Towards Building a Robust Computational Framework to Simulate Multiphysics Problems - A Solution Technique for Simultaneous Three-Phase (Gas-Liquid-Solid) Interactions

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Abstract

In this talk, we show a robust numerical framework to model and simulate gas-liquid-solid three-phase flows. The overall algorithm adopts a non-boundary-fitted approach that avoids frequent mesh-updating procedures by defining independent meshes and explicit interfacial points to represent each phase. The coupling between the phases is done via RKPM meshfree interpolation functions. In this framework, we couple our existing solvers, the immersed finite element method (IFEM) and the connectivity-free front tracking (CFFT) method that model fluid-solid and gas-liquid interactions, respectively, for the three-phase models. A modified IFEM algorithm is derived for modeling fluid-solid interactions that accounts for the dynamics of the solid, while the CFFT is used here to simulate gas-liquid multi-fluid flows that uses explicit interfacial points to represent the gas-liquid interface and for its easy handling of interface topology changes. Instead of defining different levels simultaneously as used in level sets, an indicator function naturally couples the two methods together to represent and track each of the three phases. Several 2-D and 3-D testing cases are performed to demonstrate the robustness and capability of the coupled numerical framework in dealing with complex three-phase problems, in particular free surfaces interacting with deformable solids. The solution technique offers accuracy and stability, which provides a means to simulate various engineering applications that involve high Reynolds number flows, large deformations, and high density disparities among the phases.

Keywords: fluid-structure interactions, multiphase flows, three-phase interactions, immersed finite element method (IFEM), connectivity-free front tracking (CFFT)