УДК 677.074:620.17

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ANALYTICAL OF METHOD MONITORING OF FABRIC STRUCTURE PARAMETERS

Purpose. *Development of a method for non-destructive testing of fabric structure parameters in the dynamics of maintenance.*

Methodology. *The research was based on the use of methods of comparative analysis, analytical calculations, experimental studies. The determination of structural characteristics was carried out using a digital microscope and computer equipment.*

Findings. *It was developed a non-destructive method for monitoring the fabric structure parameters, which allows checking the quality of textile materials at all stages of production, maintenance, and also in the sales.*

Originality. *It was obtained an analytical dependence for calculating the surface weight of cotton fabrics.*

Practical value. *The results can be used to improve the control over the change in the products properties during their maintenance and to prevent the falsification of information on the product characteristics.*

Keywords: *fabric weight, non-destructive testing method.*

Introduction. The manufacture of the garment is based on the use of a number of textile materials: bottom, lining, interlining, finishes. Each of these layers has a complex of properties which can change in a wide range within their product category. The design of garments, technological parameters of their manufacture, maintenance conditions depend on the properties of these materials significantly. Ignoring fabric properties leads to defects at the production or maintenance stages.

Given the current relationship between suppliers of textile, manufacturers, distribution networks, as well as the lack of equipment with special measuring devices, it is often necessary to identify the causes of a number of deficiencies or defects at the finished product stage. Therefore, the methods of non-destructive testing of basic properties become topical.

Problem definition. The importance of structural characteristics in a complex of general properties is due to the fact that the mechanical, physical properties of materials depend on them, as well as the technological conditions of their processing and maintenance behaviour. The structural characteristics in materials science traditionally include linear dimensions (width, length and thickness), yarn parameters, fabric weight, fabric weaves and some others [1].

One of the most important factors of the woven fabric structure is the surface weight. This factor is strictly regulated in the standards and technical documentation for materials. The deviation actual fabric weight from the normative one is considered as a defect and indicates to a discrepancy from the standards.

Fabric weight is one of the key characteristics by confectioning of materials for clothing, since from its value are depend such important properties as product weight, durability, hygiene, saving of shape and dimension of product after multiple washing, ironing and dry-cleaning. Fabric weight has a direct influence on reliability factors: stiffness, wrinkle resistance, elasticity, tensile strength, abrasion resistance.

The fabric weight should be checked at the stage of their incoming inspection. Usually such inspection is carried out based on standard methods by weighing samples of materials of specified sizes and recalculating the received mass per unit area. It is clear that such a checking is possible only if samples of materials are available. Concerning finished product and the control of its properties in the dynamics under the influence of maintenance factors - conducting such investigations is always connected with attracting a number of finished products and their destruction, which leads to additional costs.

According to the foregoing, the task of this study was the development of a method for non-destructive testing of fabric structure characteristics, such the fabric weight, at the stage of product maintenance.

Results of the research. There are some classical measuring methods to determine the fabric weight, which are traditionally used in textile industry.

Also for a investigation of fabric structure characteristics are widely used optical methods, which differ in the principles of data processing and collecting. Optical systems for analyzing the geometric structure of textiles are primarily based on the use of optical sensors that respond to a missed or reflected by textile material light. Such this are methods of light microscopy, photo- and video grammetry, electronic method (2D and 3D-scanning) [2-6].

Promising is use of information technologies for data measurement and processing. Such methods are based on the information processing about the measurement object that was received by means of various installed directly on processing equipment sensors. Also it becomes common methods with use of the latest optoelectronic devices, allowing to carry out quickly express-control of structural characteristics of textile materials. Development of computer technologies allows to determine geometrical characteristics of textile materials structure automatically by the digital image of the material that can be taken with sufficient enlargement. As the repeating structure of textile can be simulated by simple geometrical figures, distances can be easily measured in them. Complexity consists only in finding of adequate model of the initial image [7-8].

The **disadvantages** of these methods include: difficult process of sample preparation, need for specific equipment and software for research, use of complicated mathematical calculation for the final determination of parameters.

Therefore a development of a simple and available way for determining of fabric structure parameters are research problem that is relevant now.

In the course of studying on the given problems, it was established that the fabric weight, Mp, can also be determined analytically using the equation (1):

$$M_p^s = 0{,}01(\Pi_o T_o + \Pi_y T_y)\alpha \quad , \tag{1}$$

where T_o, T_y – warp and weft yarn count (tex);

Π_o, Π_y – the number of yarns per 10 cm on the warp and weft;

α – coefficient which depends on the fabric type, α=1.04 for cotton plain fabrics [1].

