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DEPENDENCE OF THE ANTISTATIC PROPERTIES OF FABRICS FOR OVERALLS ON THEIR STRUCTURE

ЗАВИСИМОСТЬ АНТИСТАТИЧЕСКИХ СВОЙСТВ ТКАНЕЙ ДЛЯ СПЕЦОДЕЖДЫ ОТ ИХ СТРУКТУРЫ

Savochkina V.G.*, Ryklin D.B.
Vitebsk State Technological University, Belarus
*e-mail: veronika1300@mail.ru**
Савочкина В.Г.*, Рыклин Д.Б.
Витебский государственный технологический университет, Республика Беларусь

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Abstract. The paper presents influence of the location of electrically conductive components, namely Bekinox fibers, in workwear fabric samples on their antistatic properties. The analysis of the obtained results of the specific surface electrical resistance with a normalized and predictable value obtained by the model described earlier was carried out. It has been determined that the model used makes it possible to predict the specific surface electrical resistance of fabrics with sufficient accuracy for practical purposes, however, the choice of the location of the antistatic yarns in the fabric should be carried out taking into account its subsequent use.
Аннотация. В работе было определено влияние расположения пряжи с содержанием стальных волокон Bekinox в образцах тканей для спецодежды на их антистатические свойства. Проведен сравнительный анализ полученных результатов удельного поверхностного электрического сопротивления образцов с нормируемым и прогнозируемым значением при расположении антистатических нитей только вдоль утка и в виде сетки. Установлено, что используемая модель позволяет прогнозировать удельное поверхностное электрическое сопротивление тканей с достаточной для практических целей точностью, однако выбор места расположения антистатической нити в ткани следует осуществлять с учетом ее последующего использования.

At present, industrial development and the emergence of ever new branches of production impose such requirements on textile materials that natural fibers with their properties are no longer able to satisfy. One of them was to develop textiles with desired properties that are necessary in specific areas of human activity. The ability of textiles to change their properties in the direction necessary for a person turned out to be very important.

Now the development of electrically conductive textiles for technical applications is becoming more and more widespread. The most preferred technology of antistatic fabrics production is the fabrics manufacturing with electrically conductive yarns containing fibers Bekinox.

Fibers Bekinox are stainless steel wire pieces. These fibers are blended with other types of fibers to obtain yarn with antistatic properties. The distribution of the charge occurs due to the structure of the yarns and the fabric of them. The charge instantly “spreads” over the “cells” of the fabrics forming a closed circuit as a result of which it decreases to a non-hazardous value for a person.

The following requirements are imposed on electrical conductors: low density, high specific physical and mechanical characteristics, the possibility of a wide variety of electrical characteristics, resistance to aggressive environment, high adhesion to binders, low thermal coefficient of linear expansion [1].

Requirements for overalls for protection against static electricity are given in standard GOST 12.4.124-83. In accordance with this standard, the specific surface electrical resistance for materials used for workwear should not exceed 10^7 Ohm. This fabrics sample property is determined according to standard GOST 19616-74. It should be noted that antistatic yarns provide a discharge of static electricity accumulated on overalls by creating a continuous conductive circuit that must be grounded. However, the standard does not contain requirements for the content and location of the electrically conductive component in the test sample.

In the article [2], a model is proposed that describes the influence of the percentage of steel fibers Bekinox $\boldsymbol{\beta}$ (%) on the decimal logarithm of this indicator:

$$lg\left(p_S\right) = 4{,}7 + \frac{4}{10^{3\beta}}. \tag{1}$$

This formula was obtained for fabrics produced on the base of 2/2 twill fabric of warp cotton yarns 25 tex × 2 and wefts blended (cotton/flax) yarn 25 tex × 2. When developing model (1) authors used experimental data obtained for fabric samples in the structure of which antistatic yarns were arranged in the form of stripes along the weft and in the form of a grid. In this regard, it is of interest to determine the influence of the location of the yarn containing electrically conductive components in fabrics on the fabric antistatic properties.

To determine the effect of the location of the electrically conductive component on the specific surface resistance and its deviation from the predicted value, samples were produced on the basis of a 2/2 twill weave fabric using yarn 20 tex × 2 of the following composition: 90 % polyester fiber, 10 % Bekinox. The samples are characterized by an approximately equal content of steel fibers in the fabric, they can be divided into 2 groups:

- samples with the location of the electrically conductive component only in weft with distance between antistatic yarns 0.5 cm;

− samples with the location of the electrically conductive component in the form of a grid of 1 × 1 cm.

The specific surface electrical resistance of fabric samples in the form of rectangular fabric strips 100 × 200 mm in size was determined on the IESTP-2 device under the conditions of the Testing Center of VSTU.

The results of tests of prototype fabrics with Bekinox fibers in comparison with the results of calculations using formula (1) are presented in Table 1.

Experimental fabrics can be considered as antistatic textiles, the studied samples have specific surface electrical resistance less than 10^7 Ohm.

Table 1 – Test results for samples containing antistatic fiber

Location of antistatic yarns in the fabric	Weft		Grid (warp and weft)	
Distance between antistatic yarns, mm	5		10	
Estimated value of Bekinox fiber content, %	0.46		0.47	
Specimen orientation during testing	Along the warp	Along the weft	Along the warp	Along the weft
Predicted value, Ohm	$7.36 \cdot 10^4$		$7.17 \cdot 10^4$	
Average value, Ohm	$8.85 \cdot 10^4$	$1.30 \cdot 10^5$	$1.72 \cdot 10^5$	$1.96 \cdot 10^5$
Maximum value, Ohm	$2.37 \cdot 10^5$	$2.37 \cdot 10^5$	$1.85 \cdot 10^5$	$2.64 \cdot 10^5$
Minimum value, Ohm	$2.37 \cdot 10^4$	$2.50 \cdot 10^4$	$3.56 \cdot 10^4$	$9.89 \cdot 10^4$

The international standard GOST EN 1149-1-2018 “Occupational safety standards system. Special protective clothing. Electrostatic properties. Part 1. Test method for measurement of surface resistivity” (EN 1149-1:1995) points out that the applied method gives a discrepancy between the measurement results between different testing laboratories up to 10 times, that is up to 1 order. In this regard, the differences between the actual and predicted value can be considered acceptable. However, for a sample with antistatic yarns arranged in one direction, the difference between the obtained and predicted value for the weft is noticeably greater than for the warp. In the case of the sample in which the electrically conductive components are arranged in a grid pattern for both warp and weft, the actual values and the values obtained by formula (1) is quite close. The predicted value for both samples is lower than the actual value.

The scatter in the values of the specific surface electrical resistance for samples containing an electrically conductive component only in warp is within order 1 for the warp and weft. For samples with a grid, the spread of values exceeds order 1, both in the warp and in the weft.

Analyzing the obtained results, we can conclude that the location of antistatic yarns in samples containing an equal amount of electrically conductive components affects the specific surface electrical resistance. Mesh-shaped samples are isotropic; however, the best performance is obtained by a sample with an arrangement of electrically conductive components only in one direction. The measured values of specific surface electrical resistance of this sample are lower in the warp than those in the weft.

Thus, the obtained model (1) makes it possible to predict the specific surface electrical resistance of fabrics with sufficient accuracy for practical purposes, however, the choice of the location of the antistatic yarns in the fabric should be carried out taking into account its subsequent use.

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