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Abstract

An important problem of the textronic application of a textronic contact junction is connecting electronic systems to textile sensors, actuators or power supply systems. This paper presents a special construction of a textronic contact junction. This kind of textronic junction has the form of electroconductive textile velcro. A textile contact junction consists of two electroconductive textile parts: a male and female pin. The construction of an automatic stand for testing the mechanical and electrical properties of textile velcro is also described in this paper. The force, displacement and resistance for different parameters of the connecting process are recorded on the stand. The laboratory stand consists of two compact pneumatic actuators, a force sensor, a displacement sensor, resistance (indirect method) sensors and a PC computer recording system. Some basic research on textile junctions is also presented in this paper.

Key words: mechatronics, tektronics, connection, contact resistance, measurement, pressure force.

Introduction

An essential characteristic of a textronic product is the connection of textiles with electronics, computer technologies, sensors and actuators [1, 5], all involving textile power supply lines. The connectors should be characterised by a small transmission resistance, flexibility, and waterproof properties. The electronic system has to be disconnected from the textronic clothing during the (wet) conservation process [3, 4, 6].

The main aim of the work carried out was to create a fully efficient and disconnected textronic junction.

An example of using this kind of textile junction is a textronic system with textile electrodes for muscle electrostimulation, in which a textile junction connects a medical generator to the electrodes. Up till now, metal connectors have been widely used, but they are not very comfortable for users. Glued and soldered connections are also sometimes used, but they are not stable in clothing structures. The junction presented was tested in a real textronic system that was part of a textile system for muscle electrostimulation, in which a textile electrode was connected to a medical generator.

Construction of a textile junction

For the construction of a textile junction, typical textile velcro with a chemical electroconductive cover was used. The junction consisted of two elastic and electroconductive parts, see **Figure 1** [2]. The junction conducts current through miniature linked connectors (hooks and loops). One part of the textile electrical

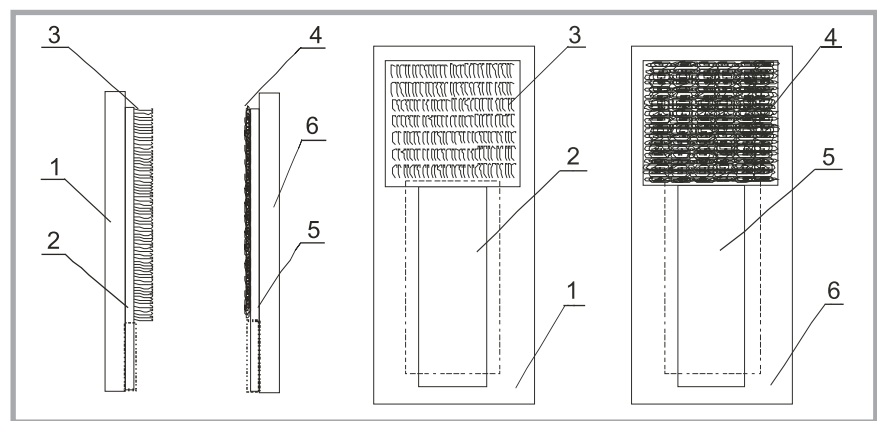


Figure 1. Simplified scheme of the textile junction: (A) cross section, (B) view of disconnected state. 1, 6 – elastic bandage, 2, 5 – textile electroconductive materials, 3 – layer of textile electroconductive hooks (male pin), 4 – textile electroconductive loop layer (female pin).

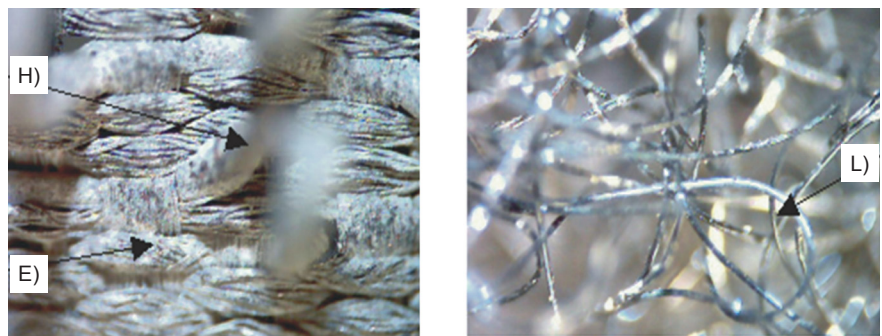


Figure 2. Microscopic photo of the textile junction; H) hook, E) electroconductive yarn, L) loop.

