Kalina Pashkevich[1], Maryna Kolosnichenko[1], Olga Yezhova[2], Olena Kolosnichenko[1], Nataliia Ostapenko[1]
[1] Kyiv National University of Technologies and Design, Faculty of Design, Nemirovich-Danchenko str. 2, 01011 Kyiv, Ukraine
[2] Volodymyr Vynnychenko Central Ukrainian State Pedagogical University, Shevchenko str. 1, 25006 Kropyvnytskyi, Ukraine

Study of Properties of Overcoating Fabrics during Design of Women's Clothes in Different Forms

Študija lastnosti tkanin med oblikovanjem ženskih vrhnjih oblačil različnih oblik

Short Scientific Article/*Kratki znanstveni prispevek*
Received/*Prispelo* 08-2018 • Accepted/*Sprejeto* 09-2018

Abstract
The article presents a study of the process of designing women's garments of the coating and suiting assortment, made from different fabrics to determine the fabric properties effect on the parameters of shaping the volume-silhouette form of clothes. An expert evaluation of the significance of material properties for the creation of tectonic forms of clothes was carried out and the most significant properties were determined, i.e. rigidity, thickness, drapeability, mass per unit area, type of weave, raw material composition. An experimental study of physical and mechanical characteristics of overcoating fabrics was performed. To validate the research results, we made samples of women's coats in different forms at a garment company. It was determined that the raw material composition of fabrics does not affect significantly their physical and mechanical characteristics (drapeability, rigidity). The weave of fabrics which determines other indicators was considered to be more significant. As a result, the relationships between the physical and mechanical properties of fabrics of the coat group and the shaping of women's coats in different volume-silhouette forms were identified. The latter can be used in the design of garments for an individual and mass production.
Keywords: clothing form, coat, fashion design, tectonic system, textile materials

Izvleček
V članku je predstavljena študija procesa oblikovanja vrhnjih ženskih oblačil, od plaščev do vrhnjih oblek, ki so bila izdelana iz različnih tkanin z namenom, da bi ugotovili vplive lastnosti tkanin na parametre oblikovanja volumske silhuete oblačil. Strokovno je bil ovrednoten pomen posameznih lastnosti materialov za ustvarjanje tekstonskih oblačilnih form. Med ugotovljene najpomembnejše lastnosti spadajo togost, debelina, pad, površinska masa, vezava in surovinska sestava materiala. Opravljena je bila analiza fizikalnih in mehanskih lastnosti izbranih tkanin za vrhnja oblačila. Preverjanje dobljenih rezultatov je bilo izvedeno na vzorcih ženskih plaščev različnih oblik, izdelanih v oblačilnem podjetju. Ugotovljeno je bilo, da surovinska sestava tkanin ne vpliva bistveno na njihovo togost in pad. Vezava tkanin se je izkazala za vplivnejši dejavnik. Posledično so bila ugotovljena razmerja med fizikalnimi in mehanskimi lastnostmi tkanin in oblikovanjem ženskih plaščev različnih volumskih oblik in različnih silhuet, ki jih je mogoče uporabiti pri oblikovanju oblačil po meri posameznika in za masovno proizvodnjo.
Ključne besede: plašč, modna oblačila, tektonski sistem, tekstilni materiali

Corresponding author/*Korespondenčna avtorica:*
Dr. Eng. Professor Kalina Pashkevich
E-mail: pashkevich.kl@knutd.com.ua

Tekstilec, 2018, ***61****(4), 224-234*
DOI: 10.14502/Tekstilec2018.61.224-234

1 Introduction

Modern fashion offers the consumer a wide range of volume, silhouette and design solutions of clothes made of various materials. In the theory of clothing design, fashionable structural parameters of the form, as well as the methods of shaping that determine the plastic properties of materials are given subjectively, giving rise to a number of inconsistencies to the architectonic demands of fashion.

The international experience of well-known brands in the fashion industry shows that the design of new forms and design & technological solutions of clothes begin with the consideration of material properties in order to create new design solutions, i.e. the modern process of designing clothes is based on the principles of tectonics. The tectonic approach to the formation of clothes should take into account not only the compositional features of goods, but also the physical and mechanical characteristics of materials the clothes are made from, providing the goods with the necessary level of ergonomics, aesthetics and quality in general. The main direction of the development of the tectonic approach to the design of clothes is the in-depth study of physical and mechanical characteristics of textile materials and the study of their influence on the tectonic form of clothes [1].

KyoungOk Kim, Shigeru Inui and Masayuki Takatera (2011) investigated the effect of pressing on the flexural rigidities of the fabric face side, adhesive interlining and bonded composite fabric, and verified the prediction method for the flexural rigidity of these. Predicting the methods of flexural rigidity for the composite with the fabric face side and adhesive interlining based on laminated theory were verified by measuring the flexural rigidities and thickness of samples using the KES-FB system [2].

