PROVISION OF THE QUALITY OF DECORATION OF SEMI-FINISHED FASHIONABLE CLOTHES, MADE OF SUITING FABRICS WITH COTTON CONTENT (DENIM TYPE)

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Abstract: *The article is devoted to the problem of provision of the quality of decoration of semi-finished fashion products from the fabrics of suiting group of denim type, embroidered by a machine method. Standard methods of the research of geometric properties of textile materials (thickness, surface density), as well as rupture characteristics at constant-rate-of-extension (CRE) testing machine (force at rupture, extension) are used. The embroidery of the samples is made using the Brother Innovis 750S machine. As a result of the analysis of 7 samples of the materials of suiting group, "stretch-denim" type, it is found that elongation at rupture in weft of all of the samples exceeds the value of such indicator in warp and reaches 37.5%, and the samples with elastane and polyamide content have higher value of the indicator. The conducted correlation analysis showed a strong correlation between weight and force at rupture in warp (r = 0.84), as well as between weight and thickness (r = 0.74). All samples of denim-like fabrics are conventionally divided into 3 groups in accordance with their elongation at rupture in weft: 1) 30 - 40%; 2) 20 - 30% 3) 15 - 20%. Classification of the defects of embroidered semi-finished products is improved. All defects are divided into: 1-dimensional (stitch defects); 2-dimensional (defects of setting the fabric in the embroidery frame, embroidery defects); and 3-dimensional (deformation of the embroidered area; deformation of the area, adjacent to the embroidered area; deformation of the materials along the embroidery frame line). The method of evaluation of the quality of semi-finished products embroidery using the 4-point scale (where 0 - unsatisfactory, 3 - no identified defects) is proposed. Evaluation of embroidery with a complex design is recommended to be carried out separately for each area of the image. The use of a duplicate glutinous material for stabilization of semi-finished products, made of denim-like fabrics, for machine embroidery is recommended. The research is a contribution to the development of fashion design of the products, made of denim-like fabrics, decorated with machine embroidery.*

Keywords: *fashion design, decoration, denim, fabric, machine embroidery, quality, stabilization of semi-finished product.*

1 INTRODUCTION

The development of the design of modern clothes begins with the selection of the materials: basic, applied, decorative etc. When choosing the parameters of the design and the methods of processing and decoration of the product, it is necessary to consider the properties of the materials: fiber composition, physical and mechanical properties, technological features etc. That is why the study of the properties of the materials at the pre-design stage takes an important place in design-projecting of the modern clothes. Recently, designers and users of the fashion clothes have turned their attention to the products from suiting and dressing assortment range, which are made of denim and denim-like materials: trousers, shorts, skirts, dresses, jackets, vests. The author of the article [1] considers that «we're in an exciting era of reinvention for denim». An up-to-date decoration of such products is embroidery. Modern and effective way of embroidery for semi-finished products is embroidery on computerized machines using the double-thread lock stitch (machine embroidery). This process requires a reasonable selection of technological modes of execution of embroidery operation and selection of stabilizing materials, depending on the properties of the main material of the product. Embroidery of the fabrics with stretch effect (elongation) requires special care, since such materials can deform the most during the embroidery, sewing and operation. Thus, selection of the optimal models of machine embroidery on the elastic suiting materials of "stretch-denim" type is an actual task, the solution of which can ensure the quality of embroidered semi-finished products.

The purpose of the article is the development of recommendations regarding the provision of the quality of semi-finished products, made of the fabrics of suiting group, denim type, embroidered by machine, taking into account the properties of the materials. For this purpose, the following tasks should be solved:

- determination of composition and indexes of physical and mechanical properties of the materials of suiting group of "stretch-denim" type;
- development of methodology of evaluation of the quality of embroidery on semi-finished products;
- selection of the optimal package of materials for stabilization of the materials for machine embroidery;
- development of recommendations regarding machine embroidery on the materials of suiting group of "stretch-denim" type.

2 LITERATURE REVIEW

The problem of determining the physical and mechanical properties of suiting materials (denim type) with the cotton content is at the center of attention of a number of researches.

