Solidification of a Magnesium Alloy Using In-Situ Neutron Diffraction

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Magnesium (Mg) alloys are obtaining increasing attention in the automobile industry because of their high specific strength, high stiffness and machinability [1]. As the lightest structural metal, (density = 1.74 g/cm^3, [2]) Mg and its alloys continue to be utilized extensively for automobile airbag supports, brake/clutch pedals and suspension supports [1]. Replacement of current Al automotive casting components such as engine cradles, transmission cases and crankshafts with equivalent castings made of Mg will result in a ~25% reduction in vehicle weight, increasing the fuel efficiency and reducing carbon emissions of both gasoline and electric-hybrid vehicles. An improvement in the understanding of Mg alloy solidification will promote their use for more structurally demanding automotive applications.

In-situ neutron diffraction was conducted to observe the solidification behaviour of a Mg-6wt.% Zn alloy refined using Zr. The experiment was performed at C2 powder diffractometer at the Canadian Neutron Beam Centre in Chalk River, Ontario, A sample that was machined from the alloy had diameter of 6.2mm and length of 40 mm. The sample was installed in a graphite crucible at C2, melted, and slowly cooled from 650 °C to 300 °C in a stepwise fashion. The monochromatic neutron beam used in the experiment had a wavelength of 2.37Å. Neutron diffraction data was collected at several pre-set temperatures. The resulting diffraction spectrum of the (0002) plane is shown in **Figure 1**.

When the alloy is fully molten, diffusion scattering takes place and neutrons scatter in all directions. As solid phases begins to form, neutrons begin to scatter at specific angles (diffraction peaks) that, according to Bragg's law, correspond to specific *hkl* d-spacing of the solid phases. The growth of the solid phase with each step of the temperature reduction can be calculated based on increase in the diffraction intensity of the peak being analyzed.

A resulting plot of fraction solid versus temperature is shown in **Figure 2.** The solid fraction gradually increases with decreasing temperature until it settles around 1 (or 100%) indicating complete solidification. The results show that in-situ neutron diffraction studies could be used to examine the solidification behaviour of Mg alloys with insights not possible with the traditional thermal analysis or X-ray diffraction techniques.

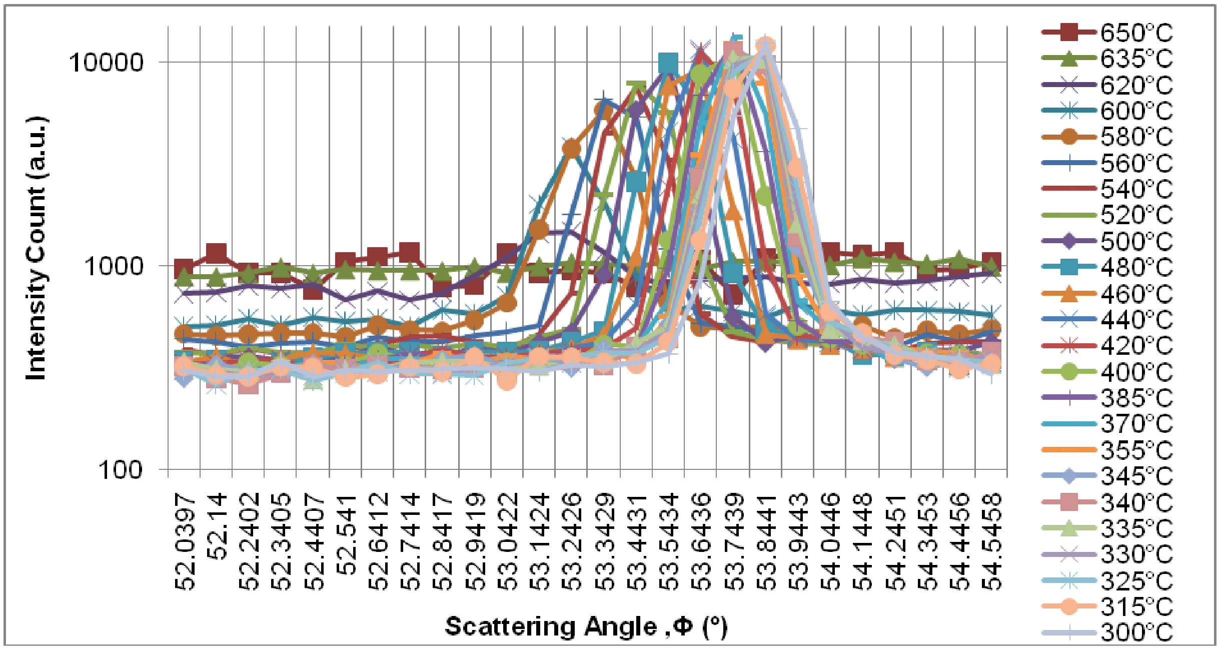

Figure 1-Neutron diffraction plot of Mg-6wt.%Zn alloy (0002) plane refined using 0.7wt.% Zr at different temperatures from 650 to 300°C

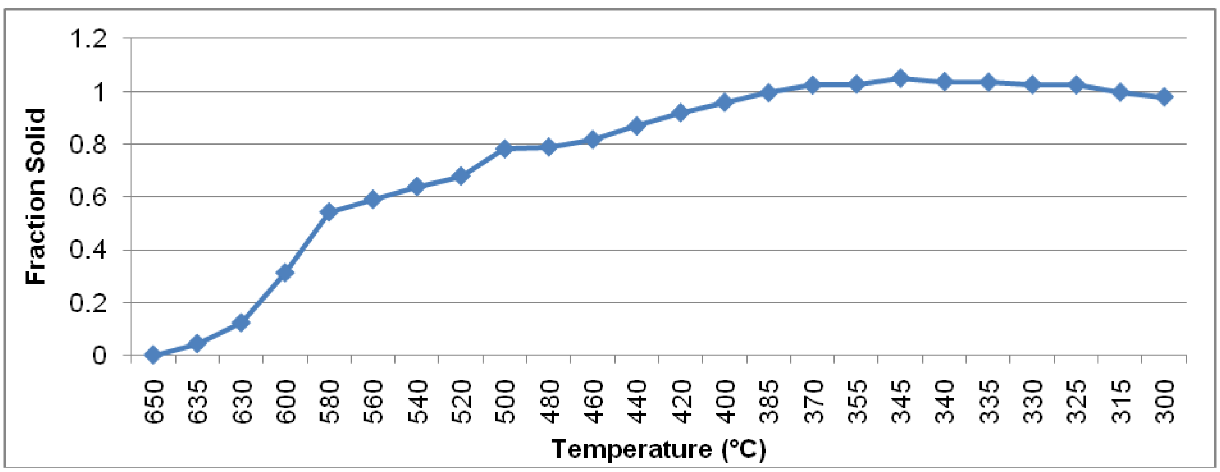

Figure 2-Fraction solid versus temperature for Mg-6wt.% Zn alloy (0002) plane refined using 0.7 wt.% Zr with +/-5% margin of error

References

[1] Cole, G.S. and A.M. Sherman, *Lightweight Materials for Automotive Applications.* Materials Characterization, 1995. **35**: p. 3-9.

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