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Properties of R-HPDC Al-Zn-Mg-Cu aluminium alloys

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2015-06-01
http://hdl.handle.net/10539/18507

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Summary

Five different Al-Zn-Mg-Cu alloys were produced by rheo-high pressure die casting (R-HPDC) of which the as-cast microstructures were characterised with scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX). The primary aluminium grains and eutectic phases were observed with SEM backscattered electrons (BSE). The overall compositions of the eutectics were measured with EDX and were found to be relatively similar, regardless of the alloy composition. Two further Al-Zn-Mg-Cu alloys were produced with the same compositions as the eutectics in the R-HPDC alloys. These eutectic alloys were also characterised with SEM and EDX. One of the R-HPDC alloys was also cooled in vacuum and characterised with SEM and EDX.

The as-cast alloys were characterised with differential scanning calorimetry (DSC) and X-ray diffraction (XRD). DSC results showed that all the as-cast alloys had different melting points depending on the phases present in the solidified alloy. XRD showed that the as-cast alloy eutectics had one of two crystal structures for the second component besides the (Al) phase, which were hexagonal or cubic, or a combination of both depending on the overall composition and cooling rate.

Modelling of non-equilibrium alloy solidification was also done using Thermo-Calc with the most recent aluminium database. It was found that the calculated and measured results compared favourably.

The remaining phases in all the alloys, after homogenisation and artificial ageing, were characterised with SEM and EDX to assess the influence of impurity elements. It was found that Fe and Mn react with Cu, and Si with Mg.

Experiments were also conducted to assess the effect of composition on the hardness and yield strength of all the alloys after homogenisation and artificial ageing. A precipitate composition for the T6 condition, from literature, was used for the calculations. It was found that there were reasonable straight line relationships if the impurity elements were neglected. On the other hand, there were near perfect linear fits when the influence of impurity elements was taken into account.

The optimum Al-Zn-Mg-Cu alloying ratio for a dilute aluminium alloy is the composition of the precipitate modelled. The ratios were $Al_{7.4}Zn_{45.4}Mg_{38.6}Cu_{8.6}$ for the T6 condition and $Al_{15}Zn_{39}Mg_{33}Cu_{13}$ for the T73 condition.