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Title: A 3D ALE-FEM Method for Microscale Two-Phase Flows

In Engineering, the study of microscale two-phase flows is important in many areas such as micro-reactors and cooling of electronics. A full description of flow behavior in some situations is hard to predict experimentally, therefore a different approach is necessary to study particular cases and investigate, in detail, the flow field. Many authors have used different approaches to represent the interface between two fluids, varying from front-capturing to front-tracking methodology. These techniques, used separately, have pros and cons related to mass conservation, interface representation and topological changes in the interface. Thus, hybrid methods are becoming popular to overcome the disadvantages and to describe accurately the surface tension. In this work direct numerical simulation is employed to simulate two-phase flow phenomena considering the well known continuum method for surface tension modeling proposed by [1]. The Navier-Stokes equations are modeled in a different manner using the Arbitrary Lagrangian Eulerian Technique (ALE) and discretized by the finite element method. By applying the ALE technique to two-phase flows, we are able to use the best aspects of both reference frames [2], allowing us to track the interface in the Lagrangian fashion whilst keeping the mesh fixed in a Eulerian point of view relative to the remaining flow field. This is particularly interesting when investigating for bubble/bubble and bubble/wall interactions. The unstructured moving mesh is regularized at each time step through a Laplacian smoothing operator which tends to distribute the mesh nodes optimally in each time step. This technique improves the accuracy of the method resulting in uniform elements throughout the mesh. The curvature calculation is obtained geometrically as the variation of the normal or the tangent vector along the curve that defines the interface [3]. The computation of the curvature is easy to implement since the interface between the fluids is represented by computational nodes that are convected with the interface leading to reduced mass conservation errors [4] and to low-cost computational efforts because the calculation is done only at the interface nodes. The results obtained so far have been compared to those found in the literature. This showed that the methodology proposed to simulate two-phase flows provides good accuracy to describe the interfacial forces and bubble dynamics. A 3D microscale simulation of bubble flow will be presented.

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