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SECTION 25. Technologies of materials for the light and textile industry.

INVESTIGATION PHYSICAL AND MECHANICAL PROPERTIES OF ELECTRICAL CONDUCTING FABRIC FOR FOOTWEAR AND COMPREHENSIVE ASSESSMENTS

Abstract: *The work is devoted to the research of physical-mechanical and electrical performance of textile fabrics with conductive properties for safety footwear with conductive properties. The article compares the results of a comprehensive evaluation of performance of conductive fabrics taking into account weighting coefficients and without taking them into account. The studies made an informed choice of conductive tissue samples for footwear parts.*

Key words: *conductive antistatic shoes, textile materials based on conductive fiber, physical properties, integrated assessment, weighing indicators.*

Language: *English*

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Introduction

Static electricity is one of the most common harmful production factors, the potential danger that exists in many industrial fields associated with high-speed processing of raw materials and processing of dielectric materials, such as Oil and gas, defense purposes of the enterprise, electronics, production of synthetic materials, textile etc.

Wearing shoes with special physical properties is one of the main measures to prevent the accumulation of electrostatic charges [1]

It is used a wide range of materials of various structures in footwear. Along with the development and improvement of technology of materials for footwear, it is carried out investigations intensively on giving these materials special properties such as: heat resistance, high strength, electrical conductivity, etc. One of such materials is electrically conductive fabric based on fibers conductive fibers [2]. These fabrics have unique properties: high electrical conductivity characteristic of metal; lightness, flexibility, and other valuable characteristics peculiar to textile materials such as good breathability, dimensional stability, durability, flexibility, comfort and light weight.

Whatever method for producing a metalized fibrous material there are two types of metallic coatings [3] solid - electrical conductivity relatively little differ from the corresponding bulk metal, and the "islet" - with the hopping mechanism of transfer of charge carriers through multiple energy barriers.

Conductive fibers and materials derived from them are used in various sectors of the economy. One of the widest applications of conductive fibers - is the production of anti-static material not electrified. Tissues with low electrical resistance are used for creating special conductive footwear.

In 1990 in the Republic of Uzbekistan by professor D.N.Akbarov has been developed the technology for producing electrically conductive fiber (EPVN) (TU 40-02-90) and established a unique CIS pilot production line for its production. EPVN on the physical and mechanical properties close to the well-known natural and synthetic fibers, so that can be processed into yarn mixed with cotton or other fibers on the cotton spinning series equipment

Objects and methods of investigation

In this paper the properties of two groups of electrically conductive fabrics are investigated in order to identify the most optimal variant for creating footwear designs with physical properties [5]. It is also studied the physical, mechanical and electrical performance of conductive fabrics' samples based on a blend of cotton and EPVN specifications, which are listed in the table 1.

Table 1

Structural characteristics of samples of fabrics

№	Designation of fabrics samples	Structural characteristics				
		Linier density, tex		Fabric density, th/dm		Weave pattern
		warp	weft	warp P_o	weft P_y	
	Fabrics for prolonged insole					
1.	Sample 1.1	25□4	50	110	150	Plain
2.	Sample 1.2	25□4	50	110	150	Twill 1/3
3.	Sample 1.3	25□4	50	110	150	Satine 5/3
	Fabrics for the main liner					
4.	Sample 2.1	25□2	50	220	150	Plain
5.	Sample 2.2	25□2	50	220	150	Twill 1/3
6.	Sample 2.3	25□2	50	220	150	Satine 5/3

Before testing the properties of fabrics the normal atmospheric conditions are created in the laboratory rooms, the relative humidity should be 60 ± 5%, and the temperature of -20 ± 3° C (according to GOST 10681-75). The obtained physical and mechanical characteristics and properties of determining the specific volume and surface electrical resistance of the right and wrong sides of samples are given in Table 2

Table 2

Methods of testing and dimensions samples of fabrics

№	Controlled Quality	Equipment identification	Sample size, mm
1.	Breaking load, cN Elongation at break,%	Autograph AG-1	50×300
2.	Abrasion cycle	M235/3	Ø 80, Ø 140
4.	Surface density, g/m^2	GX-400	100×100
5.	Surface resistivity, Om/m	laboratory setup	50×100
6.	Volume resistance, Om·m	ИЕСТП-1	50×50
7.	Breathability g/cm^3	AP-360-SM	100×100
8.	Electrified,V	RS-101D	60×60, 25×170

Surface resistivity of fabric samples is determined by a constant current potentiometer method at a given current strength (5 mA) and a fixed distance between the current collecting electrodes Fig.1

A sample of material and is clamped between the electrodes A and B, which voltage is supplied from the constant current source. To the electrodes C and D connected voltmeter with high input impedance (and the digital valve). The voltage drop is measured at the site of the CD. Therefore, contact resistance values of the current electrodes has AB.