Authors [3] made a comprehensive review of the measurement methods developed to evaluate the fabric and garment drape. Moreover, the parameters proposed for measuring drapeability were considered. The authors suggested that the use of the flat fabric methods does not accurately reflect the drape of fabrics when worn.

In the work [4], the author recommended quilted fabrics from the point of view of their usability for outdoor clothing on the basis of the results of the study of their comfort-related properties, e.g. thermal resistance, thermal conductivity, thermal absorptivity, water vapour resistance and air permeability.

In the research by C. K. Chan et al (2006), the Kawabata Evaluation System was adopted to investigate the mechanical properties of uniform fabrics currently in use on the basis of different commercial types of uniform materials obtained from different sources [5].

The paper [6] investigated the effect of a slight variation in the fabric structure and finishing on the flexural and drape properties of woven fabrics for tailored garments. The obtained results showed that a variation in weft density and weft yarn count can influence fabric flexural stiffness and drapeability.

Experimentally, the main physical and mechanical characteristics of fabrics of a suiting group were identified according to standardised methods. The conducted experimental researches represented the basis for the development of a suiting group fabrics classification in terms of their flexural rigidity to develop the recommendations for designing clothes of different three-dimensional forms [7].

The interdependence between the drape parameters and mechanical properties of fabrics was studied in [8]. A good correlation was found with the flexural and shear properties of the fabric.

Based on a series of laboratory experiments performed to investigate the total hand value and low-stress mechanical properties, the paper [9] compares the impact of fusible interlining and printable interlining on a woollen fabric using the Kawabata Evaluation System. The total hand value and five mechanical properties, i.e. tensile, flexural, shearing, surface friction and compression, were obtained. The results proved that printable interlinings can replace fusible interlinings on woollen fabrics and improve the fabric total hand value and its flexural, shearing and tensile properties.

The Kawabata Evaluation System was used to measure the mechanical properties of the samples of suiting fabrics and each sample was made into a shoulder-back as a part of a men's suit [10]. The aim of the paper [11] was to investigate the feasibility of using a wool handle metre as an economical and effective method to predict the handle characteristics of wool-rich woven fabrics suitable for winter suiting. An independent set of woven samples was selected to validate the regression models on the basis of the Kawabata Evaluation System for Fabrics, subjective handle evaluation and the formability index F-FAST.

The paper [12] compares the mechanical properties, hand and tailorability of wool blended fabrics for outerwear clothing. The fabrics in plain and twill weave of identical fibrous composition, and identical warp and weft count were tested on KESF-B instruments for the fabric objective evaluation under small loads. The mechanical properties of a plain and twill weave fabric showed the difference in its flexural, shearing and surface properties.

The authors [13] noted that fabric characteristics such as rigidity, drapeability, crease resistance, as well as relaxation characteristics, inherent to the single-cycle stretching of textile materials, have a significant impact on the quality of the appearance of garments.

To clarify the impact of fabric mechanical behaviour on the changes in form and quality of garment appearance associated with it, the impact of particular parameters of the fabric mechanical properties on the quality of the garment appearance was investigated in [14]. The obtained results indicated that the quality of the garment appearance is strongly affected by three components, i.e. formability, elastic potential and draping.

In the work by Petrova O. S. [15], it was determined that such groups of properties as physical and mechanical (rigidity, drapeability, crease resistance, thickness, linear density in warp (in weft), mass per unit area), artistic and aesthetics (colour, pattern, texture), and hygienic (thermal resistance and thermal conductivity) are the most important. As a result of further researches, the author found that rigidity, drapeability, crease resistance, linear density in warp (in weft), mass per unit area and thickness are the most important properties.

Kirsanova O. A. [16] considered the relationships between the structure of the form of a garment and the materials making it. In order to provide clothes with the form of a certain configuration, it was necessary to choose among the whole assortment range of materials only the ones that can in accordance with their physical and mechanical characteristics ensure the compliance with the given form and maintenance.

The authors [17] considered the uniformity of clothes and factors affecting this indicator. Despite the fact that they considered the stability and preservation of the form of clothes during their use, such conducted research can be used in the design stage as well. They found that the uniformity of clothes is a complex characteristic caused by the compositional, constructive features of clothes and by fabric properties. In their opinion, the following properties of fabrics affect the uniformity of clothes: flexural rigidity, raw material composition, thickness, mass per unit area, drapeability, type of weave, crease resistance.

It was confirmed by the research [18] that the following fabric characteristics have the greatest influence on the tectonic form of clothes: type of weave, thickness, mass per unit area, rigidity, drapeability, linear density and raw material composition.

