UNION OF ENGINEERS AND TEXTILE TECHNICIANS OF SERBIA

V INTERNATIONAL SCIENTIFIC CONFERENCE

CONTEMPORARY TRENDS AND INNOVATIONS IN THE TEXTILE INDUSTRY

V MEĐUNARODNA NAUČNA KONFERENCIJA

SAVREMENI TRENDOVI I INOVACIJE U TEKSTILNOJ INDUSTRIJI

PROCEEDINGS

EDITOR:
Prof. dr SNEŽANA UROŠEVIĆ

Belgrade, 15-16th September, 2022.
Union of Engineers and Technicians of Serbia
Dom inženjera „Nikola Tesla“

UNION OF ENGINEERS AND TEXTILE TECHNICIANS OF SERBIA

AND

UNION OF ENGINEERS AND TECHNICIANS OF SERBIA
FACULTY OF TECHNOLOGY AND METALLURGY IN BELGRADE
FACULTY OF TECHNOLOGY, SHTIP, NORTH OF MACEDONIA
SOCIETY FOR ROBOTICS OF BOSNIA I HERZEGOVINA
BASTE - BALKAN SOCIETY OF TEXTILE ENGINEERING, GREECE

V INTERNATIONAL SCIENTIFIC CONFERENCE

CONTEMPORARY TRENDS AND INNOVATIONS IN THE TEXTILE INDUSTRY

V MEĐUNARODNA NAUČNA KONFERENCIJA

SAVREMENI TRENDOVI I INOVACIJE U TEKSTILNOJ INDUSTRIJI

CT&I TI

PROCEEDINGS

ZBORNIK RADOVA

EDITOR: Prof. dr SNEŽANA UROŠEVIĆ

Belgrade, 15-16 th September, 2022
Union of Engineering and Technicians of Serbia

Conference is financially supported by The Ministry of Education, Science and Technological Development of the Republic of Serbia

UNION OF ENGINEERS AND TEXTILE TECHNICIANS OF SERBIA

"CONTEMPORARY TRENDS AND INNOVATIONS IN THE TEXTILE INDUSTRY" CT&ITI 2022

PROCEEDINGS

Editor: Prof. dr Snežana Urošević
University of Belgrade, Technical Faculty in Bor

Technical Editor: Doc.dr Violeta Stefanović
Cover design: Andrijana Stanković

Publiher: Union of Engineers and Textile Technicians of Serbia, Belgrade, Serbia, September, 2022.

For the publisher: Prof. dr Snežana Urošević

Printed: SatCip,Vrnjačka banja, Serbia

Printing: 100 copies

ISBN-978-86-900426-4-7

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд
677(082)
687.1(082)
МЕЂУНАРОДНА научна конференција Савремени трендови и иновације у текстилној индустрији (5 ; 2022 ; Београд)
Zbornik radova = Proceedings / V međunarodna naučna konferencija Savremeni trendovi i inovacije u tekstilnoj industriji = V International Scientific Conference Contemporary Trends and Innovations in the Textile Industry, CT&ITI, Belgrade, 15-16 th September, 2022 ; [organized by] Union of Engineers and Textile Tehnicians of Serbia ... [et al.] ; editor Snežana Urošević. - Belgrade : Union of Engineers and Textile Technicians of Serbia, 2022 (Vrnjačka Banja : SatCip). - [12], 446 str. : ilustr. ; 25 cm
Radovi na srp. i engl. jeziku. - Tiraž 100. - Str. [4]: Preface / Snežana Urošević. - Napomene i bibliografske reference uz radove. - Bibliografija uz svaki rad.
ISBN 978-86-900426-4-7
а) Текстилна индустрија -- Зборници б) Индустрија одеће -- Зборници
COBISS.SR-ID 73148937

V International Conference
„Contemporary trends and innovations in textile industry"
15-16th September 2022. Belgrade, Serbia

INVESTIGATION OF THE QUALITY OF FLAX PLAIN SINGLE JERSEY WEFT-KNITTED FABRICS

Koviljka A. Asanovic[1*], Mirjana M. Kostic[1], Tatjana V. Mihailovic[1], Nadiia Bukhonka[2], Slavica B. Maletic[3]

