THE ANALYSIS OF SOME SEWED HEATING TEXTILE ELEMENTS (Poster Presentation)

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ABSTRACT

The creation of textile products with heating properties entails the manufacturing of a system based on a set of elements that must ensure the desired functionality of a particular fabric. Even if there are several types of textile heating elements, the study focuses on functional products whose structures incorporate various electroconductive yarns specially designed for this particular purpose. Currently, such yarns acquired characteristics which are similar to those of conventional textile yarns (fineness, flexibility, the ability to be processed on machines that are specific to the textile industry), due to their progressive evolution. As a consequence, the electroconductive yarns can be easily and effectively integrated into textile structures, thus allowing the use of a wide range of implementation and processing techniques that are specific to this field of activity.

Key Words: *textiles, functional, heating, testing, evaluation*

1. INTRODUCTION

Body temperature is a factor that plays an important role in preserving the vital functions of the human body; this is the reason why it becomes paramount to make sure that it is maintained at a constant value, a process that is carried out, first and foremost, through the clothes one wears. Heating apparel has become more and more complex during the recent period, focusing on assuring thermal protection when the wearer spends a considerable amount of time in a cold environment and on maintaining a normal thermal comfort in the case of people with health problems.

Here are some factors that influence the thermal balance of the human body:

- The genetic heritage of each and every individual, influencing the degree to which temperature fluctuates in various body parts:
  - The temperature of internal organs located in the torso area is higher than the temperature of extremities;
  - The temperature of specific body areas and extremities modifies according to environmental temperature changes;
- The quantity of heat produced by our bodies depending on physical activities (the heat produced by our bodies reaches 1000W when one executes activities that require physical effort, 1250-2100W in cases of extreme physical effort, and drops to 70-100W in a state of rest);
- Environmental conditions (environment temperature, air speed, humidity level) correlated with the time of the day, influence the optimal thermal level of the human body (the lowest level is recorded during the earliest morning hours whereas the highest level occurs towards the evening);
- Types of clothing – textile articles/products with heating properties must meet several specific design criteria in order to assure protection and/or increase human thermal comfort:

- The structure of a certain apparel product must be conceived so as to guarantee the desired heating effect;
- The initial phase of the design process entails the determination of temperature levels that must be reached by taking into consideration the referential temperatures for the targeted applications. For example, if one must create an undergarment product with heating properties, the temperature level will be correlated to the body temperature at the skin level; on the other hand, if we want to heat an outer garment, its temperature level will be determined according to the thermal conditions that are specific to the environment in which the wearer will carry out his or her activities.
- When designing heating apparel products, one must keep in mind the heat generated by muscles in distinct body areas, depending on the activities that are executed. Thus, the heating areas must not be placed on the entire surface of the apparel product, but only on those areas where thermal problems occur. It suffices if the thermoregulation process of the heating flux takes place only in those particular spots.

2. SEWN APPAREL PRODUCTS WITH HEATING FUNCTIONS

In order to enjoy an active healthy lifestyle, one must achieve an adequate level of thermal adjustment depending on the individual's specific wearing requirements and health condition. Such thermal comfort can be assured by creating an array of textile articles/products with heating areas manufactured through various technologies. Garments with heating properties rely on a modular system whose objective is to guarantee the desired functionality of the textile product (Figure 1).

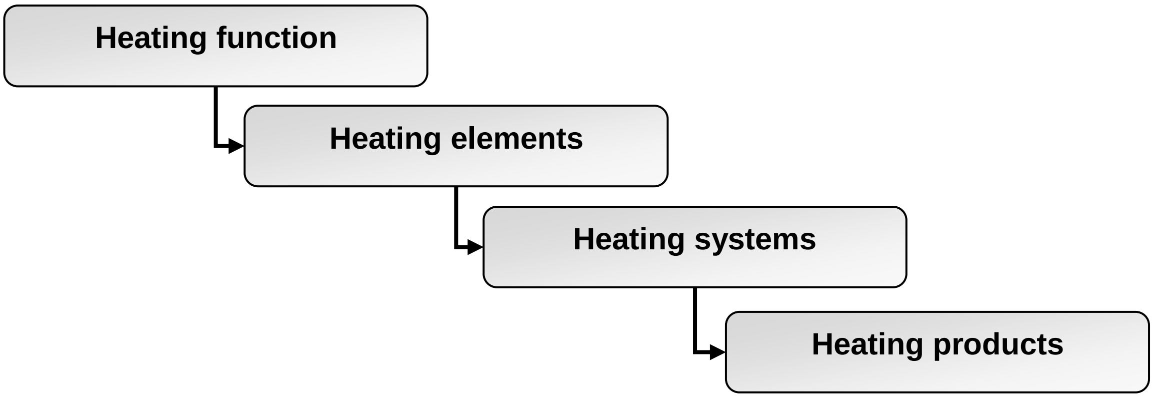


Figure 1. A general description of how the heating function is implemented within the textile products

The heating element itself used within the designed heating articles consists of electroconductive yarns sewn on various textile supports [1]. Apart from the electroconductive yarns used for assembling the product's heating system, there are other related aspects that must be taken into consideration, such as: the nonconductive yarns, the connections between yarns (in terms of strength and sturdiness), other electronic elements, preserving the integrity of the conveyed signal and the system's mechanical properties, as well as maintaining textile properties (reduced weight, flexibility, resistance, etc.) [2, 3].

