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Mechanical properties and anisotropy of ME20 magnesium sheet produced by unidirectional and cross rolling

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ABSTRACT

The microstructures and textures of 90% unidirectionally (UR) and cross rolled (CR) RE-containing magnesium alloy ME20 were investigated for different reductions per rolling pass (r.p.p). During cross rolling the strain path was changed between the rolling passes which led to a weaker texture development and a finer recrystallized grain size compared to conventional unidirectional rolling. The presence of Ce-containing second phase particles with micrometric sizes is suggested to facilitate recrystallization by particle stimulated nucleation (PSN). The tensile mechanical properties in terms of strength and ductility, and also the sheet anisotropy of the UR and CR rolled materials were investigated at room temperature. CR specimens showed enhanced ductility of 26% elongation-to-fracture and an average *r*-value close to 1, which was attributed to the soft sheet texture prior to tension.

1. Introduction

Magnesium alloys are promising light-weight structural materials with great potential for automotive, aerospace and biomedical applications. Over the last decade, wrought Mg alloys have demonstrated an increasing trend to replace steel or aluminium components. However, from a cost perspective, even the most established wrought Mg alloy; AZ31 cannot compete effectively with commercial wrought Al alloys and current generation steels. It is therefore urgent to develop a new generation of wrought Mg alloys with better combination of strength and ductility, and sufficient corrosion resistance to satisfy the market demand.

In general, standard Mg rolled sheet products exhibit a typical basal texture with the majority of basal poles oriented parallel to the sheet plane. In this case (*c*-axis compression), the easiest slip mode; basal slip is suppressed since the Schmid factor (SF) in the basal plane is equal to zero, which results in strain localization and premature shear failure [1,2]. It has been shown in a number of studies [3–7] that the addition of rare earth (RE) elements can significantly improve the mechanical properties of rolled sheet without any loss of ductility. From all available RE elements, cerium (Ce) has been the one mostly investigated, probably due to its lowest cost among all other RE elements. Couling et al. [8] and Barnett et al. [9] reported that a small amount addition of Ce (0.15–0.3 wt.%) can actually promote cold deformation, which was assigned to the fact that cerium can effectively weaken the deformation texture. Mackenzie and Pekguleryuz [6] found that during recrystallization in a Mg–Zn based alloy containing Ce, the typical basal texture component was not only weakened but also replaced by a untypical component with basal poles rotated ~45° towards the transverse direction (TD). Stanford [10] compared the influence of different RE elements during extrusion and concluded that strong interaction of RE solutes with dislocations and grain boundaries is responsible for the observed texture weakening at very low alloying levels.

During most metal forming processes the material usually undergoes a complex strain history. In the relatively simple process of flat rolling, the material near the surface is subjected to significant shearing due to the interaction of the metal with the rolls, which is superimposed on a plane strain compression (PSC) mode in the center of the sheet. Changing the strain path during rolling has major effects on the deformation texture and microstructure of the sheet. In a previous study, Al-Samman and Gottstein [2] investigated the effect of strain path change on the rolling behavior of Mg by subjecting the rolled material to two different rolling modes; unidirectional (UR) and cross rolling (CR). They reported that cross rolling yielded a number of interesting properties such like a decreased texture strength and an enhanced rollability.

Up to this date, a large number of studies related to the rolling behavior and texture evolution of Mg alloys (with and without RE elements) have been published [11–15]. However, and to our knowledge, none of these studies investigated the effect of UR and CR on the rolling behavior of Mg alloys containing RE

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