A Numerical Study of Natural Convective Heat Transfer in a Cavity Using a High-order Differential Scheme

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Abstract

A high order Galerkin discretization scheme is used for solving steady compressible Navier-Stokes equations. The pointwise numerical fluxes are separated into convective fluxes, acoustic fluxes, and viscous fluxes. The separation of convective flux and viscous flux is to avoid round off errors.
The separation of the acoustic flux is due to non-central scheme employed near the wall. The ideal-gas approximation for air is assumed and viscosity
is computed using Sutherland’s law. The overall residual is integrated using
fourth-order Runge-Kutta scheme with a preconditioning matrix. No numerical smoothing is required for Rayleigh number up to 105. For diffusion dominated flow, Rayleigh number less than 103, the high-order differential scheme is effective to resolve the flow field than the the low-order schemes. However, for convection dominated flow, Rayleigh number greater than 105, the beneficial of a high-order scheme is limited. For the same Rayleigh number, using a large temperature change across the vertical walls, the streamlines is shifted toward the cool wall significantly
even the Mach number within the cavity remains incompressible limit.

Keyword：Galerkin high-order differential scheme, Rayleigh number,