Presentation and extensive characterization of a nonlinear SMA actuated pivot articulation developed with 3D printing technique

López-Walle, Beatriz[1]; Gendreau, Dominique[2]; Mohand-Ousaid, Abdenbi[2]; Rentería-Baltiérrez, Flor[1]; Llamas-Hernández, Mayra[1,2]; Reyes-Melo, Edgar[1]; Rakotondrabe, Micky[2]

[1]*Facultad de Ingeniería Mecánica y Eléctrica, Universidad Autónoma de Nuevo León, San Nicolás de los Garza, Av. Universidad s/n Ciudad Universitaria 66450 Nuevo León, MEXICO*
Email:mayra.llamashr@uanl.edu.mx,Web site: http://www.fime.uanl.mx/posmateriales/personal.html

[2] *Automatic Control and Micro-Mecatronic Systems (AS2M) Department, FEMTO-ST Institute, UMR CNRS 6174 – University of Burgundy Franche-Comté / UFC, 24, Besançon, rue Alain Savary 25000 Besançon, FRANCE*

Shape memory alloys (SMAs) are thermomechanical materials which convert heat into mechanical work by means of their internal crystalline structure resulting from cooperative atomic movements [1]. SMA wires are lightweight, silent, reliable for cyclic operation and able to deliver high power to weight ratio. For these reasons, they are ideal candidates for innovative applications. This work presents a modular pivot articulation based on a passive structure fabricated by additive printing techniques and actuated *via* two "antagonist" SMA wires. The monolithic 3D structure is designed and fabricated in one operation without assembly. Then, SMA wires are guided within through intended grooves. This articulation is two times smaller than our previous versions [2, 3] and lets better heat transfer thanks to some holes specially placed for this purpose. The operation principle is depicted in Fig. 1a. Only one SMA wire is activated at a time, causing an angular displacement. When the other SMA wire is activated, an opposite displacement occurs.

This paper presents the new optimized modular pivot articulation (Fig.1a and b) and provides its extensive performances characterization. For this aim, the SMA based articulation is tested with constant and sine driving electrical currents of various amplitude and frequency with consideration of natural and forced cooling conditions. All the tests were implemented with two different SMA wire diameters: 200 µm and 250 µm. Results demonstrate, first, the feasibility of the optimized SMA actuated pivot articulation; second, the effect of critical parameters (e.g. heating currents, convective cooling) and third, the rate-dependency of the hysteresis response that typifies the articulation. The experiments also show that the maximal angular displacement reaches 25° for an applied current of 0.608 A. Fig. 1b shows an example of a displacement versus current loop obtained with 0.304A of amplitude and 0.1Hz of frequency.

This modular articulation is projected as the elementary block of complex serial or parallel robots. In order to create a complete model of these robots, a model of the modular articulation is formerly necessary. Further works deals therefore with a phenomenological model of the behavior and a control system of the articulation position.

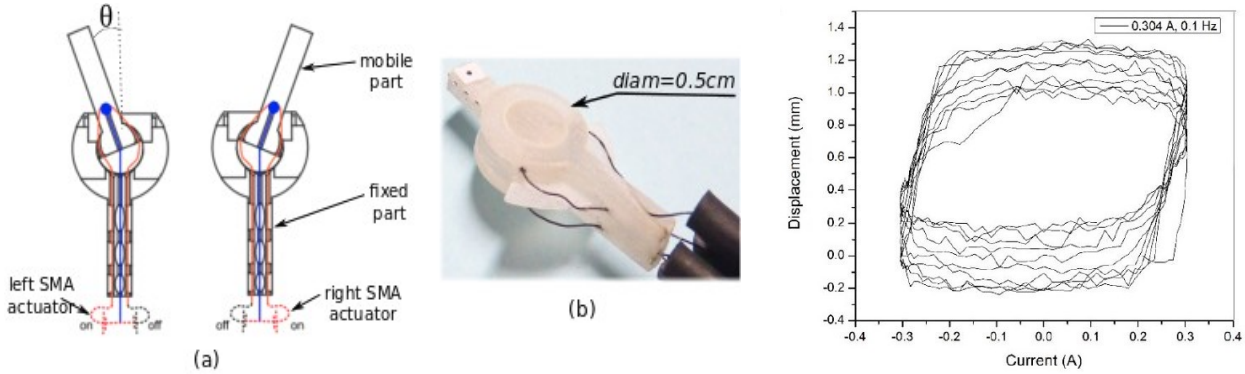

Fig.1: SMA actuated pivot articulation: a) principle operation, b) displacement vs current loop.

References

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