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THE ROLE OF MICROSTRUCTURE IN DEFORMATION MECHANISMS IN EXTRUDED AZ31 MAGNESIUM ALLOY

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1. Introduction

Contemporary trends in vehicle and airplane designing place great emphasis on the reduction of the weight. This contributes to energy saving and to reduction of their negative environmental impact. One of the methods of weight reduction is use of magnesium alloys. Magnesium is the lightest structural element with desirable mechanical properties and its use is environment-friendly. However, due to hexagonal close-packed crystal structure, resulting in insufficient independent number of slip systems, magnesium alloys exhibit poor formability at ambient temperature.

2. The microstructure of Mg-AZ31 alloy

Conventional methods of hot extrusion of results in formation of inhomogeneous microstructure consisting of α-Mg matrixes and fine particles identified as Al-Mn phase with presence of inclusions and pores. The grain size and shape is remarkably diversified. Typically elongated coarse grains are surrounded by much smaller equiaxed recrystallized grains (Fig. 1 left). Such microstructure is not beneficial for plastic properties of magnesium alloys. The elongated coarse grains have base planes mostly parallel to the direction of extrusion so their rotation due to base slip at room temperature is very limited. These grains undergo contraction or tensile twinning depending on applied strain tensor. The result of this process is that many twinning boundaries are formed inside elongated grains and they are recognized as spots of crack initiation during cold deformation [1].

Hot extruded rods typically have strong fiber texture with base planes and $\langle 01{-}10\rangle$ direction lying parallel to the extrusion direction. Such texture formation is ascribed to preference of base slip even at high temperatures due to large difference in critical resolved shear stress (CRSS) between the base slip and non-base slips [2]. Strong texture decreases the ability of Mg-AZ31 alloy extrusions to deform at room temperature, because again base slip is the main deformation mode. But the effect of deformation twinning in coarse grains enables some strain until twin saturation. It has been observed that almost whole initial grains can be consumed by following generations of twins [3].

We discuss the possibility of enhancing plasticity of magnesium alloys by proper modification of microstructure. The application of new method of hot extrusion prevents formation of coarse elongated grains having a detrimental effect on the Mg-AZ31 alloy plasticity. Grain refinement can also support activation of additional prismatic slip, which has relatively low CRSS, due to stress concentration at grain boundary [2].

In the paper the results of investigations of ductile Mg-AZ31 alloy are presented. The rod extrusions, favorably oriented for $\{10{-}12\}$ $\langle 10{-}11\rangle$ twinning were tested in compression to various extent. Analysis of grain orientation, twinning saturation and crystallographic texture supports description of the microstructure changes. An acoustic emission (AE) technique was also used in this approach to detect the moment of twinning or slip activation during compression tests (Fig. 2). The comparison of AE diagrams with orientation image maps shows correlation between microstructure changes and AE peak occurrence. The effect of texture and grain size on twinning and deformation mechanisms was considered.

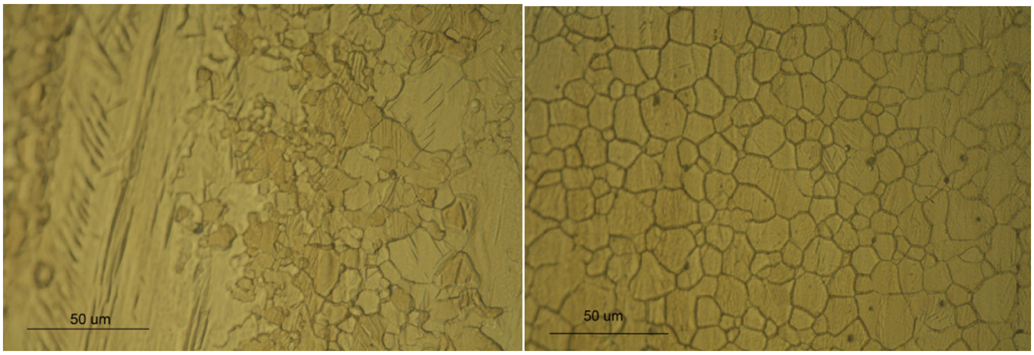

Fig. 1. Microstructures of conventionally hot extruded Mg-AZ31 alloy with elongated coarse grains (left) and refined hot extruded with equiaxed grains (right).

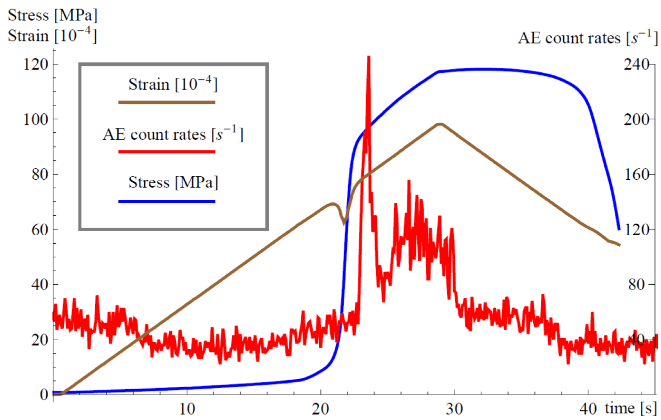

Fig. 2. Stress-strain curve, AE count rates and strain in interrupted compression test for Mg-AZ31 alloy at room temperature and strain rate of 0.00035 1/s.

References

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