The yarn count can be calculated by converting the equation to determine the nominal diameter of the yarn, d:

$$\mathrm{d} = 0{,}0357\sqrt{\mathrm{T}/\delta}, \tag{2}$$

where δ - the average density, tabular value, δ=0.9 for cotton yarns [1].

From (2) we receive value of warp and weft yarn count:

$$T_o = (d_o{}^2\delta)/0{,}0013\ , \quad (3)$$

$$T_y = (d_y{}^2\delta)/0{,}0013\ . \quad (4)$$

Based on the above equations, the problem of determination of fabric weight comes down to definition of number of warp and weft yarns on 10 cm and diameters of warp and weft yarns. Traditional methods of measurement of these parameters are connected with mechanical destruction of fabric structure [2]. In our work, it is proposed to use a digital microscope with the ability of photo and video recording to set the fabric density and the diameters of textile yarns. The use of microscope allows us to obtain an enlarged image of the fabric surface with the indication of the zoom options. Measurements can be taken on any part of the product without its destroying.

For the purpose of this research, 12 cotton fabrics of the same plain weaves were taken. The resulting digital images of the surface were used to count the number of textile yarns per length unit and to establish their diameter. The calculations were performed by determining the average statistical index of the results of 10 measurements within the confidence interval (table 1).

Table 1.

Characteristics of the tested fabrics

№ sample	Composition	Thickness, mm	Nominal yarn diameter, mm		Number of threads per 10cm		Yarn count, tex	
			d_o	d_y	$П_o$	$П_y$	T_o	T_y
1	100% cotton	0,2	0,16	0,14	570	340	11,57	8,86
2	80% cotton; 20% PES	0,2	0,19	0,24	380	297	16,32	26,03
3	100% cotton	0,2	0,17	0,29	267	239	13,06	36,71
4	80% cotton; 20% PES	0,2	0,19	0,22	380	240	16,32	17,01
5	100% cotton	0,2	0,21	0,23	260	220	19,93	23,91
6	80% cotton; 20% PES	0,2	0,20	0,17	312	348	18,26	13,06
7	55% PES; 45% cotton	0,2	0,18	0,19	320	300	14,64	14,50
8	80% cotton; 20% PES	0,2	0,16	0,15	400	570	11,71	10,17
9	100% cotton	0,2	0,15	0,15	590	442	10,58	9,63
10	100% cotton	0,2	0,14	0,16	592	520	9,11	12,16
11	100% cotton	0,2	0,19	0,16	378	322	16,32	11,57
12	100% cotton	0,3	0,21	0,26	270	251	18,99	31,02

By comparing the values of the fabric weight obtained by the analytical method and the actual value obtained by the method of weighing the point sample, a certain discrepancy was established. It is clear that the difference in results is caused by ignoring of consideration

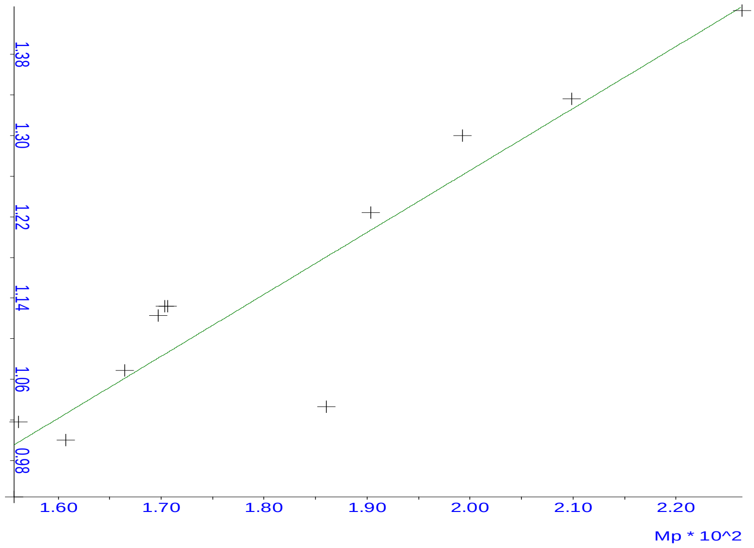

Figure 1. **Correlation between the experimental and theoretical values of fabric weight**

in the calculations of a number of important factors, such fiber density, the factor of fiber packing in the yarn, the weave repeat, the number of effect-changes in the repeat, the position of intersection points in the weave repeat and the flexibility coefficient of yarns. However, correlation analysis of the experimental and theoretical values shows a close relationship between the given parameters (Fig. 1).

