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INFLUENCE OF THE LOOP TYPE ON THE ENERGY ABSORPTION PERFORMANCE OF WEFT-KNITTED FABRICS PRODUCED WITH NiTi WIRES

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ABSTRACT

It is widely acknowledged within the textile engineering community that Shape Memory Alloys (SMA), exhibit great potential for several applications. This paper presents the research undertaken at the University of Minho aiming to study the behaviour of weft-knitted structures produced with SMA wires.

Ultimately, fibers, yarns, fabrics and other fibrous structures with added-value features have been successfully developed for specific applications as technical and/or high performance end-uses. An excellent overview of smart technologies for clothing design and engineering was provided by Tang and Stylios, 2006. Technical textiles have been promoted as alternative materials for an unlimited range of applications including medical, automotive, aerospace, civil and mechanical engineering, among others.

According to Tao, 2001, shape memory materials have been considered as an ultra smart material, because they have the ability to sense stimuli and react according to the programmed way, by moving the internal molecular structure, leading the material for a pre-programmed shape. These physic factors stimulate the Shape Memory Effect (SME), making them to reach and transform as a specific shape, position, force or another pre-programmed characteristic (Bonnot et al. 2007). Wherefore, when the stimulus is applied on a SMM, this must return to its memorized shape without deformations. However, the SME should be only performed if the stimuli achieve the glass transition temperature of SMM (Nurveren et al. 2008). Shape memory materials (SMMs) can rapidly change their shapes from a temporary shape to their original (or permanent) shapes under appropriate stimulus such as temperature, light, electric field, magnetic field, or others (Meng and Hu, 2009).

Shape memory alloy wires are widely used for permanent works in various applications such as on stents (Taís and Fangueiro, 2009), eyeglass frames, coffee pot thermostats, electrical connectors, heat pipes, clamps, and sculptures, medical apparatus, textiles applications, among others. Especially on clothing sector, high performance materials have attracted much interest for designs, sports and protective clothing (Tang and Stylios, 2006).

For the current work, Nitinol® wires type B (which shows SME at body temperature) were used, with three different diameters: 50µm, 127µm and 210µm, in order to produce weft-knitted fabrics with three different loop types: stitch, tuck and miss. The samples were produced on a flat knitting machine, with 8 needle/inch, based on a single jersey structure. The structural parameters of the samples are listed in Table 1.

Table 1: Structural parameters of the samples

Parameters	**Miss loop**			**Stitch loop**			**Tuck loop**		
Wire diameter (µm)	50	127	210	50	127	210	50	127	210
Loop Length (mm)	3,7	4,9	4,2	4,9	6,7	6,1	5,4	7,2	6,9

A 70tex acrylic yarn was used as a basis for the formation of loops with the nitinol® wires in the samples. The stitch loop structure (single jersey), were made using stitch loop on the ground structure and for the NiTi wire course. The knitted structure with tuck loops, were produced by alternating stitch loops with tuck loops in adjacent needles in the same course and the knitted structure with miss loops, had been produced by alternating sticth loop with miss loop in adjacent needles in the same course, as shown on figure 1 (a, b and c), respectively.

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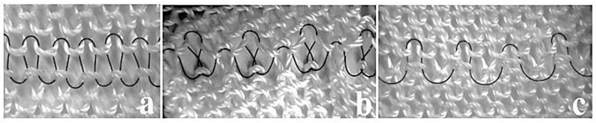

(a) (b) (c)

Figure 1: Knitted structures showing stitch loop (a), tuck loop (b) and miss loop (c).

After the sample production, the NiTi course had been removed from each sample, as can bee seen in figure 2.

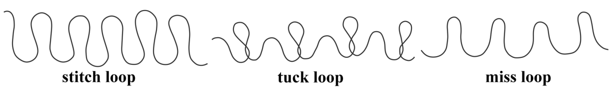

Figure 2: Knitted courses produced with NiTi wires

The NiTi course samples were then placed into an oven with a temperature of 550ºC, during 30 minutes, in order to memorize the shape of the wires, according to the deformed loop types (Memry Metalle, 2009).

The samples of NiTi knitted courses were used to analyse the deformation force energy. The Tensile tests were carried out according to ISO 1462, using a H100KS Hounsfield Universal Testing Instrument, using an initial gauge length of 95mm and crosshead speed of 10mm/min. Three tests were carried out for each sample, to calculate the influence of the loop type on the performance of the weft-knitted fabrics, in terms of energy absorption.

The values were generated for each experiment and were treated using the software OriginPro®8. The results are shown on table 2.

Table 2. Energy absorption for different loop types

Energy		NiTi wire diameter		
		50µm	**127µm**	**210µm**
Loop type	**Miss**	0,67mJ.mm^{3}	0,75mJ.mm^{3}	0,96mJ.mm^{3}
	Stitch	0,71mJ.mm^{3}	1,58mJ.mm^{3}	1,86mJ.mm^{3}
	Tuck	1,60mJ.mm^{3}	2,70mJ.mm^{3}	3,27mJ.mm^{3}

Several conclusions could be taken considering the processability of the NiTi wires:

- The 50µm wire showed to be too thin to be knitted in the flat knitted machine 8 gauge;

- The 50µm wire does not represent great percentage of SMA in the knitted structure, which can avoid its smart effects.

- The 210µm NiTi wire shown to be hard to process on the knitting machine due to its high stiffness. In Table 2, are shown the resume for the energy absorption for different loop types.

- The 127µm NiTi wire shown to be the best among the analysed ones, due to the process and energy absorption ratio.

- Finally, for the same NiTi wire diameter, tuck loop presents the highest energy absorption capacity. Moreover, larger energy absorption capacity had been obtained for higher NiTi wire diameters. The results obtained are a good contribution to design weft-knitted structures with shape memory ability aiming to future applications of SMA in the development of new textile materials.

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