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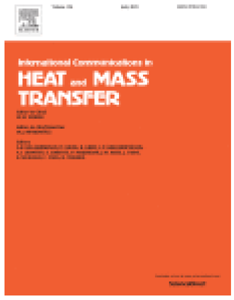

Numerical investigation on natural convection of Al_2O_3/water nanofluid with variable properties in an annular enclosure under magnetic field

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Abstract

Numerical investigation of the natural convection of Al_2O_3-water nanofluid is carried out in a differentially heated vertical annulus under a uniform magnetic field. An in-house Fortran code has been developed to solve the system of equations governing the magneto-hydrodynamic flow. Computations are carried out for different Rayleigh numbers ($10^4 \leq Ra \leq 10^6$), nanoparticle diameter ($d_p = 13$ and 47 nm), nanoparticle volume fraction ($0 \leq \varphi \leq 0.09$), radius ratio ($2 \leq \lambda \leq 10$), and different Hartmann numbers ($0 \leq Ha \leq 100$). According to the simulation data, nanoparticle size is crucial for evaluating nanofluid properties, such as viscosity and thermal conductivity. The computational results reveal that, for nanoparticles with a diameter $d_p = 47$ nm, the average Nusselt number $\overline{Nu}_i$ on the inner cylinder wall decreases as the nanofluid volume fraction increases. This decrease in $\overline{Nu}_i$ number is observed up to a volume fraction $\varphi = 0.05$, after which it increases again. For the full range of volumetric fractions, it is shown that increasing *Ra* number causes $\overline{Nu}_i$ to increase, while increasing *Ha* number and increasing the magnetic field causes $\overline{Nu}_i$ to decrease. Furthermore, as the *Ha* number increases, the heat transfer enhancement ratio *En* increases mainly when the magnetic field is oriented radially. Finally, new correlations of $\overline{Nu}_i$ versus *Ra*, φ, *Ha*, and λ are derived for the axial and radial magnetic fields cases.

Keywords

Natural convection, Al_2O_3-water, Lorentz forces, annulus enclosure, variable properties