Characteristics of mixed convection heat transfer in a lid-driven square cavity with various Richardson and Prandtl numbers

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Abstract

In mixed convection flows, a common knowledge is that the heat transfer in a cavity is increased with increasing Grashof or Reynolds number when its respective Reynolds or Grashof number is kept at constant. On the other words, the heat transfer would increase if the flow proceeds toward pure natural convection or forced convection dominated regimes. An unanswered question is that would the heat transfer be increased continuously with simultaneously increasing both Grashof and Reynolds numbers, while keeping the Richardson and Prandtl numbers constant. And to what extent the mixed convection flows would change from laminar to chaos. These questions motivate the present study to systematically investigate the flow and heat transfer in a 2-D square cavity where the flow is induced by a shear force resulting from the motion of the upper lid combined with buoyancy force due to bottom heating. The numerical simulations cover a wide range of Reynolds (10 Re 2200), Grashof (100 Gr 4.84 106), Prandtl (0.01 Pr 50), and Richardson (0.01 Ri 100) numbers. The average Nusselt numbers are reported to illustrate the influence of flow parameter variations on heat transfer, and they are also compared with the reported Nusselt number correlations to validate the applicability of these correlations in laminar flow regimes. Time traces of the total kinetic energy and average Nusselt number are presented to demonstrate the transition of the flows from laminar to chaos.

Keyword：Mixed convection; Lid-driven cavity; Hopf bifurcation, Total kinetic energy