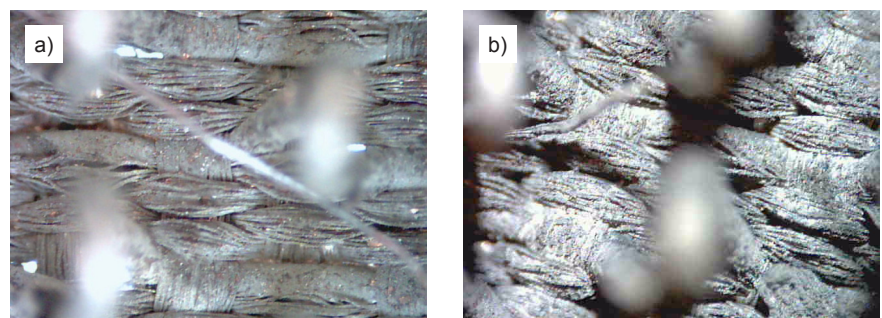


Figure 3. Microscopic photo of a male pin (one part of the textile junction) before (b) and after (a) the plasma treatment process.

junction consisted of a textile layer with a loop cover made of electroconductive fibres - loop (female) connectors.

This part of the textile junction can be linked to supplying devices in textronic clothing. The second part of the textile electrical junction consisted of a textile layer with a hook cover made of the same electroconductive fibres - hook (male) connectors. The three-dimensional junction structure makes the connection of micro connectors in the junction non-synchronous. This phenomenon causes current commutation, but it is not dangerous in the case of textronic elements because the connection and disconnection processes function without current. A microscopic photo of all the elements is presented in **Figure 2**.

The connecting process of the junction caused the self-cleaning of the micro connectors, which is of great advantage.

Plasma treatment as a method of obtaining the electroconductive properties of textile junctions

The plasma treatment method and Classic 500 devices were used to obtain electroconductive properties. During the technological process, both parts of the textile junction were sprinkled with silver powder. The silver electroconductive layers were on hooks, loops and on a textile base.

A $4 \cdot 10^{-5}$ mbar vacuum was obtained, and the sprinkling process was conducted in this condition for 5, 10 and 15 minutes. Different durations of the sprinkling process helped to obtain silver layers of different thickness. It was found that a 10 minute plasma treatment is optimal. A microscopic photo of a male pin covered with silver layers is presented in **Figure 3**.

Figure 3.b presents homogenous silver layers on both a textile base and hooks. The figures show the difference in the male pin before and after the plasma treatment process.

The plasma treatment process is a well know method of obtaining electroconductive materials [7, 8]. However, using textile layers as the base is still a new approach, which needs further research. The homogenous metal layers which ap-

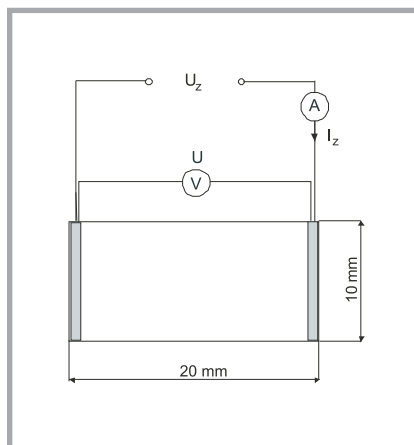


Figure 4. Simplified scheme of the resistance measurement.

peared on the textiles after using plasma treatment are an advantage of this method. Another possibility of obtaining the electroconductive properties of textiles is (electro) plating or padding. These methods are not so resistant to mechanical and chemical factors.

