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5. Conclusion

Textile-based sensors are feasible by using printing technologies such as screen printing and digital printing. Sensors for measuring temperature and movement could be realised by printing sensing materials on electrically conductive interdigital structures. Electrical switches were developed on basis of both resistivity and capacitance measurement. The latter acts as proximity sensor. So far, screen printing is still favoured for printing electro-conducting patterns due to a high paste add-on whereas inkjet printing requires pre-treatment and several overprinting.

The application of thin sensing layers and translucent electrically conducting layers can be realised via inkjet printing. Digital Chromojet is considered as a sophisticated printing process for e-textiles as it offers the opportunity to print both small and large amounts of ink. It turned out that the thickness of the electrical insulation layer must be adapted to the mechanical stress during production to avoid short circuits.

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4D BODY SCANNING AS A TOOL FOR COMPRESSION STOCKING DEVELOPMENT

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1. Compression garments: requirements versus comfort

A compression garment is special skin-tight clothing containing elastomeric fibers or yarns designed to apply substantial mechanical pressure to a certain part of the body for stabilizing, compressing, and supporting underlying tissues.

Today there are three main aspects of using compression garments: medicine, sport, and body shaping. The medical application was started in the 1970s. Since that time the variety and sophistication's level of materials and technologies used in their production have improved tremendously. Pressure therapy imparted through compression garments is a well-established line for both treatment and rehabilitation.

Sportswear with moderate compression distribution is widely used now and is expected to enhance the performance of athletes, decrease the possibility of injury, and accelerate the process of recovery.

The principle of vanity clothing is to compress, lift, or support certain body parts preferentially in order to create an artificially sculpted and perfectly shaped body.

Requirements for pressure are based on two aspects: clinical effectiveness and comfort in wear. For clinical effectiveness, a tightly fitting garment made of elastic fabric is necessary to produce the required pressure over the scarred area, and the pressure should be capable of being maintained over a prolonged period.

However, if the pressure values are higher than the patients' pressure pain thresholds, they cannot accept the garments.

A comfort perception with tight clothes is subject to continued investigation despite existing research results. Acceptable clothes pressure is perceived differently by men and women and greatly depends on body parts. But even in a definite point of the body, the difference in possible pressure acceptance is too big.

The degree of pressure produced by a compression garment is determined by a complex interrelation between clothes and the body. The design and fit of the garment, structure, and physical properties of its materials are the principal factors from the clothing point of view. As for the body, they are the size and shape of the body`s part to which it is applied and the nature of the activity undertaken. Thus, the correct adaptation of compression clothes to the individual geometry of the body is an important aspect of both compression effect and clothes comfort.

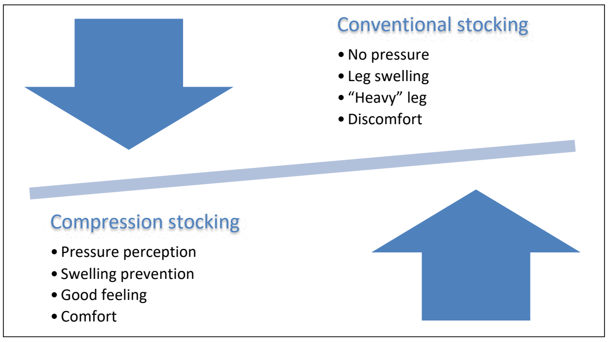

Figure 1: Pressure versus comfort

2. Digital technology in compression stocking development

Modern innovative technologies are being successfully implemented in the development of compression clothing. The development of reliable full-body scanning has provided a new tool for the study of the interaction between the body and clothing. We used the MOVE 4D system from Valencia Polytechnic University at ITM TU Dresden.

The project focuses on 4D body scanning for the investigation of the changes in size and shape of lower legs at a static position and during different activities (walking, going upstairs, bending, etc.) to develop a tool for evaluation an effectiveness of the ready-to-wear compression stockings as well as for future design of an advanced product based on individual aspect. Three volunteers who used the same stocking size L according to RAL GZ 387-1: 2088 were scanned. The scanning time for each movement was 4 seconds with a frequency of 15 frames per second. Scans were made for control leg and within stocking wearing: just after putting on stockings (0 hour) and after wearing time of 1 and 4 hours. Conventional stockings and two types of compression stockings were used.

After the scanning and data processing a large list of files with the body geometry is available and needs an evaluation. In this study the following software was used: MeshLab 2022.02 – for planar section and for area or/and circumference measurements; ParaView 5.11.0 – for slices and data transfer; Excel 2016 – for data sorting, organizing, and calculation.

3. Evaluation of leg shapes and sizes

It is well known that the human body has its shape and size that differ from others. It leads to some issues when using pre-sized compression garments, for example, stockings. The study results (Fig.2) of the lower legs of three volunteers with the same L size prescribed stocking show differences that will affect the therapeutic results. It is clear, that there is a difference even between the right and left legs for each patient.