[1]University of Belgrade, Faculty of Technology and Metallurgy, Belgrade, Serbia
*(koka@tmf.bg.ac.rs)
[2]University of Novi Sad, Technical faculty "Mihajlo Pupin" Zrenjanin, Serbia
[3]Faculty of Physics, University of Belgrade, Belgrade, Serbia

ABSTRACT: *This work aimed to investigate the quality of three plain single jersey weft-knitted fabrics produced from the same flax yarn but with different structural characteristics. The quality of knitted fabrics was evaluated in terms of their electro-physical and compression properties. DC volume electrical resistivity and dielectric properties (effective relative dielectric permeability and AC specific electrical conductivity) were examined in the scope of this investigation. Compressibility and compressive resilience were selected to determine the influence of compression properties on the quality of the knitted fabrics. The current study showed that the sample with the highest stitch density, weight, thickness, moisture content, and the lowest porosity, has the lowest DC volume electrical resistivity and compressibility, but the highest effective relative dielectric permeability, AC specific electrical conductivity, and compressive resilience. Based on the application of the ranking method, the best quality sfowed the knitted fabric with the most compact structure and the highest moisture content; the worst quality was manifested by the knitted fabric with the least compact structure and the lowest moisture content.*

Keywords: *quality, flax, weft-knitted fabric, electro-physical properties, compression properties*

ISPITIVANJE KVALITETA LANENIH DESNO-LEVIH POTKINIH PLETENINA

APSTRAKT: *Cilj ovog rada je bio da se ispita kvalitet tri desno-leve potkine pletenine izrađene od istog lanenog prediva, ali različitih strukturnih karakteristika. Kvalitet pletenina je ocenjivan u pogledu njihovih elektrofizičkih i kompresionih svojstava. U okviru ovog istraživanja ispitivana su specifična zapreminska električna otpornost i dielektrična svojstva (efektivna relativna dielektrična propustljivost i specifična električna provodljivost). Kompresibilnost i elastični oporavak su odabrani da bi se utvrdio uticaj kompresionih svojstava na kvalitet pletenina. Sprovedeno ispitivanje je pokazalo da uzorak sa najvećom* *gustinom petlji, površinskom masom, debljinom, sadržajem vlage i najmanjom poroznošću ima najmanju specifičnu zapreminsku električnu otpornost i kompresibilnost, ali najveću efektivnu relativnu dielektričnu propustljivost, specifičnu električnu provodljivost i elastični oporavak. Na osnovu metode rangiranja ustanovljeno je da najbolji kvalitet ima pletenina najkompaktnije strukture sa najvećim sadržajem vlage; najlošiji kvalitet ispoljava pletenina najmanje kompaktne strukture sa najmanjim sadržajem vlage.*

Ključne reči: *kvalitet, lan, potkine pletenine, elektrofizička svojstva, kompresiona svojstva*

1. INTRODUCTION

The advantages of using knitted fabrics for the production of clothing textiles, as opposed to conventional fabrics, lie in their low cost, improved barrier properties, adequate comfort, and strength properties [1]. Among knitted fabrics, plain single jersey knitted fabric is the easiest and most economical knitted structure to produce [2]. Furthermore, plain knitted fabrics have more advantages: this fabric is a soft, lightweight, possesses good extensibility in both length and width direction under low load, has a potential recovery of 40% in width after stretching [1-3], possesses lower thermal resistance and higher relative water vapor permeability compared to single jersey derivatives which makes them suitable for use in hot weather condition [4], i.e. suitable for producing summer clothes.

Among natural fibers, flax is an excellent candidate for making summer clothes because it has numerous good properties such as good electrostatic and thermal properties, high absorbency and hygroscopicity, specific luster and handles, high protection against UV radiation, lack of any allergenic effect, optimum conditions for the skin, and very high strength (stronger in wet state) [5,6]. However, flax fibers have low elasticity [5]. This disadvantage of the flax fibers can be avoided or alleviated by the right choice of the combination of fabric structural parameters.

Determining the electro-physical properties of fabrics allows us to predict if textile material would generate static electricity and the impact on the usability of the finished product [7] and thus on its quality. Furthermore, the magnitude of compression load generated in the textile material and the way how it is distributed on the skin influence human perception of fabric softness and fabric quality [8].