The aim of this work was to determine the relationships between the physical and mechanical properties of fabrics of the coating group and the shaping of women's coats in different volume-silhouette forms which can be used in the design of garments for an individual and mass production.

2 Materials and methods

The main elements that characterise the form of clothes are volume, silhouette, compositional and constructive solutions, material, structure etc. Materials, in turn, affect the form of clothes by their aesthetic indicators (fabric appearance, texture, colour, decoration etc), and physical and mechanical characteristics. Depending on the values of these indicators, the purpose of goods, their model and design features, the technology of their production are determined.

In order to assess the significance of fabric properties to design the tectonic form of clothes, we conducted an expert evaluation. Expert and working groups consisted of 20 employees of experimental departments of the clothing companies Dolcedonna and Dana-moda (Kiev), i.e. draftsmen, artists-designers and technologists. The experience of the working group members in the design and manufacture of clothes is from 10 to 34 years; hence, they can be considered experts. In order to assess the significance, the following properties of fabrics were included in the questionnaire: raw material composition, type of weave, thickness, mass per unit area, linear density, flexural rigidity and drapeability. During the selection of indicators of fabric properties, aesthetic properties were not included since they cannot be estimated with instrumental methods.

The results of the survey showed that flexural rigidity (X_8, λ = 0.23) is the most important factor, followed by thickness (X_3, λ = 0.18) and drapeability (X_9, λ = 0.13) (Table 1). Other indicators are arranged in the following order: mass per unit area, type of weave, raw material composition, linear density, crease resistance, breaking load. The value of the concordance coefficient W = 0.76 indicates the level of consensus of the experts' opinions, since the table value of the Pearson criterion χ^2_T is less than the estimated χ^2_P, i.e. $\chi^2_T = 0 \div 12.6 < \chi^2_P = 21.5$.

Table 1: Fabric properties significant for design of tectonic form of clothes

Code	Indicator	Weight coefficient, λ
X_1	Raw material composition	0.09
X_2	Type of weave	0.10
X_3	Thickness	0.18
X_4	Mass per unit area	0.11
X_5	Crease resistance	0.05
X_6	Breaking load	0.03
X_7	Linear density	0.08
X_8	Flexural rigidity	0.23
X_9	Drapeability	0.13
	$\sum R = 0.5n\ (n+1)$	1.00

Thus, on the basis of the analysis, it was determined that the core indicators of fabrics which affect the creation of the tectonic form of a garment and which need to be taken into account in the design-projecting stage are flexural rigidity, thickness, drapeability coefficient, mass per unit area, type of weave and raw material composition.

With regard to the aim of the research, we decided to analyse 9 samples of overcoating fabrics of a different raw material composition with different properties (thickness, texture, mass per unit area, type of weave etc). The main focus was put on the determination of the following fabric properties: thickness, mass per unit area and linear density, flexural rigidity and drapeability. The research was held in accordance with valid standards, considering all the demands of the objects in the experimental research. The processing of the measurement results was made using a mathematical apparatus for a statistical data analysis.

The thickness of the material was determined by using the manual thickness tool of indicative type TP 10-1 [19]. The linear density and mass per unit area of fabrics were measured in accordance with GOST (State Standard) 3811–72 [20]. For the analysis of fabric rigidity by the console contactless method, we used the device type ПТ-2 in accordance with GOST (State Standard) 10550-93 [21] (Figure 1).

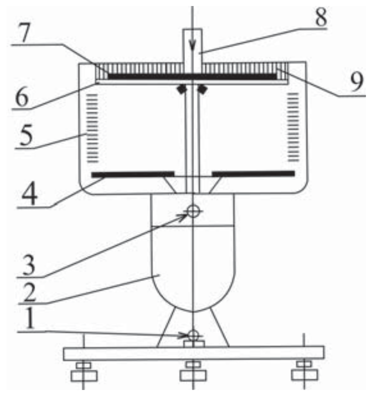


Figure 1: Scheme of device type ПТ-2 for determination of fabric rigidity by console method (State Standard of Russia [21]): 1 – tumbler, 2 – moving mechanism, 3 – screw, 4 – indicator of fabric flexure, 5 – scale of absolute flexure, 6 – horizontal plane, 7 – sample, 8 – weight, 9 – scale of symmetry checking

The methodology of experiments was as follows: five elementary samples in longitudinal and transverse directions, 160 × 30 mm in size, were cut out; prepared tested strips had to be kept in climatic conditions for not less than 24 hours before the testing [22]; the test had to be conducted at the same conditions; elementary samples of each direction (5 samples of each direction) were weighed on scales with the error no higher than 0.01 g and the total weight m (g) of samples of longitudinal and transverse directions was determined.

