Addition of Fe Elements for CuAlMn Shape Memory Alloy

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Abstract

Nowadays where the age of communication has reached its peaks, especially the value of materials science and materials with different behaviors has increased. Important examples for the shape memory alloys are also mentioned in the materials have different behaviors remarkable work done and continues to do. Shape memory alloys lose their shape with effects such as force, temperature and magnetic. They are defined as exhibiting memory behavior by regaining their lost forms by removing these effects. NiTi alloy, Cu-based alloys and Fe-based alloys can be shown as alloy with shape memory effect. In this study, Cu-based shape memory alloy was used, which is more cost-effective compared to NiTi alloy and is more resistant to corrosion than Fe-based alloy. The CuAlMnFe quaternary shape memory alloys were obtained by using high purity elements in the arc melting furnace. This alloy was kept at 900 °C temperature for one hour and homogenized in order to remove the stresses in the material internal structure. After homogenization, differential scanning calorimeter device was used to obtain the solid state phase transition temperatures of the material and the results were evaluated.

Keywords: Shape memory alloys, Cu Based Shape Memory Alloys, Martensitic Transformation

Introduction

Nowadays where the age of communication has reached its peaks, especially the value of materials science and materials with different behaviors has increased. Important

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In shape memory alloys (SMA) which react to stimuli such as temperature, transformations called phase transitions to result in phenomena such as shape memory effect and super elasticity.

The Shape Memory Effect (SME) is realized by means of solid state phase transformation without diffusion in the material. These phase transformations are generally provided by the temperature or magnetic effect between the phases known as austenite (main phase) and martensite (product phase). Before transformation, the austenite phase of the solid state changes to the martensite phase by changing the crystal structure with external effects such as temperature. The internal structure of martensite contains the most twins of structural defects. The transformation of the martensite phase into the austenite phase in the SMA is generally described as a thermodynamic cycle and it also exhibits a reversible structure. During the transformation between phases, the release of chemical free energy creates the driving force under the shape recall. This force creates the shape memory effect. Although the displacement amounts of the atoms in phase transformation are very small, this movement is carried out in the same direction and causes large scale changes in the material. Crystal structure changes in the alloy provide high quality properties such as Shape Memory Effect and superelasticity [1, 2]. The temperature at which the martensite phase starts during phase transformation is expressed as M_s, while the temperature value at which the phase transformation is completely terminated is expressed as M_f. These abbreviations are used in the literature as A_s and A_f for the starting and finishing temperature values of the austenite phase [3, 4].

The SMA are used in medical, aerospace, aerospace, machinery, electronics and construction sectors for example applications such as stents, jet engine parts, solar panels, actuators and dampers, as well as being subject to many scientific studies [5, 6]. Due to the expansion of the usage area, the SMA whose charm has been increasing rapidly have become easily accessible thanks to the alloys such as NiTi. SMA was first discovered by Arne Olander in 1932 [7]. NiTi alloy, Cu-based alloys, and Fe-based alloys can be shown as an alloy with shape memory effect.

Cu Based Shape Memory Alloys

Cu-based Shape Memory Alloys have started to be used as an alternative and cheaper material due to their good formability, electrical and thermal conductivity. There are different alloy types such as CuZnAl, CuAlNi, CuAlBe and CuAlMn.

The high order sequence and the high elastic anisotropy of the ß phases of CuAlNi and CuZnAl alloys lead to the brittle structure of these alloys [8]. However, in the studies conducted by researchers to search for new products, it has been observed that the mechanical properties, in particular, the ductility, have been observed to be quite good by discovering that the low-grade sequence of the main phase in the use of CuAlMn alloy is relatively low in aluminium [9]. In addition, Mn element in the CuAlMn alloy can exhibit magnetic properties [10]. As with all other Shape Memory Alloys, alloying elements and their quantities [11, 12] and heat treatment methods [5, 13] offer the possibility of introducing different properties to the user by changing the physical and mechanical character structures shown by the materials. In this study, arc melting furnace shown in Figure 1 is used for the formation of quartet alloy by adding element Fe to alloy CuAlMn.

Figure 1. Arc Melting Furnace

CuAlMnFe quartz shape memory alloy was obtained by using high purity elements in arc melting furnace. The usage rates of the elements are given in Table 1.

