

Possibilities and applications of smart textiles

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Abstract. In the process of creating of new clothing products, the designers choose textiles which have: appearance, comfort, durability, shape retention, protection from bad weather, etc. These aspects not fully satisfy the new factors, such automatic regulation of body temperature; signs of heart attack; fever and others. Smart textiles possess such advanced properties. The functionality of smart textiles consists in informing, protecting and relaxing the wearer. In this research, we approached and revealed the application of e-textile materials and their importance in clothing. The research methodology consists in the efficacy of applying Cu wires to the fabric and the result obtained. The results obtained are positive and they are revealed in the research.

1 Introduction

With the development of personal computers (PCs), in the mid-70's together with the advent of the Internet (in 1989), an unprecedented technological explosion was recorded, with major implications in all areas of human activity. Everyday life, current requirements call for the use of phones, PDAs, technical means of which people cannot be deprived. An applicability of informational sources constitutes also the intelligent textiles: dresses, shirts, jackets and girdles, all being obtained by weaving high conductivity yarns together with cotton, nylon or polyester yarns [2]. The metal wires connect the sensors to the microcontrollers inserted in the garments and the special programs control the communications in the semi-fabric network.

To begin with, it is necessary and reasonable to give an explanation of the term „e-textile”, which is, in fact, a combination of high tech apparel and fashionable apparel.

The notion of „e-textile” [1] was introduced in the late 90's in order to disseminate the materials that change their properties under the action of certain stimuli, where processes take place by introducing substances with specific properties (detection, processing, updating, etc.) in materials of different textile-types, plastic, metal or metal alloys, building constituents, etc.

The three processes (detection-processing-updating) are embedded separately in intelligent materials and must be joined by means of an automatic control system.

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The concept of intelligent material derives from the intelligent forms of natural systems (fabrics/materials), that is, living organisms. As a result, Intelligent Materials are designed as a material that performs natural functions of sensing, actuation, control and intelligence. Intelligent materials (“smart / intelligent materials”) have the ability to adapt themselves to external stimuli.

The use of the smart textile were a preoccupation for the researchers and some of the research results were published over the years.

Chan Vili studied the use of shape memory materials in developing high performance smart textiles, taking into consideration ways for enhancing aesthetics of woven interior textiles [2]. Such materials are capable of monitoring the temperature change and can react by the textiles shape.

Mondal showed that the use of phase change materials could be considered as advantageous in using the storing or releasing the latent heat, when such materials are incorporated in thermos-regulated smart textiles [3] by coating or encapsulation. He analyzed the use of some recent concepts and applications in the field of smart textiles and their extension in the market.

Diaconescu et al. described an experimental study aiming to measure and display the temperature by means of a commercial sensor [4]. An electrical scheme able to incorporate the sensor was designed and applied. The experimental study proved the possibilities of using such a solution to highlight the temperature inside and outside.

Massaroni et al. took into the use of fiber optic sensors incorporated in smart textiles to continuously monitor some physiological parameters [5]. They found that there are fields of application where the so called standard sensors cannot be employed. The smart textiles could be applied in respiratory and heart beat monitoring, offering good metrological performances.

The research presented in this paper aimed to present some results of using certain sensors in generating and analyzing the behavior of smart textiles.

2 Methodology of experimental investigation

Smart textile materials are made of intelligent fibers and yarns, using nanotechnologies, sensors, processors, devices for various usages: military equipment, medical articles (for determining the health condition, prophylaxis and treatment) protection equipment (for firefighters, workers operating in particular conditions, etc.), sports equipment (mountaineering, swimming, athletics, etc.), entertainment (apparel products with built-in music devices), household and industrial appliances, etc. [6].

Depending on the type of reaction to stimuli, smart textile materials [7] can be: passive (only sensing the external stimuli), active (sensing and responding to stimuli) and very smart (sensing, reacting and adapting to stimuli).

The concept of “smart materials” is based on outstanding properties in terms of durability, comfort adjustment, thermal protection, shape maintenance, scratch restoration/mending, reduced weight, low production costs, etc.

Other types of „e-textile” materials [4] are also electronic textiles, they combine the finishing processes of air and vapor permeable fabrics with the insertion of metallic materials.

The adding of nickel, copper or silver as a superficial layer having different thicknesses in the textile material gives it special physical and electrical properties, which can have many applications.

