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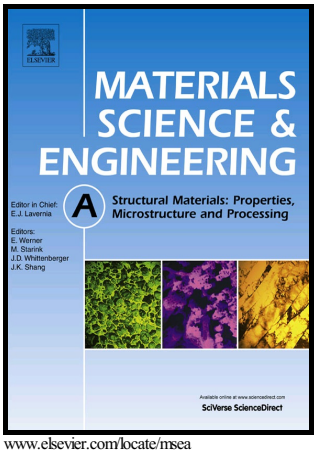

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Friction stir processing of newly-designed Mg-5Al-3.5Ca-1Mn (AXM541) alloy: microstructure evolution and mechanical properties

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Abstract

Friction stir processing (FSP) of a new rare earth-free Mg-5Al-3.5Ca-1Mn (AXM541) alloy resulted in significant microstructural refinement and mechanical properties comparable to existing AXM series Mg alloys. Severe refinement of the Al-Ca (C36) phase during FSP led to uniform dispersion throughout the microstructure. The synergistic effect of high heat input and the presence of these 1-4 µm size particles resulted in dynamic recrystallization via particle stimulated nucleation (PSN), with an average grain size of 4.5 µm after FSP. Further, improved mechanical properties of the AXM541 alloy along the processing direction produced a tensile yield strength (TYS) of 322 ± 14 MPa and a total elongation of 16 ± 3%. The increase in strength was also attributed to the dispersion strengthening effect associated with Al-Ca and Al-Mn (D810) particles. Moreover, the AXM541 alloy showed a better mechanical response compared with other AXM alloys irrespective of high Ca/Al ratio, due to the effective refinement and redistribution of Al-Ca phases resulting from FSP. However, strain hardening ability and TYS of the AXM541 alloy could be further improved if the Mn/Al ratio could be tailored, as Al-Mn particles do not break down during FSP.

Keywords: Magnesium alloys; strength; ductility; friction stir processing; alloy design

1. Introduction

The good strength-to-weight ratio of Mg (and its alloys) makes it especially attractive for automotive applications, as vehicle fuel consumption is greatly reduced. Recently, Mg and its alloys have been used to produce powertrains in die cast form. However, their limited use in