The distance between the AC and BD is 2 cm.

$$R_n = U/IL \text{ Om/m,} \quad (1)$$

where, R_n- surface resistivity of material Om/m; U – voltage, B; I- current, A; L- the distance between the current collecting electrodes.

For the result of the determination of the specific surface and the front of the sample surface the wrong side of the electrical resistance of the samples the arithmetic mean value for each of these indicators the five samples.

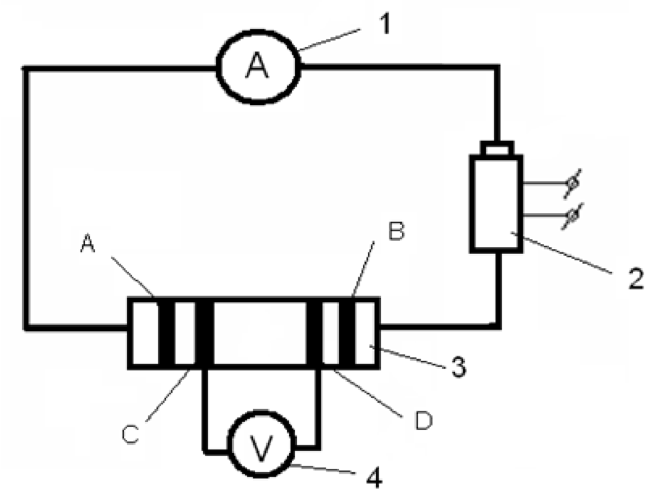

Figure 1 - Scheme of measuring the electrical resistance of the fabric strips.
1- ampere meter, 2- laboratory autotransformer; 3- measuring cell, 4- Digital DC voltmeter, A,B-C,D current and potential electrodes

The test results were processed using the methods of mathematical statistics. At 0.95 the error experience did not exceed 5%.

Results and discussion

Definition of the complex index of industrial production features many papers [6]. Based on a comprehensive assessment of given possible rank investigated samples of materials on the most important properties in view of their significance.

For the generalized results of a comprehensive evaluation of performance and clarity, using the graphical method, providing for the polygon vertices are located on the axes of a circle centered at the intersection of the axes. On the charts beams laid the experimental numerical data in natural units, such as the weight in grams, and the demand and aesthetic properties in points, assigned to them by expert.

The diagram represented in such a way that each of the axes in a limited circle, plotted the best (or standard) indicators for the larget and smallest positive to negative.

Resulting in a polygon a graphic visualization of a complex system, it allows the designer or customer to make the right decision on the comparative assessment of different materials (product model), ranking them in the preferred number by comparing the areas of polygons Figure 1. Polygon, contoured lines connecting points on the radius vector corresponding to the values of parameters, having a large area, have the best complex refractive properties [7].

It should be noted that this technique is well known and widely used in practice, however, is not considered the importance of the outcome parameters in it, i.e. on the radar chart axes laid metric values without taking into account their weight and relevance. Results of this choice may be adequate in the event that all the studied properties of materials and have the same equivalent weight.

Table 2

Physical and mechanical properties of samples and weighting coefficients

№	Indicator name	Weighting factor	Value of the indicator					
			sample					
			1.1	1.2	1.3	2.1	2.2	2.3
1	Electrical Resistivity of front surface, Om	0,253	191,8	154,4	141,8	226	206	201,2
2	Specific volume electrical resistance, Om m	0,199	19,3	18,4	18,4	17,5	18,8	19,7
3	Resistance of the electrical parameters to the effects of sweat, %	0,178	107	109	105	106	104	108

4	Surface density g/m^2	0,151	329,9	327,9	310,8	294,9	289	279
5	Electrified, V	0,058	67	52	40	48	39	29
6	Breathability, g/cm^3 s	0,123	17,41	25,4	27	40,5	51,6	50,5
7	Abrasion, cycle	0,023	23510	21600	20550	18500	16800	16300
8	breaking load by warp, N	0,015	1265	1188,5	1086	676	587	520

Several authors emphasized the necessity and importance of the weighting coefficients of individual properties when determining the comprehensive quality index.

Of the existing methods of determining the weighting factors (cost, the probabilistic expert, mixed), the most widely expertise that is based on taking into account the views of experts. The importance and weight of rates is determined by known methods of a priori ranking [8].

In a comprehensive assessment of performance of conductive fabrics choice of nomenclature of properties and determine their weighting factors produced by the method of expert questionnaire survey of experts. The consisting of the expert group of 10 people, which shall be sufficient to obtain reliable estimates. For experts were presented eight most important indicators of the properties of materials for antistatic, conductive footwear among the groups of physical and mechanical, electrical and sanitary properties.

