Overview of high shear melt conditioning (HSMC) technology for processing Al and Mg alloys

J.B. Patel, Y. Zhang and Z. Fan

Light alloys of Al and Mg are used in many industrial applications where lightweighting is of paramount interest. Lightweighting has become more important for increased fuel efficiencies, with the increase in the mass of cars as a result of the weight of the batteries or fuel cells associated with electric vehicles.

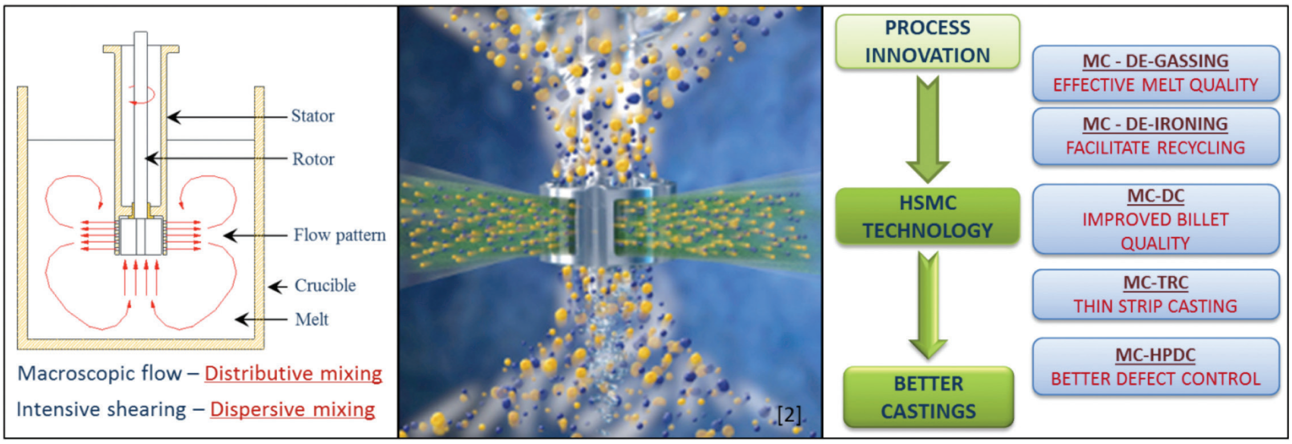

FIGURE 1. Schematic illustrations of the high shear melt conditioning (HSMC) technology and its potential applications.

The development of high strength alloys and composites requires a refined microstructure with a reduced defect distribution together with a homogeneous composition profile in the final product. Solidification and casting is essential for processing metallic materials, regardless of whether the final product is used in the cast or wrought form. The quality of the casting and in turn the quality of the melt is crucial in determining the final properties. Oxides, gas and other inclusions usually deteriorate the quality of the melt, and in turn the properties and quality of the castings. The reduction in defect density and the resultant increase in strength would contribute to the lighter parts, and this may be achieved through melt conditioning, especially with intensive melt shearing.

There are numerous existing methods including electromagnetic stirring, mechanical stirring with an impeller, melt filtering, and rotary degassing, which are used to treat the liquid metals. The rotor–stator device developed within BCAST provides intensive melt shearing, dispersing inclusions into finer scale particles that enhance the number of nucleation sites [1].

The HSMC technology uses a simple rotor-stator arrangement to provide intensive melt shearing. It comprises of a set of rotor and stator attached to an electrical motor with a speed control. The HSMC technique provides macro-flow in a volume of melt for distributive mixing and intensive shearing near the tip of the device for dispersive mixing. Hence, the HSMC technology can be used for; physical grain refinement by dispersing naturally occurring oxides, for degassing of melts, for the preparation of metal matrix composites and also for preparation of semi-solid slurries. In turn, these characteristics can be applied to benefit various conventional casting processes such as direct chill casting, twin roll casting and high pressure die casting, in order to improve the quality of cast products. Currently, grain refinement of Al and Mg alloys is usually achieved by enhancing heterogeneous nucleation by means of chemical inoculation methods. However, in the case of application of intensive melt shearing, which is termed as a physical treatment as supposed to chemical treatment, previous research has demonstrated that naturally occurring oxides and other inclusions present in Al and Mg alloy melts are amenable to physical manipulation by intensive melt shearing. The dispersed oxide particles can act as potential nucleating agents for the primary (α) phase in both Al and Mg alloys.

The concept of high shear melt conditioning in Al and Mg melts has been extensively studied and well understood in terms of solidification and application to industrial casting processes to solve some commonly associated fundamental problems. It has also proven to be applicable to different casting processes making it a 'multi-purpose' liquid metal treatment technology, which can be easily integrated to benefit various industrial casting processes. One of the key features is that it can be easily applied in-line to an existing launder system in large scale operations requiring very little size scale-up of the HSMC equipment.

REFERENCES:
[1] Z. Fan, Y. Zuo and B. Jiang: Apparatus and method for liquid metals treatment, WO 2012035357 A1.
[2] www.silverson.co.uk/en/resource-library/videos/batch-animation-uk

Brunel University London