Inetrnational Conference

PROCEEDINGS

2022

XIII International Conference

TEXTILE SCIENCE AND ECONOMY
Zrenjanin, 21. October 2022.
Serbia

UNIVERSITY OF NOVI SAD
TECHNICAL FACULTY „MIHAJLO PUPIN“
ZRENJANIN, REPUBLIC OF SERBIA

13th international scientific – professional conference

TEXTILE SCIENCE AND ECONOMY

Proceedings

Zrenjanin, 21st October 2022

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UNIVERSITY OF NOVI SAD

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Ministry of Education, Science and Technological Development

FACTS

SUSTAINABLE FUTURES IN FASHION & TEXTILE

INELAS ERECO DOO

Organiser of the Conference:

University of Novi Sad, Technical Faculty „Mihajlo Pupin“, Zrenjanin, Republic of Serbia

Publisher:
University of Novi Sad, Technical Faculty „Mihajlo Pupin“, Zrenjanin, Djure Djakovica bb, 23000 Zrenjanin, Republic of Serbia.

For publisher:
Dragica Radosav, Ph. D, Proffessor, Dean of the Technical faculty „Mihajlo Pupin“.

Editor:
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CIP - Каталогизација у публикацији
Библиотеке Матице српске, Нови Сад
677(082)(0.034.4)
INTERNATIONAL Scientific-Professional Conference Textile Science and Economy (13 ; 2022 ; Zrenjanin)
Proceedings [Elektronski izvor] / 13th International Scientific-Professional Conference Textile
Science and Economy, Zrenjanin, 21st October 2022. ; [organiser] Technical Faculty "Mihajlo
Pupin", Zrenjanin ; [editor Marija Pesic]. - Zrenjanin : Technical Faculty "Mihajlo Pupin", 2022.
- 1 elektronski optički disk (CD-ROM) : tekst, ilustr. ; 12 cm
Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovnog ekrana. - Elektronska publikacija u formatu pdf opsega 199 str. - Bibliografija uz svaki rad.
ISBN 978-86-7672-359-1
а) Текстилна индустрија -- Зборници
COBISS.SR-ID 77581577

Note:

All the papers presented in this publication have been reviewd. However the editor’s and organizer are not responsible for the contents presented within paper.

VOLUME ELECTRICAL RESISTIVITY OF FLAX SINGLE JERSEY WEFT-KNITTED FABRICS

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ABSTRACT

The aim of this work was to investigate the volume electrical resistivity of three plain single jersey weft-knitted fabrics produced from the same flax yarn but with different structural characteristics. The influence of structural characteristics of knitted fabrics (number of courses, mass per unit area, and thickness), atmospheric conditions (relative air humidity and temperature), as well as pilling caused by abrading knitted fabrics with the same knitted fabric, on the volume electrical resistivity of knitted fabrics, were examined in the scope of this investigation. The study showed that the increase in structural characteristics leads to a decrease in the volume resistivity of knitted fabrics. A decrease in air humidity causes an increase in the volume resistivity of investigated knitted fabrics. An increase in temperature causes a decrease in volume resistivity in all examined knitted fabrics. Furthermore, a decrease in the volume resistivity for all knitted fabrics after pilling was registered.

Key words: flax weft-knitted fabric, volume electrical resistivity, structure, atmospheric conditions, pilling

INTRODUCTION

Textile materials can be in contact with machine parts in the production process, in mutual contact, and with the user's body during exploitation. As textile materials are typical dielectrics (insulators), with very high electrical resistance, contacts and/or friction of textile materials with non-fibrous and fibrous materials cause the appearance of static electricity (Gonzalez J.A., 2005). Generated static electricity on the surface of textile materials can cause serious problems during their manufacturing (fire in the process of production of textile materials, disruption of fiber orientation in spinning products, increase in interruptions during weaving, etc.), and in their commercial use (increased dirt, cleaning problems, sticking textile materials for the consumer bodies or other textile materials, increased pilling, as well as the appearance of fatigue, headaches, and other physiological disturbances) (Morton W.E., and Hearle J.W.S. 2008, Asanovic K.A. et al., 2007, Kramar A. et al., 2014). The generation and difficult dissipation of static electricity from textile materials is connected to the high electrical resistance of materials. The electrical resistance is often determined as an indicator of static electricity dissipation from the textile surface, because the intensity and speed of dissipation of the generated static electricity from the textile material are inversely proportional to its electrical resistance (Asanović K. et al., 2010, Kramar A. et al., 2014).

