An enthalpy/ narrow-band level-set method with application to two non-standard Stefan problems

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Abstract The Stefan problem involves the melting of a domain under a heat input imposed on a part of the boundary. In the standard problem the material is pure, the interface between solid and liquid phases is sharp, and the phase change temperature and latent heat are constants. This is a moving boundary problem and a numerical solution has to be able to track the movement of the solid-liquid interface. A classic fixed grid numerical solution, dating back to the middle of the last century, is the enthalpy method, wherein the melt boundary is tracked by the calculation of the liquid fraction. In recent literature, however, fixed grid methods for moving boundary problems are typically based on level set approaches. In these approaches the moving boundary is associated with the zero level of a level set function that measures distance from the boundary. The keys to using a level set approach are to (i) provide a sound way of updating the level set function as the boundary moves and (ii) a means of incorporating level set function values into the governing field equations.

There are two objectives of this talk. The first is to show that the enthalpy method can be recast as a level set method; a manipulation that leads to a simple robust and efficient solution scheme for Stefan problems. Secondly the utility of this approach is demonstrated by solving two non-standard Stefan problems; (i) a problem where the latent heat is a function of space arising from a model of landscape building, and (ii) a problem where the phase change temperature changes with space a problem related to the solidification of an under-cooled melt.

Bibliography Vaughan Voller is Professor in the Dept of Civil Engineering at the University of Minnesota, where he has been for over 20 years. An applied mathematician by training he became inexorably involved in engineering problems when modelling coke ovens for his PhD thesis (supervised by Prof Mark Cross). During this time he became involved in phase change and moving boundary problems, a class of problems which has engaged his attention intermittently ever since. His original enthalpy based algorithms are embedded within most CFD simulation tools as the basic technique for capturing solidification/melting.