한국소성가공학회 2008년도 추계학술대회 논문집 pp. 35~37

압출공정을 이용한 급속응고 Mg 합금분말의 고강도화

김택수

Strengthening of Rapidly Solidified and Extruded Mg Alloy Powders

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Abstract

The light Mg alloys bearing the remarkably high strength, corrosion resistance and elevated temperature stability stand on the center of interest. The accomplishment so far is, however, only by alloy modification without any consideration on the rapid solidification effect. This work is to report not only the effect of rapid solidification of $MgZn_{4.3}Y_{0.7}$ alloy powders, but the extrusion behavior on the materials properties. The average grain size of the atomized powders was about 3-4㎛. The extrusion was carried out with the area reduction ratio of 10:1 to 15:1. As the ratio increased, homogeneous microstructure was obtained, and the mechanical properties such as tensile strength and elongation were simultaneously increased.

Key Words : Mg powders, Rapid solidification, Extrusion, Strengthening, Microstructure control.

1. Introduction

Mg alloys stand on the center of investigation due to their high potential of application to the structural area as well as the functional materials field, corresponding to the low density and abundance. However, the intrinsic low strength and corrosion resistance have limited the industrial application of Mg alloys. The problem has been modified by an addition of rare earth elements and reported a remarkable improvement in the properties [1-2]. The typical composition bearing the high strength is Mg-Zn-Y, leading to high strength and hardness, low friction coefficient and low interfacial energy in both the ambient and elevated temperature. The improvement is corresponding to the homogeneous distribution of meta-stable icosahedral phase (I-phase) in the Mg phases [3].

In addition, rapid solidification applied to the Mg-Zn-Y alloys leads to the further enhancement in the materials properties as well as the modification of low workability of cast product. Recently, an advance in powder metallurgy process (PM) regards as an alternative to overcome the drawback of cast alloy, but also the low productive and complicated procedure of melt spinning commonly used [4]. However, the investigation on the PM Mg-Zn-Y alloys has been conducted using a laboratory scale gas atomizer, so that industrially oriented research is absolutely performed. In the present work, materials properties of Mg_{85}-$Zn_{4.3}$-$Y_{0.7}$ alloy powders prepared using an industrial scale gas atomizer were investigated. In addition, the extrusion behavior of powders was also evaluated, depending on the initial powder sizes.

2. Experimental

$MgZn_{4.3}Y_{0.7}$ alloy powders were fabricated by remelting and gas atomizing the master alloy prepared by an induction furnace. The melting temperature was 200 K above the liquidus temperature. The industrial high-pressure gas atomizer was constructed a boron nitride melt delivery nozzle of 5 mm in diameter and an annular Ar gas nozzle operating at a pressure of 5 MPa. The melt flow rate, as estimated from operating time and weight of atomized melt, was about 1.0 kg/min. Size distribution of the atomized powders was measured by a conventional sieving method, and the powders were divided into three groups, defined as follows ; group A - powders less than 33 μm, group B 46~63 μm and group C 64~90 μm. Each group of powders was canned and degassed at 500K for 20min., followed by extrusion at 300 K with an external pressure 280 MPa under an area reduction ratio of 10:1.

The structure of powders as atomized and bulks consolidated was characterized using a X-ray diffractometry (XRD) with monochromatic Cu-Kα radiation over 2θ range of 20°-80° at power of 5kW in a Philips 1729 X-ray diffractometer. The microstructure was examined by optical microscopy (OM ; Simzu) and scanning electron microscopy (SEM ; JSM 5410). Tensile strength of extruded bar was measured at room temperature using Instron type machine. Fracture patterns of the tested samples was observed using scanning electron microscopy (SEM).

3. Results and Discussion

$MgZn_{4.3}Y_{0.7}$ powders as rapidly solidified present an average accumulated size distribution of about 55 μm in diameter. The powders observed to have near spherical shapes with the partial formed satelites. No change in the morphology was found with the powder sizes. The XRD trace indicates a distribution of I-phases (Icosahedral, $Mg_3Zn_6Y_1$) and W-phases (Cubic, $Mg_3Zn_3Y_2$) in the Mg matrix. Embedding both the phases is an effective way to lower the coefficient of friction and interfacial energy, to enhance the corrosion resistance and thermal stability, and to improve the strength and hardness, simultaneously.

The grains of rapidly solidified powders became much fine, regardless of the initial powder sizes, compared with those of as cast sample which was reported to be about 30μm [6]. $MgZn_{4.3}Y_{0.7}$ alloy powders atomized using an industrial scale gas atomizer presented almost spherical morphology, and the mean powder sizes accumulated were about 55 μm in diameter. The grain size was about 2~5 μm with the powder Groups, and became fine after the extrusion being about 2~3μm. The grain size difference between the groups became narrow in the extruded bars, compared with in the as solidified powders. The powders as solidified consists of icosahedral (I-) phases and cubic W phases embedded in the α-Mg matrix. Concentration of Zn and Y elements are rich in the grain boundary. The highest UTS of 260 MPa and elongation of 17% were obtained from the bar extruded using the finest group of powders. Both the properties were increased as the powder sizes are decreased. Increasing the area reduction ratio will be an effective way for improving the strength further.

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