The electrical resistance of textile materials depends on several factors: raw material composition (Morton W.E., and Hearle J.W.S. 2008, Chen Q. et al., 2021, Asanovic K.A. et al., 2021), moisture content in fibers (Morton W.E., and Hearle J.W.S. 2008, Asanovic K.A. et al., 2021), electrolyte content (Morton W.E., and Hearle J.WS. 2008), air humidity (Morton W.E., and Hearle J.W.S. 2008, Asanovic K.A. et al., 2021, Ivanovska A. et al., 2020, Ivanovska A. et al., 2022), temperature (Morton W.E., and Hearle J.W.S. 2008), and polarization effect (Morton W.E., and Hearle J.W.S. 2008). Furthermore, alkali modification and oxidation of fabrics (Ivanovska A. et al., 2020), washing/drying cycles (Tunàkovà V. et al., 2017), softening (Ivanovska A. et al., 2022), coatings with different substances (Gan Lu. et al., 2015, Ivanovska A. et al., 2022), thermal fixation of woven interlining on the woven fabrics (Asanović K. et al., 2020), as well as abrasion of textile materials change their electrical resistance (Asanovic K.A. et al., 2021, Varnaitė S., and Katunskis J. 2009).

As already mentioned, the electrical resistance of textile materials depends on several factors, but also on changes in some characteristics of textile materials created as a consequence of washing, cleaning, wearing, or coating. Furthermore, in the available literature, no attention has been paid to the influence of pilling on the electrical resistance of knitted fabrics.

Pilling is a phenomenon that occurs when loose fibers are pull out of the fabric construction and roll into small spherical bundles (pills) on the surface, which usually happens during abrasion and wear (Binjie X., and Hu J., 2008). Pilling, as a fabric surface defect, causes an unattractive appearance and an uncomfortable fabric handle (Binjie X., and Hu J., 2008), as well as changes in some properties of knitted fabrics such as compression, comfort, and strength (Asanovic K.A. et al., 2022a). Therefore, the aim of this study was to evaluate the influence of structural characteristics of knitted fabrics (number of courses, mass per unit area, and thickness), atmospheric conditions (relative air humidity and temperature), and pilling on the volume electrical resistivity of knitted fabrics.

MATERIALS AND METHODS

Materials

In this work, the three plain single jersey weft-knitted fabrics, produced from the same flax spun yarn with a linear density of 27x2 tex, were used as experimental material. Some structural characteristics of the investigated knitted fabrics are given in Table 1.

Table 1: Structural characteristics of the investigated knitted fabrics

STRUCTURAL CHARACTERISTICS	SAMPLE 1	SAMPLE 2	SAMPLE 3
Number of wales, cm^{-1}	7.0	7.9	8.0
Number of courses, cm^{-1}	7.2	8.4	10.1
Stitch density, cm^{-2}	50.4	66.4	80.8
Mass per unit area, $g \cdot m^{-2}$	189	211	226
Thickness, mm	0.726	0.769	0.779

Methods

The number of fabric wales, the number of courses, and stitch density were determined according to standard EN 14971:2006 using Method A. Fabric mass per unit area was not determined by the standard method. The deviation from the standard refers to the dimension of the samples. Namely, the samples were in dimensions of 2x5 cm, which is needed to determine the volume electrical resistance. In this way, it is possible to determine the mass of the samples before and after pilling under the same conditions, and the obtained results are comparable. The thickness of knitted fabrics was measured at a pressure of 9.96 kPa using a thickness tester (AMES, type 414-10, USA). The average of ten measurements for the number of fabric wales, fabric courses, and thickness, as well as five measurements of mass of each sample, before and after pilling, was considered. All measurements were realized at 31±1°C and 40% relative air humidity.

Investigated knitted fabrics were subjected to pilling using SDL ATLAS M235 Martindale Abrasion and Pilling Tester. Pilling was performed at 7000 rubs using the same knitted fabric as abrasive materials.

The volume electrical resistance of the investigated knitted fabrics was determined in the course direction using the voltage method (Asanovic K.A. et al., 2010). The measurement was performed under the decrease of the relative air humidity (in further text humidity) in the chamber (from 60% down to 40%) at room temperature (31±1°C) for samples before and after pilling, as well as at 40%

humidity and 23±1°C for samples before pilling. All examined samples consisted of two fabric specimens connected to electrodes during each measurement. Based on the determined knitted fabric volume electrical resistance, the volume electrical resistivity of samples (in further text volume resistivity (ρ)) was calculated before and after their pilling (Asanovic K.A. et al., 2010).