In the research [2], tensile properties of elastic denim fabrics are studied using the KES-F system. In particular, it has been found that the fabrics with higher polyester content and lesser cotton content recover better after stretching. In the research [3], as a result of the analysis of suiting fabric with cotton fibers, it has been identified that the main physical and mechanical characteristics that have an effect on the shape and design of the clothes are thickness, surface density (weight), rigidity and drapeability of the fabric. The influence of the characteristics of denim on its sewing properties is studied in the study [4]. The author has developed and implemented the method of forecasting the quality of stitching, depending on the properties of denim and the parameters of the stitch.

In the article [5], the author has selected the most suitable washing treatment for denim-like knitted fabrics to prevent the loss of strength. In the study [6], the denim for the clothes for motorcycle riders is developed. Such created material has the increased tensile strength and abrasion resistance in comparison with the classic denim. The assessment and provision of the quality of the embroidered semi-finished products have become the subject of the scientific research of the researches. In the study [7], the dependence of the embroidery machine vibration on the parameters of the embroidery pattern is identified. In the article [8], it has been found the following dependence: the higher the level of heat gathered in the thread, the higher the risk of thermal damage. The study [9] is dedicated to the synergism of design and technology in order to optimize the quality of the embroidered elements. The technique of designing and analysis of the design for the machine method of embroidery is discussed in the following publications.

In the article [10], the technology of creation the embroidery design by means of the universal CAD system is considered. In the paper [11], an automated analysis system for Tatami embroidery fabric images is proposed.

At the same time, we could not find any publications in which the scientifically grounded recommendations regarding the technology of stabilization of the fabric during the machine embroidery are described. Therefore, the problem of the choice of stabilizing materials for machine embroidery is not sufficiently researched and needs to be considered.

3 MATERIALS AND METHODS

In accordance with the aim and the objectives of the researches, 7 samples of suiting elastic fabrics of denim type with cotton twill weave, which differ as to their geometric and physical and mechanical properties, have been selected for the experiment (Table 2, Columns 1, 2). In order to characterize the fabrics, the following indicators have been selected. General properties are determined by the fibrous composition (%) and the structure of the interweaving (for all of the samples it is twill). Geometrics parameters are described using such indicators as thickness and surface density. The main characteristic that distinguishes the selected materials among the other suiting fabrics of denim type is elasticity. In this regard, mechanical tensile characteristics have been determined, such as: force at rupture *Pr* [N], relative force at rupture P_{rel} [Nm/g], breaking extension *Lr* [mm] and relative breaking elongation *Er* [%]. Depending on the values of these indicators, assortment range and design of the product, technology of its manufacture and decoration are determined.

Testing of the properties of materials has been carried out in accordance with the current normative documents, observing the regulations to the objects of the experimental research; the processing of the results of the measures has been made using the mathematical apparatus of statistical analysis of data. The test has been conducted in climatic conditions in accordance with ISO Standard 139:2005 [12]. Before the test, each sample is kept in climatic conditions (relative humidity of 65±4% and temperature of 20±2°C) not less than 24 hours. Thickness is measured under the pressure of 1 kPa according to ISO standard 5084-1996 [13]. Weight *Ms* in g/m^2 is determined in accordance with ISO standart 3801:1977 using the formula (1):

$$Ms = \frac{m \times 10^4}{L \times b} \quad (1)$$

where *Ms* – weight [g/m^2]; *m* – mass of the point sample [g]; *L* – length of the sample [mm]; *b* – width of the sample [mm].

The mechanical characteristics of elongation are determined by standard strap method in accordance with ISO standard 13934-1:2013 [14]. From each sample, 6 test samples with a size of 350x50 mm are taken, 3 in warp and 3 in weft. The study has been carried out at a tensile-test machine (Figure 1) with a constant rate of extension (CRE) 100 mm per min. The gauge length of the samples is 200±1 mm.

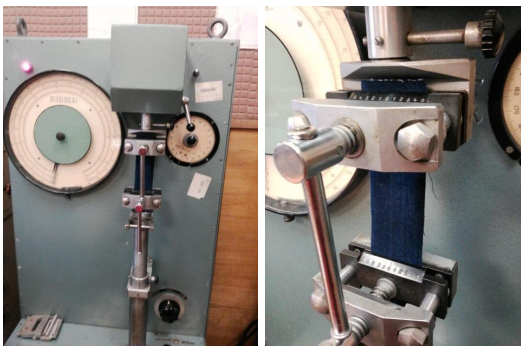

Figure 1 The research of rupture characteristics

The following characteristics are measured: force at rupture *Pr* [N], and breaking extension *Lr* [mm].

