Microstructural Characterization of Friction Stir Welded Dual Phase (Al, Zn, Mg)-Fe Hypoeutectic Cast Alloy for Structural Automotive Applications

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Abstract

Weight reduction in automobiles means reduced fuel consumption and better fuel efficiency. Aluminium alloys are well suited for such applications owing to their low density and structural integrity. Newly developed medium-strength, high-elongation (Al-Zn-Mg)-Fe (HE700) alloys have the potential to fulfill the demand for significant lightweighting of components over conventionally used cast aluminium alloys. The alloy used in the present work is a dilute hypoeutectic Al-Fe system with Zn and Mg as strengtheners and Ti as a grain refiner. Near net shape HE700 alloy plates were processed by high vacuum high pressure die casting (HVHPDC) route. Joining such shape-casting alloys to form a high-integrity component assembly is a critical process in structural lightweighting. In this work, friction stir welding (FSW), which is an established solid-state joining technique for Al alloys, was used, and the microstructure evolution was thoroughly studied. The microstructure of this new generation Al-Zn-Mg cast alloy was modified significantly during friction stir welding. Al-Fe based eutectics or intermetallic phases were present at the intergranular regions in the microstructure of as-cast Al-Zn-Mg alloy. These types of Al-Fe based phases were refined to the nano-scale and distributed uniformly in the welded region during friction stir welding. The grain size of the alloy was also refined significantly in the stir zone. A continuous type dynamic recrystallization (CDRX) process seems to have occurred in the microstructural evolution during FSW. These factors lead to a significant strengthening of the weld zone. A major emphasis of the work is on the understanding of microstructural evolution, especially the evolution of precipitates and the eutectic (intermetallic) phase present in the alloy. Advanced characterization tools like electron back-scattered diffraction (EBSD), high-resolution transmission electron microscopy (HRTEM), atom probe tomography (APT), and high-angle annular dark field (HAADF) techniques have been used for the same.

Keywords: AlZnMgFe (HE700) cast alloy, Friction stir welding, Lightweighting, Dynamic recrystallization (DRX), Microstructural Evolution, AlFe intermetallics

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