To get a complete picture of the quality of investigated knitted fabrics, electro-physical and compression properties of three flax plain single jersey weft-knitted fabrics, produced from the same flax yarn but different structural characteristics, have been studied. Values of investigated properties (DC volume electrical resistivity, effective relative dielectric permeability, AC specific electrical conductivity, compressibility, and compressive resilience) served for establishing the level of quality of clothing knitted fabrics by the application of the ranking method. Based on the obtained results, the sample with the best quality from the aspect of analyzed properties was selected.

2. MATERIALS AND METHODS

2.1. Materials

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

Table 1: Structural characteristics of the investigated knitted fabrics and their moisture content

Structural characteristics and moisture content	Sample 1	Sample 2	Sample 3
Number of wales, cm^{-1}	6.9	7.2	8.0
Number of courses, cm^{-1}	7.1	8.1	10.4
Stitch density, cm^{-2}	49.0	58.3	83.2
Weight, $g \cdot m^{-2}$	179	202	232
Thickness, mm	0.703	0.769	0.816
Total porosity, %	83.5	83.1	81.6
Moisture content, %	5.54	5.57	6.65

2.2. Methods

The number of fabric wales, courses, and fabric stitch density were determined according to standard EN 14971:2006. Fabric weight was determined according to the standard EN 12127:1997. 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 and courses and stitch density and five measurements for weight and thickness of each sample was considered.

The total porosity of the samples, defined as the total amount of air in the samples, was described by Asanovic et al. [9]. The fabrics' moisture content was measured according to the thermo-gravimetric method using an Infrared Moisture Analyzer (Sartorius MA35). Before measurements, the samples were exposed to relative air humidity of 35% and temperature of 22 °C for 24 hours. The average of three measurements for each sample was considered.

The DC volume electrical resistance of the investigated knitted fabrics was determined in the course direction using the voltage method [8]. The measurement was performed under the decrease of the relative air humidity in the chamber (from 50% down to 30%) at room temperature (22±2 °C). For each sample, two measurements were conducted, whereby during each measurement, four fabric specimens were connected to electrodes. Based on the determined knitted fabric DC volume electrical resistance, the DC volume electrical resistivity was calculated [8].

The measurements of the dielectric properties of knitted fabrics (effective relative dielectric permeability, and the AC specific electrical conductivity) were performed on Precise LCR Hameg 8118 instrument (details given in the reference [10]). The samples of 25 mm in diameter were used for investigations. The measurements were conducted on samples exposed to relative air humidity of 35 ± 1% under 24 h.
A thickness tester (AMES, type 414-10, USA) was used for the investigation of knitted fabrics' compression properties, compressibility and compressive resilience, determined according to the procedure described by Asanovic et al. [11]. The reported results are the mean values of five measurements per sample.
The quality of tested fabrics was assessed using the ranking method (details given in the reference [8]).

3. RESULTS AND DISCUSSION

3.1. Electro-physical properties of knitted fabrics

According to the literature [12], the electrical resistivity of textile materials strongly depends on relative air humidity and, therefore, on fabric moisture content. For that reason, the measurements of electrical resistivity were performed at different humidities. The values of DC volume electrical resistivity (in further text resistivity) in the course direction of knitted fabrics, determined by decreasing the relative air humidity (in further text humidity) in the chamber, are shown in Figure 1.