An elementary sample was placed on the supporting horizontal plane 6 face side up and symmetrically to the midline, combining the outer edge of the sample and the plane. In the middle of the sample put the weight 8 with the 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 the elementary sample from the surface of the plane 6, the ends flexure *f* of the sample were measured using the indicator of the fabric flexure 4. As the final flexure, we took the arithmetic average of 10 measurement results of each direction with the error no higher than 1 mm. The conventional value of rigidity EI (μN·cm^2) was calculated separately for the longitudinal and transverse directions with equation 1:

$$EI = 42046 \times \frac{m}{A} \quad (1),$$

where m is the total weight of all five elementary samples of the fabric (g), A is the function of relative flexure f_0, which is determined in the standard [21] according to the value f:

$$f_0 = \frac{f}{l} = \frac{f}{7} \quad (2),$$

where f is a value of the arithmetic average of flexure of samples (cm), l is the length of the weighed sample (cm) and is equal to:

$$l = \frac{(L - 2)}{2} = 7 \text{ cm} \quad (3),$$

where L is the length of an elementary sample (cm).

The rigidity coefficient of a material C_{EI} (%) was calculated as the ratio of rigidity values in longitudinal and transverse directions:

$$C_{EI} = \frac{EI_{\text{longitudinal}}}{EL_{\text{transverse}}} \quad (4).$$

The recommended values of mass per unit area and conventional rigidity of fabrics of the overcoating group are presented in Table 2 [23].

Table 2: Oriented values of mass per unit area and flexural rigidity of fabrics of overcoating group

Group of fabrics	Mass per unit area [g/m^2]	Flexural rigidity [μN·cm^2]
Cotton	200–400	6000–100,000
Linen	200–400	6000–100,000
Wool	250–400	6000–100,000
Synthetic fibres	150–300	6000–100,000

The research of drapeability of samples of suiting fabrics was performed on a device for the determination of drape by the disk method [24], since it was necessary to evaluate the fabric drapeability in their longitudinal and transverse directions at the same time. This method is not standardised; however, it is used very often in the garment industry due to its simplicity. The scheme of the device is given in Figure 2.

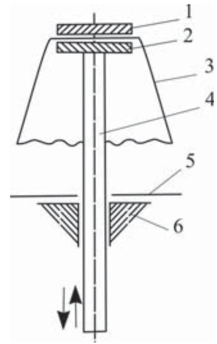


Figure 2: Scheme of device for determination of fabric drapeability by disc method (Buzov B. A. et al, Russia [24]): 1 – pressed disc, 2 – table, 3 – fabric sample, 4 – rod, 5 – paper circle, 6 – horizontal plane

Fabric sample 3 that was cut as a circle with the diameter of 200±1 mm was put on table 2 with the diameter of 50±1 mm, which had a needle for fixing the sample. On the top of the sample, the pressed disc 1 was placed, the size and shape of which matched the size and shape of table 2. The table was lifted. The edges of the sample were hanging down. In order to provide the sample with a constant natural form, the disc with the sample was lifted up and moved down 5 times and after 3 min, the projection of sample 3 outlined on a paper circle with the diameter of 200±1 mm, which can be obtained by lighting from the top by parallel rays of a light perpendicular to the sample plate. Afterwards, the projection area of the material was determined.
During the research of fabric samples, the drapeability coefficient (C_d) was calculated using the results of weighing paper (with an error no more than 0.001 g) cut in accordance with the projections of undraped sample (mass m) and draped (mass m_d) with equation 5:

$$C_d = 100 \times \frac{(m - m_d)}{m} \quad (5),$$

where m is the projection area of an original undraped sample (g) and m_d is the projection area of a draped sample (g).
The recommended values of the drapeability coefficient C_d for the main functional groups of fabrics are presented in Table 3 [23].

Table 3: Estimation of drapeability degree of fabrics of different types

Type of fabric	Drapeability coefficient, C_d [%]		
	Good, more than	Satis-factory	Bad, less than
Woollen clothing	80	68–80	68
Woollen suiting	65	50–65	50
Woollen overcoating	65	42–65	42

3 Results

The tectonic system of the first type (TS1) is typical of the types of clothes, the form, the silhouette and the cutout which are subordinate to the human body outlines. The form of such clothes is characterised by a small degree of volume and an adjoining silhouette, and is formed in line with the properties of the material and its cut. The tectonic system of the second type (TS2) is less dynamic than of the first type and it can have one or two supporting areas (for shoulder products). Such products have a small or medium three-dimensional form, semi-adjoining silhouette, they are X-shaped, rectangular or expanded to the lower part. The clothes of such tectonic systems freely interact with the figure of a person and are kept mainly on the constructive belts of the figure. The tectonic system of the third type (TS3) is embodied in the goods the form of which remains relatively unchanged in the dynamics and, in most cases, does not obey the human figure. Such goods are characterised by greater static, rigidity and the presence of one supporting area which holds the entire construction. This system is characterised by large volume, and rectangular or trapezium shaped forms. The tectonic system of the fourth type (TS4) is characterised by preferred static, large or very large volume of the form, and an extended, less direct silhouette. The form of clothes is rigid or very rigid and is of trapezium, oval or rectangular form.

