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Natural Convection of Al_2O_3-Water Nanofluid in a Wavy Enclosure

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Abstract. Natural convection heat transfer and fluid flow inside enclosures filled with fluids, such as air, water or oil, have been extensively analysed for thermal enhancement and optimisation due to their applications in many engineering problems, including solar collectors, electronic cooling, lubrication technologies, food processing and nuclear reactors. In comparison, little effort has been given to the problem of natural convection inside enclosures filled with nanofluids, while the addition of nanoparticles into a fluid base to alter thermal properties can be a feasible solution for many heat transfer problems. In this study, the problem of natural convection heat transfer and fluid flow inside a wavy enclosure filled with Al_2O_3-water nanofluid is investigated numerically using ANSYS-FLUENT. The effects of surface waviness and aspect ratio of the wavy enclosure on the heat transfer and fluid flow are analysed for various concentrations of Al_2O_3 nanoparticles in water. Flow fields and temperature fields are investigated and heat transfer rate is examined for different values of Rayleigh number. Results show that heat transfer within the enclosure can be enhanced by increasing surface waviness, aspect ratio or nanoparticles volume fraction. Changes in surface waviness have little effect on the heat transfer rate at low Rayleigh numbers, but when $Ra \geq 10^5$ heat transfer increases with the increase of surface waviness from zero to higher values. Increasing aspect ratio causes an increase in heat transfer rate, as Rayleigh number increases the effect of changing aspect ratio is more apparent with the greatest heat transfer enhancement seen at higher Rayleigh numbers. Nanoparticles volume fraction has a little effect on average Nusselt number at low Rayleigh numbers, when $Ra \geq 10^5$ average Nusselt number increases with the increase of volume fraction. These findings provide insight into the heat transfer effects of using Al_2O_3-water nanofluid as a heat transfer medium and the effects of changing geometrical parameters, which will help in developing novel geometries with enhanced and controlled heat-transfer for solar collectors, electronic cooling, and food processing industries.

Keywords: Natural convection, Nanofluids, Numerical modelling, Wavy enclosure.