SMART CLOTHING

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Abstract
The article deals with applications of electric conduction in smart textiles and their use for the application of modern audio devices, including the headphones and microphones. The article explains technology of dismount of electrical connection on clothing and its behaviour when wearing and maintenance of costumes. Electric conductions are created by sewing process.
Key words: smart clothing, electric conduction, dismountable connection

1. Introduction

New modern fabrics, also called smart fabrics and intelligent cloth become now a real fact, are commonly sold and used. The main goal is to find new improved features of material than classic textile materials and garments, mainly audio applications of electronics into clothing, as well as other electrical components and sensors. Area of smart clothing is constantly expanding and reaching the casual wear, work clothing, special protective clothing, medical garments and applications in military uniforms. Structuring of smart textiles is very difficult, however we can use the classic division into passive smart fabrics, allowing only monitoring of changes, and active smart fabrics, which enables the monitoring of prescribed quantities by sensors as well as the response to the initiative. For example sports and protective clothing to the stabilization of temperature with heating elements could be named. Third generations are super smart clothes which adapt their function according to external conditions, these clothes are mostly in the development stage.

This paper focuses on some problems and design of smart clothing. That is creating and testing of various conductive pathways on fabric, which is a precondition for electrical connections at various places on the clothes. Clothes are designed for smart sensors, control panels, power supply, headphones, microphones, cameras, heating elements etc. which are located in different parts of the garment and the aim is to connect them with electrics conductive pathways. For smart clothing technology is necessary to set up a connection inside the garment between the various parts of the garment as well as between men and clothing and men and surrounding areas.

In the article is described formation of conductive pathways using special sewing thread and conductive metal wire and also a comparison with commercially available conductive ribbons. Sewing method for networking has been chosen for its simplicity and accessibility. In this work, detachable parts were tested at the end of conductive pathways that are necessary for connection and disconnection of electrical equipment.

2. Analysis of the issue

Efficient formation of the conductive pathways in smart clothing fabrics requires some specifics:

I. basic requirement for electrically conductive path is minimal electrical resistance which should not have negative influence on the transmission of electrical signals,
II. specific maintenance along with clothing, which means washing, ironing, dry cleaning,
III. for the application on the garment, the conductive path must flexible, soft and should not bother the wearer,

IV. the end of conductive paths must allow dismountable connection with other instruments and devices which could be connected (eg. headphones, batteries, cell phones, GPS see [4] ...), so for the connection is traditionally used technology of press studs,

V. creation of conductive pathways must be simple and cheap, therefore a classic sewing technique is used as in normal fashion technology.

3. Experimental creation of conductive pathways

The conductive thread, copper wire and a comparison of commercially supplied ribbon Gibbon (created with conductive copper wires) has been used for the experiment.

The following tables show the measured electrical resistances of each sample. Measures are then compared in Table 1, 2, 3, 4. Electrical resistance was measured by the length of 20mm and subsequently transferred to 1m.

Sample No. 1 - Silver plated polyamide 234/34x4Ply

Table 1. Parameters of the conductive threads

Conductive material	Silver plated polyamide 234/34x4Ply
Electrical resistance	1,69 [Ω/20mm]
Composition	PAD/Ag
Thickness	26 tex
Length of roll	68 m
Melting Point	255,66
The direction of twist	Z

Sample 2 - coated copper wire

Table 2. Parameters of copper wire

Conductive material	coated copper wire
Length of roll	125Km
Composition	Cu
diameter	0,118 mm

Sample.3 - **Ribbons Gibbon**

Table 3. Parameters of ribbons

Conductive ribbon	Gibbon
Size: 2 path	10X200 x 0.030 mm
Size:6 path	5x200 x 0.030 mm
Composition	PL/ Ag

Table 4. Electrical resistance

	Conductive material					
	Conductive thread		Cu wire		Ribbon - Gibbon	
	R [Ω/m]	G [S*m]	R [Ω/m]	G [S*m]	R [Ω/m]	G [S*m]
$\bar{x}$	84,5	11,81	2,21	0,452	1,375	0,727

Formation of the conductive tracks carried on by the specially adapted and tuned sewing machine to stitch class 301, 401, 602, example see Fig.1

Figure 1. Cover stitch 602 a) stitch formed by a conductive thread, b) stitch made of copper wire

Testing for resistance to the washing and ironing, washing the samples has been carried out at 30° C - 80 min, 5 times with common washing detergents. Further the ironing at 150 ° C has been carried out.

4. Achievements

Results of change of resistance of conductive pathways after washes and ironing are shown on the following charts with regard to conductive-plated polyamide yarn 234/34x4Ply.

