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Influence of inkjet print parameters on thermal resistance of printed knitwears

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Introduction

Comfort is a basic and universal need of a human being and represents one of the most important aspects of clothing. When wearing clothes, the heat and humidity produced by the body stop as layers of air before passing into the environment, resulting in a characteristic microclimate between skin and clothing and is defined as a feeling of comfort (Yoo et al, 2000; Grujić et al, 2010). One of the most important thermal characteristics of clothing is, of course, thermal resistance; which represents the ability of a material to resist heat transfer. The thermal resistance of garments, made of a number of textile materials, mostly depends on the thickness and porosity of individual layers (Matusiak, 2010). Thus, increasing the thickness of the material leads to an increase in the value of thermal resistance (Oğlakcioğlu et al, 2007). In the printing process, a layer of ink is transferred to the clothes, and part of the printing ink covers the surface clothing, while the other part fills the pores between the fibers. In this way the paint represents a new layer material, i.e. an additional barrier in heat transfer from the body surface to the environment. This paper will show the influence of this new layer of material obtained by the printing process on the thermal resistance of clothing. The influence of the number of ink applications and the tone value, as well as the influence of material type, are making a difference on the thermal resistance of printed textile materials. The thermal resistance of textile materials depends on the type of fiber. Then a layer of printing ink is applied to and in the textile material by the printing process. Printing ink covers the surface of the fibers, making a significant influence on the thermal resistance of textile material (Kašiković et al, 2019).

Methods

Research of the effect of tone value and a different number of ink applications on thermal resistance was performed on two types of textile knitwear, of approximately the same surface mass and surface structures but different material composition. Thermal resistance, i.e. thermal insulation, is greatest when a person is at rest, because then the air under clothes is also at rest. Examination of thermal resistance of knitwear is performed with KES-F7 (Thermo Labo II) measuring device with a larger measuring body BT, which is located in the wind tunnel and which is heated to a temperature of 35 °C. At the same time, the air in the wind tunnel was constantly moving at a speed of 1 ms^{-1}, at a temperature of 20 °C ± 2 oC. Constant air movement is achieved by turning on the fan.

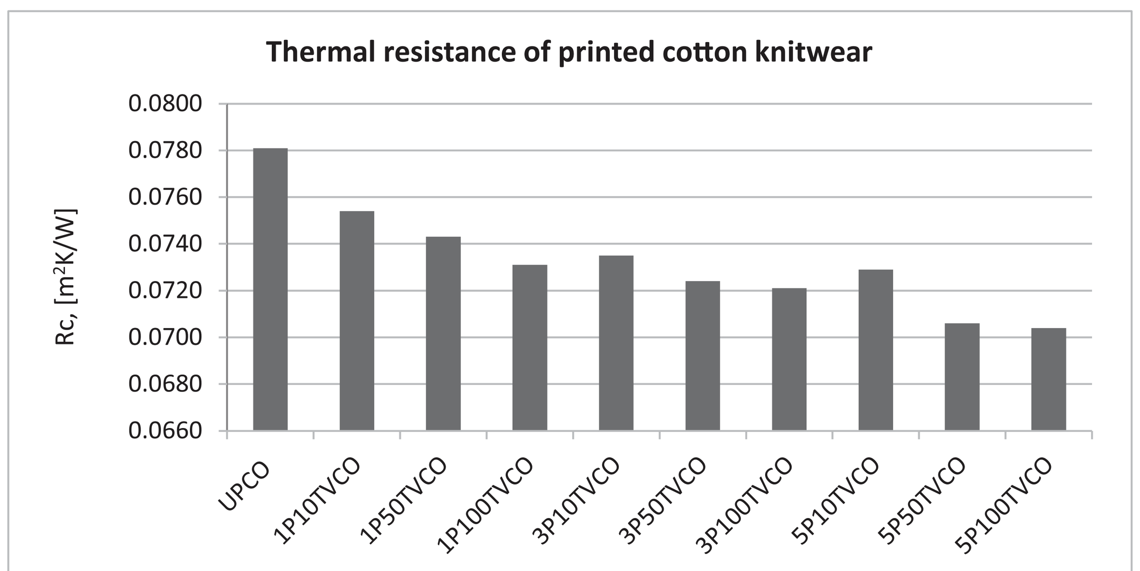

Figure 1

Thermal resistance of cotton knitwear subjected to the printing process (Note: UP – Unprinted, 1P, 3P and 5P mark indicates the print with 1, 3 and 5 passes, 10TV, 50TV and 100TV denote a print with 10%, 50% and 100% of tonal values, CO stands for cotton)

Results

The measured values of thermal resistance of printed cotton knitwear materials (CO) are shown in Figure 1. They are noticeably lower than the given values of the unprinted sample. It can be also noticed that the thermal resistance of printed cotton knitwear decreases with increasing of ink coverage. At the same time, with the increase in the number of ink applications, there is also a decrease in the value of thermal resistance. By analyzing the values of thermal resistance of printed cotton knitwear, it can be noticed that by combining the tone value and the number of ink applications, it is possible to achieve similar values of thermal resistance. The obtained results showed that approximately equal values of thermal resistance were obtained by printing samples with 10% TV with five coats of ink and 100% TV with one coat of ink.

