3D Modelling of thermoelectric effect during solidification under magnetic field of Al-Cu alloys

Y. Du Terrail Couvat*, O. Budenkova, R.Tarpagko, A. Gagnoud, Luc Salvo and Pierre Lhuissier

* SIMaP Laboratory
1130 rue de la Piscine
38400 Saint Martin d'Hères, France

e-mail: yves.duterrail@simap.grenoble-inp.fr, web page: http://simap.grenoble-inp.fr

ABSTRACT

During experiments on solidification of metallic alloys, it has been observed that thermoelectric effect coupled with magnetic field may affect considerably the final micro-structure of the solidified alloy [1]. The electric currents combined with magnetic field produce forces which can move and rotate solid grains in liquid metal, and also brake dendrite arms. Simulations of these effects have generally been done on simplified geometries like circle and rectangular shaped grains in 2D and sphere or hexaedron in 3D [2].

A general 3D model has been developed, coupling thermal, electric and fluid equations. In a first approach it has been applied considering a single grain with simple geometry. By this way, results of simulation can be compared and validated with an analytical solution defined on sphere and ellipsoidal geometries [3]. In a second approach, a real 3D grain has been treated. In a third one, multiple grains has been considered at the same time. For that, a Finite Element multi-domain approach based on Chimera meshes [4],[5], has been developed. Different steps of simulation building will be presented :

- physical equations of coupling phenomena
- Finite element formulations and implementation in a multi physic and multi domain approach
- geometry construction from X tomography, of grains and mesh generation
- finite element simulation coupled with ODE equations for simulation of movements and rotations of grains during solidification

REFERENCES

[1] Xi Li, Annie Gagnoud, Jiang Wang , Xiaolong Li, Yves Fautrelle, Zhongming Ren, Xionggang Lu, Guillaume Reinhart, Henri Nguyen-Thic, "Effect of a high magnetic field on the microstructures in directionally solidified Zn–Cu peritectic alloys", Acta Materialia, Volume 73, Pages 83–96, (2014)

[2] F. B, J. WANG, S. LETOUT, Z. M. REN, X. LI, O. BUDENKOVA AND Y. FAUTRELLE. F. Baltaretu, J. Wang, S. Letout, Z.M. Ren, X. Li, O. Budenkova and Y. Fautrelle, "Thermoelectric effects on electroconducting particles in liquid metal",*Magnetohydrodynamics,* vol. 51, No. 1, pp. 45–55, (2015)

[3] Y. Du Terrail Couvat, O. Budenkova, R. Tarpagko, A. Gagnoud, "Modeling of the effect of a thermoelectric magnetic force onto conducting particles immersed in the liquid metal", MCWASP Congress, IOP Conference Series: Materials Science and Engineering, Volume 84, conference 1 , (2015)

[4] J.L. Lions, O. Pironneau, "Domain decomposition methods for CAD",C.R.A.S., 328, pp73-80, Paris, (1999)

[5] C. Romé, "méthode de raccordement de maillages non-conformes pour la résolution des équations de Navier-Stokes ", PHD thesis., University of Bordeaux, France, (2006)