Materials and Design 32 (2011) 1526–1530

Contents lists available at ScienceDirect

Materials and Design

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

Short Communication

Effect of heat treatment on strain hardening of ZK60 Mg alloy

Xianhua Chen [a,b,*], Fusheng Pan [a,b], Jianjun Mao [a], Jingfeng Wang [a,b], Dingfei Zhang [a,b], Aitao Tang [a,b], Jian Peng [a,b]

[a] College of Materials Science and Engineering, Chongqing University, Chongqing 400044, PR China
[b] National Engineering Research Center for Magnesium Alloys, Chongqing University, Chongqing 400044, PR China

ARTICLE INFO

Article history:
Received 21 July 2010
Accepted 8 October 2010
Available online 16 October 2010

ABSTRACT

Strain hardening behaviors of extruded ZK60 Mg alloy under different heat treatments (T4, T5 and T6) were studied using uniaxial tensile tests at room temperature. Hardening capacity, strain hardening exponent as well as strain hardening rate curve were obtained according to true plastic stress–strain curves. T5 and T6 treatments decrease strain hardening of extruded ZK60 alloy, and subsequently give rise to an obvious reduction in tensile uniform strain. While, as-T4 treated specimen shows the strongest strain hardening ability among these specimens, and its hardening capacity and strain hardening exponent are nearly twice those of as-T5 and T6 treated specimens. These effects were analyzed in terms of the microstructural variation and dislocation storage in ZK60 alloy.

1. Introduction

The low density of Mg and its alloys makes it an ideal choice for automotive and aerospace industries, such as body panels and space frames [1–3]. However, their extensive application is restricted due to their limited strength, ductility and formability. To improve the mechanical properties, many investigations have focused on optimizing heat treatment processing routes including solid solution, artificial aging etc. Great attention has been paid lately on the investigation of the effect of heat treatment on microstructures and room-temperature mechanical properties of Mg alloys [4–10].

Strain hardening is one of the most important considerations in the evaluation of plastic deformation of metallic materials [11]. The strength, ductility, toughness and deformability of materials are intimately related to strain hardening characteristics [12]. For this reason, abundant investigations have been carried out on the strain hardening behaviors and physical mechanism of conventional metallic materials [13–15]. The strain hardening behavior of cubic metals is fairly well understood, and the accumulation of a forest of dislocations is the dominant hardening mechanism [14,15]. Hexagonal metals present a more complex case due to their low symmetry, which restricts the number of slip systems, and their strong plastic anisotropy [14]. Hitherto some studies have been provided on strain hardening behavior of Mg and its alloys [10,16–26]. Most of the researchers focused on the effects of texture, grain size, twinning, temperature, strain rate on the hardening characteristics of Mg alloys.

However, only limited studies on the influence of heat treatment on the strain hardening behavior of Mg alloys are reported in the open literature [10]. The aim of the present work is to investigate the strain hardening response in ZK60 Mg alloy under different heat treatment conditions by means of tensile testing at ambient temperature. Our study will provide important basis for controlling the strength and ductility of Mg alloys by optimizing heat treatment conditions.

2. Experimental procedures

Alloy ingots of ZK60 were prepared from high purity Mg (99.98 wt.%), Zn (99.99 wt.%) and Mg-27.85 wt.% Zr master alloy in an electric resistance furnace. When the temperature reached 780 °C, molten alloy was stirred for 8 min and subsequently held for 45 min. Then semi-continuous casting was used to prepare cylinder ingots of ZK60 magnesium alloy with a diameter of 90 mm. The actual chemical composition of the alloy was determined by a photoelectricity spectrum analyzer (APL4460).

The ingots were homogenized at 420 °C for 18 h and then hot-extruded into rods with diameter of 16 mm. Extrusion ratio was 27:1, and ingot temperature was 390 °C. Three different heat treatments were performed on the as-extruded specimen, namely solid solution at 420 °C for 8 h and cooled at air (T4), solid solution at 420 °C for 8 h and cooled in air plus artificial aging at 180 °C for 15 h (T6), and direct artificial aging at 180 °C for 15 h (T5). The extruded and heat-treated samples were machined into tensile specimens of 5 mm gauge diameter and 50 mm gauge length. Tensile testing was carried out on a CMT5105 material test machine at a

* Corresponding author at: College of Materials Science and Engineering, Chongqing University, Chongqing 400044, PR China. Tel./fax: +86 23 65102821.
E-mail address: xhchen@cqu.edu.cn (X. Chen).

0261-3069/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2010.10.008