Interactive Textile Vestimentary Systems for Wellbeing

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Abstract. In response to the changes, international research and innovation has as a priority, the development of a sustainable health system with tools to ensure both the personalization of the medical act and the implementation of prevention activities. The motivation for the use of textile elements, in this context, addresses functional, aesthetic, social, communicative, psychic and moral aspects. The balance between functionality, durability, economy, ergonomics and beauty in the case of textile systems, that change the quality of life and add value, is the result of modern design focused on meeting the requirements of use. The paper presents the results of an experimental study for the realization and testing under static conditions of textile structures used as a support for attachment sensors or electronic functions.

1. Introduction:

The textile sector has, as a driving force, the development of the technical articles and the implementation of the results in the field ensuring the sustainable development of the economic agents and the social inclusion of the labour force. [1]

In EU-28, in accordance with EUROSTAT data, technical textiles represent 15% of total textile employment, 8% of the company’s active in the textile sector and 23% of the turnover of the sector. The dispersion is large inside EU countries. People's health, being a precondition for economic prosperity, influences the productivity of the economy, human capital and expenditure levels. The Union's health strategy sets out measures to prevent the emergence of diseases and to work on lifestyle-related health determinants such as working conditions, nutrition and physical activity. Promoting health is particularly important in the context of an aging population, a phenomenon stemming from increased life expectancy, and birth reduction. The projections show that by 2060 the percentage of people over 65 will increase in Europe from 17% (in 2010) to 30% [2].

In this context, textile systems used as instruments that ensure both the medical presentation and the implementation of prevention activities, define the clothing that goes beyond the type of body that approaches the spectrum of body types and ensures comfort, accessibility and style. Textile elements used as a flexible interface for attaching sensors or as a surface with textiles and electronics are part of the body-clothing-environment system. It is an open system that is permanently in dynamic interaction with the environment; physical, sensory, psychological and informational.

The human being is a complex bio-psycho-social entity; therefore, regardless of the nature of an external factor, whether harmful, aggressive or beneficial, the human individual’s organism reacts as a whole on all its manifestations: physical, physiological, neuroendocrine, psycho-behavioural, social.

The trend in the textile-garment sector to include consumer requirements in the technical aspects of
the product is the key to the sustainable development of the sector. In theory, satisfying consumer requirements and technical aspects (functionality, ergonomic apses, comfort, etc.) are just as important as ensuring the success of the product [3-5].

Companies have quickly learned that clothing needs to be functional, versatile and durable. There are two product-making philosophies: a so-called "product-out" where the manufacturer’s decision takes into account the technological and product design specifications, and a "market-in" that embraces the consumer's requirements in the product making process.

According to this philosophy, the demands and needs of the consumer, who want attractive and functional products in correlation with his personality, are transformed into technological and design requirements.

The motivation for the use of textile elements, in this context, addresses functional, aesthetic, social, communicative, psychic and moral aspects.

The balance between functionality, durability, economy, ergonomics and beauty in the case of textile systems that change the quality of life and add value is the result of modern design focused on meeting the requirements of use. The paper presents the results of an experimental study for the realization and testing under static conditions of textile structures used as a support for attachment sensors or electronic functions.

2. Material and Methods

The base textile yarns are spun type: polyester with special cross section, which improve the psychosensorial and thermal comfort, at the skin surface, respectively the cellulose type.

The interactive yarns is double component type, with safety torsion. A spun cotton yarn and a monofilament copper wire, resin covered. The yarns are knitted and woven on conventional textile machine. No additional sets, or accessories, or development are necessary. All the experiments realized in the Experimental Station of INCOTP.

The structure characteristics of the yarns are conventional, usually used for textile clothes, garments.

3. Results and discussion

Generally, the requirements for interactive textile systems, are the same from macro to nano levels, and from component parts to whole textile systems, like a fractal. There are two types of requirements, namely, conventional/ classical and specific.

Specific requirements are vectors which define the structure of the system. A textile system allows the textile component to support and embed nontextile behaviours which cumulate functionalities, includes interactive functionalities.

