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Effects of sintering temperature on grain growth of NiTiCu shape memory alloy

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ABSTRACT

Nickel-titanium based shape memory alloys (NiTi SMAs) are extensively used in the biomedical field due to its unique properties such as superelasticity and shape memory effect. The martensite transformation can be executed in SMAs using these unique properties. The martensite transformation can be mainly influenced by the size of the grains presented in the alloy. Therefore, the control of grain size as per the requirement is a crucial in smart materials development. In this work, the nickel-titanium-copper (NiTiCu) SMA has been developed using spark plasma sintering (SPS) process at different temperatures. The sintering temperature is a significant factor that influences the size of grains in the consolidated alloys. The formation of grains in the sintered alloys has been evaluated with respect to the temperature which led to the formation of precipitates such as Ni_3Ti, Ni_4Ti_3 and Ni_3Ti_2 in the SMA. The effects of sintering temperature on the grain size have been investigated using computational thermokinetics at different temperatures such as 700 °C, 800 °C and 900 °C. Moreover, the same has been carried out in experimentally and evaluated using transmission electron microscope (TEM) analysis. The results of the simulation and experiment exhibited the trend of the growth of grain with an increase of sintering temperature. In addition to these, the dislocation density, sub-grain size and recrystallized fractions were investigated on the sintered alloy.

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1. Introduction

Nickel-titanium based shape memory alloys are used in various range of applications which means from the macro level bridge structure to biomedical device and micro level sensors to actuators [1,2]. Shape memory alloys are fascinated in different applications due to its tremendous properties such as superelasticity (SE) and shape memory effect (SME) which could be supported to yield its original condition. In addition to this, it has some credulous characteristics such as good ductility, biocompatibility, vibration absorption, corrosion resistance and high fatigue strength [3,4]. The functional properties of shape memory alloys mainly influenced by the composition of nickel (Ni) in the NiTi matrix as well as the processing temperature. These two parameters decide the application of SMAs by controlling their phase transformation temperatures [5].

However, the grain size in the material is an essential criterion for controlling all the mechanical and functional characteristics. The better mechanical properties such as higher fatigue strength and formability can be achieved with the reduction of grain size in SMAs. Moreover, the formation of ultra-fine and nanocrystalline structured SMAs can be found in different applications to enhance the functional stability [6].

The size of grains can be changed due to the recrystallization and thermal transformation processes. The surface energy can be reduced with this grain growth which led to the reduction of the grain boundary area [7]. The mechanical properties of the shape memory alloys could be affected by the changes in grain size which caused the precipitation hardening. The grain growth in shape

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