Experiments on Shape Memory Alloy actuator and practical applicability considerations

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Abstract

This paper describes the design and the experimental work on a force-generating Shape Memory Alloy (SMA) actuator concept. The objective of the work was to test the applicability of the actuator concept for semi-active vibration control. The actuator was designed for bolt-force adjustment in structural joints. The SMA material applied was standard commercial *NiTinol* alloy. Two different actuator designs were constructed and tested: a smaller air-heated design, and a larger water-heated design. The actuator's ability to generate a force as a function of the bolt pre-tension was studied in the experiments. The magnitude of the forces generated was from 1 kN to 70 kN. In terms of design and control, non-linear behaviour of the actuator was considered a challenge. For the industrial application point-of-view, the long-term behaviour and the price of the material were considered the greatest challenges. Ability to generate large forces relatively quickly was seen as a promising opportunity. Furthermore, both actuator constructions were relatively simple and consisted of small number of components.

Introduction

The objective of the presented work was examine the applicability of standard commercial Shape Memory Alloy (SMA) for semi-active vibration control. The aim was to design a SMA actuator capable to adjust a bolt force in a range up to several thousands of Newton.

SMA material restores its shape when heated over a transition temperature. This behaviour is based on the phase change in the material. The original shape is taught during a thermal treatment. When heated, this shape is restored due to change to the austenitic phase. In the lower-temperature martensitic phase, the same material is more flexible, even super-elastic. Thus the actuator that is deformed in a lower temperature, aims to restore its shape when heated above the transition temperature. [REF]

In semi-active vibration control, the characteristics of a structure are adjusted in such a way that vibration response is minimised (or maximised, if wanted). Compared to the purely active vibration control methods, the energy driven into the system is relatively low in semi-active vibration control solutions. For example, a component with controllable stiffness may be used to adjust the natural frequency of a structure. This provides an opportunity for resonance-avoidance control. For further interest in active vibration control, see [1, 2]. Controllable friction joints have been utilised as the actuators in semi-active vibration control [3]. In some applications, controllable friction