

MODELING DENDRITIC SOLIDIFICATION WITH FLUID FLOW USING X-FEM AND LEVEL SET TECHNIQUES

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In most solidification processing techniques the formation of dendrites plays a vital role in the quality of the final product. Due to its technological importance, modeling of dendritic growth in pure metals and alloys remains a significant challenge in the field of materials science and applied physics. Successful modeling of this process requires both the solution of a complex free-boundary problem and an accurate computation of the surface tension and kinetic anisotropies. The numerical simulation of this process is further complicated by the influence of convection on growth. The Extended FEM (X-FEM) is a promising technique that has been applied by a few researchers to dendritic solidification. In this work, the X-FEM technique is coupled with a fluid solver to concurrently simulate the thermal, solute as well as fluid evolution during the growth of the dendrite. Comparisons with other techniques as well as analytical results emphasize the fidelity of the method.

Issues of implementation and optimization are discussed. The dimension-independent formulation allows the simulation of two- and three-dimensional dendritic solidification, with and without fluid flow. The effect of the strength of the fluid flow on the growth history and morphology is addressed for two- and three-dimensional growth conditions. The possibility of the application of these techniques in biological crystal growth is also discussed.

References

- [1] N. Zabaras, B. Ganapathysubramanian and L. Tan, "Modeling dendritic solidification with melt convection using the extended finite element method (XFEM) and level set methods," *Journal of Computational Physics*, submitted.
- [2] J. Dolbow, N. Moes and T. Belytschko, "An extended finite element method for modeling crack growth with frictional contact," *Computer Methods in Applied Mechanics and Engineering*, v. 190, p. 6825-6846, 2001.
- [3] H. Ji, D. Chopp and J. Dolbow, "A hybrid extended finite element/level set method for modeling phase transformations", *International Journal for Numerical Methods in Engineering*, v. 54, p. 1209-1233, 2002.