Conventional requirements are associated with a textile assembly with well-known attributes, such as:

- to allow to human body to move, which means to take into considerations the dimensional modification/ variations, in dynamic way,
- to be a changing media for heat, humidity, air or different fluids, between human body and a defined environment, which means to take into consideration of physiological reaction of the body,
- to ensure protection and safety.

Specific requirements depend from a domain to other, between target groups, and between persons, inside a population of a target group.

The requirements result from temporary or constant needs of a defined population. Specific requirements allow attributes like, monitoring in real time of a status, improve the behaviour of the textile components of the system through nontextile active, passive interactive functionalities.

Clothing motivation may vary depending on what is being considered. Thus, we have practical, aesthetic, social, combative and psychological motivations.

Regardless of the motivation, the clothing ensemble has an important role in managing the interactions between the human factor and the action environment in order to optimize the active and
passive connections (figure1).

These factors influence each other, being in almost total interdependence, in the body-product-climate system, the only free variable is the clothing ensemble.

**Figure 1. Textile vestimentary system concept.**

Considering that the multifunctional textile support, which is used as a flexible interface for attaching sensors, is an important centrepiece, its realization has taken into consideration the following aspects:

- understanding the causes and mechanisms underpinning the maintenance of health and / or well-being;
- definition of new potential tools to be used in disease management and remote monitoring, secondary prophylaxis, drug treatment according to personalized protocols;
- establishing the relationships between the physical and mechanical characteristics and the functional ones;
- the potential sensors attached to the textile support for the manufacture of clothing used for non-invasive monitoring of physiological signals can be: body temperature - both central and average cutaneous; heart rate including heart rate; blood pressure; angular acceleration and tilt, all integrated by specific algorithms in formulas that allow description and quantitative hierarchy of comfort, respectively problematic / including critical

Considering the above-mentioned considerations, the experiments have resulted in the realization of knitted textile structures by processing different composition yarns and different structures, such as basic or additional yarns, to provide psycho-sensorial comfort on knitting machines with a link design system, (seamless) in "anatomical cuts" for on-the-go comfort.

Determination of physical-mechanical characteristics, in static conditions, indicates performance values in comfort.

Experimental models are knitted underwear, with insertion of narrow belts/ stripes. The narrow-woven fabrics are realized with interactive yarns, for monitoring the diaphragm movement. This movement could characterize the respiratory activity, in terms of frequency, of amplitudes.

In figure 2, are presented underwear structures.
Figure 2. Knitted underwear, seamless type (a), with different patterns, derivate of jersey (b) and (c) support for attaching narrow woven fabrics, ribbon type.

The incorporation/ embedding of the interactive elements was realized in the area of the diaphragm, respectively of the heart.

The textile support, in which the embedding took place, was the woven structure, narrow woven ribbon. This structure is characterized by greater dimensional stability, compared with knitted fabrics. This float length, optimal for fabrics, is complemented by the evolution of a yarn system, on a single coordinate. And are 2 yarn systems, orthogonal, one to each other.

Figure 3. Details for interactive yarns embedding.

The embedding is done at the level of textile thread, in the direction of the warp or warp system or on a predetermined contour by depositing the thread by sewing / embroidery (Figure 3). Another option
is by weaving narrow strips, with a width that allows a milling in the monitoring area, by ensuring permanent contact with the extremities of the body in the defined anatomical areas, for monitoring.

The results obtained show that the underwear- can be used as a component of a textile monitoring system for the following reasons:

- The combination of used yarn systems (cotton, elastane and functionalized yarns) ensure stability, flexibility, comfort
- Use the "anatomical cut", ensure the comfort of movement, and the implementation of the medical indications on the sensor location areas.
- Experimentation, through static specific measurements in the context of adaptive behaviour, has highlighted the potential of the product to be used as a support for attachment of sensors or as components of a vital function monitoring system (heart rate, respiration).

4. Conclusion
Textile knitted fabrics by processing combined yarn systems on knitting machines with a link design system can be used as a flexible interface to integrate through specific algorithms, some vital function monitoring sensors.

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