From the wide range of electroconductive yarns (metallic yarns, yarns made of conductive polymers, polymeric yarns with a high level of conductive particles – carbon, silver, etc.), we selected only those which were adequate for manufacturing heating applications.

In order to manufacture various heating textile products, one of the main textile technologies we approached within our research is sewing.

The sewing technology allows us to:

- Use electroconductive yarns and a significant array of textile supports such as woven fabrics, jersey, nonwoven fabrics, and leather;
- Manufacture several heating textile products for various industrial sectors, such as: outer garments, footwear, undergarments, socks, gloves, bed linen, covers for car seats or desk chairs, medical furniture (beds, covers for beds, pillows, mattresses), protection clothing, and work equipments.
- Assure an adequate stability of the textile heating systems. On one hand, the integrated heating components are quite fixed, which makes it easy to achieve a steady heating behaviour; on the other hand, the risk of contact between yarns is relatively low.

Several aspects are considered when using the sewing technology for manufacturing heating apparel:
- the type of electroconductive yarn used, with adequate sewing properties;
- the width of the stitch;
- the surface covered in stitches;
- the textile support.

Here are some types of electroconductive yarns used for sewing and testing within our research:
- Carbon polyester yarn, KC-782 R, fineness: 20/4 dtex ;
- Single metallic conductive yarn, covered in textured polyester yarn,DA5340, fineness: 78/34 dtex;
- Single metallic conductive yarn covered in textured polyester yarn DA5393, fineness: 167/96 x1 dtex;
- Silver-coated electroconductive yarn, Shieldex® 117/17 dtex 2-ply HC+B, final fineness: 300 dtex .

From all of the above yarns, we selected the Shieldex® 117/17 dtex 2-ply HC+B yarn (Figure 2), which has adequate machinability properties when being processed by using the desired textile technology (sewing) and is also functional as a heating element within some textile articles/products. Each obtained sample that we tested is different from the others because of the following aspects:
- The use of two types of textile supports (jersey and woven fabric);
- The use of three types of stitches (504, 602, 603) executed on specific sewing machines;
- The stitches were executed by using the selected electroconductive yarn, with two distinct methods of powering the circuit;
- The obtained stitch/stitches can be assimilated to a series / parallel electric circuit.

Figure 2. Shieldex® 117/17 dtex 2-ply HC+B yarn

Examples of obtained samples are presented below:

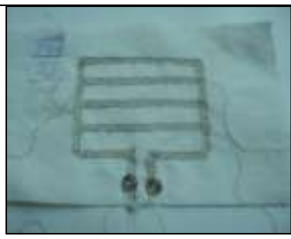
Sample of glove lining with heating properties.
The sample was obtained by producing a stitch (type 602) on a Uberdeck machine with 2 needles and 3 yarns (the horizontal rows at the tip of the glove executed on both sides of it) and a stitch on the Triploc machine (the outline of the glove) by using 100% cotton jersey as textile support in a plated single jersey structure with lining yarn. The stitch in the fingertip area comprises a four-route circuit that behaves like a parallel electric circuit, on both sides of the glove. The electroconductive yarn is powered at the distributor of inferior covering yarn, spreading **on both sides of the glove**.

M1

Sample of glove lining with heating properties.
It was obtained by producing a stitch (type 602) on a Uberdeck machine with 2 needles and 3 yarns, with the electroconductive yarn powered from the distributor of inferior covering yarn and using as a textile support a 100% cotton jersey, in a plated single jersey structure with lining yarn. The stitch is executed with a single route that behaves similar to a series circuit, without following the glove's outline at the top. The modified route is placed in the fingers area. The electroconductive yarn spreads **on one side of the glove.**

M2

The sample was obtained by producing a stitch (type 603) on an Uberdeck machine with 2 needles and 4 yarns, on several routes that behave similar to a parallel electric circuit, using as a textile support the 100% polyester woven fabric. The electroconductive yarn is powered at the distributor of superior covering yarn, spreading **on one side of the textile support**.



M3

The sample was obtained by producing a stitch (type 603) on an Uberdeck machine with 2 needles and 4 yarns, on a single route, covering the superior side of the surface that behaves similar to a series electric circuit, using as a textile support the 100% polyester woven fabric. The electroconductive yarn is powered at the distributor of superior covering yarn **on one side of the textile support**.

M4

A number of tests were conducted by using complex equipment whose main component was the Fluke Ti 125 infrared thermovision camera. The results consisted in an array of thermal images of the assessed samples and temperature-current correlation charts. In Figure 3 one can observe the thermal images corresponding to the four analysed samples and, based on the temperature-current correlation, charts pertaining to every sample. Test results and observations were also included (Table 1).

