On Sliding air bubbles and their Interaction with Natural Convection Flow

- A comparative study of the OpenFoam Alpha scheme and Fluent's implementation of the PLIC VOF scheme.

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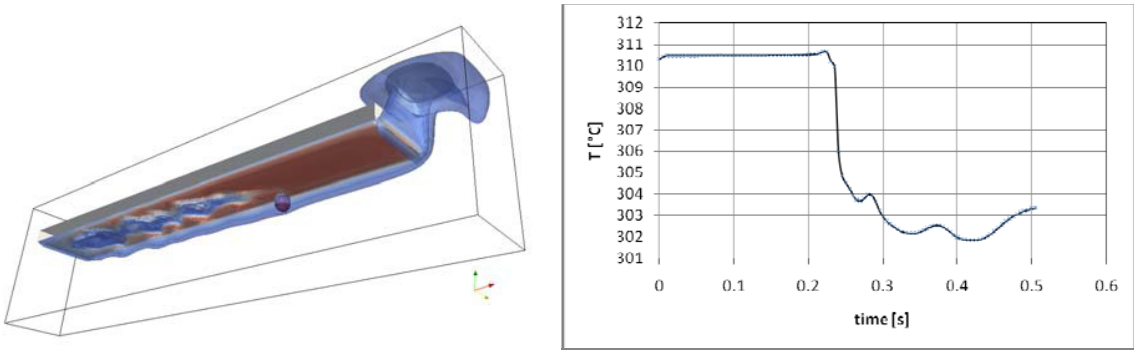
Abstract

The CSF and static contact angle formulation for surface tension modelling in two fluid flow has been found to induce non physical effects when the gas liquid interface approaches a solid surface. Most notably, bouncing by the bubbles has been found to be partially suppressed. These observations where made with a VOF formulation based on a piecewise linear reconstruction of the interface (PLIC) which preserved the sharpness of the interface[1]. It can be expected that a more diffusive interface advection scheme could have a significant effect on the predicted dynamics of air bubbles sliding along flat surfaces. OpenFoam's interface compression scheme, although efficient at limiting diffusion, typically spreads the interface over at least two to three cells. This study aims to compare predictions from OpenFoam's interface advection scheme with simulations produced by the PLIC implementation of Fluent CFD. The numerical problem considered is the interaction of a sliding air bubble along a heated and immersed flat plate. The liquid considered is water and the thermal boundary condition is a uniform heat flux. The air bubble is injected once the liquid in contact with the plate reaches a temperature of 310.5°C. Differences in the numerical predictions obtained by the two numerical schemes will be assessed by comparing temperature profiles along the plate centerline.

Computations with OpenFoam have required modification to the interFoam solver to include a solution to the energy equation. The overall solver is based on an incompressible flow formulation but takes accounts of the variable thermal and transport properties. This means that an extension to the twoPhaseMixture class was also required. Sample results from this solver are illustrated in the figures below.



(a) (b)

Effect of sliding bubble on thermal boundary layer due to free convection from a inclined and immersed flat plat as predicted by OpenFOAM. (a) Contour plot of thermal boundary layer. (b) history plot of wall temperature at a point along the plate centreline.

Key words: Sliding Bubble, Natural Convection

References

[1] S. Senthil Kumar, Y.M.C. Delauré, B. Donnelly and D. B. Murray: *Numerical Study of a Sliding Bubble Dynamics using a SIMPLE VOF/PLIC-CSF multi-fluid flow model*, In Preparation