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Abstract

In the paper one focuses on some fundamental issues in the modeling and design of dynamic control devices conceived for structural applications, based on the exploitation of Shape Memory Alloys (SMAs). General properties and advantages are described which make these alloys particularly suitable for applications aimed at the response reduction under dynamic events, and some indications to be considered at the design stage of the SMA devices are outlined in function of the re-centring and/or dissipation tasks one wants to accomplish. Numerical investigation is presented as well relevant to some possible application.

Author keywords

Control devices; Dynamic control of vibrations; Shape memory alloys; Smart materials; Structural applications

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Properties and Design of Dissipative Visco-recentring SMA members for Civil Structures

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General properties and advantages are described which make these alloys particularly suitable for applications aimed at the response reduction under dynamic events, and some indications to be considered at the design stage of the SMA devices are outlined in function of the re-centring and/or dissipation tasks one wants to accomplish. Numerical investigation is presented as well relevant to some possible application.

Keywords—Smart materials, Structural applications, Dynamic control of vibrations, Shape Memory Alloys, Control devices.

I. INTRODUCTION

CONTROL strategies may be successfully adopted for dynamic control of vibrations in civil structures [1]-[21].

Actually the need of supplying self-adjusting capacity with respect to unknown dynamic events to structures, thus making them smart, it is one of the main objectives of any control system and the major inspiring idea when conceiving a structural dynamic control strategy.

New technologies allow to couple benefits of passive and active control strategies in semi-active systems, also by adopting smart materials able to change their state during the dynamic motion or to exploit some special peculiar properties, as in the case of Shape Memory Alloys (SMAs) [1]-[15].

Shape Memory Alloys (SMA) are a group of metallic materials that demonstrate the ability to return to some previously defined shape or size when subjected to the appropriate thermal procedure. Generally, these materials can be plastically deformed at some relatively low temperature, and upon exposure to some higher temperature will return to their shape prior to the deformation.

Materials that exhibit shape memory only upon heating are referred to as having a *one-way shape memory*. Some materials also undergo a change in shape upon recooling. These materials have a *two-way shape memory*.

Although a relatively wide variety of alloys are known to exhibit the shape memory effect, only those that can recover substantial amounts of strain or that generate significant force upon changing shape are of commercial interest. To date, this has been the nickel-titanium (NiTi) alloys and copper-base alloys such as CuZnAl and CuAlNi.

Because of the complex load–deformation–temperature behaviour, besides the shape memory effect, SMAs exhibit a pseudo-elastic behaviour at high temperatures.

Therefore two major features may be observed at the macroscopic level: the shape memory effect (depending on the capability in recovering possible accumulated deformations by heat treatment) and the super-elasticity (i.e. the recovery of large deformations in loading-unloading cycles, occurring at sufficiently high temperatures).

The shape-memory effect derives from a first-order martensitic phase transformation and gives the SMAs a high dissipative capacity with comparison to ordinary metals, achieving large hysteretic loops without incurring plastic deformation.

The model body is composed of lattice particles arranged in layers and stacks as shown in Fig.1. Tensile loads make the layers shear and flip thus producing elastic and quasi-plastic deformation respectively. Heating produces the austenitic phase and leads to shape recovery.

The hysteresis, here actually due to the growth and re-orientation of the martensite crystals (that can be reduced to their original configuration upon the application of heat), renders particularly interesting the SMAs applications in the field of earthquake engineering for the realization of dissipative devices.

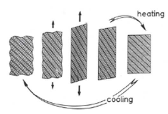

Fig.1: Model body.

The super-elastic behaviour of SMAs, due to elastic loading of the austenitic parent up to the threshold stress where-upon the transformation from austenite to martensite occurs, is able to provide an energy-absorbing effect combined with a theoretically zero residual strain upon unloading.

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