As a result of the conducted analysis of modern clothes, the assortment range of clothes which are typical of different types of tectonic systems was defined [25]. The clothes of the tectonic system of the first type are presented by knitted or elastic fabric dresses, skirts, jumpers, lingerie and corsets that repeat or fix the human body. The clothes of the tectonic system of the second type are presented by dresses, blouses, trousers, jackets. The tectonic systems of the third and fourth types are characterised by rigid or very rigid forms; therefore, the clothes of coating & suiting assortment range (jackets, raincoats, coats, cardigans, waistcoats) are typical of these systems (Figure 3).

TECTONIC SYSTEM OF CLOTHES			
TS1	TS2	TS3	TS4
Dynamic, small three-dimensional form, adjoining silhouette, both soft and rigid (fixing) forms	Dynamic, small and medium three-dimensional form, semi-adjoining silhouette, soft form of clothes	Preferably dynamic, medium and large three-dimensional form, straight and extended silhouette, rigid form of clothes	Preferably static, large and very large three-dimensional form, extended silhouette, rigid and very rigid form of clothes
			

Figure 3: Classification of tectonic systems of clothes

A women's coat is the most diverse as to the constructive and decorative solutions type of clothing, which determines the immediacy of the problem of taking into account the properties of overcoating fabrics when designing clothes of the third and fourth type of tectonic systems. The question of the formalisation of the methods of designing the tectonic forms of women's coats made of different materials remains unresolved.

At a garment company, we selected the fabric samples, and their basic physical and mechanical characteristics were determined in the research laboratory using standardised methods. As the result of experimental research, the properties of nine samples of overcoating fabrics were identified (Table 4).

The results of the experimental research showed that samples F1 and F8 had the biggest thickness, whereas samples F3 and F4 had the smallest thickness. Samples

Table 4: Physical and mechanical characteristics of overcoating fabrics

Fabric sample	Raw materials [%]	Weave	Mass per unit area [g/m²]	Yarn linear density [tex]		Thickness [mm]	Flexural rigidity [μN·cm²]		Rigidity coefficient	Drapeability [%]
				warp	weft		warp	weft		
F1	60% wool/40% polyester	harness-satin	360	105	102	1.42	6569	5913	1.11	45
F2	20% wool/80% polyester	basket	379	133	307	1.40	7777	7843	0.99	51
F3	79% wool/17% polyacryl onitrile/4% elastane	plain	443	155	141	1.06	6563	7496	0.87	36
F4	80% wool/20% poly-acrylonitrile	plain	353	108	118	1.00	8195	4935	1.66	42
F5	100% wool	compound double-cloth	372	108	113	1.34	12909	9960	1.29	43
F6	100% wool	broken twill	362	80	184	1.34	43337	44955	0.96	25
F7	40% wool/60% polyester	twill	366	61	32	1.18	15377	39226	0.39	29
F8	30% wool/20% cotton/50% polyester	compound double-cloth	485	75	95	1.46	37731	31124	1.21	25
F9	60% wool/40% polyester	pile construction	457	92	161	1.40	7903	9329	0.85	45

F3, F8 and F9 had the maximum mass per unit area, when sample F4 had the minimum one. As presented in Table 2, the interdependence between the parameters of thickness, mass per unit area and type of weave was shown in this sample. For example, sample F8 had the biggest thickness and maximum mass per unit area, due to its complex double-layer weave. Sample F4 of linen weave was characterised by the smallest indicators of investigated quantities. However, other samples did not show such interdependence, which can be explained by the different structure of yarn and threads in samples, as well as by different weaves.

The results of measuring linear density showed that samples F1, F3, F4, F5 and F8 had insignificant differences between the values of linear density in warp and weft. The values of linear density in warp and in weft of other samples differed from each other (Figure 4).

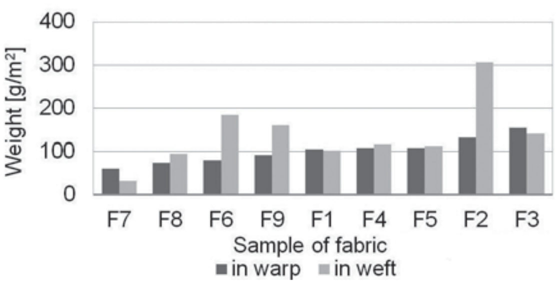


Figure 4: Comparison of mass per unit area of samples of overcoating fabrics in warp and weft

The rigidity indexes of investigated fabrics in warp and in weft were determined. Comparative characteristics of flexural rigidity of fabrics in warp and in weft are provided in Figure 5.