RESULTS AND DISCUSSION

Influence of structural characteristics on the knitted fabrics' volume resistivity

The obtained results of volume resistivity of investigated knitted fabrics are presented in Figure 1. The volume resistivity was determined in the course direction at room temperature of 31±1°C and 50% humidity in the chamber.

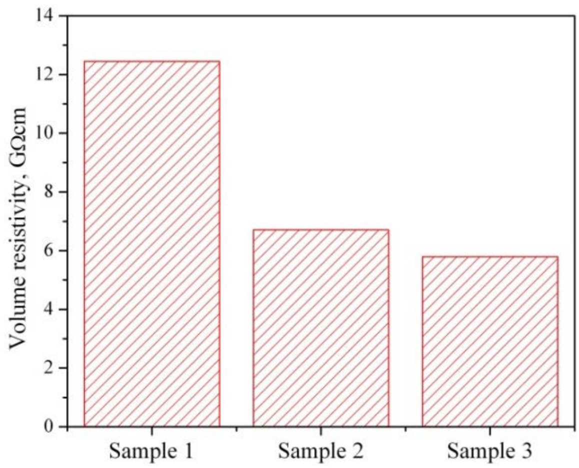

Figure 1: Volume resistivity of the knitted fabrics

The histogram presented in Figure 1 shows that with the increase in values of structural characteristics (number of courses, mass per unit area, and thickness, Table 1), the volume resistivity of knitted fabrics decreases. The highest differences in resistivity were between Samples 1 and 3 ($\rho_{(Sample\ 1)}/\rho_{(Sample\ 3)}$=2.15), and the lowest differences were between Samples 2 and 3 ($\rho_{(Sample\ 2)}/\rho_{(Sample\ 3)}$=1.16). Sample 3 has higher values of all structural characteristics than Sample 1 (number of courses for 28.7%, mass per unit area for 16.4%, and thickness for 6.8%). The higher values of structural characteristics, primarily the higher number of courses, ensure the easier flow of directional movement of charge in Sample 3 than in Sample 1 and, thereby, lower volume resistivity value.

Influence of atmospheric conditions on the knitted fabrics' volume resistivity

Atmospheric conditions (humidity and temperature) are also important factors that influence on the electrical resistance of textile materials (Morton W.E., and Hearle J.W.S. 2008). The values of volume resistivity of investigated knitted fabrics in the course direction, determined by decreasing the humidity from 60% down to 40% at 31±1 °C, are shown in Figure 2.

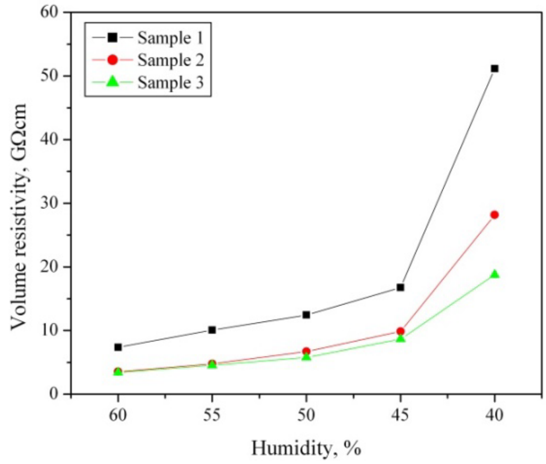

Figure 2: Volume resistivity of the samples throughout the humidity decrease

Volume resistivity at 40% humidity was higher about 7.0 times for Sample 1, 8.0 times for Sample 2, and 5.5 times for sample 3 than at 60% humidity (Figure 2). Much lower values of volume resistivity at 60% than at 40% humidity can be explained by the influence of humidity on partly ionization of water molecules, which were around the knitted fabrics, and neutralization of electric charges on knitted surface by these molecules (Ivanovska A. et al., 2020). The presented results confirm the significant influence of humidity on the volume resistivity of knitted fabrics.

The influence of temperature on the knitted fabric volume resistivity at 40% humidity is presented in Figure 3.