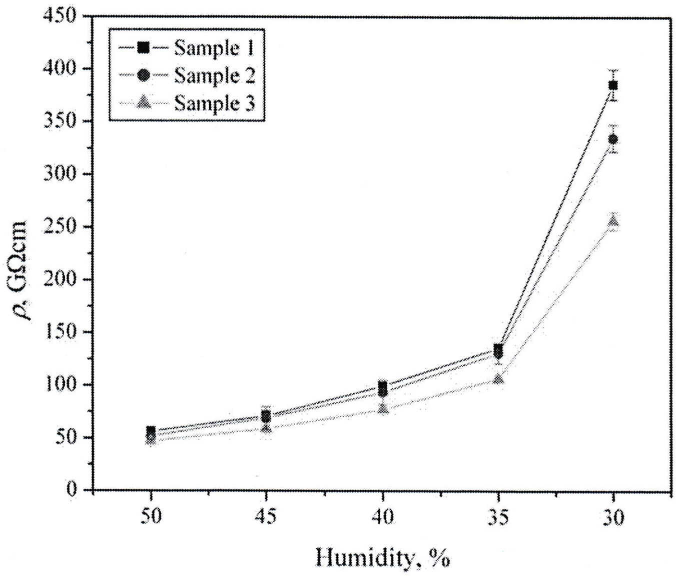


Figure 1: Resistivity (ρ) of the samples throughout the humidity decrease

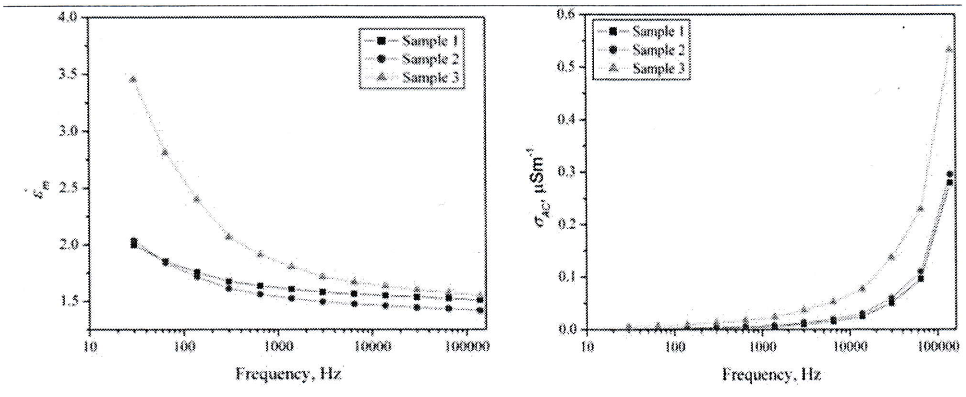
A decrease in the humidity from 50% down to 35% is accompanied by a gradual increase in the samples' resistivity values, while with a decrease in the humidity from 35% down to 30%, the samples' resistivity values very sharply increase (Figure 1, Table 2).

Table 2: Values of the changes of knitted fabrics' resistivity while the humidity decrease

Sample number	ρ_{30} / ρ_{50}	ρ_{35} / ρ_{50}	ρ_{30} / ρ_{35}
Sample 1	6.84	2.40	2.85
Sample 2	6.45	2.52	2.56
Sample 3	5.44	2.26	2.41

The presented results confirm the significant influence of air humidity on the resistivity of textile materials. This can be explained by the influence of air humidity on partly ionization of water molecules, which were around the knitted fabrics, and the neutralization of electric charges on the fabric surface by these molecules [13]. Based on that, the highest resistivity values of all fabrics at 30% humidity are the consequence of the lowest amount of water molecules presented around the fabrics at this humidity (Figure 1). Furthermore, in all humidities, the highest resistivity value shows a Sample 1 and the lowest Sample 3. Since all knitted fabrics were knitted from the same yarn, it is clear that the fabrics' structural characteristics and moisture content determine their resistivity. Sample 3 has higher all structural characteristics (number of courses, weight, and thickness) and moisture content than Sample 1 (31.7%, 22.8%, 13.8%, and 16.7%, respectively). Higher moisture content (16.7%) and, among all mentioned structural characteristics, a higher number of courses (31.7%), ensure the easier flow of directional movement of charge in Sample 3 than in Sample 1 and, thereby, lower resistivity value. Regression analysis shows a very high coefficient of linear correlation between resistivity and moisture content (r = -0.991), as well as between resistivity and number of courses (r = -0.990).

From the dielectric properties, effective relative dielectric permeability (in further text ε'_m) and AC specific electrical conductivity (in further text σ_{AC}) were determined. The ε'_m of the material describes its polarization (dipole rotation and dipole distribution) [10]. Frequency dependence of the determined dielectric properties (ε'_m, and σ_{AC}), for tested knitted fabrics exposed to the relative air humidity of 35%, determined at room temperature, is shown in Figure 2.



