; m_d – projection area of draped sample [g].

Drapability value is essential for overcoating, suiting and clothing fabrics; it is taking into account during the confectioning of materials for the product. Recommended values of drapability coefficient C_d for the main functional groups of fabrics presented in Table 2 [1, 2, 8, 9].

Table 2 Estimation of drapability degree of fabrics of different types

Type of fabric	Drapability coefficient C_d [%]		
	Good, more than	Satisfactory	Bad, less than
Woolen:			
clothing	80	68-80	68
suits	65	50-65	50
overcoating	65	42-65	42

Drapability of textile materials depends primarily on their rigidity and it is closely related to the structural parameters and operations of decoration. Good drapability can have fabrics with different fibers without sizing, with low surface density [8].

3 RESULTS AND DISCUSSION

Physical and mechanical parameters and characteristics of fabrics of the suiting group that were obtained as a result of experimental research summarized in Table 3.

For comparison of the obtained data concerning the thickness and surface density of the researched suiting fabrics it was defined their interdependence and presented in diagrammatic form (Figure 3).

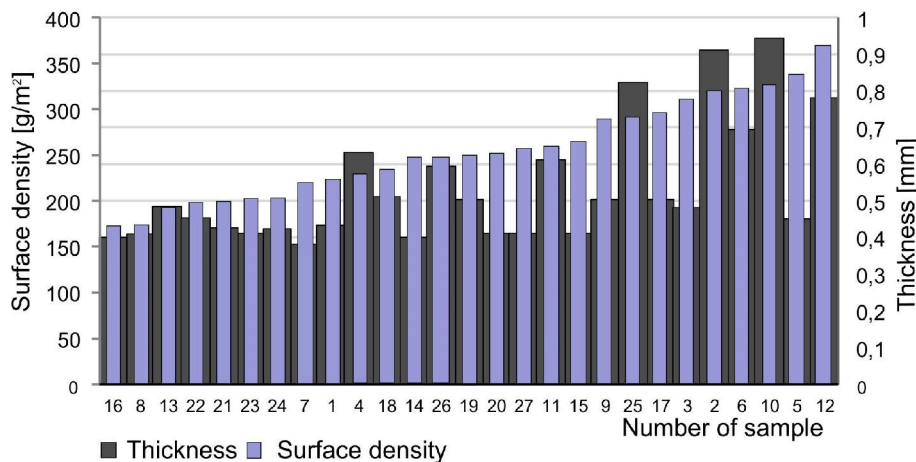


Figure 3 Interdependence of the surface density and thickness of the suiting fabrics

Table 3 Summarized characteristics of suiting fabrics

Number of sample	Raw components	Type of weave	Surface density [g/m ²]	Thickness [mm]	Flexural rigidity [μN·cm ²]		Rigidity coefficient	Drapeability coefficient [%]
					in warp	in weft		
1	2	3	4	5	6	7	8	9
Sample 1	35% wool, 25% PES, 40% PA	satin weave	220	0.43	2923	2407	1.21	38
Sample 2	70% wool, 25% cotton, 5% PES	plain weave	316	0.91	7870	5346	1.47	42
Sample 3	40% wool, 28% PES, 32% PA	compound twill weave	308	0.48	1882	2036	0.92	63
Sample 4	40% cotton, 50% PES, 10% ME	plain weave	226	0.63	2661	2313	1.15	42
Sample 5	65% wool, 35% PA	compound twill weave	332	0.45	1055	1283	0.82	50
Sample 6	70% wool, 30% PA	plain weave	320	0.69	1470	1974	0.74	54
Sample 7	55% cotton, 45% PA	sateen weave	216	0.38	2509	2449	1.02	38
Sample 8	25% wool, 45% cotton, 30% PA	plain weave	172	0.41	1657	1991	0.83	40
Sample 9	50% wool, 20% cotton, 30% PAN	satin weave	286	0.50	7137	7973	0.9	35
Sample 10	75% wool, 25% PA	figured weave	322	0.94	6486	6746	0.96	36
Sample 11	40% wool, 30% PES, 30% cotton	compound figured weave	256	0.61	2045	2162	0.94	48
Sample 12	10% wool, 90% PES	compound twill weave	366	0.8	7718	6395	1.18	46
Sample 13	35% wool, 25% PES, 40% PA	compound twill weave	189	0.5	4698	4117	1.14	38
Sample 14	10% cotton, 90% PES	sateen weave	244	0.4	2024	2467	0.82	42
Sample 15	5% wool, 95% PES	plain weave	261	0.4	4230	2420	1.74	50
Sample 16	20% cotton, 50% PES, 25% PA	satin weave	169	0.4	2201	1727	1.27	51
Sample 17	100% PA	figured weave	293	0.50	9553	6047	1.57	38
Sample 18	40% wool, 60% PES	compound plain weave	232	0.51	2402	2338	1.03	42
Sample 19	65% wool, 35% PA	compound twill weave	246	0.50	4729	4594	1.03	36
Sample 20	70% wool, 30% PA	satin weave	247	0.41	2032	2090	0.97	35
Sample 21	55% cotton, 45% PA	plain weave	196	0.42	2439	2408	1.01	36
Sample 22	50% wool, 20% cotton, 30% PAN	plain weave	194	0.45	2554	2491	1.02	46
Sample 23	75% wool, 25% PA	sateen weave	199	0.41	2004	2002	1.0	53
Sample 24	40% wool, 30% PES, 30% cotton	plain weave	199	0.42	1638	2078	1.74	39
Sample 25	50% wool, 20% cotton, 30% PES	satin weave	288	0.82	3066	3208	0.78	35
Sample 26	75% wool, 25% PA	figured weave	245	0.59	2692	2694	1.57	43
Sample 27	40% wool, 30% PES, 30% cotton	compound figured weave	252	0.41	1401	1649	0.99	57

