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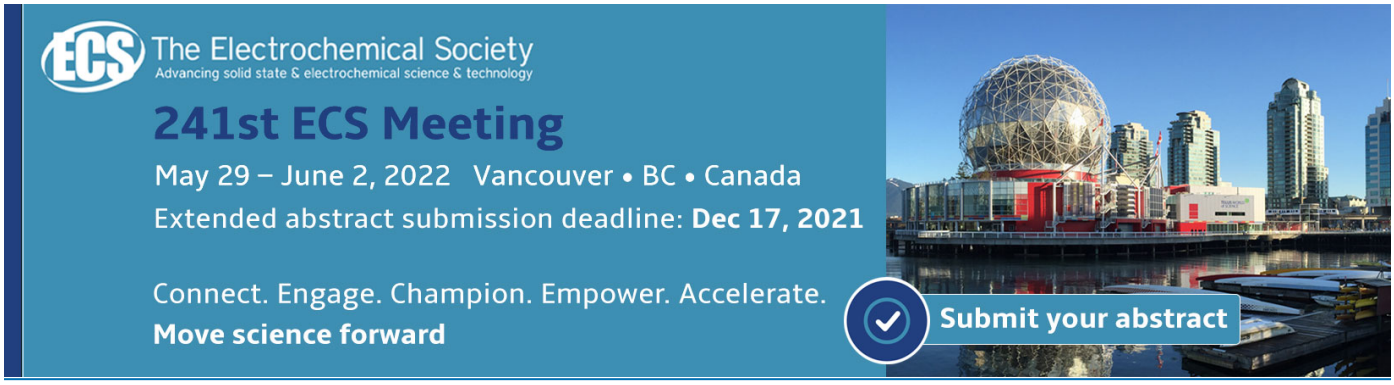

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Formation of a Tool Base for Studying the Technological Properties of Fibrous Materials

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Abstract. The object of the study is the characteristics of fibrous materials' technological properties, ensuring the preservation of their appearance and integrity, and the subject is instrumental methods for determining the thread slippage and falling out of textile fabrics. The object of the study is the characteristics of the technological properties of fibrous materials, ensuring the preservation of their appearance and integrity, and the subject is instrumental methods for assessing the resistance to thread slippage and the resistance to thread falling out of textile fabrics. The purpose of the work is to develop express methods for evaluating the considered characteristics of technological properties, providing increased accuracy and objectivity of the estimated data and the possibility of forming an electronic database of material properties characteristics. To achieve this purpose, the tasks of an analytical, methodological and technical nature has been solved. The result of the development is new patentable methods for determining the resistance to thread slippage and falling out in fiber materials. The developed methods for assessing technological properties, as well as technical devices for their implementation, are intended to determine the parameters of the resistance to thread slippage and falling out in the production and processing of different fibrous materials. The technical solution of the device for evaluating the resistance to thread slippage provides the possibility of visual optical scanning of the position of the device working parts, thereby achieving increased accuracy of the evaluation result. The technical device for evaluating the resistance to thread falling out makes it possible to measure the applied force at a fixed moment of falling technological resistance due to the disappearance of friction between the threads of the fabric. The developed methods belong to the class of express methods and provide the ability to automatically generate an electronic database of material properties. Testing of the proposed solutions was carried out by comparing the estimates obtained using the developed methods and standardized methods and showed sufficient accuracy and the possibility of practical application of the developed methods.

1. Introduction

In the practice of designing and manufacturing sewing products, especially clothing for various purposes, it is known [1–3] that, when choosing design parameters that provide the required volumetric-silhouette shape of products and processing methods, a whole range of characteristics of the materials technological properties is taken into account, including resistance to thread slippage and falling out in the woven fabrics. The considered parameters of the material in case of non-compliance with the

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established requirements can lead not only to a deterioration of the appearance, but also to the destruction of the product and, as a result, to a reduction in its life. An analysis of the practical tools for assessing these characteristics of the canvas mechanical properties [4-12] showed that the currently available technical and technological support for the research process does not meet modern requirements, which determines the need to develop new assessment methods. Using the existing experience in the development of methods and technical tools for studying the technological properties of materials [13-18], the authors of the article proposed new methods for assessing the thread slippage and falling out in fabric.

2. Relevance and scientific significance of the issue

The significance of the resistance to thread slippage and falling out characteristics of fibrous materials for the selection of constructive and technological design solutions in the manufacture of garments determines the need for a quick and accurate determining the considered technological characteristics of the of textile fabrics. The methods and devices currently used in the practice of sewing production in the Russian Federation for the study of the resistance to thread slippage and falling out [4–23] are characterized by a number of drawbacks, the main of which are the construction complexity of the technical means for implementing the assessment methods or the need to use additional equipment, insufficient accuracy of the data obtained, a high level of subjectivity of the determined indicators, a significant duration of the technological procedure, the inability to evaluate the important factors affecting the result of the assessment, the lack of technical capabilities for creating a database in an automated mode. The presence of these shortcomings predetermines the relevance and scientific value of the development of new modern methods for determining the resistance to thread slippage and falling out in fibrous materials that meet the requirements of accuracy, manufacturability and reliability, and which can be attributed to express methods by the duration of the technological procedure.

