Artificial muscles performance based on TCP-NiCr actuators

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***Abstract*—In the past years, artificial muscles (and or soft-actuators) have gained attention to be used in rehabilitation robots due to their inherent compliance. Twisted and coiled polymers (TCP) artificial muscles are one of the prominent alternatives. A recently introduced method to activate the TCP is to use an embedded metallic wire. This work analyses the strain and the response time of TCP actuators with different Nichrome (NiCr) wire diameters.**

***Clinical Relevance*— This work constitutes a preliminary guideline to design TCP-NiCr artificial muscles for rehabilitation or assistive soft robotics devices.**

I. Introduction

In the last decade, exoskeletons have gain interest in the field of healthcare. Current exoskeletons rely on cumbersome elements, making it challenging to overcome adaptability, comfort and safety problems. Consequently, researchers started to pay attention to more compliant components such as artificial muscles and soft-actuators.

TCPs are artificial muscles fabricated by inserting a twist in precursor fibre while attaching a dead weight at the end until it forms a coil structure, followed by heat treatment. TCPs are thermally driven with high power to weight ratio, high stress, a considerable strain, low hysteresis [1].

So, to activate the TCP, the most used strategy is Joule heating. Recently the use of metallic embedded resistance wire into the TCP is gaining attention. However, this method can affect the actuators' performance, changing the strain in a wide range (from 5.5% to 40% [2]-[4]). The main goal of this study is to evaluate the strain and response time of TCP-NiCr.

II. Methods

10 cm length TCPs were fabricated using a monofilament Nylon fishing line as the precursor fibre (BURNSCO®) with a diameter of 440 μm. The nylon fibres were twisted and coiled along with a NiCr wire, using a weight of 250g (≈ 20 MPa). The NiCr wire was also suspended from the motor shaft but only straightened using a small weight (≈ 1.2 MPa). Five different diameters (0.06 mm to 0.16 mm) of NiCr wires were used for the experiments.

Each actuator was hanging above a laser displacement sensor (0d80 15p850, Sick Optex®), with a weight of 250g attach to one end. A square signal of 90 seconds on (0.15 W/cm) and 90 seconds off was applied on all the tests to activate the actuators.

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III. Results

The relationships between strain and diameter, and response time and diameter; for the five different samples are plotted in Fig. 1. The behaviour in both cases appears to be linear, except for an anomaly at 0.08 mm. This anomaly could be related to the applied tension to the NiCr wire, as in the case of the 0.08 mm, the stress was slighter higher (<0.1 MPa).

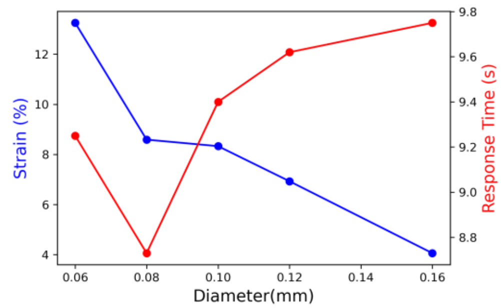

Figure 1. Strain and response time of TCP actuators fabricated with different NiCr wire diameters.

IV. Discussion & Conclusion

This work provides pilot guidance to design TCP actuators with metallic embedded wires. However, to better understand the effect of the metallic wire, an evaluation of the impact caused by different precursor fibre sizes is needed. Another essential aspect that required further investigation is the applied tension on the NiCr, as it seems to impact how the wire wraps around the fibre. In conclusion, this study provides highlights on how to tune the desired strain on TCP-NiCr actuators, which is the main parameter to generate motion in artificial muscles for wearable rehabilitation robots.

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