(a) (b)

Figure 2: Frequency dependence for samples exposed 24 h to 35% humidity: (a) effective relative dielectric permeability (ε'_m), and (b) AC specific electrical conductivity (σ_{AC})

Results presented in Figure 2a show that Sample 3 with the highest stitch density, thickness, weight, and moisture content, but the lowest porosity has the highest value of ε'_m. In contrast, Sample 1 and Sample 2, with very close values in porosity and moisture content, have similar ε'_m, especially at lower frequency values. For all knitted fabrics, the highest values of ε'_m, were noticed at the lowest measured frequency (30 Hz). A significant decrease of ε'_m with an increase in the frequency (between 30 Hz and 3 kHz), especially for Sample 3, was registered, while ε'_m has slightly changed in the frequency between 3 kHz and 140 kHz. The registered decrease of the ε'_m with the increase in frequency is in accordance with the literature [10,14] and can be explained by the fact that when the frequency increases, dipoles have less time to orient themselves in the direction of the alternating field, which leads to a low polarization [10]. From the literature [10,15,16], it is evident that the fabric is referred to as a heterogeneous three-phase system ("fiber–moisture–air"). In that way, ε'_m is very sensitive to fabric's chemical composition, moisture content, and porosity. Namely, the value of ε'_m primarily depends on the presence of the hydroxyl groups (–OH) in the flax fiber, which enhance the moisture absorption of the investigated fabrics due to the interaction of hydroxyl groups and water molecules from the air. Accordingly, the increase in fabric stitch density, weight, and thickness, as well as a decrease in porosity, increases the fiber content in fabrics and consequently increases moisture content. In other words, the higher the moisture content of the knitted fabric, the higher the value of ε'_m. Conducted regression analysis shows the perfect linear correlation between ε'_m and moisture content ($r = 1$), as well as a very high coefficient of linear correlation between ε'_m and total porosity ($r = -0.984$).
Contrary to the values of ε'_m, the highest values of σ_{AC}, for all knitted fabrics, were noticed at the highest measured frequency (140 kHz), Figure 2b. The σ_{AC} at a frequency from 30 Hz

to 140 Hz is almost independent of frequency (the plateau is observed). Between 140 Hz and 1400 Hz, the σ_{AC} slightly increases with the increase of the frequency, and after that, the σ_{AC} sharply increases. The differences in σ_{AC} between fabrics are the highest at the highest frequency. The presented results followed the data reported by Asanovic et al. [16] obtained for cellulose based woven fabrics. According to the presented results (Figure 2b), in the whole frequency range (i.e., between 30 Hz and 140 kHz) the σ_{AC} values of Sample 1 and Sample 2 are almost the same, while Sample 3 shows the highest values of σ_{AC}. Based on the above mentioned, that the fabric is referred to as a heterogeneous three-phase system, and that the flax fabrics were knitted from the same yarn, it is clear that the moisture content, as well as porosity, determine their σ_{AC}. Samples 1 and 2 have almost the same moisture content and total porosity (5.54% vs. 5.57%, 83.5% vs. 83.1%, respectively, Table 1) and consequently the same σ_{AC} values. In other words, the highest moisture content and the lowest porosity of Sample 3 (6.65%, and 81.6%, respectively, Table 1) is the reason for the highest σ_{AC} values of Sample 3. Namely, the presence of moisture increases the number of the polar groups and facilitates the flow of current through amorphous regions of fibers [10]. Furthermore, regression analysis shows an almost perfect linear correlation between σ_{AC} and moisture content ($r = 0.999$) and a very high coefficient of linear correlation between σ_{AC} and total porosity ($r = -0.990$).
The obtained results for resistivity correspond with the results obtained for investigated dielectric properties (ε'_m and σ_{AC}).

3.2. Compression properties of knitted fabrics

Keeping in mind that one of the significant properties of textile materials intended for clothing purposes is their ability to alter the thickness at relatively low compression loads [8], the compression properties (compressibility and compression resilience) were determined and presented in Table 3.