In order to compare the properties of the fabrics of various mass, the relative force at rupture P_{rel} [Nm/g] is determined using the formula (2):

$$P_{rel} = P_r / M_s b \quad (2)$$

where *Pr* - force at rupture [N]; *Ms* – weight of the fabric [g/m^2]; *b* – width of the sample of the fabric [m].

In order to compare the breaking extension of the materials regardless of the squeezed length of the sample, the relative breaking elongation *Er* [%] is determined using the formula (3):

$$Er = 100 \times Lr / L_0 \quad (3)$$

where L_0 – the initial length of the sample.

During the evaluation of the properties of the samples, the recommended values of indicators for suiting cotton fabrics, including denim, have been taken into account (Table 1).

Table 1 Oriented values of the properties of suiting fabrics of denim type in accordance with [15]

Indicator	Units	Recommended value		
		Total	In warp	In weft
Thickness	mm	0.5-0.9	-	-
Weight	g/m^2	150-300	-	-
Force at rupture	N	-	785-981	392-589
Elongation at rupture	%	-	15-20	15-20

4 RESULTS

As a result of the conducted experimental research, the properties of 7 samples of suiting fabrics (denim type) have been determined, which have different raw material composition, thickness, surface density and other physical and mechanical properties. All identified characteristics are generalized in Table 2.

To illustrate the results of the measures of thickness and surface density of denim-like fabrics, the diagram (Figure 2) is constructed, where the samples are ranged as to the growth of their weight values.

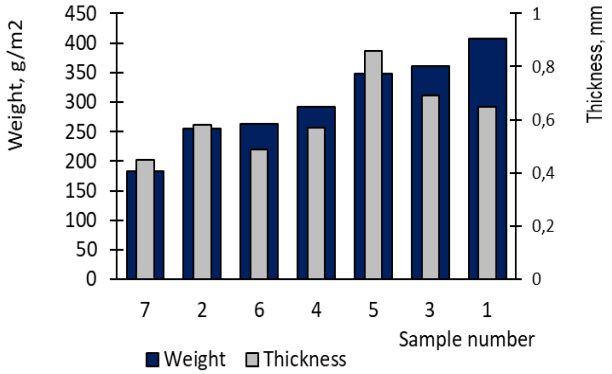

Figure 2 The interdependence between weight and thickness of the denim-like fabrics

The thickness of the fabric depends on the linear density of the yarn and its twist, the structure of the threads weaving, the density and the nature of processing of the fabric. Samples 3 and 5 have the largest thickness (0.69 and 0.86 mm respectively). Samples 6 and 7 have the lowest thickness (0.49 and 0.45 mm respectively). Consequently, the thinnest sample has the thickness almost 2 times smaller than the thickest one. Surface density depends on the thickness of warp and weft threads, on the density of the fabric and on the type of processing. Sample 1 has the maximum weight (407 g/m^2), sample 7 – the minimum weight (183 g/m^2).

In order to illustrate the results of the measurements and calculations of the elongation at rupture for denim-like fabrics, a diagram (Figure 3) is constructed, in which the samples are located on the basis of the elongation at rupture growth in warp. Characteristics of material elongation at rupture depend on the fiber composition, on the density and the structure of threads and fabric.

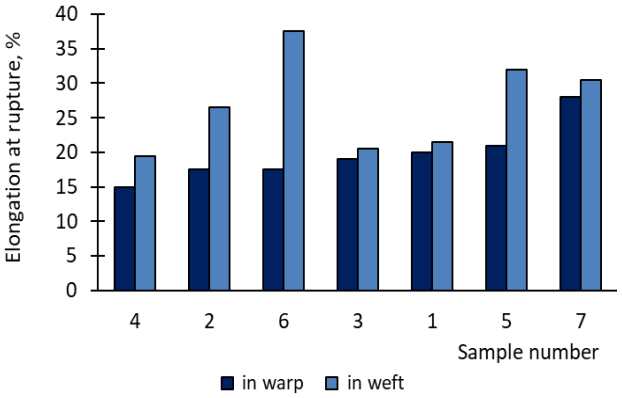

Figure 3 The interdependence between the elongation at rupture in warp and in weft for denim-like fabrics