Research on the textile junction

Measuring the resistance of each part of the textile junction was the next part of the work. An LCR meter, ELC-3133A, with a basic accuracy of 0.3%, and 4 wire measurement methods were used. A simplified measurement scheme is presented in **Figure 4**.

Table 1. Results of the resistance value received before and after the washing process of the textile junction.

| Measurement | Female pin | | Male pin | |
|-------------|--------------------|--------------------|--------------------|--------------------|
| | R_{loop}, Ω | R_{loop}, Ω | R_{hook}, Ω | R_{hook}, Ω |
| | before wash | after wash | before wash | after wash |
| Test 1 | 0.31 | 0.42 | 0.29 | 0.36 |
| Test 2 | 0.17 | 0.19 | 0.25 | 0.76 |
| Test 3 | 0.22 | 0.32 | 0.25 | 0.48 |
| Average | 0.23 | 0.31 | 0.26 | 0.53 |

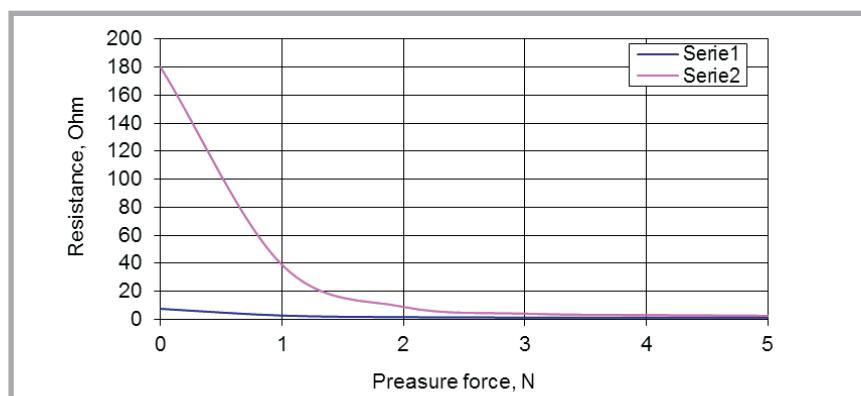


Figure 5. Static characteristic of the textile junction before (series 1) and after (series 2) the washing process.

Typical textile velcro was used in the research work, but in textronic applications it is possible to use smaller pieces of textile junction. The authors suggest that the smallest fragment of a textile junction to be used is 5 mm per 10 mm. These dimensions make it possible to obtain good mechanical and electrical properties.

The next step of the work was to check the resistance properties after the washing process. The washing process was carried out twice according to EU standards. The measurement results received for each part of the textile junction (male and female) are presented in **Table 1**.

An important parameter of a textile junction is the transmission resistance, which should be small, otherwise thermal power will appear in the junction. The structure of the junction is three-dimensional and elastic. In the first stage of the research, the static characteristic of the junction was established. The transmission resistance in a constant state was measured, and it turned out that it depends on the force pressure of the textronic junction. The result of resistance measurement R received is dependent on the force pressure F , which is presented in **Figure 5**.

The highest resistance after the washing process is a result of the fragmentary mechanical destruction of the silver layers.

