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Microstructure Evolution, Mechanical Properties and Fracture Analysis of a High-Pressure Die-Cast Secondary AlSi10MnMg(Fe) Alloy

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Abstract

The current study presents a preliminary investigation into the microstructure evolution, mechanical properties and fracture analysis of a novel secondary AlSi10MnMg(Fe) alloy with 2 mm wall thick- ness produced by high pressure die casting (HPDC). The as-cast microstructure manifests the formation of less detrimental α-$Al_{15}(FeMn)_3Si_2$ phase instead of the brittle β-Al_5FeSi phase found in the conventional HPDC alloys. The precipitation of different phases in the secondary alloy determines its regional hardness distribution. Moreover, the tensile properties of the alloy are supposedly influenced by its chemical composition, the skin effect and the casting defects.

1 Introduction

High pressure die casting (HPDC) is a process with high geometrical accuracy and reduced cycle time. It allows the production of extremely thin-walled castings of large dimensions, thus largely reducing the number of parts required to produce a chassis and body in white structure of an auto- mobile [1]. The conventional alloys used in the HPDC process are based on Al-Si-Mg system by virtue of their excellent castability. These alloys often contain Fe with mass content in a range of 0.8-1.1%. However, such high Fe content in the alloy leads to the formation of brittle β-Al_5FeSi phase, which deteriorates the mechanical properties of high ductility castings and safety parts. This problem has led to the development of primary AlSi10MnMg alloy, via addition of Mn with mass content in a range of 0.5-0.8% and simultaneous restriction of Fe to a maximum mass content of 0.15%. On one hand, addition of Mn promotes the formation of less deleterious α-Fe phase instead of the β-Fe phase. On the other hand, restricting the Fe content to the desired amount significantly increases the die sticking tendency and increments the production cost. Considering these pros and cons associated with the primary alloy, along with the fact that the current era calls for production of sustainable materials that are more environment friendly with respect to industrial applications, there is a growing interest for recycled secondary alloys to be used in the HPDC process for manufacturing the structural parts of automobiles. The usage of secondary alloy, which usually contains somewhat higher Fe content than the primary alloy, can significantly reduce the production cost and CO_2 emission and arguably still be able to exhibit mechanical properties within a range that are desirable in the cast components [2,3].

As the usage of recycled secondary alloys in HPDC process is relatively new, the literature lacks experimental data on the behavior of such materials. Thus, the aim of the current work is to gather preliminary knowledge about the microstructure evolution and mechanical properties imparted in a HPDC-produced novel secondary AlSi10MnMg alloy (will hereafter be denoted as AlSi10MnMg(Fe)) with higher Fe and Cu content than its primary counterpart. As the recent structural castings in industrial applications are extremely thin-walled in the order of 1.5 - 2.5 mm, our research focuses on the characterization of as-cast alloy having 2 mm thickness.