INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

The doctoral thesis primarily focuses on the development of a generic and robust finite volume based CFD solver for miscible flow interactions for both non-reacting and reacting fluids/species. The solver is capable of handling arbitrary hybrid unstructured meshes in an efficient manner. The mathematical formulation is based on a quasi-incompressible approach wherein flows are characterized by non-solenoidal divergence field, even though the Mach numbers are low. Discretization of the governing partial differential equations is done using finite volume method with collocated grid arrangement. The temporal discretization is done using implicit Euler time stepping whereas diffusive fluxes are computed using central differencing scheme. For the convective fluxes, different flux schemes with both first and second order accuracy, such as first order upwind (FOU), Khosla-Rubin and the high resolution CUBISTA scheme have been implemented in the present solver. Preconditioned Krylov solvers are used for solving linear system of equations governed by conservation of mass, momentum and species mass-fractions. This linear solver is implemented using the Library of Iterative Solvers (LIS).

A detailed analysis of truncation error and discretization errors has been performed by using the method of manufactured solutions to quantify the numerical errors associated with a particular convective scheme and to establish a relation between the truncation and discretization errors. The accuracy of the developed solver has been thoroughly verified and validated against a number of benchmark problems. Furthermore, a novel passive micromixer is conceptualized by incorporating thin curved ribs (as flow obstacles) to enhance the mass transfer rate in microfluidic applications. The mixing performance assisted by the use of this newly devised curved obstacles has been explored rigorously using the develop solver in both two- and three-dimensional cross-T type microchannels.

Similar study is also carried out to analyze the mixing characteristics with respect to a binary gaseous mixture in sinusoidally corrugated channels. Results show that wavy channels with 0^{o} phase difference shows better mixing capability than 180^{o}phase difference for same wavelength and amplitude. As a final step, attempts have been made to extend the quasi-incompressible approach to simulate mixing of gaseous reacting species. This, however, can be considered as a preliminary work involving only laminar gaseous diffusion (non-premixed) flames.