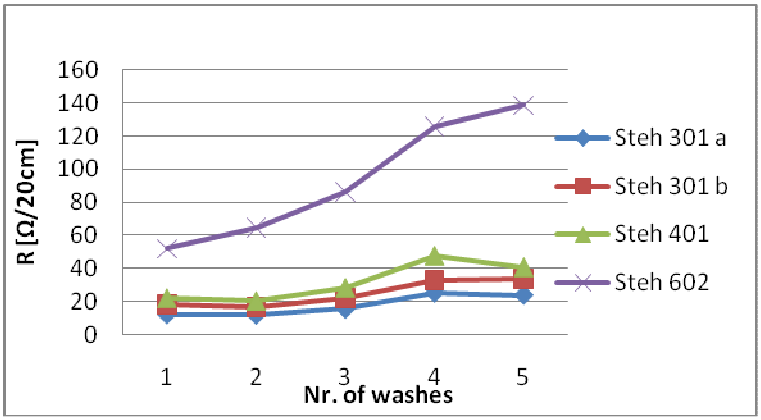

Figure 2.Electrical resistance of the conductive yarn after 5 washes

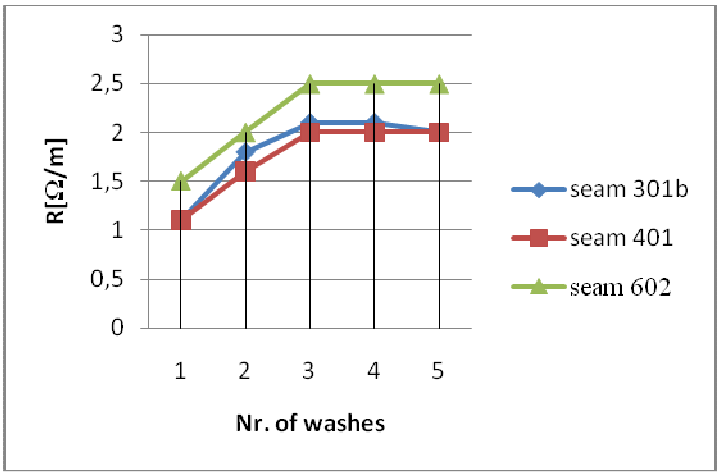

Figure 3. Electrical resistance of the conductive wire after 5 washes

The measured values show that the resistance of the conductive thread after washes has increased (especially the stitch 602). While the resistance of the conductive tracks made of the

Cu wire was about 10 times less and its resistance did not change too much after the washing and ironing [1].
Conductive yarn was used as a lower (labelled a) and the upper cover (labelled Z). It can be assumed that the rods bends (see Fig. 4) caused a decline in silver plate and an increase in electrical resistance. This stitch is not suitable for the formation of conductive pathways. However the copper wire has passed the test with better results. Electric resistance of ribbon made of Cu did not change at all.

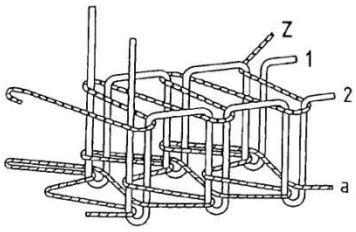

Figure 4. Double sided cover stitch 602

For comparison the ribbon gibbons were also tested by the washing and ironing [1].

4.1 Ending of the conductive pathways

Ending of the conductive paths is always a problem. It is necessary to ensure good electrical connection and the possibility of disconnection. The remaining connection to the garment must withstand the normal maintenance of clothing, such as washing, ironing and cleaning. In the clothing industry are traditionally used studs which generally meet all the requirements. See Fig.5.

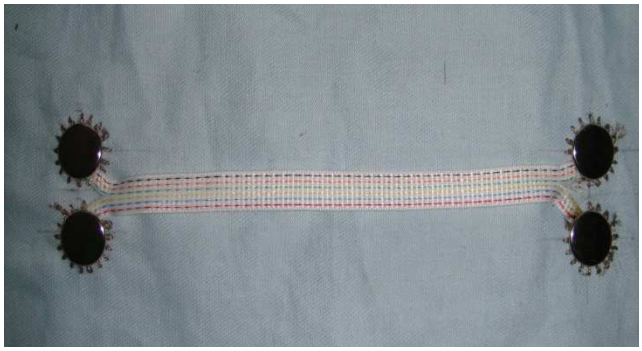

Figure 5. Connection with press studs

The problem is always interconnection of conductive threads with the press studs. That is why the following solution has been suggested. The conductive path should be ended by the round embroidery together with the press studs located inside. This solution fully complies with the tests performed, see Fig 6.

Figure 6. Connection with press studs and threads

5. Conclusion

This article focuses on chosen problems of smart clothes, such as the formation of conductive tracks to connect sensors, audiovisual equipment and other electrical devices. The conductive path must be fully functional also after washing and steam iron and throughout the lifetime of the garment. Our institution has been engaged in special methods of making conductive paths sewing process for long time. The results of the research work show that the special conductive threads are able to be sewed well, but their properties (relatively high electrical resistance, the resistance increases even for washing and a small life) are not sufficient enough to be commercially used. Cu wires have an excellent electrical properties, may be well sewed however the thickness of them must be tested first so as not to be damaged during the use and maintenance. Connection with the press studs, using embroidered circles, completely met the requirements for the industrial application.

6. References

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