CHARACTERIZATION RESULTS OF A NOVEL SHAPE MEMORY ALLOY AND PIN PULLER MECHANISMS BASED ON THIS TECHNOLOGY

Collado, M.(1), Nava, N. (1), Cabás, R. (1), San Juan, J.M.(2), Patti, S.(3) , Lautier, J-M. (3)

(1)*Arquimea Ingeniería, S.L., C/ Margarita Salas 16, 28919 – Leganés, Spain, Email: mcollado@arquimea.com*
(2)*Dpto. Física de la Materia Condensada, Universidad del País Vasco, Bilbao, Spain.*
(3)*ESA ESTEC, P.O. Box 299. 2200 AG Noordwijk, The Netherlands.*

ABSTRACT

A novel Shape Memory Alloy (SMA) has been developed as an alternative to currently available alloys. The material and related processes are fully European. This material, called SMARQ, shows higher working range of temperatures with respect to the SMA materials used until now. This temperature restriction is one of the most critical limitations of the current SMA devices for their use in space and other applications.

This new alloy has been proposed for its use in actuators for space mechanisms. A full characterization test campaign has been completed in order to obtain the main material properties and check its suitability as active material in space actuators. The test campaign includes: strength characterization, temperature characterization, electrical activation at different environment temperatures in the range from -70ºC to +125ºC, lifetime tests and vacuum tests at ambient temperature. Results of this characterization test campaign will be presented in this work.

As part of this project, two versions of Pin Puller mechanism working in the temperature range -30ºC to +125ºC have been designed and analysed. Operative demonstrator models of both devices were built and tested. The main characteristics of these devices as well as preliminary operating results will be reported in this work.

1. INTRODUCTION

Shape Memory Alloys (SMAs) are metals, which exhibit two unique properties, different to any other group of materials: the superelastic or pseudoelastic effect and the shape memory effect [1].

Shape Memory Alloys can be defined as materials which, after an apparent plastic deformation in the martensitic phase, undergo a thermoelastic change in crystal structure when heated above its transformation temperature range, resulting in a recovery of the deformation that can be used to drive mechanisms [2].

When the material is at its high temperature (austenitic) phase, it can undergo large deformations by the action of an external stress and then instantly revert back to its original shape once the stress is removed. This behaviour is known as pseudo-elasticity and it is due to the formation of stress induced martensite. This martensite can withstand large deformations that can be completely recovered once the stress is removed [3].

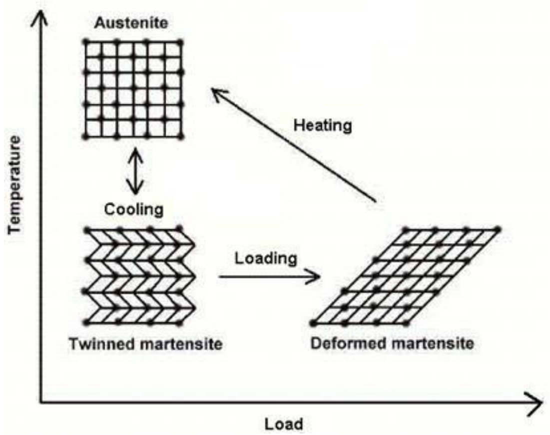

Figure 1: Microscopic diagram of shape memory effect.

The shape memory effect appears during the phase transformation from the martensite or low temperature phase to the austenite or high temperature one. Once the temperature is reduced (under no external forces), the material is transformed into *twinned* martensite, without any shape variation. When mechanical stress is applied, the martensite structure is reordered, producing a macroscopic deformation, apparently plastic. When the material is heated, it changes to austenite, recovering its initial shape. This mechanism is shown in *Figure 1*. The strain capabilities of this mechanism are limited usually to 7-8%.

The Martensitic transformation takes place in a temperature range. This range is one of the main parameters for the SMA alloys, and is called *transition temperatures* (Figure 2). The transformation occurs in the range defined by M_s (Martensite Start Temperature) and M_f (Martensite Finish Temperature). The inverse transformation (austenitic transformation) takes place

'14th European Space Mechanisms & Tribology Symposium – ESMATS 2011'
Constance, Germany, 28–30 September 2011