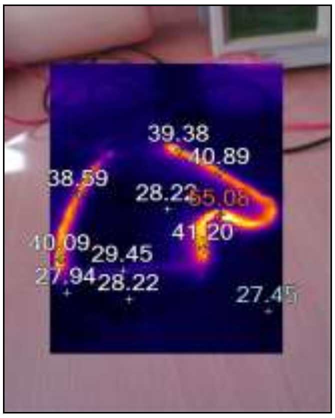
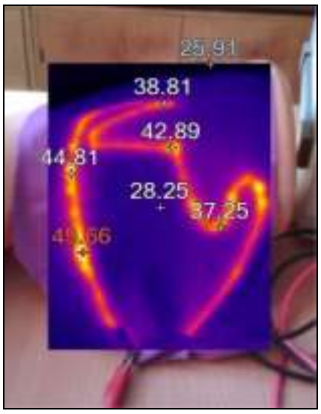
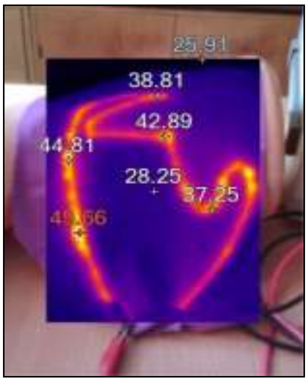
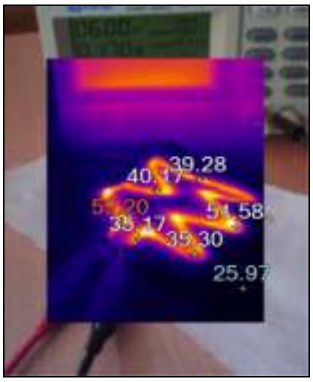
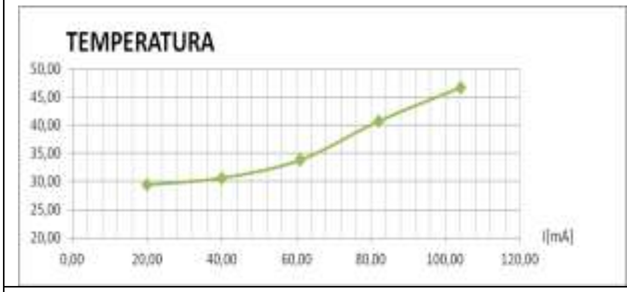
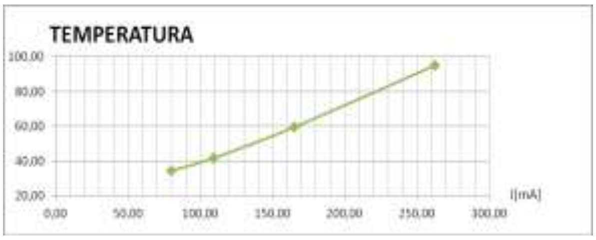
 a. Sample M1	 b. Sample M2
 c. Sample M3	 d. Sample M4

Figure 3. Thermographic images of the selected samples

Table 1. Results and discussion

Temperature-current property	Observations and results
Sample M1 	- The resistance of the executed circuit is of 104.1 Ω. - It was recorded an *adequate, partial heating* on the outline of the glove, on the shortest route. No heating was recorded in the superior part of the fingers area. Towards the tip of the glove, the current is distributed on the four routes, therefore its value is low on every single route (about 35mA, with small variations depending on the electrical resistance on each route) and it cannot lead to the heating of the 4 routes in a parallel circuit. - To obtain a temperature of about 40^{0}C: U = 10V, I = 112mA.
Sample M2	- The resistance of the executed circuit is

Temperature-current property	Observations and results
	of 101 Ω. - It was recorded an adequate heating on the entire stitch route. - To obtain a temperature of about 40^{0}C: U = 8V, I = 82mA.
Sample M3 	- The resistance of the executed circuit is of 19.2 Ω. - It was recorded an *adequate, partial heating* on the shortest route, and no heating at all on the rest of the surface covered with circuits. Towards the superior area, the current is distributed on the 4 routes, thus having a lower value on each route and being incapable of heating the 4 routes in a parallel circuit. - To obtain a temperature of about 40^{0}C: U = 2V, I = 112mA.
Sample M4 	- The resistance of the executed circuit is of 39.6 Ω. - It was recorded an adequate heating of the entire stitch route. - To obtain a temperature of about 40^{0}C: U = 3.9V, I = 100mA.

5. CONCLUSİONS

The main interest of the studies developed is to obtain a proper heating temperature at a lower voltage which will allow us building a constant current source powered from limited number of AA- or AAA-sized NiMH rechargeable batteries. A constant current source with a LM317 can easily provide I=~100mA to drive the heating within the proposed electro-textiles. The M2 and M4 which presents continuous stitch route seem to be the most suitable for the planned application.

Acknowledgements
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