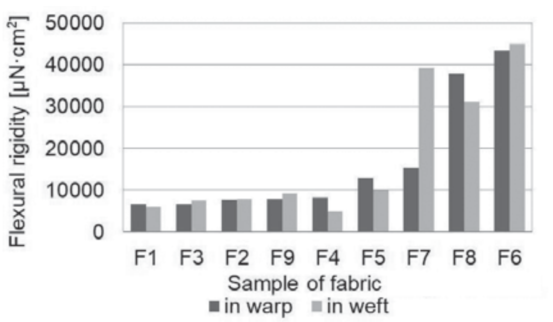


Figure 5: Comparison of flexural rigidity of investigated fabrics in warp and weft

The ratio of rigidity indicators in warp and weft is reflected through the rigidity coefficient. We found that for most samples, i.e. samples F1, F2, F3, F5, F6 and F9, the rigidity coefficient was close to 1, whereas samples F4 and F7 had significant deviations from 1, indicating the fact that such fabric samples have different flexural rigidity in warp and weft. In addition, as it can be seen from the diagram, samples F6 and F8 had significantly higher rigidity as they had the biggest thickness, mass per unit area and complex weave. The analysis of experimental data showed that samples F3 and F6 were better draped in their longitudinal direction, sample F7 had better drapeability in warp, while other fabrics had the same ability to drape in both directions. The drapeability coefficients, determined by us, showed that sample F2 had the best draping ability, whereas samples F6 and F8 had the worst. The inverse relationship of the drapeability coefficient and flexural rigidity in warp and in weft of investigated fabric samples was determined (Figures 6 and 7). The more rigid the structure of the material, the greater the force which is required to bend it and the worse the drapeability. An increase in density and mass per unit area of the fabric causes an increase in fabric rigidity, and at the same time a decrease in its drapeability.

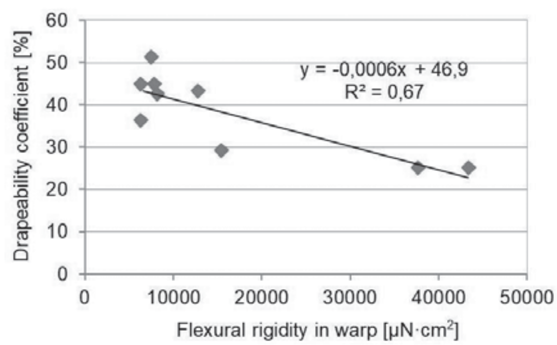


Figure 6: Drapeability coefficient vs flexural rigidity in warp

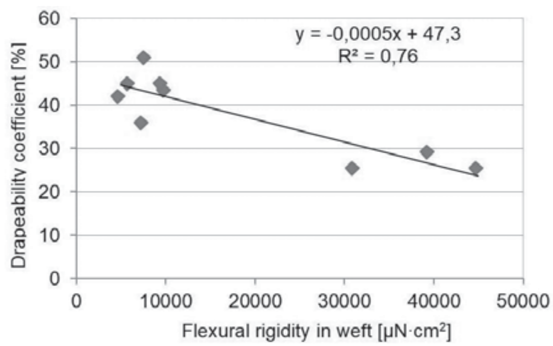


Figure 7: Drapeability coefficient vs flexural rigidity in weft

It was determined that raw material composition of the fabrics did not affect crucially their physical and mechanical characteristics (drapeability, flexural rigidity), since fabrics of different raw material composition were used in the research. The weave of fabrics was considered to be more important since it determines other physical and mechanical characteristics, a complex fabric weave increases its thickness and rigidity.

In order to provide recommendations as to the design of clothes taking into account the properties of overcoating fabrics, all analysed samples were divided into three groups in accordance with their flexural rigidity. Very soft forms are not characteristic of clothes of the coating assortment range; therefore, a classification was applied to soft, rigid and very rigid forms (P2, P3 and P4). The overcoating fabrics should be used with the rigidity of up to 12000 $\mu N{\cdot}cm^2$ for the manufacture of soft form goods; 12000–30000 $\mu N{\cdot}cm^2$ for rigid; more than 30000 $\mu N{\cdot}cm^2$ for very rigid forms. The samples of overcoating fabrics are recommended for the manufacture of garments of different plastic forms, i.e. samples F1, F2, F4, F5 and F9 for the manufacture of soft form clothes (P2); samples F3 and F8 for rigid forms (P3); samples F6 and F7 for a very rigid form (P4) (Table 5).

