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Numerical Study of Natural Convection in a Nanofluid-Filled Vertical Cylinder under an External Magnetic Field

Authors : M. Maache, R. Bessaih

Abstract : In this study, the effect of the magnetic field direction on the free convection heat transfer in a vertical cylinder filled with an Al_2O_3 nanofluid is investigated numerically. The external magnetic field is applied in either direction axial and radial on a cylinder having an aspect ratio H/R0=5, bounded by the top and the bottom disks at temperatures Tc and Th and by an adiabatic side wall. The equations of continuity, Navier Stocks and energy are non-dimensionalized and then discretized by the finite volume method. A computer program based on the SIMPLER algorithm is developed and compared with the numerical results found in the literature. The numerical investigation is carried out for different governing parameters namely: The Hartmann number (Ha=0, 5, 10, ..., 40), nanoparticles volume fraction (ϕ=0, 0.025, ...,0.1) and Rayleigh number (Ra=103, Ra=104 and Ra=105). The behavior of average Nusselt number, streamlines and temperature contours are illustrated. The results revel that the average Nusselt number increases with an increase of the Rayleigh number but it decreases with an increase in the Hartmann number. Depending on the magnetic field direction and on the values of Hartmann and Rayleigh numbers, an increase of the solid volume fraction may result enhancement or deterioration of the heat transfer performance in the nanofluid.

Keywords : natural convection, nanofluid, magnetic field, vertical cylinder
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