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A Composite Grid Solver for Conjugate Heat Transfer Problems

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We describe a numerical method for simulating conjugate heat transfer problems that involve fluid flows coupled to heat conduction in solids. This approach can be used to model a wide range of fluid-structure systems in complex two- and three-dimensional geometry. The computational region is divided into a number of sub-domains corresponding to fluid domains and solid domains. There may be multiple fluid domains and multiple solid domains. Each fluid or solid sub-domain is discretized with an overlapping grid. The entire region is associated with a *composite grid* which is the union of the overlapping grids for the sub-domains. Separate physics solvers are associated with each sub-domain while a multi-domain solver coordinates the solution process. Fluids are modeled with the temperature dependent incompressible Navier-Stokes equations using the Boussinesq approximation. Heat transfer in solids are modeled with the heat equation. Appropriate interface equations are applied to couple the solutions across different domains. We discuss and analyse the stability and accuracy of a discretization of the interface equations. The coupled interface equations may be solved directly when using explicit time stepping methods in the sub-domains. For implicit time stepping methods we solve the interface equations in a de-coupled manner to avoid forming a coupled implicit system across all sub-domains. We analyse different iteration strategies for solving these implicit equations. Numerical results are presented to illustrate the approach. The accuracy of the technique is verified using the method of analytic solutions. The solver runs on parallel distributed memory computers and some parallel results are presented.

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