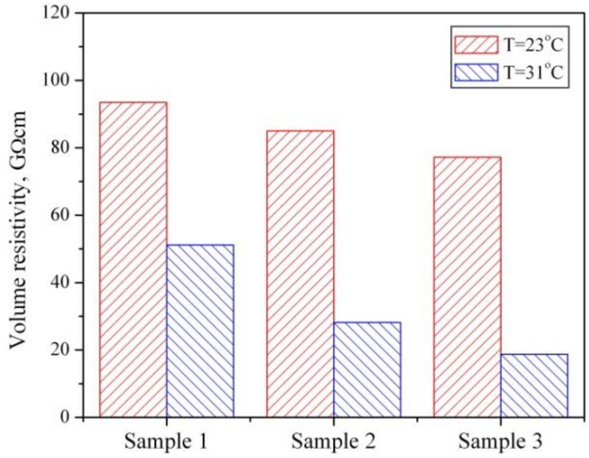

Figure 3: Volume resistivity of the samples at different temperatures

An increase in the temperature from 23°C up to 31°C is followed by the decrease in the samples' volume resistivity values for all knitted fabrics, probably due to increasing the mobility of water molecules with an increase in temperature. The obtained results are in accordance with the results presented in the literature (Morton W.E., and Hearle J.W.S. 2008). Presented results show that with the increase in fabrics' structural characteristic values (from Sample 1 to Sample 3, Table 1), the differences between the resistivity of the same sample determined at two temperatures also increase (Figure 3). The highest difference is in Sample 3, but the lowest is in Sample 1. This phenomenon appears probably due to a simultaneous increase of values of structural characteristics from Sample 1 to Sample 3, followed by an increase in moisture content of samples (Asanovic K.A. et al., 2022b), and an increase in mobility of water molecules at a higher temperature. All three mentioned factors together ensure the easier flow of directional movement of charge through the sample.

Influence of pilling on the knitted fabrics’ volume resistivity

The volume resistivity was determined in the course direction at room temperature of 31±1 °C and 40% humidity. Resistivity’s were determined before and after pilling (Figure 4). The effect of pilling on the knitted fabric volume resistivity after 7000 rubs was considered.

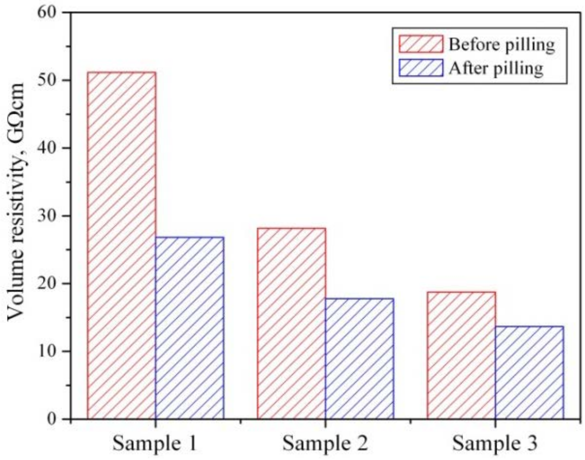

Figure 4: Influence of pilling on the knitted fabrics’ volume resistivity

The histogram presented in Figure 4 shows that pilling leads to a change in the volume resistivity of all investigated samples. A decrease in the volume resistivity due to pilling was registered in all samples ($\rho_{(before\ pilling)}/\rho_{(after\ pilling)}$ for Sample 1, Sample 2, and Sample 3 are: 1.9, 1.6, and 1.4, respectively). The decrease in volume resistivity is not expected, bearing in mind that pilling causes a reduction of values of all structural characteristics of knitted fabrics (number of courses from 2.4% up to 4.0%, mass per unit area from 6.9% up to 18.1% and thickness from 13.1% up to 14.4%), thus decreasing the lot of knitted fabrics which participates in the transport of directional movement of charge through the sample. The reason for the decrease in the volume resistivity after pilling can be found in the changes on the fabric surface during the abrasion process that causes a pilling of knitted fabrics. Surface fuzzing and formed pills are evident on the surface of knitted fabrics after pilling. Furthermore, fuzz is not present only on the surface of the fabric. Fuzz also fills the space between the loops, thus contributing to the easier flow of directional movement of charge and decreasing the volume resistivity in all samples.

CONCLUSION

The presented results showed that the lowest value of volume resistivity has the knitted fabric with the highest number of courses, mass per unit area, and thickness. The highest values of structural characteristics ensure the easiest flow of directional movement of charge through the sample which leads to the decreased volume resistivity. Volume resistivity of knitted fabrics was higher at 40% humidity than at 60% humidity for about 5.5 times up to 8 times. An increase in the temperature from 23°C up to 31°C is accompanied by the decrease in the knitted fabrics’ volume resistivity due to an increase in mobility of water molecules with an increase in temperature. The highest decrease in volume resistivity, with an increase in the temperature, is noticed for knitted fabric with the highest values of all structural characteristics (Sample 3). Furthermore, it was noticed a decrease in the volume resistivity after pilling for all knitted fabrics from 1.9 times down to 1.4 times, probably due to surface fuzzing during pilling. Formed fuzz, which fills the space between the loops, allows the easier flow of directional movement of charge thus decreasing the volume resistivity of all knitted fabrics.

