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Numerical simulation for impact of Coulomb force on nanofluid heat transfer in a porous enclosure in presence of thermal radiation

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ABSTRACT

Influence of thermal radiation and external electric field on Fe_3O_4-Ethylene glycol nanofluid hydrothermal treatment is presented in this article. The lid driven cavity is porous media and the bottom wall is selected as positive electrode. Influence of supplied voltage on viscosity of nanofluid is taken into account. Control Volume based Finite Element Method is utilized to estimate the roles of radiation parameter (Rd), Darcy number (Da), Reynolds number (Re), nanofluid volume fraction (ϕ) and supplied voltage ($\Delta\varphi$). Results indicate that shape of nanoparticles can change the flow style and maximum rate of heat transfer is obtained by selecting platelet shape nanoparticles. The convective heat transfer improves with augment of permeability and Coulomb force.

1. Introduction

Electric field can be introduced as very effective active method for heat transfer improvement. Nanotechnology can be combined with this active method. Rarani et al. [1] reported good correlation for viscosity of nanofluid. Hayat et al. [2] investigated mixed convection of nanofluid in presence of thermal radiation. Sheikholeslami et al. [3] investigated the impact of external magnetic field on nanofluid convective heat transfer. Nanofluid natural convection in a three dimensional enclosure was demonstrated by Sheikholeslami and Ellahi [4]. They depicted that velocity detracts with augment of Lorentz forces. Sheikholeslami and Chamkha [5] presented the influence of electric field on natural convection of nanofluid in wavy cavity. Sheikholeslami and Shehzad [6] presented the influence of radiative mode on flow style of ferrofluid. They were taken into account MFD viscosity.

Sheikholeslami and Shehzad [7] presented the shape factor effect on nanofluid behavior in existence of external magnetic field. Yadav et al. [8] illustrated nanoparticle transportation due to external forces. Kuznetsov and Sheremet [9] reported the conjugate heat transfer in existence of constant heat flux. Conjugate heat transfer of nanofluid has been simulated by Selimefendigil and Oztop [10]. They considered various inclination angles. Sheikholeslami and Shehzad [6] considered variable viscosity in simulation of nanofluid flow in existence of Lorentz forces. Sheikholeslami and Sadoughi [11] investigated the influence of melting surface on nanofluid flow and heat transfer. Sheikholeslami [12] presented three dimensional simulation of MHD non-Darcy natural convection. Impact of variable Kelvin forces on ferrofluid motion was reported by Sheikholeslami Kandelousi [13]. Heat flux boundary condition has been utilized by Sheikholeslami and Shehzad [14] to investigate the ferrofluid flow in a porous media. Nanoparticle movement in a channel due to Lorentz forces was demonstrated by Akbar et al. [15]. Sheikholeslami et al. [16] reported the nanoparticle transportation under the influence of thermal radiation. In recent decade, various researcher published papers about heat transfer [17–29].

The main goal of this paper is to model the influence of thermal radiation on nanofluid behavior in existence of Coulomb forces via CVFEM. Roles of Darcy number, Reynolds number, supplied voltage, radiation parameter and Fe_3O_4 volume fraction are presented in outputs.

2. Problem definition

Porous enclosure and its boundary conditions are depicted in Fig. 1. Ethylene glycol-Fe_3O_4 nanofluid is considered as working fluid. All walls are stationary except for positive electrode. Influ-

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Nomenclature

S_E	Lorentz force number
D_e	diffusion number
$\underset{\sim}{v}, u$	vertical and horizontal velocity
F_E	electric force
N_E	electric field number
Re	Reynolds number
$\underset{\sim}{Pr}_E$	electric Prandtl number
$\vec{E}, E_x, E_y$	electric field

Greek symbols

ϕ	volume fraction
ρ	density
σ	electric conductivity
μ	dynamic viscosity
φ	electric field potential

