Modelling the action of DC and AC fields on small conductive solid grains immersed in conductive/insulating fluid

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ABSTRACT

Many researches have been driven on the action of magnetic and electromagnetic fields on small particles, conductive or not, moving in conductive/insulating fluid. Applications are various, from inclusions separation in continuous casting of metals to final micro-structure control during alloy solidification process [1].

Electromagnetic or magnetic field induce differential distribution of Lorentz forces between solid and liquid material, due to the variation of electrical conductivity with the matter state. Grains which are moving in the liquid, according to gravitation and fluid movement may have modified trajectories according to the intensity of the field and the frequency.

The physical problematic is highly multi-physics and realistic modelling must consider the following physical phenomena : Magnetic and electromagnetic fields, electric potential and current, thermal diffusion and transport, fluid movements, coupling of particle trajectories with magnetic, thermal and fluid phenomena.

Furthermore size of particles ($1\ \mu m \rightarrow 1$mm) are very small comparatively with device dimensions.

To understand and quantify the different phenomena according to different magnetic conditions, we have realized numerical simulations on a finite element code. This code is built with a general approach considering 2D or 3D domains, strong coupling of multiple equations and multi-mesh coupling by Chimera method. A mesh may be associated to any state variable or component of a state variable. By this way we can construct a multi-scale model, by associating to each particle a specific mesh which is 'immersed' numerically and moves inside the mesh of the liquid..

Different calculations have been done considering 'academic' grain geometries like spheres or hexaedra, or realistic ones issued from X ray in 2D or tomography in 3D. Motion equations of particles governed by fundamental dynamic law are coupled weakly with the finite element resolution.

Such simulations are heavy and time consuming. Comparisons with analytical solution [2] and experimental data obtained during AlCu equiaxed solidification experiments validate the numerical modelling. Simulations of continuous or low frequency electromagnetic fields effects on metallic grain motion will be presented.

REFERENCES

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