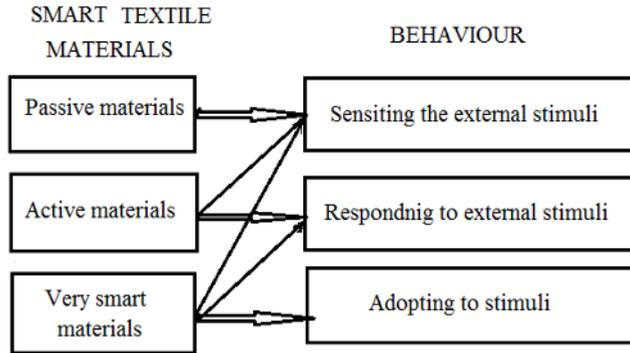


Fig.1. Classification of smart materials considering their behavior.

For example, the thermal conductivity of fabrics increases thousands of times in consort with the metal fiber, while ordinary fabrics offer a minimal isotherm.

Another category of conductive materials is represented by electronic textiles that allow the passage of electricity through them or incorporated portable devices, microphones, sensors, counters or integrated circuits.

Electronic apparel products [1] have a new and revolutionary property, namely sharing of information.

Clothes are now capable of recording, analyzing, storing, sending and displaying information, having many applications: in medicine, for example, smart bandages that monitor the health parameters of injuries, security-detection of danger and help requesting, sport-monitoring of parameters.

Smart textiles will only be successful in the long run if the sensors and their associated components are fully integrated into the product.

This represents a great challenge because, besides the technical aspects, concepts, materials, structures and treatments, we must primarily take into consideration the suitability of the product to the field of use in or as a textile material [8].

The technique of weaving and knitting of copper yarns inside the thread makes their incorporation into the suit lead to a skin particular contact so that the signals can be directly taken over, without the need for the use of the electrode.

Similarly, the girdle is considered comfortable, inoffensive, safe, wearable and having maintenance (washing) possibilities. Figure 2 shows a portion of the girdle, facilitating the visibility of the position of copper wires, the interconnections and the signal transmitting antenna.

Further down we present the proposed scheme for the experiment (Figure 2).

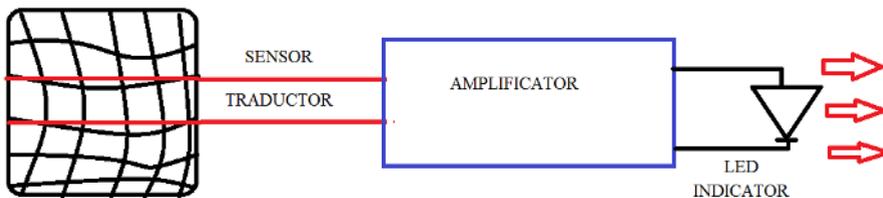


Fig. 2. Electrical operating diagram.

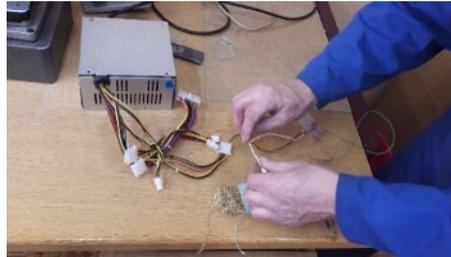


Fig. 3. Experimental method of sensor verification.

The girdle was made of natural fibers, having Lycra elastomeric yarns in their composition, copper wires with a diameter of 0.3...0.5 mm which are placed 2 cm one from another, because located at smaller distances, they are sensible and react even at the touch of the hand.

3 Results of experimental investigations

The permeability to vapors. In order to assess the vapor transmission through diffusion, direct permeability indicators are used P_v [g] and vapor permeability coefficient μ [g/m²h]. As an indirect indicator, the resistance to vapor transmission R_v [mm.m².h/g] is used for calculations. The determinations are carried out according to STAS 9005-79.

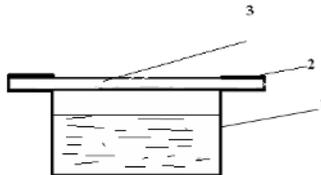


Fig.4. Herfeld glass with textile.