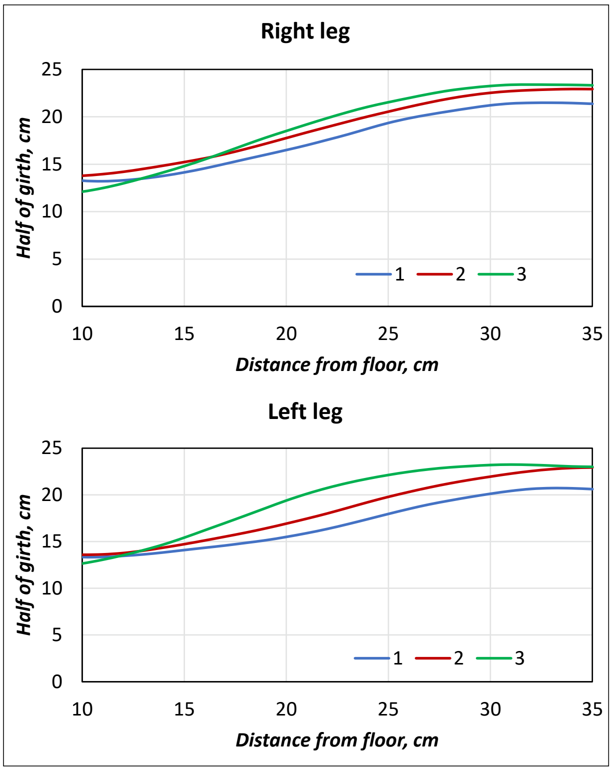

Figure 2: Legs contours of different volunteers

Within this research the lower leg's girths and areas at different sites at static position and different activities while wearing the different stockings. The example of results at the 30 cm site for the right leg of the first volunteer is presented in Table 1.

The 4D scanning simplifies the evaluation of the leg's swelling and the effectiveness of compression stockings. It was found that within four hours leg areas increased up to 9%, 11%, and 12% at the calf and up to 15%, 16%, and 18% at the ankle for the second, first, and third volunteers respectively. Just after putting on a compression stocking the leg area decreases due to the compression effect. But within the wearing time, there are different tendencies for different people. For the first and third volunteers, the area increased while wearing I CCl stockings and was similar to the control leg while wearing II CCl stockings. For the second volunteer, the area has kept the size similar to the control leg while wearing I CCl stocking. Thus, I CCl stocking was recommended for a second volunteer and II CCl stocking was recommended for others.

Table 1: Right leg area at 30 cm site for the first volunteer

Activity	Time	Conventional		CClass I		CClass II	
		S [cm^2]	Δ [%]	S [cm^2]	Δ [%]	S [cm^2]	Δ [%]
Static position	Control	119	–	128	–	134	–
	0 hour	119	0	126	-1.9	124	-7.9
	1 hour	130	9.1	136	6.3	131	-2.1
	4 hours	133	**11.1**	138	**7.5**	131	**-2.4**
Walking (max value)	Control	119	–	128	–	129	–
	0 hour	119	0	126	-1.6	126	-2.3
	1 hour	130	9.2	133	3.9	127	-1.6
	4 hours	132	**10.9**	135	**5.5**	131	**1.6**
Tip toe (max value)	Control	118	-	122	-	128	-
	0 hour	118	0	121	-0.8	123	-3.9
	1 hour	127	7.6	130	6.6	127	-0.8
	4 hours	128	**8.5**	131	**7.4**	127	**-0.8**

The leg scans and appropriate software allows the quick comparison of the legs' shape during wearing time and different activity. The evaluation can be done not only by the leg area at a certain site but by the cross-sectional contours and girths as well. It allows evaluate the leg's part change more and even calculate the curvature radius.

4. Data for design of compression stocking

The prototype of a stocking can be created by applying different stretching levels of future knitted stocking, the initial data differ for different legs (Fig.3). The scan's data and a leg's avatar (Fig.4) are the start points for design advanced compression stocking which will fully match the certain person.

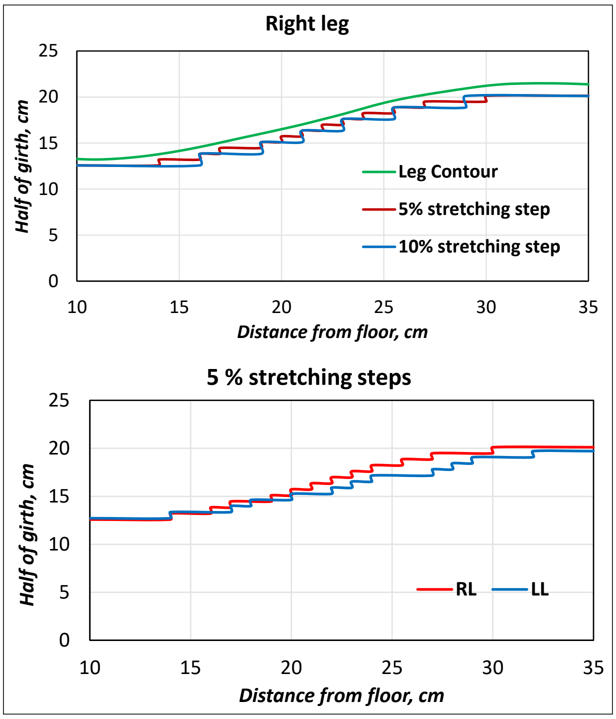

Figure 3: Initial data for different stretching levels and different legs

Figure 4: Avatar with mesh

5. Future stages

The project continues within the next steps. First of all, it is the comparative study of the changes in the legs' shape and size as well as the compression effect during different activities. Then the development of an algorithm for transforming data obtained during the scanning into processing data software followed by the development of a technological map for the knitting machine. They will be the basis for the individual design of knitted compression products according to the needs of certain patients.

