11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

UNSTRUCTURED 3D NUMERICAL MODELING OF THE MELTING OF A PCM CONTAINED IN A SPHERICAL CAPSULE

P. A. Galione[1] [3], O. Lehmkuhl[1] [2], J. Rigola[1], C. D. Pérez-Segarra[1], A. Oliva[1]

[1]Heat and Mass Transfer Technological Center (CTTC),Universitat Politècnica de Catalunya - BarcelonaTech, ETSEIAT, Colom 11, 08222, Terrassa (Barcelona), Spain.
[2] Termo Fluids S.L., Av. Jacquard 97 1-E, 08222, Terrassa (Barcelona), Spain.
[3] Instituto de Ingeniería Mecánica y Producción Industrial (IIMPI), Universidad de la República (UdelaR), Uruguay.

Key words: *Multiphysics Problems, Computing Methods, Melting, PCM*

Fixed-grid enthalpy models have been used extensively for solid-liquid phase-change computational fluid dynamics (CFD) simulations. Generally, implicit time schemes are used by most authors [1, 2].

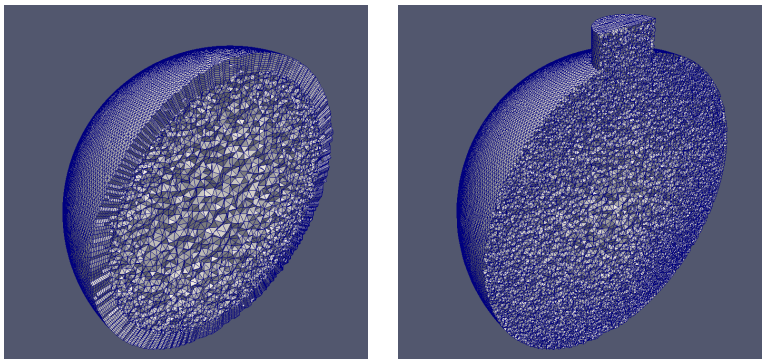
Tan et al. [2] presented an experimental and numerical study of the melting of a phase change material (PCM) contained in a spherical capsule; where a two-dimensional (2D) model was used for the numerical simulations, assuming axisymmetry with respect to the vertical axis.

This work is a continuation of an earlier work [3], which dealt with fixed-grid solid-liquid phase-change modeling using explicit time schemes, specially suited for its combination with turbulence models for simulation of the fluid motion. Here, the numerical model is applied for both 2D and 3D simulations of the experiment of Tan et al., using unstructured meshes. The 3D treatment allows to reproduce 3D flow patterns that are not simulated with the 2D models.

Some modifications to the numerical treatment presented in [3] have been necessary, in order to avoid numerical divergence in cases where dense meshes were used. These changes are related to the treatment of the momentum equation in the solid-liquid interface.

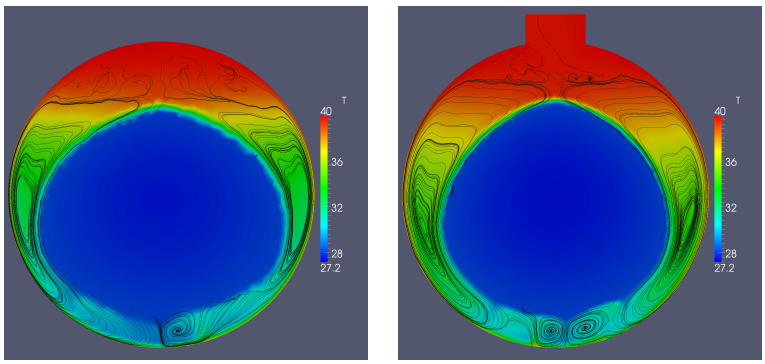
A formulation where the same density is used for both liquid and solid phases, as well as another which takes into account the expansion in the melting, are numerically solved and their results compared.

Results showing the development of the interface, as well as the evolution of the temper-



(a) Without opening (b) With opening

Figure 1: Cut view of two of the 3D meshes used, with/without opening at the top of the capsule, for cases where the density is assumed equal/different between solid and liquid phases, respectively.



(a) Equal densities (b) Different densities

Figure 2: (Front) cut view of spherical container showing temperature maps and flow streamlines, for cases with equal and different densities between phases.

ature at some selected positions, are presented and compared against the experimental results obtained from [2].

REFERENCES

[1] Voller, V. and Prakash, C. A Fixed Grid Numerical Modelling Methodology for Convection-Diffusion Mushy Region Phase Change Problems. *Int. J. Heat Mass Tran.*, Vol. **30**, 1709–1719, 1987.

[2] Tan, F. L. and Hosseinizadeh, S. F. and Khodadadi, J. M. and Fan, L. Experimental and computational study of constrained melting of phase change materials (PCM) inside a spherical capsule. *Int. J. Heat Mass Tran.*, Vol. **52**, 3464–3472, 2009.

[3] P. A. Galione, O. Lehmkuhl, J. Rigola and A. Oliva. Fixed-Grid Modeling of Solid-Liquid Phase Change in Unstructured Meshes Using Explicit Time Schemes. *Numer. Heat Transfer B*, Vol. **65**, 27–52, 2014.