Table 2 Generalized characteristics of denim costume fabrics

№	Fiber composition	Weight [g/m^2]	Thickness [mm]	Elongation at rupture [%]		Force at rupture [N]		Relative force at rupture [Nm/g]	
				warp	weft	warp	weft	warp	weft
1	98% cotton, 2% elastane	407	0.65	20.0	21.5	1410	1481	69.3	72.8
2	97% cotton, 3% elastane	255	0.58	17.5	26.5	674	1280	52.9	100.4
3	9 % cotton, 3% elastane	361	0.69	19.0	20.5	1405	1455	77.8	80.6
4	95% cotton, 5% elastane	292	0.57	15.0	19.5	978	1155	67.0	79.1
5	90% cotton, 6% PE, 4% elastane	348	0.86	21.0	32.0	943	1558	54.2	89.5
6	84% cotton, 10% PE, 6% elastane	263	0.49	17.5	37.5	1117	1827	84.9	138.9
7	71% cotton, 15% PE, 9% rayon, 7% elastane	183	0.45	28.0	30.5	597	641	65.2	70.1

In order to increase these indicators, such material as elastane can be added, in particular, to the weft threads. As can be seen from the Figure 3, sample 4 has the lowest value of elongation at rupture in warp (15%), when sample 7 has the largest one (28%). Sample 4 also has the lowest value of elongation at rupture in weft (19.5%), when sample 6 has the largest value of such indicator (37.5%). In this case, all samples have elongation at rupture in warp less than in weft, but not less than the recommended minimum values for suiting fabrics (15 - 20%). It should also be noted that the value of elongation at rupture in weft greater than 30% is found for samples 5, 6 and 7, the raw material composition of which, along with cotton and elastane, contains polyester.

In order to illustrate the results of the force at rupture measurements for denim-like fabrics, a diagram (Figure 4) is constructed, in which the samples are located on the basis of the force at rupture growth in warp.

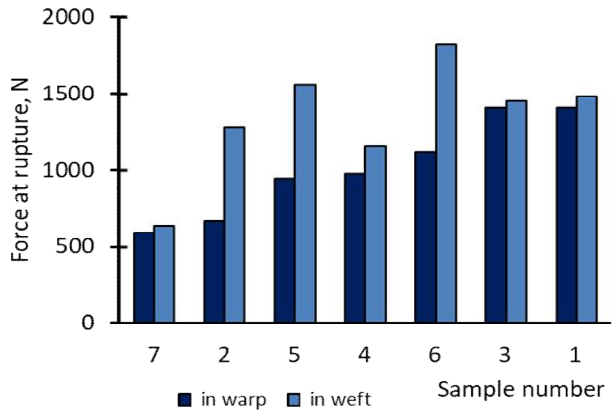

Figure 4 The interdependence between the force at rupture in warp and in weft for denim-like fabrics

As provided at the Figure 4, all samples have the force at rupture in warp less than in weft. Samples 2 and 7 have the lowest force at rupture in warp (674 and 597 N accordingly), which is less than the standard minimum for denim fabrics (785 N), but corresponds to the standard value for cotton and mixed fabrics (490 - 785 N) in accordance with GOST 21790-2005 [16]. Samples 1 and 3 have the largest force at rupture in warp (1.410 and 1.405 N accordingly). Sample 7 has the lowest force at rupture in weft (641 N), and sample 6 has the largest value of this indicator (1.827 N).

In order to illustrate the results of the relative force at rupture calculations for denim-like fabrics, a diagram (Figure 5) is constructed, in which the samples are located on the basis of the relative force at rupture growth in warp.

