Materials and Design 32 (2011) 5043–5048

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Short Communication

Corrosion properties and corrosion evolution of as-cast AZ91 alloy with rare earth yttrium

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ARTICLE INFO

Article history:
Received 28 March 2011
Accepted 22 May 2011
Available online 2 June 2011

ABSTRACT

The corrosion resistance property and the corrosion evolution of as-cast AZ91 alloy with rare earth Y addition are investigated by using immersion tests, electrochemical impedance spectroscopy (EIS), and X-ray photoelectron spectroscopy (XPS). The results show that the proper amount of Y in the alloys can improve the corrosion resistance of AZ91 alloys effectively. With the increment of Y, the corrosion rate of the modified AZ91 alloys by Y addition was markedly less than that of AZ91 alloy. The corrosion rate of AZ91 alloy with 0.3 wt.% Y was the slightest, but further addition of Y content over 0.3 wt.% make the corrosion heavier. The XPS analysis suggests that the compound film of AZ91 alloy with 0.3 wt.% Y is mainly composed of $Mg(OH)_2$ and $MgCO_3$ without any $Al(OH)_3$ and Al_2O_3, in addition, Y_2O_3 phase is found in the compound film of AZ91 alloy with 0.3 wt.% Y, which benefits to stabilize the surface film.

1. Introduction

Magnesium and its alloys have been used for a wide variety of structural and nonstructural applications, including automotive, industrial, aerospace, communications and computer equipments in reason of their excellent physical and mechanical properties, such as low density, high specific-strength, high specific-stiffness, good casting-ability, good dimensional stability, good damping capacity, and wonderful electromagnetic shielding characteristic [1–3]. In spite of the attractive physical and mechanical properties, a relatively poor corrosion resistance, especially in acidic environment and in salt-water condition, prevents their extensive use [4,5]. Therefore, it is necessary to study how to enhance the corrosion resistance of magnesium alloys. As to now, there are some kinds of technologies available for improving the corrosion resistance of magnesium and its alloys, such as coating processes [6,7], surface engineering technologies [8,9], and bulk alloying technologies [10,11]. However, the coating processes and the surface engineering technologies may face more and more environmental pressure or lead to the increase of the production cost. Although there are some researches about increasing corrosion resistance properties of magnesium and its alloys by bulk alloying methods, there are not significant progress and little investigation on corrosion mechanism.

The purpose of the present study is to clarify the corrosion evolution of as-cast AZ91 alloy with addition of rare earth Y in 3.5 wt.% NaCl solution by investigating the surface structure of oxide films on the AZ91 alloys by X-ray photoelectron spectroscopy (XPS) analysis and corrosion behavior by using electrochemical impedance spectroscopy (EIS). It is hoped that an efficient way can be developed to improve the corrosion resistance of AZ91 alloy, and the significant preliminary results can promote their widespread use in more fields.

2. Experimental

Pure magnesium (99.99 wt.%), pure aluminum (99.95 wt.%) and pure zinc (99.99 wt.%) were used in the preparation of AZ91-based alloys. Yttrium was added in form of Mg + 20.44 wt.% Y master alloy.

Four different alloys were based on AZ91 alloy (alloy I), containing 0.2 wt.% yttrium (alloy II), 0.3 wt.% yttrium (alloy III) and 0.4 wt.% yttrium (alloy IV) were cast respectively. Pure magnesium and pure aluminum were melted in a carbon steel crucible under a protective atmosphere of CO_2/SF_6 gas mixture, pure zinc and Mg–Y master alloy were added to the molten alloy in the crucible approximately at 730 °C. The smelting was held at 730 °C for 30 min under stirring to make sure that the added alloying elements were homogeneously dissolved. Casting was operated with a negative pressure container at about 700 °C, and four layers steel screens with ϕ38 μm hole were put on the entrance of the negative pressure container to prevent the inclusion into the alloy melt. The chemical composition of the four different alloys based on the AZ91 alloy is indicated in Table 1.

All samples used for tests were cut from the mid portion of the alloy ingots individually, immersion test samples with a dimension of 25 mm × 16 mm × 5 mm, electrochemical measurement specimens with a dimension of 20 mm × 20 mm × 5 mm. Before all the tests, all the samples were ground with SiC paper up to

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0261-3069/$ - see front matter
doi:10.1016/j.matdes.2011.05.038