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Short Communication

Effects of Ca additions on the microstructural stability and mechanical properties of Mg–5%Sn alloy

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ABSTRACT

Mg–Sn based alloys have great potential for high temperature applications because of the formation of the thermally stable Mg_2Sn phase in the as-cast condition. In the present investigation, for further enhancement of the mechanical properties, 0.7, 1.4 and 2 wt.% of Ca was added to the base Mg–5%Sn alloy. The dendritic structure of the base alloy was refined after the addition of Ca. It was found that the Mg–5%Sn–2%Ca alloy had the highest hardness, strength, and creep resistance among all tested materials. This is attributed to the higher volume fraction of CaMgSn second phase particles which act as the main strengthening agent in the investigated system. Results also showed that while long-term annealing treatment softened the base Mg–5Sn alloy, there was not much change in the hardness and strength of the Ca-containing materials, implying that CaMgSn intermetallic particles have successfully increased the microstructural stability of the materials.

1. Introduction

The high demand in the automotive industry for weight savings has resulted in great interest for magnesium alloys due to their high specific strength and low density. Among these alloys, those based on Mg–Al are the most promising for more development, especially in automobile industry because of an excellent combination of superior castability, good corrosion resistance, acceptable mechanical properties and reasonable cost [1–3]. Despite these advantages, these alloys have relatively poor mechanical properties and creep resistance at elevated temperatures. Generally, the poor high-temperature properties of the Mg–Al based alloys with aluminum contents greater than 2 wt.% is attributed to the formation of β-$Mg_{17}Al_{12}$ precipitates at grain boundaries and interdendritic regions [4–6]. The low melting point of this phase, however, leads to its coarsening and dissolution at temperatures above 125 °C and thus, to the deterioration of mechanical properties [3,7]. Accordingly, attempts have been made to develop new Mg alloys to address this disadvantage. The most common way of improving elevated-temperature properties is the formation of thermally stable precipitates or dispersoids along the grain boundaries to resist the deformation by grain boundary sliding. Among many possibilities, Mg–Sn based alloys are of special interest. These alloys have great potential for improving mechanical properties due to the formation of thermally stable phase Mg_2Sn, which is mainly distributed along grain boundaries in the as-cast condition [8–10].

In addition to Sn, as the major alloying element, some other elements such as RE [11], Sb [12,13], and Zn [14] have been added to magnesium as the ternary alloying elements for their influence on the formation of intermetallic phases improving mechanical properties at room and elevated temperatures. The microstructure and impression creep behavior of Ca-containing Mg–5Sn alloy were studied by Nayyeri and Mahmudi [15], who reported enhanced creep resistance with increasing Ca content of the alloys. The observed improvement was attributed to the diminishing of the less stable Mg_2Sn particles and formation of the more thermally stable CaMgSn phase which strengthens both matrix and grain boundaries during creep deformation in the investigated system. The effect of Ca additions on the microstructure of the Mg–Sn system has been investigated by Hort et al. [16], who detected CaMgSn and Mg_2Sn phases in the microstructure of the Mg–5Sn–*x*Ca alloys. They showed that the volume fraction of the Mg_2Sn particles was affected by the T6 heat treatment, implying that this phase is thermally unstable. However, the CaMgSn phase was found to be a stable phase, which did not go into the solution even after the aging treatment. In contrast to these results, Kim et al. [17] showed that, in addition to the CaMgSn and Mg_2Sn particles, a new Mg_2Ca phase can also exist in the Mg–5Sn–2Ca alloy. This new phase plays an important role in improving the mechanical properties because of its higher thermal stability at elevated temperatures, as also reported by Leil et al. [18].

The aim of this study is to examine the effects of Ca additions on the microstructure, hardness, and strength of the Mg–5Sn alloy in

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