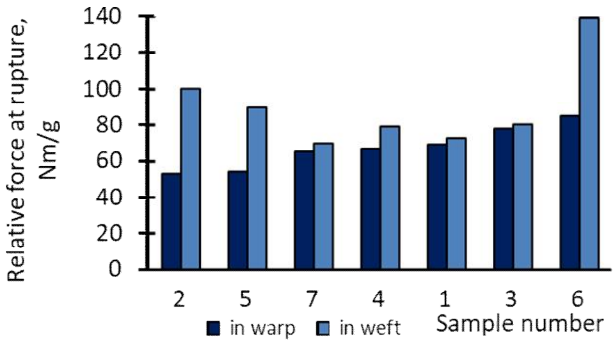

Figure 5 The interdependence between the relative force at rupture in warp and in weft for denim-like fabrics

As provided at the Figure 5, all samples have the relative force at rupture in warp less that in weft. Samples 2 and 5 have the lowest value of the relative force at rupture in warp (52.9 and 54.2 Nm/g accordingly), and sample 6 has the largest value (84.9 Nm/g). Samples 1 and 7 have the lowest value of the relative force at rupture in weft (72.8 and 70.1 Nm/g accordingly), and sample 6 has the largest value of this indicator (138.9 Nm/g).

In order to identify the degree of the interdependence between the physical and mechanical characteristics of the analyzed samples of dress fabrics, correlation coefficients between each pair of indicators are determined. The results of the correlation analysis are presented in the Table 3.

The conducted correlation analysis has showed a strong connection (r = 0.7 - 0.9) of the weight with the force at rupture in warp (r = 0.84), as well as of the weight with the thickness (r = 0.74).

Table 3 Correlation coefficients between the values of physical and mechanical characteristics of denim-like fabrics

Indicator		Weight	Thickness	Elongation at rupture		Force at rupture		Relative force at rupture
	Direction	-	-	in warp	in weft	in warp	in weft	in warp
Thickness	-	0.74	-	-	-	-	-	-
Elongation at rupture	in warp	-0.31	-0.10	-	-	-	-	-
	in weft	-0.41	-0.13	0.47	-	-	-	-
Force at rupture	in warp	0.84	0.36	-0.31	-0.33	-	-	-
	in weft	0.59	0.43	-0.47	0.26	0.63	-	-
Relative force at rupture	in warp	0.09	-0.39	-0.14	0.08	0.60	0.37	-
	in weft	-0.21	-0.21	-0.31	0.66	-0.01	0.66	0.38

The interdependence between the indicated values is shown in the graphs (Figures 6 and 7). The graphs are supplemented with trend lines and linear regression equations. The average connection (r = 0.5 - 0.7) has been found between five pairs of indicators. The corresponding cells in Table 3 are painted.

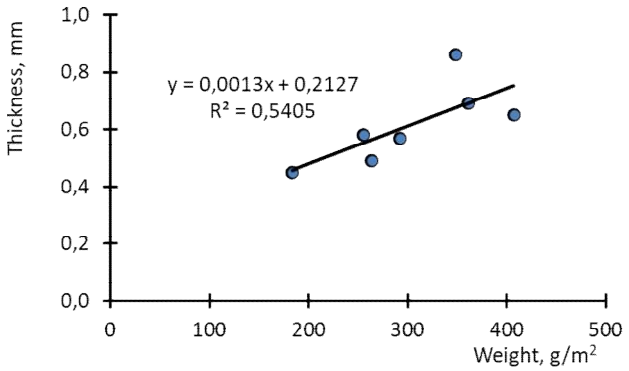

Figure 6 The interdependence between the weight and the thickness for denim-like fabrics

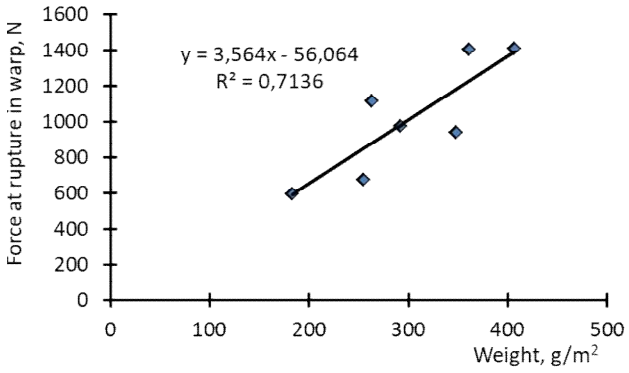

Figure 7 The interdependence between the weight and the force at rupture in warp for denim-like fabrics

Thus, as a result of the conducted experimental researches, the samples of denim-like fabrics can be divided conveniently into 3 groups as to their elongation at rupture, and recommendations regarding the selection of stabilizing materials for embroidery for each group can be developed. So, the first group with a large elongation at rupture (30 - 40% in weft) consist of samples 5, 6 and 7; the second group with a medium value (20 - 30% in weft) – of samples 1, 2 and 3; the third group with a low value (15 - 20%) – of sample 4.

