A COMPARATIVE STUDY OF THE IMPLEMENTATION METHODS OF HEATING ELEMENTS USED FOR THE DEVEOPMENT OF TEXTILE HEATERS

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Abstract: *The focus of this paper is to make a comparison between five different types of conductive, heatable samples. These samples have been produced according to the five most important implementation techniques developed so far, which are knitting, weaving, embroidery, printing and nonwoven padding –and their purpose is to help decide which conductive option best accommodates a heating application. This study was divided into four major steps: choosing the adequate materials, swatch production, conductivity measurements and heating behaviour assessment. The first three methods use electro conductive wires as heating elements, the fourth uses conductive ink and the fifth uses carbon black coating. For all of them, resistance, current and heat distribution was measured. The results show that the best options for the development of a wearable textile heating system are the printed and the knitted techniques, as their mechanical strength and elasticity, is sufficiently high and the fabric/substrate structure allows the insertion/deposition of different types of heating elements.*

Keywords: *Conductive, heating, knitting, woven, embroidery, printing*

1. INTRODUCTION

The swatches produced for this study have the final purpose of determining which type of conductive structure best suites a textile heating system. This textile heating system will be used to develop a specialized product for people with physical disabilities. To figure out the best textile heater that will keep the sensitive skin of the wearer safe, and also that will not damage the tissue due to high rigidity, five swatches were produced and analysed: knitted, weaved, embroidered, printed and nonwoven padded fabrics. They were tested for conductivity and heatability.

2. MATERIALS

In terms of materials, the afore mentioned swatches deal with two types of materials: the heating element and the substrate, which is the support fabric for the heating element. The materials that make up the heating elements were different according to the implementation technique, meaning that their parameters had to be specifically selected in order to best fit the technology used. The first three samples used the same type: specialized textile Shieldex threads, designed to generate heat when connected to an energy source, supplied by Statex, Germany. The fourth sample used Sunchemical's nanoparticle silver ink (Suntronic Jettable Silver U5603) and the fifth used carbon black padded nonwoven, supplied by Lantor BV, The Netherlands. As for the substrate, the materials ranged from cotton, PA, to nonwovens and heat resistant PES.

3. METHODOLOGY

Five samples were produced using the five implementation techniques mentioned before. The electroconductive textile thread was knitted (STOLL CMS 530), woven and embroidered (BROTHER PR-600) and the conductive ink was printed according to several patterns (JetLab 4 from MicroFab Technologies). Also, the carbon black conductive sample was manufactured with the help of Lantor BV. All these samples can be observed in the picture below.
There were two specific methods by which the samples were tested. Firstly, their resistance was measured using a basic Voltcraft VC860 multimeter, after which the heating behaviour was assessed by applying voltage using a Voltcraft VLP2403 power supply and reading the temperature with the help of a temperature sensor.

Woven Knitted Embroidered Inkjet Printed Nonwoven

Figure 1. Samples corresponding to the five implementation methods

4. RESULTS AND DISCUSSION

The results show that when it comes to obtaining textile heaters, there are a multitude of heating elements to be used and all implementation techniques are valid. The non-woven carbon black sample showed very high resistance. The aimed resistance value for a textile heater is around 100 Ω, but the analysis of the sample indicated far greater values. The fabric in it's original size has around 1 kΩ and as the tested surface decreases, the resistance goes up. A smaller sample was also tested in a attempt to obtain a smaller resistance, but the resulting value was almost double. To be more exact 2,3 kΩ. This was also supported by the fact that for an applied voltage of 41,5 V the fabric reached a internal temperature of around 25 ˚C. Unfortunately, to make such a fabric generate heat, higher voltage is needed and values above 50V are dangerous for human beings. Another aspect to be considered is the fact that carbon is toxic, and its use should be wisely evaluated if the application implies direct contact with the skin [3].

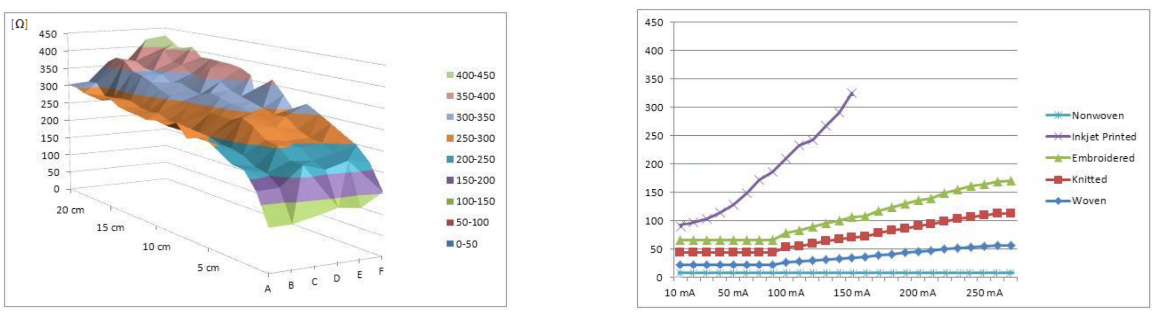

Figure 2. Resistance and temperature measurements for the carbon black nonwoven sample

Other tests done on the embroidered sample showed that the conductivity and it's heating behaviour are strongly depependent on the type of electroconductive thread used. The general conclusion is that when textile threads are used as heating element for obtaining textile heaters, averange voltage values are required. In this case, for a supplied voltage of 17 V, the maximum temperature reached was 58,4 ˚C, before the thread broke, .

The best option, as far as integrability and wearability goes, is using the printed heating element. The nonoparticle silver ink printed samples showed very good results. Not only it was neccessary just a small voltage to obtain a high temperature (4 V implied a 30 ˚C temperature), but a small increase in the intensity of the current, around 10 mA, made the temperature rise with more than 10˚C. This translates into the fact that with a small capacity battery, great heating can be achieved. The measurments were stopped when the temperature reached 105 ˚C, to protect the printed pattern from degradation.
Further tests will focus on analyzing different printed shapes and inks, and pattern integrity issues under mechanical stress. As well as observing different types of electroconductive heatable textile threads and structures.

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