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Numerical Analysis of Gas-Particle Mixtures through Pipelines

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Abstract : The ability to model and simulate numerically natural gas flow in pipelines has become of high importance for the design of pipeline systems. The understanding of the formation of hydrate particles and their dynamical behavior is of particular interest, since these processes govern the operation properties of the systems and are responsible for system failures by clogging of the pipelines under certain conditions. Mathematically, natural gas flow can be described by multiphase flow models. Using the two-fluid modeling approach, the gas phase is modeled by the compressible Euler equations and the particle phase is modeled by the pressureless Euler equations. The numerical simulation of compressible multiphase flows is an important research topic. It is well known that for nonlinear fluxes, even for smooth initial data, discontinuities in the solution are likely to occur in finite time. They are called shock waves or contact discontinuities. For hyperbolic and singularly perturbed parabolic equations the standard application of the Galerkin finite element method (FEM) leads to spurious oscillations (e.g. Gibb's phenomenon). In our approach, we use stabilized FEM, the streamline upwind Petrov-Galerkin (SUPG) method, where artificial diffusion acting only in the direction of the streamlines and using a special treatment of the boundary conditions in inviscid convective terms, is added. Numerical experiments show that the numerical solution obtained and stabilized by SUPG captures discontinuities or steep gradients of the exact solution in layers. However, within this layer the approximate solution may still exhibit overshoots or undershoots. To suitably reduce these artifacts we add a discontinuity capturing or shock capturing term. The performance properties of our numerical scheme are illustrated for two-phase flow problem.

Keywords : two-phase flow, gas-particle mixture, inviscid two-fluid model, euler equation, finite element method, streamline upwind petrov-galerkin, shock capturing
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