The method used to obtain the data needed to determine these indicators is the Herfeld glass method (Figure 4). According to this method, in a Herfeld glass (1), 50 ml of distilled water are placed and the top of the glass is covered with the test material (3) and it is fixed with a ring 2. This assembly formed of the glass is weight, water and textile material (M_i Mass), and then this assembly is introduced into an environment with relative humidity $\phi = 0\%$ (desiccator), maintaining a certain time interval (t), after which it is rewound (M_f mass). The passage of water vapor is made, therefore, from the environment with high relative humidity to the environment with relatively low humidity (from the Herfeld glass to the environment).

We made a piece of girdle using the weaving method and the other one using the knitting method. The copper threads with a diameter of 0.3 ... 0.5 mm were placed together with the warp yarn having the same diameter at a distance of 20 mm between the rows. The free ends have been connected to the 4.5 V power supply. The section of the girdle works and is considered e-material, because it reacts to humidity and the result is indicated by a LED sensor. The sensor response time starts with 80%...100% with the increase of humidity above 80 %.



Fig. 3. Woven girdle pattern.



Fig. 4. The girdle pattern made using the knitting method.



Fig. 5. Presentation of e-textiles on the blouse surface: a – obtained by the knitting method; b – obtained by the weaving method.

The conductive materials combine the finishing processes of the air and vapor permeable fabrics with the insertion of metallic materials.

The addition of nickel, copper, silver as superficial layers having thicknesses in the textile material, gives it special physical and electrical properties, which can have many applications.

Permeability P_v [g/ m²h mbar] to water vapors indicates the amount of water in grams, in the form of vapor, which passes within one hour through the surface of 1 m² of the analyzed textile material, at a partial pressure gradient of 1 mbar, oriented in the normal direction of the surface of the textile sample.

By means of the Herfeld glass method, the mass difference ($M_i - M_f$) the permeability to vapors is represented P_v [g]. If this mass difference is related to the initial mass M_i vapor permeability is obtained expressed as a percentage [%].

The relation (1) is applied for the calculation of vapor permeability at the passage of vapors P_v and the relations (2) and (3) are used to determine the vaporization coefficient μ that the resistance to the passage of vapors R_v .

$$P_v = M_i - M_f \text{ [g]} \quad (1)$$

$$\mu = Pv / S.t \text{ [g/m}^2\text{h]} \quad (2)$$

$$R_v = d / \mu \text{ [mm. h. m}^2\text{/g]} \quad (3)$$

Where:

S [m²] - the vaporization surface;

t[h] - the residence time of the Herfeld glass, with water and fabric in the desiccator.

d [mm] - the thickness of the textile material.

μ [g/m²h] - the vaporization coefficient;

R_v [mm. h. m²/g]- resistance to vapor transmission.

4 Conclusions

For the textile industry, the potential offered by combining the textile technology domain with the information technology one is immense, offering new valences to apparel products, both to normal and professional ones.

Smart clothes will certainly become the rule and not the exception in everyday life. The problem lies in the correct choice of the product market.

For the textile industry, the potential offered by the combination of these two areas of maximum and strict necessity is immense. Starting with medical products, going through the range of protective clothing and ending with interior design objects, we can say that the future is open to smart textile products, whatever they may be.

Over the years, the smart textiles materials were a subject of preoccupation for the researchers from different countries.

Taking into consideration the information found in the specialty literature, some proposals of using e-textiles obtained by the knitting method and by weaving method, respectively, were formulated.

In the future, there is the intention to investigate the behavior of this e-textiles in various experimental conditions.

References

1. European's technological platform for future industry of textiles and garments. A prospection for 2020. www.research.ro/img/.../1156747771textile%20viziune.doc/
2. Y. Y. F. Chan Vili, *Textile Research Journal*, **77** (5) (2007)
3. S. Mondal, *Applied Thermal Engineering* **28** (2008)
4. V. D. Diaconescu, L. Vornicu-Albu, R. Diaconescu, I. Racea, A. Grigoriu, *Buletinul AGIR* **3** (2015)
5. C. Massaroni, P. Saccomandi and E. Schena, *J. Funct. Biomater* **6** (2015)
6. C.A. Roberts, *Intelligent material systems – The dawn of a new materials age*, *Journal of Intelligent Material Systems and Structures*, **4** (1993)
7. M.F. Ashby, *Materials Selection in Mechanical Design* (Butterworth-Heinemann, Oxford, 1995)
8. A. Yoshihito, *Information processing using intelligent materials –Information-processing architectures for materials processors*, *J. Intell. Mater. Syst. and Struct.*, **5**-May, 418-423 (1994)