Unsteady Rayleigh-Bénard Convection of Nanoliquids in Enclosures

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Abstract : Rayleigh-B´enard convection of a nanoliquid in shallow, square and tall enclosures is studied using the Khanafer-Vafai-Lightstone single-phase model. The thermophysical properties of water, copper, copper-oxide, alumina, silver and titania at 3000 K under stagnant conditions that are collected from literature are used in calculating thermophysical properties of water-based nanoliquids. Phenomenological laws and mixture theory are used for calculating thermophysical properties. Free-free, rigid-rigid and rigid-free boundary conditions are considered in the study. Intractable Lorenz model for each boundary combination is derived and then reduced to the tractable Ginzburg-Landau model. The amplitude thus obtained is used to quantify the heat transport in terms of Nusselt number. Addition of nanoparticles is shown not to alter the influence of the nature of boundaries on the onset of convection as well as on heat transport. Amongst the three enclosures considered, it is found that tall and shallow enclosures transport maximum and minimum energy respectively. Enhancement of heat transport due to nanoparticles in the three enclosures is found to be in the range 3% - 11%. Comparison of results in the case of rigid-rigid boundaries is made with those of an earlier work and good agreement is found. The study has limitations in the sense that thermophysical properties are calculated by using various quantities modelled for static condition.

Keywords : enclosures, free-free, rigid-rigid, rigid-free boundaries, Ginzburg-Landau model, Lorenz model
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