Turbulent Natural Convection in an Enclosure at Varying Rayleigh Number

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Abstract

Most fluids used in technical applications are of low viscosity; hence, fluid flows encountered in engineering applications are mostly turbulent. Parameters that influence the distribution of the flow field of turbulent flow regimes thus significantly affect the performance of many thermal systems. In this study, we analyze the distribution of the flow field of a Boussinesq buoyancy-driven turbulent airflow for and establish the effect of the Rayleigh number on these distributions. The flow domain comprises of a rectangular enclosure of constant aspect ratio, partially heated on a sidewall and cooled on the opposite wall. Due to the rapid fluctuations in flow properties intrinsic in the turbulent flow regime, we subject the equations governing a viscous incompressible buoyant fluid flow to the Reynolds decomposition and averaging process to obtain equations that describe a turbulent flow field. We treat turbulence using the turbulence model coupled with the Boussinesq approximation.

To ensure that the conservation laws are satisfied at both the local and over the entire flow domain, the equations are discretized using the robust finite volume method. The method possesses the ability to adapt a grid structure that captures the local features of the flow domain and the final form of the discretized equations has an intimate connection to the actual physical laws. Since the equations are coupled, a segregated pressure-based iterative method is used to obtain the solution. The results obtained revealed that the flow fields are distributed non-uniformly in the flow domain and the distribution significantly depend on the Rayleigh number of the flow. The results are consistent with the experimental results of Markatos and Pericleous (1984).

Keywords

Buoyancy; Natural Convection; Reynolds Stresses; Turbulent heat flux; Turbulence Modeling.

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