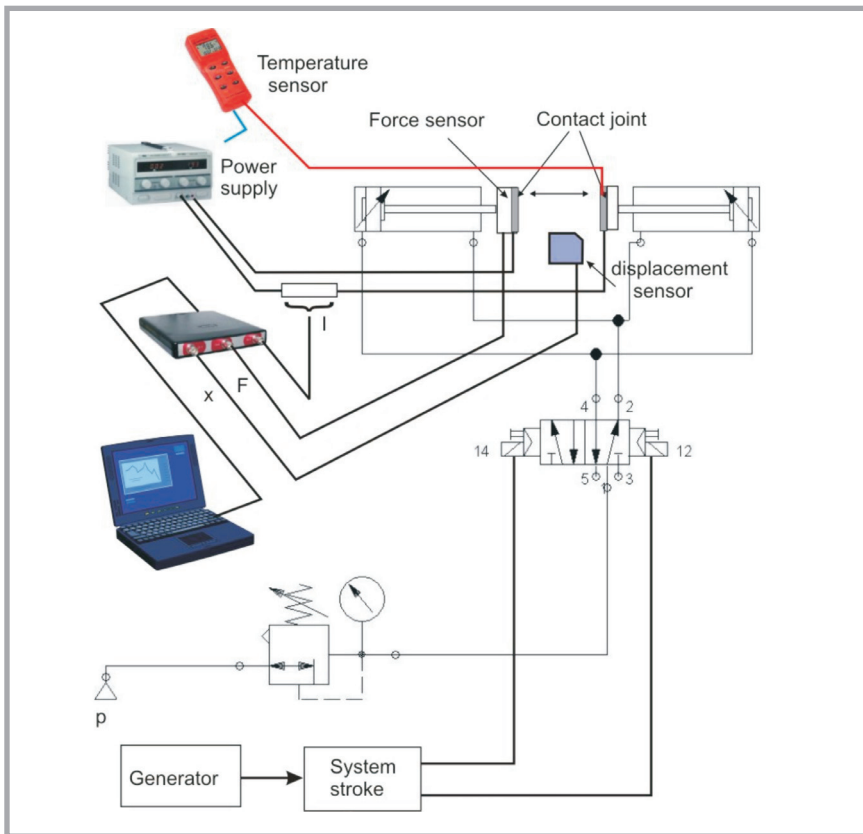


Figure 6. Block scheme of the measurement stand.

In order to determine the electroconductive properties of the textile junction, a special mechatronic stand was built, shown in **Figures 5 and 6**. The measurement stand **Figure 6** determine the properties of the junction during the cycles of connecting and disconnecting each part of the junction. The stand consists of two compact actuators, whose pistons have got mechanical clamps to fix the textronic junction. The movement of the pistons causes the connecting and disconnecting of the parts of the textile junction. 10000 connecting cycles were carried out. At the same time, during the current measurements, junction displacements and the force of the connection were also measured. An optoelectronic sensor was used for measuring the displacement and a dial extensometer for measuring the force. A personal computer with AC card was used for data recording. Measurements were conducted for different current values of the junction.

The characteristics of the junction displacement chosen i.e. the extended force and junction current, are presented in **Figures 7 - 10**.

The power-carrying capacity of the test junction was 400 mA. After 500 mA of current was applied, the junction lost its

conductive properties. High temperature appearing in the junction causes the destruction of micro-contacts.

The junction's temperature was also recorded using K type thermocouples in conjunction with a AMD 90 thermom-

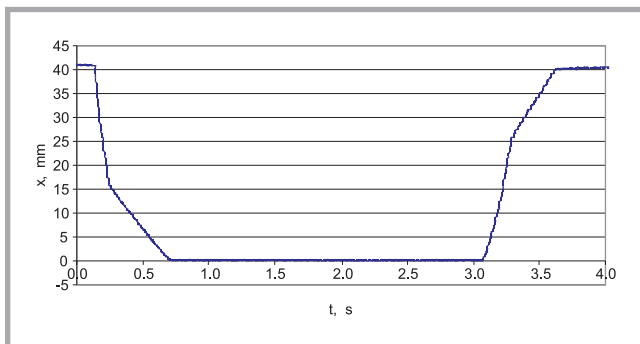


Figure 7. Displacement of junction parts during the connecting process.

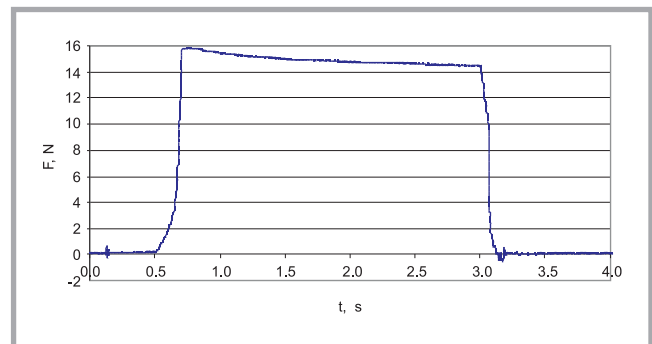


Figure 8. Characteristic of the pressure force of the textile junction in a connected state.

