Solidification of Grain Refined Magnesium Alloy Using In-Situ Neutron Diffraction (CNBC-0926A)

Abdallah Elsayed[1], Dimitry Sediako[2] and Comondore Ravindran[1]

[1]Centre for Near-net-shape Processing of Materials, Ryerson University, Toronto, ON, Canada
[2]Canadian Neutron Beam Centre, Chalk River Laboratories, Chalk River, ON, Canada

Increasing attention to magnesium (Mg) alloys in the automotive industry are being realized because of their good machinability, and high specific properties [1]. With a density of 1.74 g/cm^3 [2], Mg and its alloys will continue to contribute to the production of lightweight automobile airbag supports, brake/clutch pedals and suspension supports [1]. An improvement in the understanding of Mg alloy solidification will promote their use for more structurally demanding automotive applications to replace current aluminum (Al) automotive casting components such as engine cradles, transmission cases and crankshafts. The resulting transition from an Al to Mg component will result in a ~25% reduction in weight, increasing the fuel efficiency and reducing carbon emissions of both gasoline and electric-hybrid vehicles.

In-situ neutron diffraction was conducted to compare the solidification behaviours of two Magnesium-Zinc alloys (Mg-5 wt.% Zn and Mg-5 wt.% Zn-0.7 wt.% Zr). The addition of Zr provides exceptional grain refinement. The experiment was performed at the C2 powder diffractometer at the Canadian Neutron Beam Centre in Chalk River, Ontario, A sample that was machined from the alloy had diameter of 10 mm and length of 40 mm. The sample was installed in a graphite crucible at C2, melted, and slowly cooled from 660 °C to 200 °C in a stepwise fashion. The monochromatic neutron beam used in the experiment had a wavelength of 2.37 Å. Neutron diffraction data was collected at several pre-set temperatures. A sample resulting diffraction pattern for the Mg-5 wt.% Zn alloy showing diffraction from the the $(10\bar{1}0)$, (0002) and $(10\bar{1}1)$ α-Mg peaks 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. 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.