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Numerical modeling of nanofluid natural convection in a semi annulus in existence of Lorentz force

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Highlights

- Lorentz forces cause the nanofluid velocity to reduce and augment the thermal boundary layer thickness.
- The heat transfer improvement enhances with augment of Lorentz forces.
- Temperature gradient augments with rise of buoyancy forces but it decreases with augment of Lorentz forces.

Abstract

Influence of external magnetic source on Fe_3O_4-water heat transfer in a cavity with circular hot cylinder is studied. New numerical method is chosen namely CVFEM. Influences of Rayleigh, Hartmann numbers and volume fraction of Fe_3O_4 on hydrothermal characteristics are presented. Results illustrate that Lorentz forces cause the nanofluid velocity to reduce and augment the thermal boundary layer thickness. The heat transfer improvement enhances with augment of Lorentz forces. Nusselt number augments with rise of buoyancy forces but it reduces with augment of Lorentz forces.

Keywords: Nanofluid; CVFEM; Free convection; Magnetic field; Circular wall; Constant heat flux

1. Introduction

In order to enhance the rate of heat transfer, nanofluid can be selected as working fluid. Hsiao [1] investigated electrical MHD nanofluid flow over a plate. He utilized FDM for simulation. Sheikholeslami [2] simulated the nanofluid thermal augmentation in existence of electric field. Sheikholeslami and Ganji [3] investigated different uses of nanofluid as review paper. Sheikholeslami et al. [4] numerically investigated the influence of magnetic field on forced convection heat transfer of ferrofluid. Their outputs showed that Nusselt number has direct relationship

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Nomenclature

B	Magnetic induction
En	Heat transfer enhancement
Ec	Eckert number
H	The magnetic field strength
$\vec{g}$	Gravitational acceleration vector
Nu	Nusselt number
Ha	Hartmann number
T	Fluid temperature
Ra	Rayleigh number
V, U	Vertical and horizontal dimensionless velocity
Y, X	Vertical and horizontal space coordinates
α	Thermal diffusivity
$\Omega \& \Psi$	Dimensionless vorticity & stream function
Θ	Dimensionless temperature
γ	Magnetic field strength at the source
ρ	Fluid density
μ	Dynamic viscosity
σ	Electrical conductivity

Subscripts

nf	Nanofluid
f	Base fluid
loc	Local

Greek symbols

β	Thermal expansion coefficient
μ_0	Magnetic permeability of vacuum
c	Cold

with Reynolds number and nanoparticle volume fraction while it has reverse relationship with Hartmann number. Sheikholeslami and Ganji [5] studied of nanofluid hydrothermal behavior in presence of variable magnetic field using differential transformation method. The influence of the squeeze number, nanofluid volume fraction, Hartmann number and heat source parameter on hydrothermal behavior was examined by them. Sheikholeslami and Abelman [6] examined nanofluid hydrothermal behavior in an annulus in existence of magnetic field. Sheikholeslami and Rokni [7] reported the two phase modeling for nanofluid motion in existence of induced magnetic field. Sheikholeslami and Chamkha [8] investigated the impact of Lorentz forces on nanofluid Marangoni convection. Sheikholeslami et al. [9] reported the electric field impact on nanofluid motion. They considered variable viscosity for nanofluid.

Selimefendigil and Oztop [10] reported nanofluid conjugate conduction–convection mechanism in a titled cavity. They proved that temperature gradient rises with augment of Grashof number. Sheikholeslami and Ellahi [11] selected LBM to simulate Lorentz force influence on nanofluid temperature distribution. They depicted that temperature gradient decreases with augment of Hartmann number. Kefayati [12] considered second law analysis for nanofluid laminar natural convection in a permeable cavity. He found that irreversibilities augment as Rayleigh number enhances. MHD nanofluid free convective hydrothermal analysis in a tilted wavy enclosure was presented by Sheremet et al. [13]. Their results illustrated that change of titled angle causes convective heat transfer to enhance. Influence of non-uniform Lorentz forces on nanofluid flow style has been studied by Sheikholeslami Kandelousi [14]. He concluded that improvement in heat transfer reduces with rise of Kelvin forces. Sheikholeslami and Shehzad [15] studied the nanofluid motion in porous cavity in existence of magnetic field. Several authors investigated about nanofluid hydrothermal analysis [16–35].