3. Formulation of the problem

The purpose of the research is to develop and test new methods for determining the resistance to thread slippage and falling out in fabrics, according to the characteristics of accuracy, reliability and technological capabilities that meet the current level of requirements. Thus, the object of the research is the characteristics of the materials' technological properties, and their subject is the express methods for determining the resistance to thread slippage and falling out in fibrous materials. To achieve this goal, for the research work general engineering approaches and methods for design of testing equipment and measuring instruments was used. Testing of the developed technical and technological solutions was carried out using practiced and developed methods and devices and standard methods for processing measurement results.

4. Theoretical part

The ability to maintain the integrity of the structure and appearance of fibrous materials depends, inter alia, on the degree of fixation of the threads in the structure of the fabric, which, as applied to fabrics, is usually evaluated by the indicators of the resistance to thread slippage and falling out [24]. In this case, by thread slippage is understood the displacement of the threads of one system relative to the threads of another system. Thread falling out is the loss of filaments from open tissue sections [1]. In most cases, a high and even medium level of thread slippage and falling out are considered as negative properties of the material, requiring the use of structural and technological solutions in the manufacture of garments that impede the manifestation of these fabric imperfections. The implementation of such design decisions complicates the technological processing of products, increases the consumption of materials and, as a result, increases the level of costs for manufacturing the product and its cost.

The forces that prevent the displacement of threads in the fabric are the friction and adhesion forces [1]. Proceeding from this, the resistance of the fabric to the thread slippage and falling out can be estimated by measuring the tangential resistance force T_o, which is the resultant sliding friction force and adhesion forces that arise between the threads in the fabric structure when an external load is applied

that can cause them to shift. According to the theory of I.V. Kragelsky, T_o can be determined using the ratio:

$$To = \alpha S_f + \beta N, \quad (1)$$

where S_f - the area of actual contact of the threads surface; α and β- coefficients depending on the raw material composition, the structure of the adjacent threads, the structural features and finish of the material; αS_f - adhesion force; βN - sliding friction force; N - the value of normal pressure.

The determination of the α, β coefficient values and the actual contact area of the threads surface is largely complicated by the multilevel and easily deformable structure of fibrous materials and the practical impossibility of formalizing the multifactorial dependence of the characteristics of the materials properties on the whole complex of influence factors. In this regard, the theoretical calculation of the tangential resistance force for real conditions, especially in relation to fibrous materials, is of great complexity. Therefore, in practice, the characteristics of the resistance to thread slippage and falling out, determined by the strength of the tangential resistance between the threads, are established experimentally using various indicators. In this case, the indicator that is most suitable for the physics of the process used to assess the fabric resistance to thread slippage and falling out can be considered the value of the minimum force required to displace the threads of one system relative to another system when assessing the thread slippage, and the minimum force required to remove a layer of threads of a certain width from open a slice of a sample of material when evaluating falling out of fabric.

5. Results of the study and their discussion

Based on the results of the theoretical justification, fundamentally new schemes and technical tools have been developed [25,26], which allow implementing express methods for assessing the resistance to thread slippage and falling out in woven fabrics based on the use of computer technology for assessing the required parameters of textile materials. A detailed description of the proposed methods and devices for their implementation is given in [16,18,25,26].

The device for evaluating the resistance to thread falling out in woven fabrics is an autonomous optoelectronic module and contains two clamps for the sample, elastic elements that are informative elements of force interaction, a movable carriage with a comb and needles, deformation sensors of elastic elements, a processor, a controller, and an interface unit for controlling a helical gearmotor transferring the movement of fabric threads by loading elastic elements. An informative parameter of the resistance to thread falling out is the mechanical force applied at the time of the drop in technological resistance due to the disappearance of friction between the threads of the fabric, and the formation of shear fringe. Measuring information about the applied force in an automated mode is read by means of linear displacement sensors, and then transmitted to an electronic database.

The procedure for measuring the parameters of flaking using the developed device is as follows. After appropriate preparation of the sample, the test tissue sample with one end cut is installed in a fixed clip at a fixed distance (2 mm) from the cut of the sample to the puncture site with comb needles. Another end section is placed in a movable clamp kinematically connected through a spring with a screw gear and a carriage.

After entering the initial data on the type, fiber composition and other characteristics of the material in an interactive mode, a command is issued to create preliminary tension of the sample by briefly turning on the gear motor. Next, using the software interface, the research procedure is launched.

The drive through the kinematic links and the elastic element moves the movable clamp with the sample. At the same time, the elastic element and a specially selected spring begin to deform. At the point in time when the thread is discharged and the fringe is formed, the readings of the elastic element are a control signal for stopping the moving parts of the drive.

According to a given program, the computer calculates the interaction force of the comb needles with a tissue sample at the time of the thread falling out in fabric. The current force applied to the sample at the time of the formation of the fringe is recorded in an electronic database.

