AN ARBITRARY LAGRANGIAN EULERIAN APPROACH WITH EXACT MASS CONSERVATION FOR THE NUMERICAL SIMULATION OF THE 3D RISING BUBBLE PROBLEM

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The Arbitrary Lagrangian Eulerian (ALE) approach [1] has been extended to three-dimensions to solve incompressible multiphase flow problems. The numerical method is based on the side-centred arrangement of the primitive variables on unstructured meshes to discretize the incompressible three-dimensional Navier-Stokes equations. A special attention is given to satisfy both local and global discrete geometric conservation law (DGCL) at discrete level for the implementation of the interface kinematic boundary condition in order to conserve the total mass for each species at machine precision. The pressure field is treated to be discontinuous across the interface with the discontinuous treatment of density and viscosity. The surface tension term at the interface is treated as a force tangent to the interface and computed using the straight line integral of tangent vectors at the interface. The parasitic currents are found to be very sensitive to the numerical calculation of normal vectors. Several different normal vector calculation methods will be investigated in order to reduce the parasitic currents to machine precision in three-dimensions. The mesh vertices are deformed by solving the linear elasticity equations due to the normal displacement of the interface. The resulting algebraic equations are solved in a fully coupled (monolithic) manner and a one-level restricted additive Schwarz preconditioner with a block-incomplete factorization (ILU) within each partitioned sub-domains is utilized for the resulting fully coupled system. The classical benchmark problem of a single rising bubble in a viscous fluid due to buoyancy will be simulated to assess the accuracy of the method [2]. The method allows us to conserve the bubble mass at machine precision. In addition, the discontinuous treatment of pressure field helps us to avoid errors due to the incompressibility condition in the vicinity of the interface.

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