The average surface density of the tested fabrics varies from 170 to 250 g/m², which corresponds to the recommended values for suiting fabrics (Table 1). As it shown in the diagram (Figure 3), surface density of fabric is directly proportional to its thickness, so with an increase of thickness of fabric increases the parameter of its surface density. Samples 2, 10, 11, 12 and 25 have the biggest thickness, so their surface density is the biggest respectively. Despite this, some samples, for example, samples number 5, 20, 27, 7, 14 have average thickness but considerable surface density due to the fact that these samples have compound figured weave or satin weave.

For estimation of the obtained parameters of drapeability coefficient of the tested suiting fabrics the following diagram was presented (Figure 4).

Comparing the drapeability coefficients of the tested fabrics, we can see that fabric samples number 9, 20 and 25 have the lowest ability for draping, samples 3, 6, 23 and 27 – the biggest. Drapeability coefficient of the other samples varies on average within 35-50%, indicating the bad drapeability according to the Table 2. Just one third of the tested samples have the average drapeability.

For the analysis of obtained data and comparison flexural rigidity in the longitudinal and transverse directions of the tested suiting fabrics the following diagram was presented (Figure 5).

Rigidity of the tested samples of fabrics ranging from 2000 to 3000 μN.cm², it is less than the standard parameters for suiting fabrics. It can be due to the fact that modern fabrics have more dispersed structure, lower density, as the weave of fabric significantly affects the parameters of rigidity in warp and weft. Long overlaps of twists provide fabrics with greater thickness rather than short ones, that is why when other things being equal, fabric with the plain weave thinner than fabrics with satin or complex patterned weave. It is also well known that with the increase of the fabric density the yarn flattens or shifts and thickness of fabric increases. The highest flexural rigidity in both directions have samples 9, 10, 12 and 17, which thus have bigger thickness of about 1 mm and surface density as compared to other samples. Clearly traceable the regularity that with increase of fabric rigidity in warp its rigidity in weft increases as well.

Were determined the correlation connections between the physical and mechanical parameters of the tested samples of suiting fabrics (Table 4).