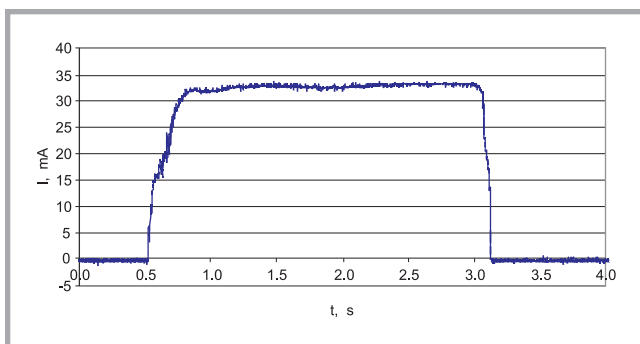


Figure 9. Characteristic of the textile junction's current in a connected state.

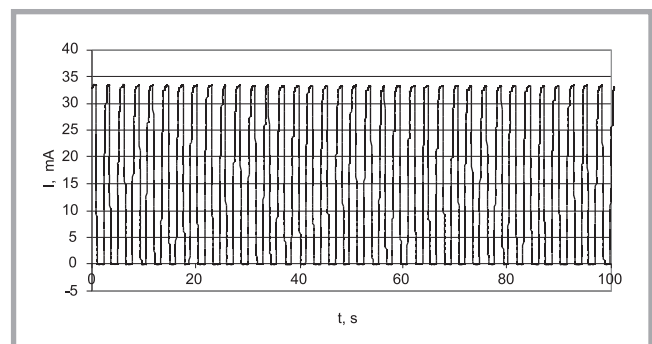


Figure 10. Current characteristic during the cyclical connecting process.

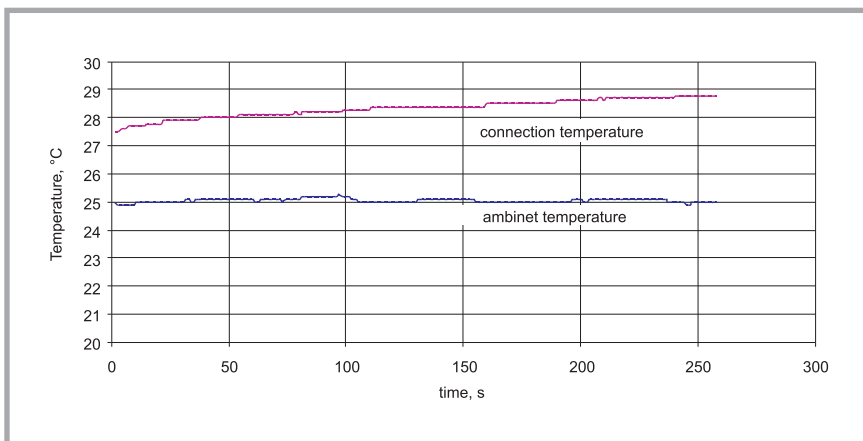


Figure 11. Junction temperature in connection state; junction current - 200 mA.

eter, characterised by a measurement accuracy of 0.1 °C . Some examples of the characteristics received are presented in Figure 11.

After a long testing time, the temperature remained at a constant level of about 29 °C, which means that the power loss was small, and contact between the parts of the junction was good.

Conclusions

The main result of the work carried out is a fully efficient and disconnected textronic junction. The main advantage of the junction junction is its textile form, which influences comfort of use. A typical clothing technological process was used to create the textronic junction. The textile form of the textronic junction

produced a new approach to intelligent clothing design.

The junction has got uniform electroconductive layers obtained by a chemical method.

The initial research shows that junctions may be successfully used in many textronic applications.

The main conclusions are as follows:

1. The present work shows the possibility of using the plasma treatment method to obtain the electroconductive properties of textile layers.
2. The contact resistance of the junction depends on the pressure force. The resistance value decreases to 0.5 Ω, while the pressure force rises.

3. The temperature of the junction changes negligibly.
4. A textronic junction is flexible and comfortable in normal use. It can be easily connected to clothing structures.

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