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Short Communication

An investigation into the mechanical behavior and microstructural evolution of the accumulative roll bonded AZ31 Mg alloy upon annealing

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ABSTRACT

The effect of annealing treatments on the room temperature mechanical properties (in the range of 23–27 °C) of an AZ31 magnesium alloy processed by accumulative roll bonding (ARB) have been investigated. The evaluation of mechanical properties was carried out using shear punch testing (SPT) method. The reliability of the method was verified through application of a well calibrated uniaxial tensile testing machine and the related correlation factors were adapted. The texture evolution was also studied upon annealing. The results showed that the room temperature strength of the ARB processed AZ31 alloy is increased by increasing the annealing temperature up to 350 °C. At temperatures above 350 °C, the deterioration of mechanical properties was taken place as a result of rapid grain growth.

1. Introduction

Magnesium and its alloys are the most attractive materials to be utilized in the automotive and transportation industries. This is mainly due to their significantly lower density (1.74 g/cm^3) compared to that of other structural materials such as steels and aluminum alloys [1]. However their inferior mechanical properties at the room temperature (23–27 °C) are considered as an important shortcoming of these exceptional materials. One of the key paths to overcome this major drawback of Mg alloys is modifying their microstructure (e.g., grain refinement) and texture. As is well established, severe plastic deformation (SPD) techniques have shown a great potential to manufacture bulk metallic materials with desired microstructure in particular ultrafine-grained (UFG) structures [2,3]. Accumulative roll bonding (ARB) was proposed by Saito et al. [4] as the sole SPD method capable of adoption by industry due to its viability as a continuous process to produce UFG materials in the form of large sheets. The effectiveness of the ARB method for the production of UFG microstructures in the AZ-series Mg alloys has been well studied by Pérez-Prado et al. [5,6]. Although conventional rolling process could be used as a continuous one as well, there are some major shortcomings regarding this process in comparison with its SPD counterpart. The ultra-fine microstructure evolves with a faster rate during ARB than during rolling [7]. This difference was primarily related to a significant amount of shear strain which is superimposed on the rolling compressive strain during ARB [8].

Nevertheless there are always difficulties in performing ARB on metals and alloys in order to improve the strength and ductility at the same time. In the case of aluminum alloys and steels, the product exhibits lower ductility after ARB [9,10]. However it is also reported that the ultimate strength could be degraded to some extent upon ARB [11]. The use of appropriate post-process treatments, such as annealing, appears to be a reasonable way of balancing the ductility and strength.

In a recent paper by Masoumi et al. [12], the post-rolling annealing treatment and its influence on the microstructure and texture evolution of a twin-roll cast AZ31 alloy sheet have been investigated. According to them, the basal texture was weakened due to the formation of the small recrystallized grains, through particle stimulated nucleation (PSN) mechanism, exhibiting orientations different from the parent grains. Furthermore, it was reported that the aforementioned annealing treatment increased the ultimate tensile strength and elongation values.

As is well documented the effective shear strength data obtained through the shear punch testing (SPT) method can be related to the tensile strength data for a wide variety of materials [13,14]. In the case of metals, a close relationship between shear punch and tensile test data has been reported by many researchers [14,15]. In the previous investigations by Zarei-Hanzaki et al. a good correlation between the shear punch and uniaxial tensile testing data has been identified [16,17]. Their latest study was conducted on a set of hot-rolled AZ31 alloys [18]. The proposed correlation has been speculated to be reliable for the same material under different processing conditions. Although a number of different manufacturing conditions are widely used, it is well known that the resulting microstructure, independent of the applied manufacturing procedure, has an important role on the properties of the material (e.g. mechanical, shear, ductility and corrosion) [19].

The present study has been mainly conducted to investigate the mechanical behavior and microstructural evolution upon annealing

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