Subscripts

s	solid particles
f	base fluid
c	cold
nf	nanofluid
h	hot

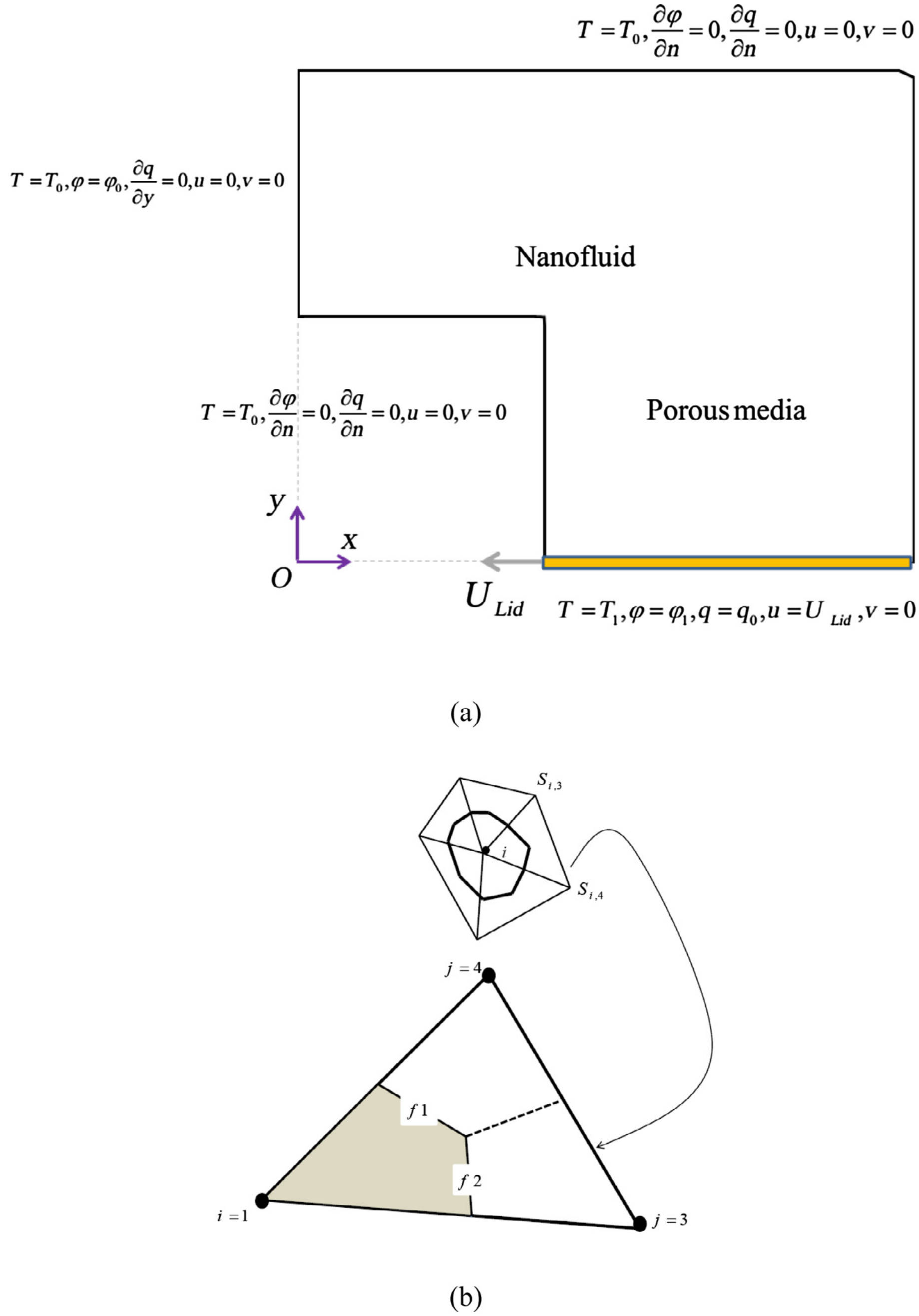

Fig. 1. (a) Geometry and the boundary conditions with; (b) A sample triangular element and its corresponding control volume.