At the garment company Dolcedonna (Kyiv) [26], the samples of coats of different tectonic systems were manufactured from analysed fabrics and the theoretical recommendations which were provided by us on the basis of fabric properties were verified (Table 5). Photos of finished goods are presented in Figure 8. The recommended and obtained type of the coat tectonic system is included in Table 6.

Having analysed the selected samples of materials and manufactured models of women's coats, we found out that four among six variants have the same recommended type of the tectonic system for the goods made of the selected material as well as the same model (Table 6).

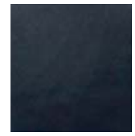
All manufactured coats had a backing (100% PES) and were reinforced with the same adhesive interlining on the fronts, collars, cuffs of the coats, which provided the same base conditions for the analysis of the obtained results and reliability of the experiment. During the design of models from samples F1, F3, F5 and F7, the material properties were taken into account; therefore, for these fabrics, the recommended type of the tectonic system matches the actual one in the finished goods. Sample F4 was characterised by a small flexural rigidity indicator and is hence recommended for the manufacture of goods TS3. Nevertheless, it can be

Table 5: Classification of overcoating fabrics by type of tectonic systems

Parameter	Fabric sample								
	F1	F2	F3	F4	F5	F6	F7	F8	F9
Plasticity of form (P)	Soft (P2)	Soft (P2)	Rigid (P3)	Soft (P2)	Soft (P2)	Very rigid (P4)	Very rigid (P4)	Rigid (P3)	Soft (P2)
Type of tectonic system (TS)	TS3	TS3	TS3	TS3	TS3	TS4	TS4	TS4	TS3

Figure 8: Models of women's coats of different tectonic systems made from investigated fabrics

Table 6: Analysis of correspondence of overcoating fabrics and tectonic systems of women's coat models

Parameter	Fabric sample					
	F1	F3	F4	F5	F7	F9
Appearance of fabric sample						
Recommended type of tectonic system (TS)	TS3	TS3	TS3	TS3	TS4	TS3
Obtained type of tectonic system	TS3	TS3	TS4	TS3	TS4	TS4

seen from Table 4 that the actual type of the tectonic system of finished goods is TS4 (huge volume of the form, straight silhouette). Analogous, sample F9 is recommended for TS3, whereas the finished goods belong to TS4 (huge volume of the form, geometric form is oval). It should be noted that in both cases, the material was not rigid enough to create the tectonic form defined in the draft; however, due to the use of adhesive layers, more rigidity was achieved, making it possible to use the indicated fabrics for the creation of volume and form-stable goods.

As a result of the approbation, it was determined that the proposed recommendations regarding the design of tectonic forms of women's coats from the fabrics with different physical and mechanical characteristics enable a shorter time of designing new clothes models. Our recommendations regarding the selection of overcoating fabrics provided by us, which should be used for designing the tectonic forms of clothes depending on their physical and mechanical characteristics during the designing of the new forms of the clothes from various materials, have been tested during the manufacture of the women's coats collections, season autumn-winter 2018–2019.

4 Conclusion

Based on the theoretical research and expert evaluation, we identified the main characteristics and properties of materials which affect the creation of the predictable, in the design conditions, tectonic form of clothes and must be taken into account in the design stage. These are rigidity, thickness, drapeability, mass per unit area, type of weave, raw material composition and linear density. The connection between the plastics of forms and the fabric properties was analysed and a classification of materials in accordance with the types of tectonic systems was developed. It was determined that the raw material composition of fabrics in this research does not affect significantly their physical and mechanical characteristics (drapeability, rigidity). The type of weave is more important and determines other indicators. The recommendations regarding the design of clothes of a certain tectonic system were developed based on the determination of their physical and mechanical properties. These recommendations were checked experimentally by manufacturing samples of women's coats at a garment company. A comparable analysis of recommended types of tectonic systems was conducted based on the results of the determination of sample properties and actual types of tectonic systems in the finished clothes from the collection.

References

1. PASHKEVICH, K. *Design of tectonic forms of clothing taking into account the properties of fabrics*. Kyiv : SPC „Profi", 2015, p. 364.
2. KYOUNGOK, Kim, SHIGERU, Inui, MASAYUKI, Takatera. Verification of prediction for bending rigidity of woven fabric laminated with interlining by adhesive bonding. *Textile Research Journal*, 2011, **8**(6), 598–607, doi: 10.1177/0040517510387212.
3. SANAD, Reham, CASSIDY, Tom, CHEUNG, Vien. Fabric and garment drape measurement - part 1. *Journal of Fiber Bioengineering and*

Informatics, 2015, **2**(4), 341–358, doi: 10.3993/jfbi12201201.