Performances were placed according to their degree of preference on the table - the most important in terms of expert property and were assigned the number 1, the least important -8. Results of the calculation are displayed in Table 2

Construction of the integrated diagrams indicators of material properties is made with regard to their validity. After determining the weighting coefficients of each axis of the chart must be corrected by multiplying the best indicator in the weighting factor. In this case, the best values of the indicators will be located at different distances from the center of radiation diagram. As a result, the diagram will look like, 2, where the best result of each property will be located at different distances from the initial position of the center of the circle, and as close as possible to the sound of the issue of choice, based on a comprehensive evaluation of materials.

Construction of the integrated diagrams produced in AutoCAD graphic environment. Polygons complex properties of electrically conductive fabrics formed serial connection command POLYLINE (polylines) points located on the radius vector corresponding to the values of the properties of indicators. The area of each polygon is determined automatically PROPORTIES window (Properties) in the AREA line (Surface).

Table 3 shows the values of the areas of complex polygons indicators diagrams conductive fabrics properties for the two groups of samples.

Table 3

The values of the areas of polygons of complex diagrams indicators electrically conductive fabrics properties.

№	Samples of conductive fabrics	The value of areas of polygons (mm^2)	
		excluding weighting factor	considering weighting factor
	Conductive fabric for protraction insoles		
1	Sample 1.1 (plain weave)	13113,8	3943
2	Sample 1.2(twill weave 1/3)	12996,8	4404,7
3	Sample 1.3 (satin weave 5/3)	12708	4384
	Conductive fabric for the main liner		
4	Sample 2.1 (plain weave)	10237,5	3630,5
5	Sample 2.2(twill weave 1/3)	9876,64	3647,0
6	Sample 2.3 (satin weave 5/3)	9979,2	3526

The table shows that the greatest polygon area (4404.6 mm^2) of the first group has a 1.3 twill weave pattern, and the second group -3647 mm^2 sample 2.3-twill weave pattern.

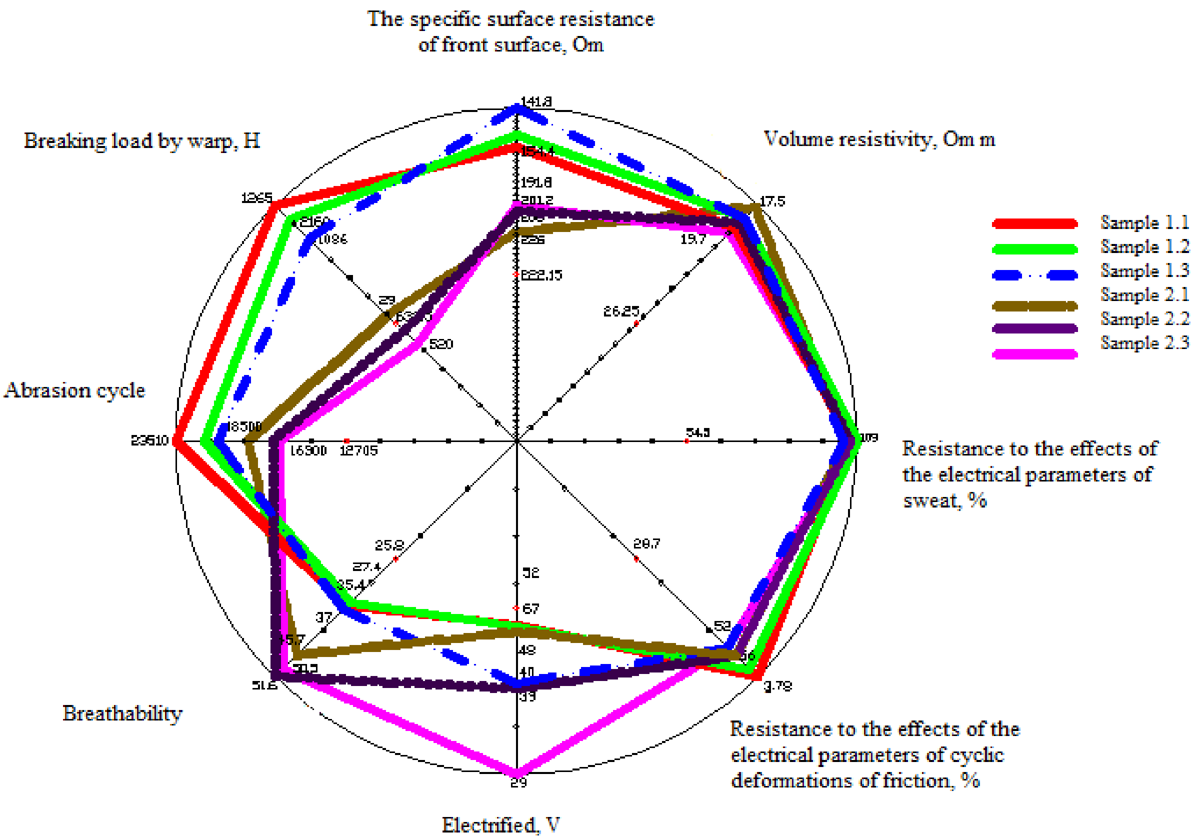

Figure 2 - Comprehensive evaluation diagram properties of materials.