4.1 Method of evaluation of the quality of embroidered semi-finished products

At the next stage the ways of stabilization of semi-finished products for the machine embroidery, depending on the properties of the materials, have been analyzed. In order to evaluate the effectiveness of stabilization clear-eyed, the method of evaluation of the quality of embroidered semi-finished products has been developed.

Defects of the embroidered fabrics are formed at the next stages: design of embroidery image; connection of the main material with the stabilizer; setting the package of the materials in the embroidery frame; embroidery; removal of stabilizing material. At the design stage, the following defects are formed: fragments of the image that are not closed by the embroidery; excessive density of covering of the image fragments with embroidery stitches; inconsistency of the neighboring areas or layers of embroidery; asymmetry of the fragments of image that has a symmetry axis. The types of the defects of embroidery fabrics are determined in accordance with the research [17]: 1-dimensional, 2-dimensional and 3-dimensional. Our article specifies and completes the list of these defects:

1-dimensional – defects of the stitch: slip stitching, thread breaking; excessive or insufficient tension of threads; interweaving of the needle and the shuttle thread on the front side of the product; cutting of the material with a needle;

2-dinemsional: defects of the setting the fabric in the embroidery frame (skewness of the package of materials, displacement of the elements of image after the repeated setting the fabric in the embroidery frame); embroidery defects (tightness, stretching of the embroidered area);

3-dimensional: deformation of the embroidered area (bulge, cavity, buckles); deformation of the area, adjacent to the embroidered area (bulge, cavity); deformation of the materials along the embroidery frame line (bulge, cavity).

The size of the tightness is evaluated as the value of reduction of the linear size of embroidered area. The size of the bulge, cavity or buckles is evaluated as the highness of the relief of the deformed area in relation to the flatness of the main material. Since at the various parts of the image the defects are presented to different extents or even absent, the assessment of the quality was carried out separately on the fragments of embroidery, the locations of which are indicated by the figures at the Figure 8.

Quantitative characteristics do not always fully assess the impact of a certain defect on the quality of semi-finished product. Visual perception of the defect as essential or unessential for the quality of the product depends on the geometric and optical parameters of the embroidery fragments. Depending on the ratio of the defect area and the area of the corresponding embroidery fragment, as well as on the color, shine and texture of the material, certain defect may be perceived as such that affects the quality of semi-finished product essentially or unessentially. With this connection, quantitative evaluation of the defect is supplemented with the expert evaluation in points, 4-point scale is used:

3 – defects are absent or almost invisible;

2 – defect is barely noticeable and somewhat affects the quality of semi-finished product;

1 – defect is very noticeable and significantly affects the quality of semi-finished product;

0 – semi-finished product cannot be used.

Figure 8 Location of the embroidery fragments for evaluation of the quality of semi-finished products

Table 4 Embroidery Quality Rating Card

Material			Main sample 4		cotton - 95%, spandex - 5%		
			Stabilizing		flizelin PE - 100%, 35 g/m^2		
Method of connection of the main and stabilizing materials					agglutination		
Threads					PE - 100%, №125		
Size of the embroidery frame [mm]					255*175		
Size of the embroidery pattern [mm]					152*118		
Fragment	**Size [mm]**	**Type of the stitch, backstitch**	**Type of the fragment defect, [number of bends]**	**Size of the defect [mm]**	**Type of the defect near fragment**	**Size of the defect [mm]**	**Evaluation of the fragment [points]**
1	40 *30	Straight, multiline 2nd layer - zigzag	~ 4	2	-	0	2
2	40*35	Straight, multiline 2nd layer - straight, multiline 3rd layer - straight, one-line	~ 2	2.5	⌒	2.5	2
3	25*3	Straight, one-line 2nd layer - zigzag 3rd layer - zigzag	-	0	-	0	3
4	38*25	Straight, multiline 2nd layer - straight, multiline 3rd layer - straight, one-line	~ 2	2.0	⌒	2.5	2
5	67*65	Straight, multiline 2nd layer - straight, multiline 3rd layer - zigzag	~ 2	3.0	-	0	2
6	20*4	Straight, one-line 2nd layer - zigzag 3rd layer - zigzag	~ 1	3.0	⌒	2.0	2
7	40*24	Straight, multiline 2nd layer - straight, multiline 3rd layer - straight, one-line	⌣ 1	1.0	⌒	2.0	2
8	40*24	Straight, multiline 2nd layer - straight, multiline 3rd layer - straight, one-line	-	0	-	0	3
	Average evaluation of the sample						2.3

