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Microstructural Interactions of Ag and Sc Alloying Additions during Casting and Artificial Ageing to a T6 Temper in a A356 Aluminium Alloy

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Abstract : Aluminium cast alloys, of the Al-Si system, are widely used for shape castings. Their microstructures can be further improved on one hand, by alloying modification and on the other, by optimised artificial ageing. In this project four hypoeutectic Al-alloys, the A356, A356+ Ag, A356+Sc, and A356+Ag+Sc have been studied. The interactions of Ag and Sc during solidification and artificial ageing at 170°C to a T6 temper have been investigated in details. The evolution of the eutectic microstructure is studied by thermal analysis and interrupted solidification. The ageing kinetics of the alloys has been identified by hardness measurements. The precipitate phases, number density, and chemical composition has been analysed by means of transmission electron microscopy (TEM) and EDS analysis. Furthermore, the SHT effect onto the Si eutectic particles for the four alloys has been investigated by means of optical microscopy, image analysis, and the UTS strength has been compared with the UTS of the alloys after casting. The results suggest that the Ag additions, significantly enhance the ageing kinetics of the A356 alloy. The formation of β" precipitates were kinetically accelerated and an increase of 8% and 5% in peak hardness strength has been observed compared to the base A356 and A356-Sc alloy. The EDS analysis demonstrates that Ag is present on the β" precipitate composition. After prolonged ageing 100 hours at 170°C, the A356-Ag exhibits 17% higher hardness strength compared to the other three alloys. During solidification, Sc additions change the macroscopic eutectic growth mode to the propagation of a defined eutectic front from the mold walls opposite to the heat flux direction. In contrast, Ag has no significance effect on the solidification mode revealing a macroscopic eutectic growth similar to A356 base alloy. However, the mechanical strength of the as cast A356-Ag, A356-Sc, and A356+Ag+Sc additions has increased by 5, 30, and 35 MPa, respectively. The outcome is a tribute to the refining of the eutectic Si that takes place which it is strong in the A356-Sc alloy and more profound when silver and scandium has been combined. Moreover after SHT the Al alloy with the highest mechanical strength, is the one with Ag additions, in contrast to the as-cast condition where the Sc and Sc+Ag alloy was the strongest. The increase of strength is mainly attributed to the dissolution of grain boundary precipitates the increase of the solute content into the matrix, the spherodisation, and coarsening of the eutectic Si. Therefore, we could safely conclude for an A356 hypoeutectic alloy additions of: Ag exhibits a refining effect on the Si eutectic which is improved when is combined with Sc. In addition Ag enhance, the ageing kinetics increases the hardness and retains its strength at prolonged artificial ageing in a Al-7Si 0.3Mg hypoeutectic alloy. Finally the addition of Sc is beneficial due to the refinement of the α-Al grain and modification-refinement of the eutectic Si increasing the strength of the as-cast product.

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