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Dispersion of particles in liquid metal using contactless electromagnetic stirring

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ABSTRACT

The use of tuned electromagnetic induction coils is investigated, for the stirring and dispersion of ceramic particles in liquid metal melts. The coil supply frequency is adjusted, until resonance is reached in the crucible, or mold containing the melt. The resulting sound waves are strong enough to cause cavitation of dissolved gases in the liquid resulting in the break-up of particle clusters, a well-known problem in metal matrix composite manufacture. Particle dispersion is then further achieved, through induction stirring caused by the mean value of the electromagnetic Lorentz force. It is expected that other benefits associated with ultrasonic vibrations can be achieved using this method, including melt degassing and grain refinement, usually carried out in light alloys using an immersed consumable sonotrode. The great advantage of the EM approach is that it is contactless and therefore can be used in reactive (Ti, Zr) or high temperature melts (Ni, Steel) without risk of contamination. In a typical application, the induction coil surrounding the crucible – also used to melt the alloy – may be adopted for this purpose with suitable tuning. Alternatively, a top conical coil, immersed in the melt (but still contactless due to EM repulsion) may be adopted. Simulations of sound, flow, and EM fields are given showing good particle dispersion and evidence of cavitation with this method.

KEYWORDS: cavitation, electromagnetic stirring, particle dispersion, metal matrix composites