The quality of the embroidered semi-finished product has been evaluated after 30 minutes of rest after the removal from the embroidery frame. An assessment of the quality of the embroidered semi-finished products is made by the group of 6 experts. All experts have a higher education in the design of the clothes, 4 of them have a Ph.D. in Technical Sciences, 2 of them have a Doctor of Technical Sciences, all of them have the experience in the fashion industry and fashion education for at least 10 years. For a comprehensive assessment of the quality of the embroidered semi-finished product, Embroidery Quality Rating Card is developed (Table 4). The experts have been asked to evaluate the quality of each piece of the embroidery separately. The valuation of the embroidered semi-finished product is calculated as an average valuation of all its fragments by the formula (4):

$$Q=\sum q_i/i \quad (4)$$

where q_i – evaluation of the i-th fragment; i – number of the fragments of embroidery.

In case if any fragment of embroidery is evaluated as unsatisfactory, the quality of the entire embroidered semi-finished product is considered unsatisfactory.

4.2 Method of selection of the optimal method of stabilization of embroidered semi-finished product

To eliminate the possible defects of embroidery, connected with the deformation of semi-finished product, it is necessary to stabilize fabric and to set it in the frame of the embroidery machine with a small tension. In order to choose the optimal method of stabilization of elastic denim-type fabric, a method of successive improvement of the initial solution has been used, in accordance with [18]. At the same time, stabilization method, which allows getting the quality of embroidered semi-finished product that is evaluated almost of about 3 points, is considered as the optimal one. To reduce a number of factors that affect the quality of the embroidered semi-finished product, the same image of embroidery is used for all samples (Figure 8). The embroidery is done at the computerized embroidery machine Brother Innovis 750S (Figure 9).

Figure 9 Embroidering at the computerized embroidery machine

First, the method of the “blind search” is used, when every next step is done regardless of the previous one [18]. Sample 4 without stabilizer is taken as a zero point of the experiment. Sample 4 is selected because it meets all the requirements for suiting denim fabrics and has the lowest elongation at rupture in warp and in weft, so it can be expected that such sample almost doesn’t need additional stabilization. Setting the fabric in the embroidery frame in accordance with the instruction to the machine (set in the embroidery frame – tighten the screw on the embroidery frame slightly – pull the material – reset again – tighten the screw to the stop) did not allow getting sufficient tension of the material in the embroidery frame. An attempt to embroider a sample as such has led to the breakage of the thread and breakage of the needle already in the beginning of the embroidery, which gives a reason to consider the embroidery of elastic denim without additional stabilization unacceptable. In this regard, zero point of the experiment is defined as unsatisfactory. The material has been set in the embroidery frame using the additional tightening of semi-finished product by hand. Such method allows for the acceptable quality of semi-finished product (Table 5) but cannot be recommended for use because of the possible breakdown of the fabric threads and embroidery frames.

Based on the analysis of the embroiderers` experience by interviewing the specialists, and the analysis of the messages at the embroidery masters sites, three main ways of stabilization of semi-finished product for embroidery aims have been identified: provision on the main material with additional rigidity; setting the main material in the embroidery frame together with the stabilizing non-stretch material; duplication of the main material with non-stretch glutinous material. All three methods are tested at the “blind search” stage.

