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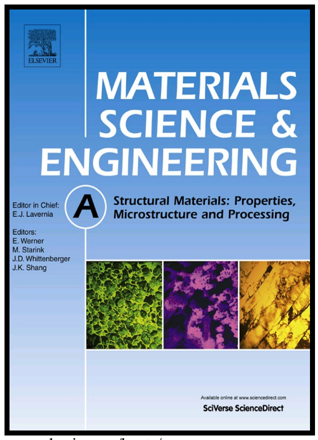

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Abstract

This study focuses on the effect of dynamic aging on the thermo-mechanical cyclic stability of $Cu_{73}Al_{16}Mn_{11}$ (at. %) shape memory alloy (SMA) during constant stress (isobaric) and stress-free heating-cooling experiments. Isobaric heating-cooling experiments under various tensile stress magnitudes revealed almost no residual strain up to 60 MPa. Subsequently, the cyclic stability of the samples was further investigated via thermal cycles under 60 MPa with increasing upper cycle temperature (UCT) values. The increase in UCT led to the ordering of the parent phase and formation of the bainite and α phases. In addition to the effect of UCT on the formation of bainite, stress had an accelerating effect on the bainitic transformation. The martensitic transformation temperatures increased due to ordering when UCTs were set to 120 °C and 145 °C and then started to decrease due to the formation of the bainite and α phases when the UCTs were set to 175 °C and 205 °C. Consequently, it was determined that the cyclic stability of Cu-Al-Mn SMAs for high temperature applications strongly depends on the UCT.

Keywords: Shape memory alloys, Cu-Al-Mn, Cyclic stability, Bainitic transformation, Martensitic transformation.

1. Introduction

Shape memory alloys (SMAs) can be utilized as solid state actuators by generating motion against the externally applied load under repeated heating and cooling. Among all SMAs, NiTi is the most robust one for actuator applications due to its superior thermo-mechanical cyclic stability and exceptional high energy density. However, the high cost of raw materials and additional processing expenses limit their commercial use, other than some few specific applications.

In this regard, Cu-based SMAs are good potential substitutes to NiTi SMAs. Cu-Al-Ni and Cu-Zn-Al are the most known Cu-based SMAs which have been studied extensively since 1970s [1, 2]. However, these alloys are brittle due to their high degree of order and high elastic anisotropy in the β parent phase with a B2 or DO_3 (or $L2_1$) structure such that formability via cold working is a problem for further exploitation of these alloys [3]. Moreover, microstructural evolution due to precipitation caused by dynamic aging which is activated with the temperature increase in cyclic heating-cooling and dislocation plasticity that may accompany martensitic transformation are potential problems affecting the thermo-mechanical cyclic stability of most of the Cu-based SMA actuators. Therefore, it is necessary to understand the behavior of these SMAs at relatively high temperatures and under specific loading conditions for revealing their limits or for designing / selecting the material according to the requirements of a specific application.

Kainuma and his co-workers [4, 5] have found that Cu-Al-Mn SMAs with Al content lower than 18 at. % show excellent ductility because of the low levels of $L2_1$ ordering in the parent phase. Therefore,