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Mixed Convection of Nanofluids in a Lid-Driven Rough Cavity

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Abstract. Mixed convection heat transfer and fluid flow of air, water or oil in enclosures have been studied extensively using experimental and numerical means for many years due to their ever-increasing applications in many engineering fields. In comparison, little effort has been given to the problem of mixed convection of nanofluids in spite of several applications in solar collectors, electronic cooling, lubrication technologies, food processing, and nuclear reactors. Mixed convection of nanofluids is a challenging problem due to the complex interactions among inertia, viscous, and buoyancy forces. In this study, mixed convection of nanofluids in a lid-driven square cavity with sinusoidal roughness elements at the bottom is studied numerically using the Navier-Stokes equations with the Boussinesq approximation. The numerical model is developed using commercial finite volume software ANSYS-FLUENT for Al_2O_3-water and CuO-water nanofluids inside a square cavity with various roughness elements. The effects of number and amplitude of roughness elements on the heat transfer and fluid flow are analysed for various volume concentrations of Al_2O_3 and CuO nanoparticles. The flow fields, temperature fields, and heat transfer rates are examined for different values of Rayleigh and Reynolds numbers. The outcome of this study provides some important insight into the heat transfer behaviour of Al_2O_3-water and CuO-water nanofluids inside a lid-driven rough cavity. This knowledge can be further used in developing novel geometries with enhanced and controlled heat transfer for solar collectors, electronic cooling, and food processing industries.

Keywords: Mixed convection, Nanofluid, Numerical modelling, Rough cavity, Surface roughness