World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:11, No:06, 2017

Weakly Non-Linear Stability Analysis of Newtonian Liquids and Nanoliquids in Shallow, Square and Tall High-Porosity Enclosures

Authors : Pradeep G. Siddheshwar, K. M. Lakshmi

Abstract : The present study deals with weakly non-linear stability analysis of Rayleigh-Benard-Brinkman convection in nanoliquid-saturated porous enclosures. The modified-Buongiorno-Brinkman model (MBBM) is used for the conservation of linear momentum in a nanoliquid-saturated-porous medium under the assumption of Boussinesq approximation. Thermal equilibrium is imposed between the base liquid and the nanoparticles. The thermophysical properties of nanoliquid are modeled using phenomenological laws and mixture theory. The fifth-order Lorenz model is derived for the problem and is then reduced to the first-order Ginzburg-Landau equation (GLE) using the multi-scale method. The analytical solution of the GLE for the amplitude is then used to quantify the heat transport in closed form, in terms of the Nusselt number. It is found that addition of dilute concentration of nanoparticles significantly enhances the heat transport and the dominant reason for the same is the high thermal conductivity of the nanoliquid in comparison to that of the base liquid. This aspect of nanoliquids helps in speedy removal of heat. The porous medium serves the purpose of retainment of energy in the system due to its low thermal conductivity. The present model helps in making a unified study for obtaining the results for base liquid, nanoliquid, base liquid-saturated porous medium and nanoliquid-saturated porous medium. Three different types of enclosures are considered for the study by taking different values of aspect ratio, and it is observed that heat transport in tall porous enclosure is maximum while that of shallow is the least. Detailed discussion is also made on estimating heat transport for different volume fractions of nanoparticles. Results of single-phase model are shown to be a limiting case of the present study. The study is made for three boundary combinations, viz., free-free, rigid-rigid and rigid-free.

Keywords : Boungiorno model, Ginzburg-Landau equation, Lorenz equations, porous medium
Conference Title : ICFMT 2017 : International Conference on Fluid Mechanics and Thermodynamics
Conference Location : New York, United States
Conference Dates : June 04-05, 2017