INDUCTION-DRIVEN CONTACTLESS ACOUSTIC WAVE GENERATION IN A CRUCIBLE

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Ultrasound treatment is used in light alloys during solidification to refine microstructure, or disperse immersed particles. The process is driven by immersing a sonotrode probe into the melt and it is most effective when the probe vibrations lead to cavitation. The same method cannot be used in high temperature melts, or in the treatment of highly reactive alloys, where contact with the probe will lead to contamination. As an alternative, a contactless method of generating sound waves is investigated theoretically, using electromagnetic (EM) induction. An additional advantage of the EM method is the strong induced stirring of the melt due to Lorentz forces that distributes the effect and has the potential to treat large volumes of material. 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. Under normal use, the vibrations induced by the induction coil are not sufficiently strong to induce cavitation in the liquid with any gas inclusions present. However, by tuning the induction coil frequency to the melt volume, sound resonance can be achieved leading to large amplitude sinusoidal pressure variation. As shown by Vives [1], large amplitudes leading to cavitation can also be effected by combining the AC induction field with a strong DC field.

Numerical simulations testing this sound generation mechanism have been performed for various cases, with and without resonance in the melt volume, with and without an auxiliary DC field. A computational hydrodynamic acoustics approach is coupled with Maxwell's equations, and likely cavitation zones are identified using the Rayleigh-Plesset equation [2]. Near-resonance conditions are most likely to produce cavitation without mechanically endangering the crucible.

Acknowledgments. The authors acknowledge financial support from the ExoMet Project (co-funded by the European Commission (contract FP7-NMP3-LA-2012-280421), by the European Space Agency and by the individual partner organizations).

References

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