Title of the thesis: Incompressible viscous flows in two and three dimensional lid-driven cavities

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ABSTRACT

The incompressible viscous flow inside lid-driven rectangular and cubic cavities with rigid walls has been studied in this work. Several numerical methods have been used to solve the incompressible Navier-Stokes (NS) equations with appropriate boundary conditions. The aim of this study is to simulate the flow inside these cavities at the maximum possible Reynolds number and to study the resulting flow patterns.

The stream function-vorticity formulation of the NS equations is used for the two-dimensional case, comprising of rectangular single and double lid-driven cavities. The Backward in Time and Central in Space and Alternating Direction Implicit methods have been used to study the flow in cavities of aspect ratio (depth to width ratio) unity or less, while a multigrid method with full approximation storage is used for cavities of aspect ratio greater than unity (deep cavities). A comparison of the results obtained here with those published in the literature shows fairly good agreement. Computations have been possible for Reynolds numbers up to 32,500 in square cavities and up to 10,000 in deep cavities of aspect ratio upto 6. The magnitude of the Reynolds number beyond which the flow inside the cavity never becomes steady seems to depend upon the grid size and numerical method used.

Computational results for the flow within shallow and deep, single and double, lid-driven cavities are few in the literature. A number of computational results for these have been presented here. The flow in deep cavities shows some interesting features, apparently not reported earlier.

The flow in cubic lid-driven cavities has been computed here using the primitive variable formulation of the NS equations by a staggered grid finite volume method. The third order accurate QUICK scheme is used for the advection terms to improve stability. At each time step the solution is obtained using the SIMPLE procedure. The unsteady nature of the flow has been studied. A computation using Large Eddy Simulation has also been carried out, using the Smagorinsky model for eddy viscosity. Comparisons made with experimental results available in the literature show fair agreement. Computations have been made here upto a Reynolds number of 10,000 using direct simulation and upto 17,000 using Large Eddy Simulation.

Key words:- Navier-Stokes, incompressible, lid-driven cavity, finite difference, finite volume, multigrid, cubic lid-driven cavity, stream function-vorticity, primitive variable, double lid-driven cavity, deep lid-driven cavity.