Acknowledgement

This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Contract No. 451-03-68/2022-14/200135). The authors gratefully acknowledge Ljiljana Parandilovic, CIS Institute from Belgrade, for assistance in the realization of pilling of the investigated knitted fabrics.

REFERENCES

Asanovic K.A., Cerovic D.D., Kostic M.M., Maletic S.B., Ivanovska A.M. (2021). Electro-physical Properties of Woven Clothing Fabrics Before and After Abrasion, *Journal of Natural Fibers*, https://doi.org/10.1080/15440478.2021.1921659.

Asanovic K.A., Ivanovska A.M., Jankoska M.Z., Bukhonka N., Mihailovic T.V., Kostic M.M. (2022a). Influence of pilling on the quality of flax single jersey knitted fabrics, *Journal of Engineered Fibers and Fabrics*, 17, 1-13.

Asanovic K.A., Kostic M.M., Mihailovic T.V., Bukhonka N., Maletic S.B. (2022b), Investigation of the quality of flax plain single jersey weft-knitted fabrics, V International conference "Contemporary trends and innovations in the textile industry", 15-16th September, 2022, Belgrade, Serbia, 99-108.

Asanović K., Mihailović T., Kostić M., Gajić I., Ivanovska A. (2020). The influence of thermal fixation of interlining on the quality of woven clothing fabrics evaluated from the aspect of their electrical resistance, *Tekstilna industrija*, 68 (4), 4-11.

Asanović K., Mihailović T., Škundrić P., Simović Lj. (2010). Some Properties of Antimicrobial Coated Knitted Textile Material Evaluation, *Textile Research Journal*, 80 (16), 1665-1674.

Asanovic K., Mihajlidi T., Milosavljevic S., Cerovic D., Dojcilovic J. (2007). Investigation of the electrical behavior of some textile materials, *Journal of Electrostatics*, 65 (3), 162-167.

Binjie X., Hu J (2008). Fabric appearance testing. In: Hu J (eds) *Fabric testing*. First edition, Woodhead Publishing Limited and CRC Press LLC, Cambridge, England.

Chen Q., Shu L., Zheng R., Fu B., Fan J. (2021). Electrical Resistance of Stainless Steel/Polyester Blended Knitted Fabrics for Application to Measure Sweat Quantity, *Polymers*, 13, 1015 (20 pages).

Gan Lu., Shang S., Yuen CWM, Jiang S. (2015). Graphene nanoribbon coated flexible and conductive cotton fabric, *Composites Science and Technology*, 117, 208-214.

Gonzalez J.A. (2005). Electrostatic protection. In: Scott R.A. editor. *Textiles for protection*, Woodhead Publishing Limited, Abington Hall, Abington, Cambridge, England.

Ivanovska A., Lađarević J., Asanović K., Barać N., Mihajlovski K., Kostić M., Mangovska B. (2022). Quality of cotton and cotton/elastane single jersey knitted fabrics before and after softening and *in situ* synthesis of Cu-based nanoparticles, *Journal of Natural Fibers*, https://doi.org/10.1080/15440478.2022.2070328.

Ivanovska A., Asanovic K., Jankoska M., Mihajlovski K., Pavun L., Kostic M. (2020). Multifunctional jute fabrics obtained by different chemical modifications, *Cellulose*, 27, 8485-8502.

Kramar A., Milanovic J., Korica M., Nikolic T., Asanovic K., Kostic M. (2014). Influence of structural changes induced by oxidation and addition of silver ions on electrical properties of cotton yarn, *Cellulose chemistry and technology*, 48 (3-4), 189-197.

Morton W.E., Hearle J.W.S. (2008). *Physical Properties of Textile Fibers*, Fourth edition, Woodhead Publishing Limited in association with The Textile Institute, Abington Hall, Abington, Cambridge, England.

Tunàkovà V., Technikovà L., Militký J. (2017). Influence of washing/drying cycles on fundamental properties of metal fiber-containing fabrics designed for electromagnetic shielding purposes, *Textile Research Journal*, 87 (2), 175–192.

Varnaitė S., Katunskis J. (2009). Influence of abrasion on electrostatic charge decay of woven fabrics with conductive yarns, *Materials Science (Medžiagotyra)*, 15 (2), 160–166.