Title: PROCESSING AND CHARACTERISATION OF ALUMINIUM - SCANDIUM ALLOYS AND COMPOSITES

ABSTRACT

Al–Sc and Al–Sc–Zr alloys were cast in resin sand mould. Al-0.3Sc-0.15Zr alloy was cast using different mould to obtain a wide range of cooling rates. A novel method of quenching the investment shell mould (QIC) along with the liquid metal in oil was also used which resulted in a significant increase in the cooling rate as compared to conventional Investment Casting process (CIC). Al-0.3Sc-0.15Zr alloy and Al-0.3Sc-0.15Zr/ $(TiB_2)_p$ composites were cast in CIC and QIC with varying additions of Mg. The phase composition of the alloys and composites and the morphology of precipitate that developed during solidification and subsequent thermal treatment were studied. XRD analysis showed that the weight percentage of the Al_3Sc / Al_3(Sc, Zr) precipitates was significantly below 1% in all binary and ternary alloys except for the virgin Al-0.5Sc-0.15Zr alloy. The amount of as-cast precipitates decreased with increase in the cooling rate. These as-cast precipitates grew at the expense of Sc in solid solution reducing the number of precipitates formed during ageing process. This results in lower increment in hardness on ageing. At higher cooling rate during solidification in the QIC of Al-6Mg-0.3Sc-0.15Zr alloy solid solubility of Sc in Al increases and the reduction in large size porosity was observed. More or less uniformly distributed coarse primary and fine as-cast precipitates of Al_3Sc and Al_3(Sc, Zr) were observed in the QIC as compared to CIC. Both these factors contributed to the increased effectiveness of the ageing treatment, and improved mechanical and wear properties of the alloy in the QIC process. Addition of Mg plays an important role in increasing the strength and ductility of the composite. Nanosized precipitates of Al_3(Sc, Zr) observed at the peak age condition and TiB_2 particles, also of nanosize contributed to the increase in strength and ductility. The presence of Sc and Zr reduced the size of TiB_2 particles down to 10nm. The optimum concentration of Mg for the best mechanical properties for the composite is in between 3.5 and 6%Mg. Enhanced improvement in hardness at the peak-aged condition was observed at lower reduction percentage and lower rolling temperatures. Corrosion resistance decreased with the addition of Mg to the ternary alloy whereas it increased with increased addition of Mg to the composite.

Keywords: Al– Sc alloys, composite, microstructure, grain refinement, solidification rate, as-cast ageing, investment casting.