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Challenges of digital printing with reactive inks

Sun Chemicals / Dr. Simon Daplyn, Claire Glenat, Dominique Houlmann, Justine Prevalet

Abstract

While being a well-established technology, digital reactive inks have a complex workflow that can represent challenges for printers looking to maximise the performance of printing and the efficiency of the process. There are many factors such as colour balance and consistency, pre-treatment application, dye fixation/wash out, image quality and image fastness, that a printer must consider to produce a vibrant and high-quality print

1. Process considerations

Prior to the fabric reaching the digital decoration phase, there is often a multi-step process involved to prepare the fabric for printing. This process is shown in figure 1 below.

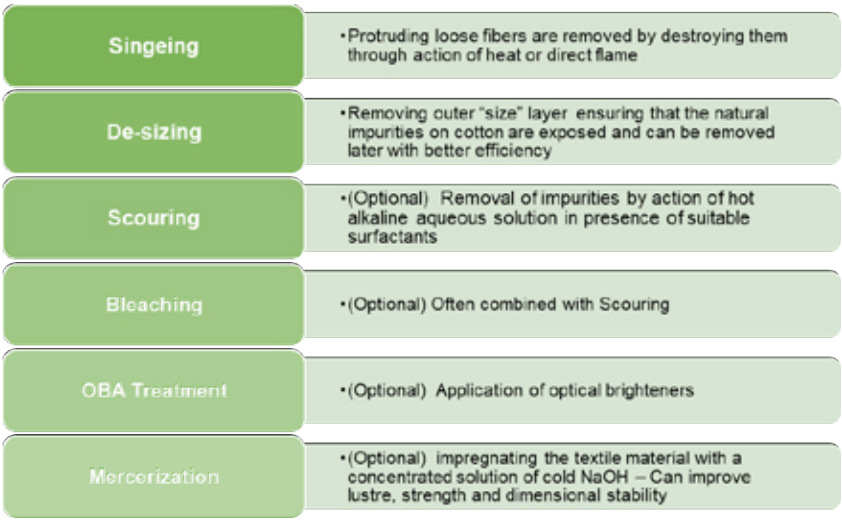

Figure 1: Process steps for fabric preparation

The reactive printing process relies on a pre-treatment of the fabric to enable the optimum conditions for dye fixation. A critical component of the pre-treatment is urea, which acts to swell the fibres under steam and an alkali salt to keep the optimum pH environment for the dye to bond to the fabric. Once pre-treatment is applied and dried, the digital print stage is undertaken and dried. After printing, the inks are fixed to the fabric (typically cellulose based fibres such as cotton and viscose) using high concentration steam at 102-104°C for 8-10 minutes. Once fixed, the fabric should be washed to remove any residual pre-treatment chemicals as well as any un-fixed dye. The end-to-end process is outlined in the schematic below.

2. Dye selection

Within a digital reactive-ink set there will be different dyes selected based on colour, shade and availability. These may be based on azo, phthalocyanine or anthraquinone dyes when using a monochlorotriazine type of dye. As the dyes are different, they have various molecular sizes and structures and, therefore, often have different rates of fixation. Due to these differences, ink manufacturers and printers must consider:

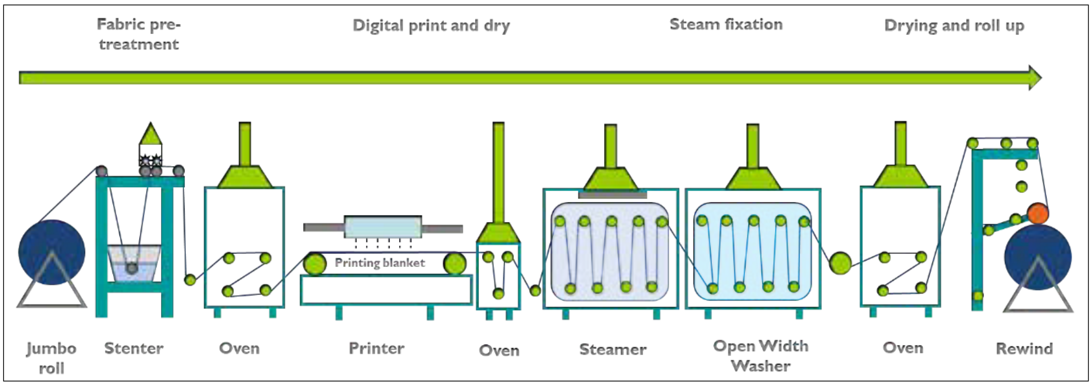

Figure 2: Digital reactive print workflow