4. MATUSIAK, Malgorzata. Study of quilted fabrics used in outdoor clothing. *Tekstilec*, 2017, **60**(4), 302–309, doi: 10.5604/12303666.1227883.
5. CHAN, C. K., JIANG, X. Y., LIEW, K. L., CHAN, L. K., WONG, W. K., LAU, M. P. Evaluation of mechanical properties of uniform fabrics in garment manufacturing. *Journal of Materials Processing Technology*, 2006, **174**, 183–189, doi: 10.1016/j.jmatprotec.2006.01.002.
6. NOFITOSKA, Maja., DEMBOSKI, Goran., CARVALHO, M. Â. F. Effect of fabric structure variation on garment aesthetic properties. *Tekstil ve konfeksiyon*, 2012, **2**, 132–136.
7. XIAOHUI, L., WANGA, Y., LUA, Y. Effects of body postures on clothing air gap in protective clothing. *Journal of Fiber Bioengineering & Informatics*, 2011, **4**(3), 277–283.
8. BEHERAA, B. K., PATTANAYAK, Ajit Kumar. Measurement and modeling of drape using digital image processing. *Indıan Journal of Fiber and Textile Research*, 2008, **33**, 230–238.
9. ZHANG, Qian, KAN, Chi-wai. Property comparison of woollen fabrics with fusible and printable interlinings. *Fibers and polymers*, 2018, **19**(5), 987–996, doi: 10.1007/s12221-018-8167-2.
10. XUE, Zhebin, ZENG, Xianyi, KOEHL, Ludovic. An intelligent method for the evaluation and prediction of fabric formability for men‘s suits. *Textile Research Journal*, 2018, **88**(4), 438–452, doi: 10.1177/0040517516681956.
11. SUN, Fengxin, DU, Zhaoqun, NAEBE, Maryam. Determination of model parameters for predicting handle characteristics of wool-rich suiting woven fabrics based on the Wool HandleMeter and KES-F. *Journal of The Textile Institute*, 2018, **109**(2), 147–159, doi: 10.1080/ 00405000.2017.1334308.
12. JANKOSKA, M., DEMBOSKI, G. Comparison of mechanical properties, hand and tailorability of wool blended fabrics for outerwear clothing. *Industria Textila*, 2017, **68**(1), 69–74.
13. SAVCHUK, N., IOKST, N. Analytical methods of estimation and forecasting of the level of quality of sewing products. *Light industry*, 2014, **1**, 12–13.
14. GERSAK, Jelka. Investigations of the impact of fabric mechanical properties on garment appearance. *Tekstil*, 2003, **52**(8), 368–379.
15. PETROVA, E. *Development of technology for the rational confectioning of fabrics under the project of a single-shaft clothes: Extended abstract of Doctor's thesis*. Moscow, 2006, p. 18.
16. KIRSANOVA, E. *Forecasting of the structure and properties of textile materials for the creation of clothes of the given form*. Moscow : IIC MGUDT, 2005, p. 161.
17. TIHHONOVA, T, GOLUBEVA, E., POLYAKOVA, I. On the question of the assessment of uniformity of clothing. *Sewing industry*, 2009, **3**, 46–47.
18. PASHKEVICH, K. L., KOLOSNICHENKO, M. V., OSTAPENKO, N. V. Research of some physical and mechanical characteristics of suiting fabrics for designing the clothes. *Vlakna a Textil*, 2016, **1**, 3–8.
19. GOST (State Standard) 12023-2003: Textile materials and products from them. Method for determination of thickness. *Standartinform*, Moscow, 2003, p. 14.
20. GOST (State Standard) 3811-72: Textiles. Fabrics, non-woven fabrics and piece wares. Methods for determination of linear dimensions, linear density and weight, *Publishing House of Standards*, Moscow, 1973, p. 14.
21. GOST (State Standard) 10550-93: Textiles. Cloth. Methods for determination of flexural rigidity. *Interstate Council for Standardization, Metrology and Certification*, Moscow, 1993, p. 15.
22. GOST (State Standard) 10681-75: Textiles. Climatic conditions for the conditioning and testing of samples and methods of their determination. *Publishing House of Standards*, Moscow, 1975, p. 27.
23. BUZOV, B. A., RUMYANTSEVA, G. P. Materials for clothes. Fabrics. *Publishing center «FORUM» : INFRA-M*, 2012, p. 224
24. BUZOV, B. A., ALYMENKOVA, N. D., PETROPAVLOVSKIY, D. G. Workshop on Material authority in garment production. *Publishing center "Academy"*, Moscow, 2004, p. 416.
25. PASHKEVICH, K., KOLOSNICHENKO, M., FROLOV, I., GERASIMENKO, O., SKRIPCHENKO, A. Design of clothing systems on principles of tectonic approach. *Bulletin of KNUTD*, 2017, **3**, 249–256.
26. Official cite DOLCHEDONNA [online]. Available on World Wide Web: https://dolcedonna.com.ua/.