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The relation between heat treatment and corrosion behavior of Mg–Gd–Y–Zr alloy

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ABSTRACT

The corrosion behavior of Mg–7Gd–3Y–0.4Zr (GW73K) was investigated in as-cast (F), solution-treated (T4) and peak-aged (T6) conditions using immersion tests and electrochemical measurements in NaCl solution (5 wt.%). Microstructure analyses were carried out on GW73K after different heat treatments by optical microscope (OM), field emission scanning electron microscope (FE-SEM), transmission electron microscope (TEM) and X-ray diffraction. It is found that GW73K alloy exhibits higher corrosion resistance in T4 than in F and T6 conditions due to the fully dissolution of cathodic coarse (Gd + Y) rich eutectic compound. The corrosion products of GW73K have different morphologies for F, T4 and T6 conditions. The product for F is less uniform and compact than T4 and T6, and it has been founded that GW73K-T6 had two different morphologies owing to the presence of β′. The results of polarization curves also confirm that proper heat treatment is beneficial to improve the corrosion resistance of GW73K alloy by transforming the microstructures.

1. Introduction

There has been a rapid growth in interest in recent years in the development of high strength, light weight magnesium alloys for elevated temperature applications [1–5]. Among various magnesium alloys, Mg–Gd system is one of the most promising candidates due to the remarkable age-hardening response and very good thermal stability of the main strengthening phase up to 250 °C [6–8]. Mg–Gd alloys exhibit good mechanical properties and high creep resistance comparable to or better than those of commercial WE type alloy by either increasing the content of Gd more than 10 wt.% [6,9] or adding Sc [10,11], Y [12] or Nd [8]. The precipitation sequence of Mg–Gd alloys has been previously investigated and was proposed. It was reported that the sequence for the binary Mg–Gd alloys was super-saturated solid solution (S.S.S.S.) → β″ ($D0_{19}$) → β′ (cbco) → β (Mg_5Gd, FCC) [13,14]. More recently, in an atom probe analysis of chemistry of precipitates in a Mg–Gd–Y–Zr alloy, Honma et al. [15] found that the β″ phase has a composition Mg_3X, while the β′ phase has a composition $Mg_{13}X_3$, which is close to Mg_5X, where X: Gd + Y. Among the four precipitate phases, the coherent β″ and phases β′ are considered to be the primary strengthening phases. The yield strength or hardness usually peak as the materials form a microstructure with fine β′ precipitates during aging [6,9,15–18].

Recently, some literatures also start to focus on improving the corrosion resistance of Mg–Gd–Y type alloy. Chang et al. [19] made a research on the effect of Gd content on the corrosion resistance of Mg alloys, and the alloy obtained its best corrosion resistance when the Gd content was 6 wt.%. Similarly, Sun et al. [20] studied the influence of Zr content on the corrosion resistance of Mg–10Gd–3Y (GW103 K) alloy, and the corrosion rate was minimal as the Zr content was 0.42 wt.%. Yi et al. [21] tried to enhance the corrosion resistance of Mg–Gd–Y alloy with Mg–Ce hydrotalcite film on the as-cast alloy surface. The as-cast alloy only released 12.5 ml H_2 during 150 h, and the average corrosion rate was about 2.17 $mg/cm^2/d$. Sun et al. [22] also found that the corrosion rate of the as-cast GW103 K alloy refined by 8% KSM-2 decreased to 5.338 $mg/cm^2/d$. Wang et al. [23–25] reported that the corrosion resistance of GW103 K alloy was improved by adding flux containing 5 wt.% $GdCl_3$ or 5 wt.% YCl_3 additions. The corrosion rate decreased to the minimum 1.1 $mg/cm^2/d$ for the as-cast specimens and reduced to 0.677 $mg/cm^2/d$ for specimens in T6 condition after refined by JDMJ + 5 wt.% $GdCl_3$ [23]. After adding flux RJ6 + 5 wt.% YCl_3, the corrosion rate declined to 1.32 $mg/cm^2/d$ for as-cast specimens [24], and the corrosion rate further decreased to 0.98 $mg/cm^2/d$ for as-cast specimens and about 0.55 $mg/cm^2/d$ for specimens in T6 condition after refined by JDMJ + 5 wt.% YCl_3 [25].

However, the influence of different heat treatment on corrosion resistance of Mg–Gd–Y type alloy has barely studied, though Chang et al. [26] and Ding et al. [27] have made some researches about the effect of the heat treatment on the corrosion resistance of Mg–3Nd–0.2Zn alloy. Therefore, this paper mainly focuses on and studies the effect of heat treatment on corrosion and electrochemical behavior of GW73K alloy in 5% NaCl solution with a pH value of 6.5.

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