Table 1. Usage ratio of elements

	[wt.%]	**[at.%]**
Al	11.81	23.80
Mn	4.18	4.14
Fe	1.25	1.22
Cu	82.76	70.84
Total	100.00	100.00

CuAlMnFe alloy formed in arc melting furnace was homogenized in the muffle furnace shown in Figure 2 at 900 °C for 1 hour, in order to eliminate the stresses in the material structure.

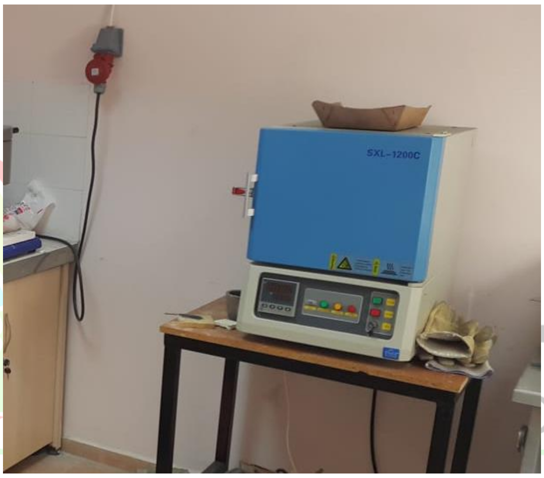

Figure 2. Muffle furnace

After homogenization, a differential scanning calorimetry (DSC) device was used to obtain the solid state phase conversion temperatures of the material and the results were evaluated. The results from the DSC device are shown in Figure 3. In addition, transformation temperatures are given in Table 2.

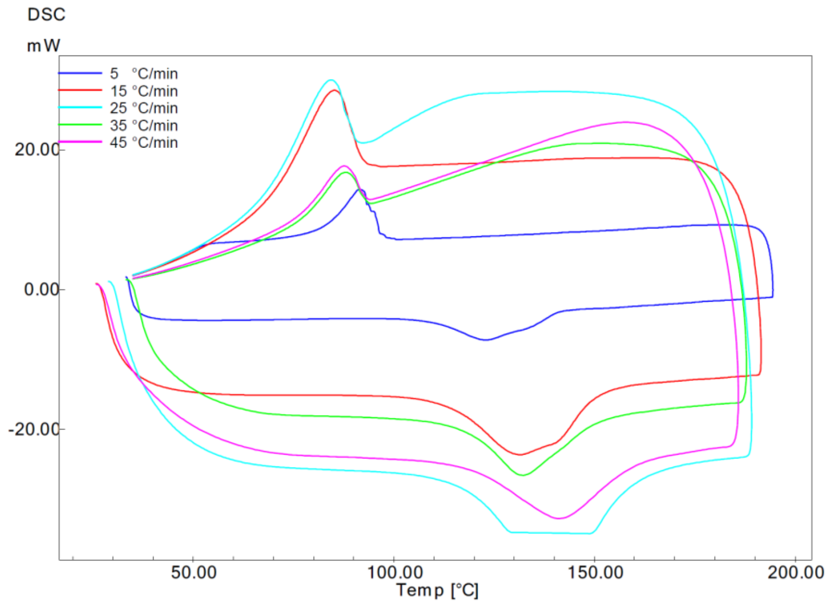

Figure 3. DSC curve of CuAlMn test sample.

Table 2. Martensitic transformation temperatures

	A_s (°C)	A_f (°C)	M_s (°C)	M_f (°C)
5 °C/min	110.68	141.27	95.22	83.05
15 °C/min	117.39	150.45	92.34	72.7
25 °C/min	117.46	161.41	90.31	73.48
35 °C/min	118.52	151.54	93.24	79.39
45 °C/min	119.37	159.92	93.02	78.08

Conclusions

Shape memory alloys are often encountered today. However, a very important factor, such as cost, makes the NiTi alloy effectively used at a disadvantage. In this respect, it is necessary to investigate alternative alloy types and obtain high-quality materials. In this study, CuAlMnFe shape memory alloy which is transformed so that NiTi alloys are generally slightly above the transformation temperatures shown at room temperature is produced and analyzed. Although the temperature shown is below the high conversion temperature, an effective material has been obtained thanks to the low hysteresis and the transformation curve above the room temperature.

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