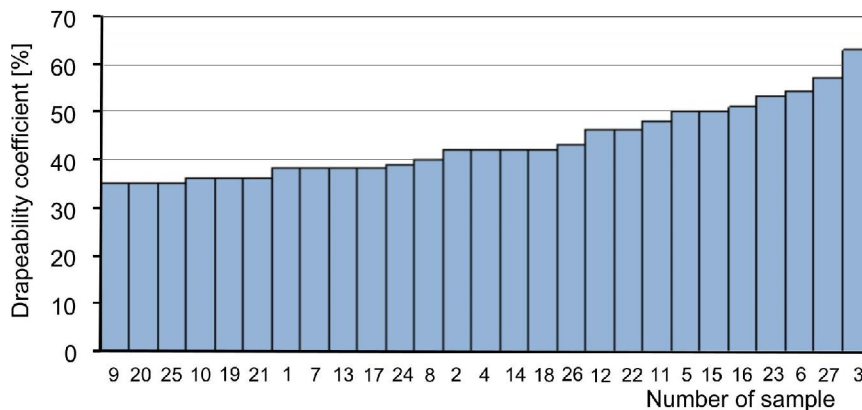


Figure 4 Drapeability coefficients of the suiting fabrics

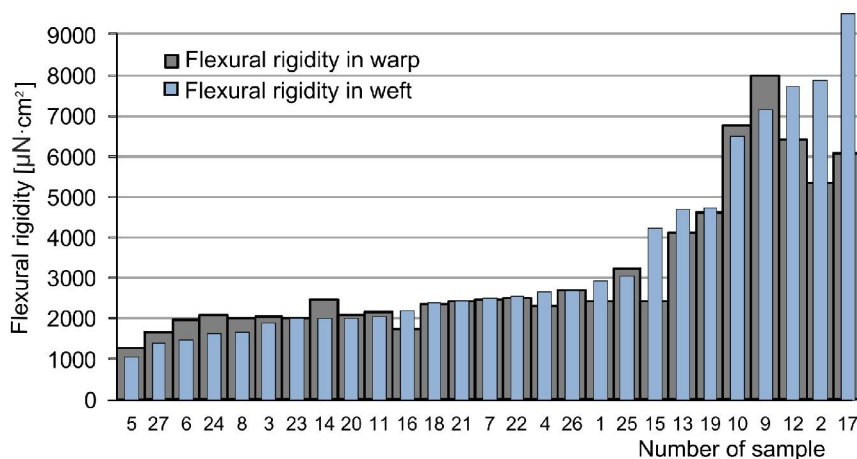


Figure 5 Flexural rigidity of the suiting fabrics in warp and weft

Table 4 Correlation connections between the values of physical and mechanical parameters of suiting fabrics

	Surface density [g/m ²]	Thickness [mm]	Flexural rigidity in warp [μN·cm ²]	Flexural rigidity in weft [μN·cm ²]	Rigidity coefficient [%]
Thickness [mm]	0.65	–			
Flexural rigidity in warp [μN·cm ²]	0.47	0.50	–		
Flexural rigidity in weft [μN·cm ²]	0.48	0.53	0.76	–	
Rigidity coefficient [%]	-0.11	-0.04	0.35	0.12	–
Drapeability coefficient [%]	0.17	-0.14	-0.37	-0.45	-0.08

The relevance of the correlation coefficients was determined from the table of the standard correlation coefficients. When the number of degrees of freedom is $(n - 2) = 27 - 2 = 25$, our calculated correlation coefficient p_{xy} should be higher than the table value 0.381, that corresponds to the probability of faultless prognosis of more than 95%. This allows us to suggest the resulting rank correlation coefficient as reliable. We identified the statistically significant coefficients in the Table 4.

The table shows that correlation connections have small or average degree. As a result of analysis, the directly proportional dependence of the surface density from the thickness of suiting fabrics was identified. Also was determined the directly proportional dependence of flexural rigidity in the longitudinal and transverse directions from the thickness of suiting fabrics.

4 CONCLUSIONS

Based on the comparative analysis, were indicated the key parameters of fabrics, which affect the creation of certain form of sewing products and can be taken into account during the design stage, such as thickness, surface density, drapeability coefficient and flexural rigidity in the longitudinal and transverse directions. Experimentally, according to the standardized methods, were identified the main physical and mechanical characteristics of fabrics of the suiting group. Analysis of experimental data showed that the raw components of fabrics do not affect significantly on their properties (drapeability, flexural rigidity). Fabrics with the different raw components can have the same or close values of these parameters. More significant is the weave of fabric, which has an effect on the rigidity characteristics of fabric in the longitudinal and transverse directions. Were identified the correlation connections between the physical and mechanical parameters of fabrics of suiting group and determined that there was the directly proportional dependence between the thickness and the surface density of fabrics and between the flexural rigidity in the longitudinal and transverse directions and the surface density. Conducted experimental researches are the basis

for development of the suiting group fabrics classification in terms of flexural rigidity for the purpose of developing the recommendations for designing the clothes of different three-dimensional forms.

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