Table 3: Values of compressibility and compression resilience of investigated knitted fabrics

Sample number	Compression properties			
	Compressibility		Compressive resilience	
	C, %	cV, %	*RC*, %	cV, %
Sample 1	37.29	3.91	23.77	3.46
Sample 2	37.20	4.72	25.32	1.14
Sample 3	33.25	6.28	25.36	2.95

Based on the results of fabrics' structural characteristics (Table 1) and the results of compressibility and compressive resilience (Table 3), it is possible to conclude that increasing fabrics' compactness (stitch density, fabric weight, fabric thickness) and decreasing the porosity cause simultaneously the decrease of compressibility and an increase of compressive resilience of knitted fabrics. During the increases of the compression force, Sample 1 is the most susceptible to flattening thanks to the lowest values of structural characteristics (number of wales, number of courses, stitch density, thickness), which provide the highest porosity, and thus the broadest spaces for yarns flattening in that sample. In contrast, the highest values of structural characteristics of Sample 3, along with the lowest porosity, prevent fabric easy compression. From the above mentioned, the knitted fabric flattens under compression; the yarns place closer to each other, which results in increasing the tension between yarn loops. This tension is higher in dense fabrics due to the closest contact between the yarns and lower porosity. Under recovery conditions, the yarns in loops tend to return to their relaxed state. Higher tension between the yarns during compression in the dense fabric allows for their easier and faster return in a relaxed state leading to an increase in the compressive resilience. Higher values in the compressive resilience, which is considered an indicator of fabric's ability to recover after compression [9], are of great importance concerning flax knitted fabrics, bearing in mind that the flax fibers have low elasticity. The obtained results for investigated compression properties are in accordance with the results presented in the literature [9,11,17]. Based on the regression analysis, it is evident that compressibility shows the best linear correlation with porosity ($r = 0.984$) while compressive resilience with the thickness ($r = 0.919$). Conducted statistical analyses by using t-test show a statistically significant difference between compressibility of Sample 3 and Samples 1 and 2 ($t_{S1/S3}$=3.54, $t_{S2/S3}$=3.23), as well as between compressive resilience of Sample 1 and Samples 2 and 3 ($t_{S1/S2}$=-3.98, $t_{S1/S3}$=-3.20); level of significance of 0.001 or 0.05. However, there is no statistically significant difference between the compressibility of Sample 1 and Sample 2 ($t_{S1/S2}$=0.09), as well as between the compressive resilience of Sample 2 and Sample 3 ($t_{S2/S3}$=-0.11).

3.3. Quality of knitted fabrics

The average grade for each sample was used to establish the rank order of the tested knitted fabrics (Table 4).

Table 4: The rank order of knitted fabrics

Sample number	G_ρ	G_ε	G_σ	G_σ	G_C	G_{RC}	G_{AV}	Rank of fabric
Sample 1	3	2	3	3	1	3	2.40	III
Sample 2	2	3	2	2	2	2	2.20	II
Sample 3	1	1	1	1	3	1	1.40	I

G_ρ—grade of DC volume electrical resistivity, G_ε—grade of effective relative dielectric permeability, G_σ—grade of AC specific electrical conductivity, G_C—grade of compressibility, G_{RC}—grade of compressive resilience, and G_{AV}—average value of grades (Grade "1" indicates the best and grade "3" indicates the poorest analyzed properties).

Results presented in Table 4 indicate that Sample 3, with the most compact structure (the highest stitch density, fabric weight, fabric thickness, and the lowest porosity), and the highest moisture content, shows the best quality (Rank I), while Sample 1, with the least compact structure, and the lowest moisture content show the worst quality (Rank III).

4. CONCLUSION

The current study showed that the sample with the most compact structure has the lowest DC volume electrical resistivity but the highest effective relative dielectric permeability and AC specific electrical conductivity, primarily due to the highest moisture content. The obtained results for fabrics' electrical resistivity are in good agreement with the results obtained for both investigated dielectric properties. Regression analysis showed a very high coefficient of linear correlation between resistivity, dielectric permeability, and conductivity with moisture content (-0.991, 1, 0.999, respectively). Furthermore, it was noticed that sample with the least compact structure has the highest compressibility, while the sample with the most compact structure has the highest compressive resilience. The highest coefficient of linear correlation between analyzed compression properties and structural characteristics of knitted fabrics is between compressibility and porosity (0.984) and between compressive resilience and thickness (0.919). Application of the ranking method showed that the fabric with the most compact structure and the highest moisture content has the best quality. At the same time, the fabric with the lowest compact structure and the lowest moisture content has the worst quality (Rank III) from the aspect of analyzed electro-physical and compression properties.