The results of thermal resistance analysis of printed polyester knitwear (PES) are shown in Figure 2. It can be noticed that increasing of the tone value leads to an increase in the value of thermal resistance. At the same time, the obtained measurement results indicate that as the number of ink applications increases, the values of thermal resistance increase, regardless of whether the samples were printed in one, with three or five ink applications. It is also noticed that the polyester knitwear obtained higher values of thermal resistance in the printing process in relation to the values that occur with unprinted material. Further analysis of the obtained results shows that approximately equal values were obtained in the case of printing samples with 10% TV with three print passes and 50% TV with one print pass, and in the case of printing 10% TV with five print passes and 50% TV with three print passes.

In order to determine dependence of thermal resistance of printed cotton and polyester knitwear, when printing with different tone value (TV) and different number of ink applications (NP), mathematical dependence models were created using multiple regression analysis. In creating model, as independent variable value were used printing process parameter values, i.e. values of ink layers applications and tone values. At the same time, as the dependent variable values were used experimentally obtained values of measuring thermal resistance of tested knitwear.

The results show statistically reliable dependences of thermal resistance on tone values and the number of passes when printing for the test of cotton and polyester knitwear.

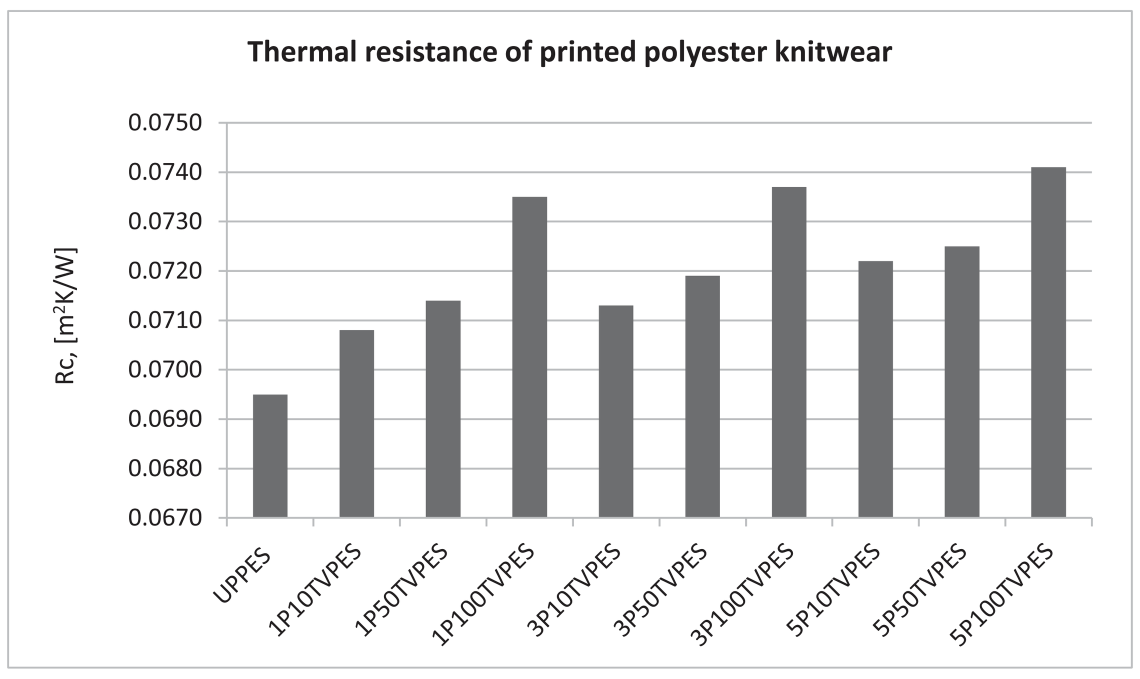

Figure 2

Thermal resistance of polyester knitwear subjected to the printing process (Note: UP – Unprinted, 1P, 3P and 5P mark indicates the print with 1, 3 and 5 passes, 10TV, 50TV and 100TV denote a print with 10%, 50% and 100% of tonal values, PES stands for polyester)

Discussion / Conclusion

Textile materials are increasingly being subjected to the process of printing. This paper examines the effect of the parameters of digital printing on thermo-physiological characteristics of printed textile materials. For this purpose, the influence of the tone value and different number of ink applications on the thermal resistance. In the analysis of cotton knitwear it was noted that increase of the tone values as well as increase of number of ink applications leads to increase of the thermal resistance. In printing the polyester knitwear initial increase of tone value results in reduction of thermal resistance. This confirms that the change in the tone value or the number of ink applications, as the parameters of digital printing, can affect change in thermal resistance.
The values of thermal resistance highly depend on the surface structure of the material. For all tested materials, it is possible to create mathematical models of the dependence of thermal resistance on the number of ink applications and tone value. Summarizing the results, it can be concluded that the print parameters have an important effect on thermal resistance, as one of the parameters of textile materials thermal comfort. In order to further knowledge it is planned to test how other process colours affect the studied parameters. Also, research is needed to expand to other physiological parameters of thermal comfort, such as thermal conductivity, warm and cold feeling, resistance to the flow of water vapour and others. In addition to the knitwear tests, listed research is needed to carry out on fabrics too.

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