Correlation analysis of initial data shows too, that values of the actual yarn diameter correlates with nominal yarn diameter, and they differ each other on the value of the linear dependence coefficient, that is equal to 1.25. Thus, the resulting coefficient value can be used to recount M_p for a given fabric group.

After substituting (3) and (4) in equation (1), as well as taking into account the defined coefficient, the analytical dependence for calculating the fabric weight took the form:

$$M_p^s = 5 \cdot \left(\Pi_o d_o^2 + \Pi_y\, d_y^2\right) \cdot \alpha \cdot \delta, \quad (1)$$

To verify the obtained dependence was carried out re-comparison the calculated values of the fabric weight, Mp, with the experimental values of Mp, the results of which are given in table 2.

Table 2.

Analysis of deviations in fabric weight calculations

Sample number	M_p, г/м^2	$M_ф$, г/м^2	ΔM, %
1	99,5	101,8	2,3
2	144,3	142,3	1,4
3	127,0	130,0	2,3
4	105,4	103,3	2,0
5	108,1	112,3	3,7
6	106,1	106,9	0,8
7	99,2	94,4	5,0
8	108,5	113,2	4,1
9	108,7	113,2	3,9
10	121,3	122,4	0,9
11	102,4	100,0	2,4
12	133,7	133,6	0,1

As it shown, the deviation value does not exceed 5%, on the basis of which it can be concluded that the results obtained are sufficiently reliable.

Conclusions. Based on these results, it can be concluded that the analytical way for calculating the fabric weight can be used for check and the subsequent monitoring the fabric weight, and also other fabric structure parameters. To ensure that the values of the analytically obtained fabric weight correspond to the experimentally obtained value, it is necessary to introduce an additional coefficient into the analytic dependence, taking into account a number of important factors, such fiber density, the factor of fiber packing in the yarn, the weave repeat, the number of effect-changes in the repeat, the position of intersection points in the weave repeat and the flexibility coefficient of yarns. The received values of structure parameters can be used for further prevention of a number of characteristics of mechanical and physical properties, such as air-permeability, bursting strength and others.

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АНАЛІТИЧНИЙ СПОСІБ МОНІТОРИНГУ ПОКАЗНИКІВ СТРУКТУРИ ТКАНИН

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Мета. *Розробка способу неруйнівного контролю структурних характеристик тканин в динаміці експлуатації.*

Методика. *Дослідження базувалися на використанні методів порівняльного аналізу, аналітичних розрахунків, експериментальних досліджень. Визначення структурних характеристик проводились із застосуванням дигітального мікроскопу та комп'ютерної техніки.*

Результати. *Розроблено неруйнівний метод моніторингу показників структури тканин, який дає змогу перевіряти якість текстильних матеріалів на всіх стадіях виробництва, експлуатації, а також в мережі збуту.*

Наукова новизна. *Отримано аналітичну залежність для розрахунку поверхневої густини бавовняних тканин.*

Практична значимість. *Результати можуть бути використані для поліпшення контролю за зміною властивостей виробів в процесі їх експлуатації та запобігання фальсифікації інформації про характеристики товарів.*

Ключові слова: *поверхнева густина, метод неруйнівного контролю.*

АНАЛИТИЧЕСКИЙ СПОСОБ МОНИТОРИНГА ПОКАЗАТЕЛЕЙ СТРУКТУРЫ ТКАНЕЙ

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Цель. *Разработка способа неразрушающего контроля структурных характеристик тканей в динамике эксплуатации.*

Методика. *Исследования базировались на использовании методов сравнительного анализа, аналитических расчетов, экспериментальных исследований. Определение структурных характеристик проводились с применением дигитальной микроскопа и компьютерной техники.*

Результаты. *Разработан неразрушающий метод мониторинга показателей структуры тканей, позволяющий проверять качество текстильных материалов на всех стадиях производства, эксплуатации, а также в сети сбыта.*

Научная новизна. *Получена аналитическая зависимость для расчета поверхностной плотности хлопчатобумажных тканей.*

Практическая значимость. *Результаты могут быть использованы для улучшения контроля за изменением свойств изделий в процессе их эксплуатации и предотвращения фальсификации информации о характеристиках товаров.*

Ключевые слова: *поверхностная плотность, метод неразрушающего контроля.*