Materials and Design 32 (2011) 4590–4597

Contents lists available at ScienceDirect

Materials and Design

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

Short Communication

The texture and anisotropy of hot extruded magnesium alloys fabricated via rapid solidification powder metallurgy

Ayman Elsayed [a,*], Junko Umeda [b], Katsuyoshi Kondoh [b]

[a] Graduate School of Engineering, Osaka University, 2-1 Yamadaoka, Suita, Osaka 565-0871, Japan
[b] Joining and Welding Research Institute, Osaka University, 11-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan

ARTICLE INFO

Article history:
Received 23 November 2010
Accepted 28 March 2011
Available online 31 March 2011

ABSTRACT

Rapid solidification magnesium alloy powders produced by spinning water atomization process were hot extruded into rectangular bars, from which tensile and compression samples have been cut at 0°, 45° and 90° angles from the extrusion direction to study their anisotropy. Electron back-scattered diffraction analysis has been used to investigate the texture evolution during the extrusion process. Texture parameters like the Schmid factor and the intensity of (0 0 0 1) basal plane in the pole figure have been evaluated and correlated to the mechanical properties. Results have shown that the extruded rods exhibited high strength and relatively less anisotropy compared to other previously reported values for wrought magnesium alloys. Tensile and compression yield stresses have shown very similar values to each other at all loading directions. This limited anisotropy could be linked to both the fine grained and inter-metallic-compound-dispersed microstructure of the extruded alloys. Dynamic recrystallization behavior during hot extrusion has also been investigated in the present study.

1. Introduction

Concerns about power saving and environmental issues encouraged efforts to increase applications of light weight materials, especially in automobiles. Magnesium is one of the most promising materials which show high strength to weight ratio. Particularly, wrought magnesium alloys are more likely to get increased markets due to their improved performance compared to cast alloys. However, applications of magnesium alloys are still limited due to lack of formability at room temperature. This disadvantage arises from their hexagonal close packed crystal structure which limits the deformation mechanisms to basal slip [1]. Improvement of the mechanical properties of magnesium alloys could be obtained via different techniques, including, but not limited to, thermo-mechanical processing and chemical alloying [2,3]. In these studies, the Hall–Petch relationship describing the trend of increasing the yield strength with decreasing of the grain size was shown to prevail. The strengthening factor of Mg alloys in this relationship has shown exceptionally high values (0.2 to 0.34 MPa $\sqrt{m}$) compared to that of other materials [4,5]. This shows the strong effect of grain refinement on the properties of Mg alloys. The current authors have previously reported the considerable impact of rapid solidification powder metallurgy processing to improve the strength of both Mg–Al–Mn–Ca and Mg–Al–Zn–Ca–La alloys through the effects of grain refinement and inter-metallic compound refinement and distribution [6–8].

Anisotropy of mechanical properties of wrought Mg alloys caused by the strong texture has been shown as a barrier in the extension of their applications. Hence, the texture analysis has become an important tool for the evaluation and understanding of the mechanical response of Mg alloys [9]. The texture evolution during thermo-mechanical processing of Mg alloys has been investigated aiming at understanding their effects on the properties of those alloys [10–12]. Based on the reported results, various conclusions have been made, with some of them suggesting that the extrusion temperature, for example, has no relation with the texture formation [10] and with others showing its effect on the amount of dynamic recrystallization [11]. The common result among most references was that the fiber texture was usually obtained after hot deformation of Mg alloys in which the basal plane is aligned parallel to the extrusion direction [13,14]. That strong texture was then linked to the anisotropy of mechanical properties through the possibility of activating twinning in both tension and compression loadings. Texture evolution during hot compression, has also been studied and the effect of both strain rate and processing temperature on the texture was revealed through the Zener–Hollomon parameter [15,16]. It could be shown that this factor controls the recrystallization behavior of the investigated alloys.

Trials have been made to modify the texture formation, and ultimately to improve the anisotropy of Mg alloys through the use of alloying elements, especially rare earth elements [17–24].

* Corresponding author. Tel./fax: +81 6 6879 8669.
E-mail address: ayman@jwri.osaka-u.ac.jp (A. Elsayed).

0261-3069/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2011.03.066