Optimisation of the heat treatment cycles of CSIR semi-solid metal processed Al-7Si-Mg alloys A356/7

by

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SUMMARY

Title: Optimisation of the heat treatment cycles of CSIR semi-solid metal processed Al-7Si-Mg alloys A356/7

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Conventional casting alloys Al-7Si-Mg A356/7 contain between 6.5 and 7.5% Si, together with 0.25-0.7% Mg and are used for critical castings in the automotive and aerospace industries. These alloys are also the most popular alloys used for semi-solid metal (SSM) forming due to good castability and fluidity imparted by the large volumes of the Al-Si eutectic. Despite their industrial importance, there is a lack of detailed research work revealing precipitate micro- and nanostructural evolution during aging of these alloys compared with the Al-Mg-Si 6000 series wrought alloys. This study characterises the heat treatment response of SSM-processed Al-7Si-Mg alloys in comparison with conventionally liquid cast alloys (investment casting and gravity die casting). It is shown that, provided that the maximum quantity of the alloy's Mg is placed into solid solution during solution treatment, and that the alloy's Fe content is within specification, the response to age hardening of Al-7Si-Mg alloys is independent of the processing technique used. The nanostructural evolution of Al-7Si-Mg alloys after artificial aging with and without natural pre-aging has been characterized using transmission electron microscopy and atom probe tomography and correlated with hardness and mechanical tensile properties. The number densities and Mg:Si ratios of solute clusters, GP zones and β''-needles were determined. The heat treatment response of SSM-processed casting alloys A356/7 alloys are also compared with SSM-processed Al-Mg-Si 6000 series wrought alloys, with the advantage of having similar globular microstructures. The high Si-content of the casting alloys compared to the wrought alloys offers several advantages, including a faster artificial aging response (shorter T6 aging cycles), higher strength for comparable Mg contents and less sensitivity to prior natural aging on peak strength. Finally, an age-hardening model was developed for the Al-7Si-Mg alloys, including a method of incorporating the effects of changes in Mg-content on the aging curves.

Keywords: Al-Si-Mg alloys, heat treatment, natural aging, artificial aging, temper, semi-solid metal, rheocasting, high pressure die casting, transmission electron microscopy, atom probe tomography.

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