For additional rigidity, a method of gelatinization is applied. The material is kept in gelatin water (25 g of gelatin per 0.5 l of water), dried, ironed and set in the embroidery frame. However, the use of gelatin has not allowed to achieve better quality of semi-finished product than with the use of additional tightening of semi-finished product by hand (Table 5). The method of gelatinization also has its disadvantages: 1) it is hard to set the gelatinized semi-finished product in the embroidery frame because of the excessive rigidity; 2) such semi-finished product requires washing after embroidery in order to remove gelatin. Consequently, such method of stabilization is not recommended for denim-like fabrics. Setting the main fabric in the embroidery frame with the stabilizing non-stretch material (non-woven fabric polyester 100%, 50 g/m^2) did not allow obtaining sufficient tension of the main material in embroidery frame.

Sample 3 Sample 4 Sample 5 Sample 6

Figure 10 Samples of the embroidery products made of denim-like fabrics

Table 5 Comparable analysis of the methods of stabilization of embroidered semi-finished product at the "blind search" stage (sample No. 4)

No. of experiment	Method of stabilization	Average score of the experts	Recommendations regarding the use
1	None	0	Not recommended
2	Additional tightening of semi-finished product	2.0	Not recommended because of the possible destruction of the fabric and embroidery frames
3	Gelatinization	1.8	Not recommended because of the difficult setting of the fabric in the embroidery frame and the need for the further washing
4	Setting the fabric in the embroidery frame together with non-glue stabilizing material	0	Not recommended
5	Duplication with interfacing fabric	2.3	Recommended, needs further research – selection of the duplicate material

At the beginning of the embroidery, the thread was torn several times, in connection with that the attempt was defined as unsuccessful. Such method of stabilization is not recommended for denim-like fabrics.

In accordance with the results of the study, the following method of stabilization of the material for embroidery is chosen – duplication with glutinous non-woven fabric (flizelin). Such method has allowed to obtain embroidered semi-finished product of satisfactory quality. This method received the average experts` score 2.3 points out of 3 possible (Table 5). The results of the experiment on selection of the optimal method of stabilization of denim-like fabrics for machine embroidery are summarized in Table 5. So, as a result of the experiment, the recommendation as to the use of duplicate glutinous material for stabilization of denim-like fabrics for machine embroidery is scientifically grounded at the "blind search" stage.

Using the developed recommendations, denim products, made from samples 3, 4, 5 and 6, have been embroidered (Figure 10). For the materials of the first group in regard to their elasticity (sample 6, elongation at rupture is more than 30 - 40%) additional duplication with the second layer of non-woven fabric (flizelin) has been applied at the embroidery image area, without the second layer has fallen under the embroidery frame.

5 CONCLUSIONS

1. As a result of the analysis of 7 samples of the materials of suiting group of "stretch-denim" type, is has been found that elongation at rupture in weft of all of the samples exceeds the value of such indicator in warp and reaches 37.5%, and the samples with elastane and polyamide content have higher value of the indicator. The conducted correlation analysis showed a strong correlation between weight and force at rupture in warp ($r = 0.84$), as well as between weight and thickness ($r = 0.74$). Thus, as a result of the conducted experimental researches, the samples of denim-like fabrics are conventionally divided

into 3 groups in accordance with their elongation at rupture in weft: 1) with a large value 30 - 40%; 2) with a medium value 20 - 30%; 3) with a low value 15 - 20%.

2. The classification of the defects of embroidered semi-finished products is improved. All defects are divided into: 1-dimensional: defects of the stitch, 2-dimensional: defects of setting the fabric in the embroidery frame, embroidery defects; and 3-dimensional: deformation of the embroidered area; deformation of the area, adjacent to the embroidered area; deformation of the materials along the embroidery frame line.
3. The method of evaluation of the quality of semi-finished products embroidery using the 4-point scale (where 0 – unsatisfactory, 3 – no identified defects) is proposed. Evaluation of embroidery with a complex design is recommended to be carried out separately for each area of the image.
4. As a result of the selection, received during the “blind search”, the use of duplicate glutinous material for stabilization of denim-like fabrics for machine embroidery is recommended. Using the developed recommendations, products made of denim-like fabrics have been embroidered.
5. Further researches will be aimed at optimization of the composition and parameters of duplicating materials in order to stabilize denim-like fabrics for the machine embroidery.

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