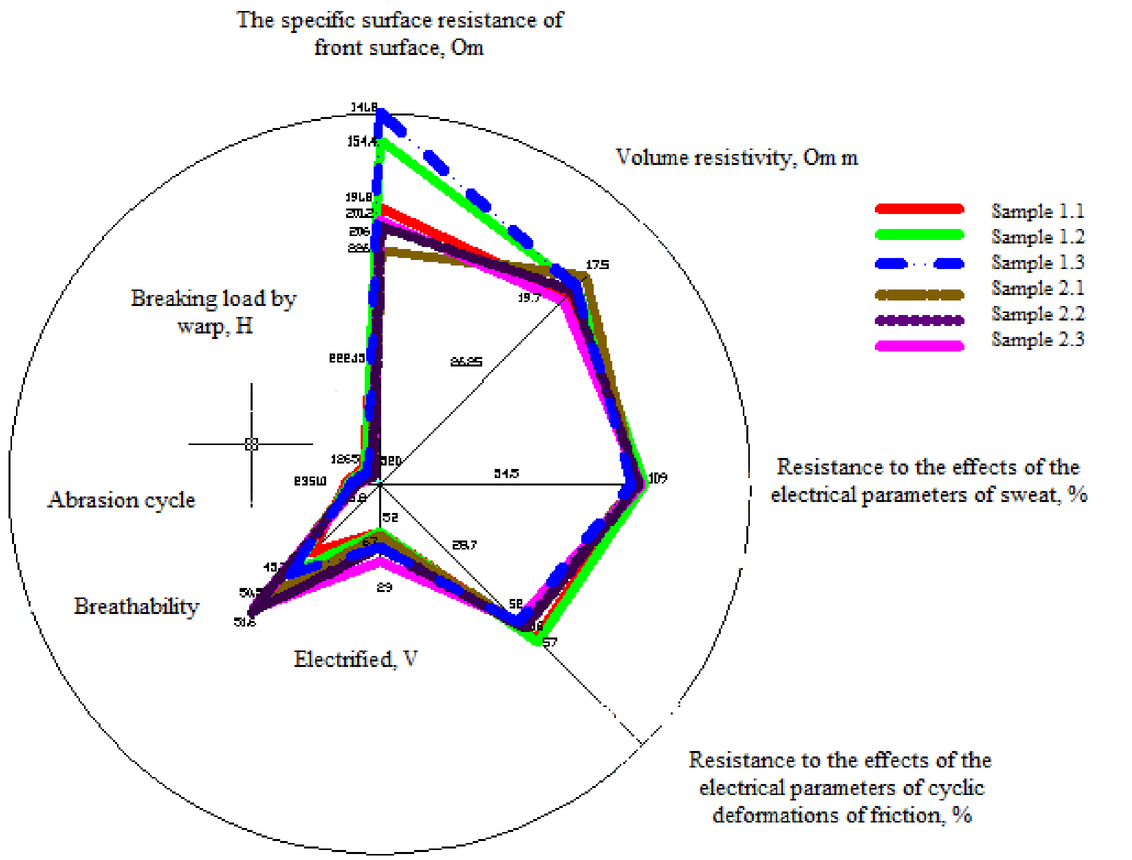

Figure 3 - Comprehensive diagram indicators material conductive properties of fabrics based on their weighting coefficients

Conclusion

The tests and complex assessment of the properties of materials by taking into account the indicators weighting coefficients allowed to choose for further research samples conductive fabrics under the number 1.2 twill (1/3) with a linear density, respectively, based on 4 × 25 tex by weft 50 text, a fabric density with 110 warp and 150 weft, as a protraction insoles and sample with 2.2 twill weave pattern (1/3) with a linear density based on 2 × 25 tex by weft 50 tex, and fabric with density in warp 220 and weft 150 yarns for the main liner of conductive footwear.

Thus, a comprehensive assessment of the properties of electrically conductive fabrics for footwear allows choosing one option from a number of visual presentations by the technical advantages of fabric samples with higher "summary" complex properties, which is difficult to be comparable with each other.

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