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 and 451-03-68/2022-14/200162). The authors gratefully acknowledge Aleksandra Ivanovska, Innovation Center of the Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, for determination of fabrics moisture content, and dielectric properties.

REFERENCES

[1] Mikučionienė, D., Milašiūtė L., Baltušnikaitė J., Milašius R. (2012). Influence of plain knits structure on flammability and air permeability, *FIBRES & TEXTILES in Eastern Europe*, 20 (5), 66-69.

[2] Spencer, DJ. (2001). *Knitting technology: a comprehensive handbook and practical guide.* 3rd ed. Woodhead Publishing Ltd, Elsevier, Cambridge.

[3] Ray, SC. (2011). *Fundamentals and advances in knitting technology*, Woodhead Publishing India, Elsevier.

[4] Mishra, R., Jamshaid H., Yosfani SHS., Hussain U., Nadeem M., Petru M., Tichy M., Muller M. (2021). Thermo physiological comfort of single jersey knitted fabric derivatives, *Fashion and Textiles*, 8 (40), 1-22.

[5] Lazić, BD. (2018). Influence of different treatments of physico-chemical modification on structure and properties of flax fibers. Ph.D. Thesis, University of Belgrade, Serbia.

[6] Lewin, M. (2007). *Handbook of Fiber Chemistry*. 3rd ed. Taylor & Francis Group, LLC, CRC Press.

[7] Asanović, K., Kostić M., Cerović D., Mihailović T., Kramar A., Pejić B. (2018). Tendency of textile materials to generate static electricity: methods for characterisation and control, *6 th SCIENTIFIC-VOCATIONAL CONFERENCE with international participation, Development Tendencies in the Textile Industry-Design, Technology, Management*, Belgrade 27 jun 2018, pp. 5-12.

[8] Asanovic, KA., Cerovic DD., Mihailovic, TV., Kosti,c M.M., Reljic, M. (2015). Quality of clothing fabrics in terms of their comfort properties, *Indian Journal of Fibre and Textile Research*, 40 (4), 363-372.

[9] Asanovic, KA, Kostic,, MM., Mihailovic, TV., Cerovic, D.D. (2019). Compression and strength behaviour of viscose/polypropylene nonwoven fabrics, *Indian Journal of Fibre and Textile Research*, 44 (3), 329-337.

[10] Ivanovska, A., Cerovic, D., Maletic, S., Jankovic, Castvan, I., Asanovic, K., Kostic, M. (2019). Influence of the alkali treatment on the sorption and dielectric properties of woven jute fabric, *Cellulose*, 26 (8), 5133–5146.

[11] Asanovic, K.A, Mihailovic, TV, Cerovic, DD. (2017). Evaluation of the quality of clothing fabrics in terms of their compression behaviour before and after abrasion, *Fibers and Polymers*, 18 (7), 1393-1400.

[12] Morton, WE., Hearle, JWS. (2008). *Physical properties of textile fibres*, 4th ed. Woodhead Publishing Limited, Cambridge.

[13] Ivanovska, A., Asanovic, K., Jankoska, M., Mihajlovski, K., Pavun, L., Kostic, M. (2020). Multifunctional jute fabrics obtained by different chemical modifications, *Cellulose*, 27 (14), 8485–8502.

[14] Cerovic D., Asanovic K., Maletic S., Dojcilovic J. (2013). Comparative study of the electrical and structural properties of woven fabrics, *Composites: Part* B, 49, 65–70.

[15] Bal, K., Kothari, VK. (2009). Measurement of dielectric properties of textile materials and their applications, *Indian Journal of Fibre and Textile Research*, 34 (2), 191–199.

[16] Asanovic, KA., Cerovic, D.D., Kostic, MM., Maletic, SB., 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, 1-12.

[17] Soltanzadeh, Z., Shaikhzadeh Najar, S., Haghpanahi, M., Mohajeri-Tehrani, MR. (2016). Prediction of compression properties of single jersey weft-knitted fabric by finite element analysis based on the hyperfoam material model, *FIBRES & TEXTILES in Eastern Europe*, 24 (2), 82-88.