The technical solution for implementing the method for assessing the resistance to thread slippage in fabrics is an optoelectronic device that contains a screw driver, a tensometric system for measuring the magnitude of the load, a webcam for measuring the magnitude of the displacement of the threads, as well as an optoelectronic system for observing and interactively correcting the position of each needle in the interline space across the width of the sample autonomously from each other.

The working part that directly interacts with the threads of the fabric is a comb with a set of needles mounted on a movable carriage. In this case, the needles are made with the ability to control the depth of their immersion and change their relative position in the micrometric range relative to each other according to the results of optical scanning of the inter-space. Such a technical solution makes it possible to increase the accuracy of estimating the thread slippage by eliminating the source of additional error due to the possible unevenness of the forces applied during the same movement of the comb. Such unevenness can be observed due to the probability of the introduction of needles into the structure of the threads when puncturing the material.

To determine the magnitude of the displacement of the threads, a webcam is used that is connected to the computer processor. To determine the magnitude of the displacement of the carriage with the comb and the threads with their displacement, optically active marks are set. The webcam, using the indicated marks, reads the amount of movement of the threads and the deformation of the elastic links that perform power transfer functions from the drive. To determine the magnitude of the load, a tensometric measuring system of the diaphragm type is used, switched through the interface unit and the controller with the processor.

The device is controlled using a computer through an interface that includes two panels: a control panel and an experimental research settings panel containing a certain set of options [18].

The technique of the express method is as follows. After appropriate preparation of the textile material, the test sample is fixed in the clamps of the device, one of which is stationary, and the second is conditionally movable and kinematically connected with the movable carriage, carrying a comb with needles.

After entering the initial data on the type of material, the fibrous composition and properties of the sample, puncture with needles, and their partial introduction into the initial free space of a non-metallic type substrate, the processor forms and displays the possibility of initiating studies and assessing the degree of the thread slippage in the textile material.

When confirming the input of initial data and the corresponding indication, the operator turns on the gear motor, which moves the carriage with needles through kinematic links and elastic elements. In this case, the force of the thread slippage resistance is transmitted to the comb, which, when moving, deforms and pushes the threads of the sample of textile material with needles.

The beginning of the movement of the carriage with needles and the movement of the boundary of the elastic elements is fixed by means of opto-active marks and a webcam for reading information. Information in pixels from the camera is transmitted to the computer processor, which, in accordance with the preliminary calibration of the movement, determines the magnitude of the degree of displacement of the threads system under the action of loading the comb needles.

When the comb with the needles reaches the 2 mm displacement, the resistance to thread slippage parameters are fixed: the displacement value and the applied force by calculating its numerical value in the processor according to the given algorithm [18].

After the drive stops and the carriage rises to its original position, a new sample is set, and the measurement cycle is repeated with the information recorded in the electronic database in real time.

Testing of the developed express methods based on new technical solutions [25,26] was carried out by comparing data obtained using the developed methods and data established on the basis of standardized and practiced methods in Russia [4,8]. During testing, we selected fabrics of various raw materials, including sample No.1 - Atlas lining fabric (raw materials: 97% polyester, 3% polyurethane; surface density 86.5 g/m^2); sample No.2 - costume fabric (raw material: polyamide 43%, polyurethane 2%, cotton 55%; surface density 272.5 g/m^2); sample No.3 - costume fabric (raw material composition: polyester 97%, polyurethane 3%; surface density 352.5 g/m^2). Sample preparation was carried out taking

into account the requirements of existing methods [4,8]. When processing the measurement results, generally accepted methods were used. A fragment of the results obtained during the experiment to assess the resistance to thread slippage in wave fabrics is presented in the table.

Table 1. The results of experimental studies of the thread slippage in wave fabrics (fragment).

Sample Number	The value of the threads shift, [mm]	The standard value [27] of the resistance force to thread slippage, [N], not less than	The value of force determined by the standard method, [N]	The value of the force determined by the express method, [N]	The magnitude of the divergence of the resistance to thread slippage indicators, [%]
1	2	7,84	8,02	7,89	1,6
2	2	19,62	59,24	57,045	3,7
3	2	19,62	29,47	28,36	2,9

From the results of comparing the obtained data, it follows that the discrepancy between the parameters of the resistance to thread slippage in the fabric according to [8] and the developed methodology of the express method on average does not exceed 5%. Similar data were obtained when testing the express method for assessing the resistance to thread falling out in fabric. The actual values of the discrepancy between the values of the crumbling parameters obtained by the standard method and using the express method were in the range from 1.3% to 4.6%.

6. Conclusion

Thus, the proposed computer technologies and methods for evaluating such parameters of the technological properties of fibrous materials as the resistance to thread slippage and falling out in woven fabric provide instrumental objectivity and accuracy of the obtained characteristics, as well as the possibility of forming an electronic database of material properties. In this case, the errors in the estimation of the thread slippage parameters depend on the accuracy of calibrating the movement of the threads and measuring the deformation of the elastic elements, and falling out - on the accuracy of setting the position of the end cut of the sample in a fixed clip. The time required to carry out the procedure for assessing the thread slippage and falling out allows us to classify the proposed methods as express methods, and the implemented procedure technology to the category of methods with computer support for the measurement technology.

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