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Title: A 3D ALE-FEM Method for 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. 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, 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 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 projection method based on LU decomposition is employed to decouple the velocity and pressure fields thus simplifying the computation of the linear system. This was achieved by reducing the multi-dimensional non-linear system into several smaller and simpler problems that can be solved sequentially thus decreasing the computational time. To validate the computation of the surface tension forces we have carried out static and dynamics tests to compare with analytical solutions and experimental results found in the classical literature, showing good accuracy to describe the interfacial forces and bubble dynamics.