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CHARACTERIZATION OF HYPOEUTECTIC AL-SI ALLOYS AT NEAR MICROGRAVITY, HIGH UNDERCOOLING CONDITIONS

Abstract

Understanding the evolution of microstructure during solidification is vital to manufacturing products with desired properties. This evolution is strongly dependent on the growth of the S/L interface during solidification, which depends on the level of undercooling of different phases. The larger the undercooling the more solidification pathways there are, making a broad range of metastable microstructures possible. Convection also plays an important role during solidification and therefore must be limited to help understand the underlying solidification mechanisms that are play.

One of the most effective ways to achieve large undercoolings is through containlerless solidification, which allows for complete avoidance of heterogeneous nucleation at container walls. A common containerless technique is Electro-Magnetic Levitation (EML) but for it to operate large forces are required to compensate for the gravitational force acting on the sample, inducing external stirring and convection. A possible solution is operating EML in a microgravity environment but this is expensive and quite difficult to setup.

To optimize both aspects a containerless ground based technique called Impulse Atomization (IA) was developed. It achieves high undercoolings in a containerless environment while having minimal if any convection in the solidifying droplets. A single fluid atomization technique, IA allows for breakup of a melt stream into small droplets through the influence of mechanical impulses. The formed droplets almost reach free fall conditions within an inert chamber reducing the experienced convection inside the droplets. Simultaneously, the small size of the droplets and inert environment allow for rapid solidification and large undercoolings to occur.

Due to these unique processing characteristics IA was used to examine hypoeutectic Al-Si alloys to quantify its effect on microstructure, morphology and mechanical properties. These alloys form an important class of cast industrial alloys. From results on IA atomized powders, a dendritic "Seaweed" microstructure was observed and appears to occur by an alternating dendrite tip splitting mechanism brought about by a change in surface tension anisotropy at the solidification interface. The bending and breaking of the growing dendrites could be caused by the rejection and subsequent build-up of solute at the solidification front, signifying a change in mechanism from what is seen in conventional alloys. Also, noticeable refinement of the -Al eutectic Si was seen which in turn led to improved mechanical properties of the alloy.