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Simulation of nanofluid flow and natural convection in a porous media under the influence of electric field using CVFEM

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ABSTRACT

Fe_3O_4-Ethylene glycol nanofluid Electrohydrodynamic flow and natural convection heat transfer in a porous medium is simulated numerically. Thermal radiation term is added in energy equation. Properties of nanofluid are considered as a function of supplied voltage and shape of nanoparticles. The bottom wall is considered as positive electrode. Control Volume based Finite Element Method is employed to obtain the outputs which are the roles of radiation parameter (Rd), Darcy number (Da), nanofluid volume fraction (ϕ), Rayleigh number (Ra) and supplied voltage ($\Delta\varphi$). Results show that maximum Nusselt number belongs to Platelet shape Fe_3O_4 nanoparticles. Nusselt number is an increasing function of Darcy number, supplied voltage and Rayleigh number.

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1. Introduction

Recently, Electrohydrodynamic has been offered as an effective active technique for heat transfer augmentation. Combination of this method with another passive technique namely nanotechnology can be considered as an effective way. Rarani et al. [1] reported good correlation for viscosity of nanofluid. They considered the nanofluid properties as a function of electric field. Ellahi et al. [2] presented the nanofluid boundary layer magnetic flow over a stretching sheet. Sheikholeslami and Bhatti [3] studied the effect of nanofluid heat transfer improvement in existence of electric field as an active approach. Three dimensional nanofluid flows was demonstrated by Sheikholeslami and Ellahi [4]. They illustrated that velocity reduces with augment of Lorentz forces. Nithyadevi et al. [5] investigated mixed convection of nanofluid inside a porous media. Sheikholeslami and Shehzad [6] presented the influence of radiative mode on magnetic nanofluid motion. They were taken into account non-uniform viscosity. Selimefendigil and Oztop [7] demonstrated nanofluid conjugate heat transfer under the influence of magnetic field. Bhatti et al. [8] simulated the impact of non-uniform magnetic field on Jeffry flow. Sheikholeslami [9] simulated the EHD flow of nanofluid in a porous cavity. Hayat et al. [10] reported the Darcy-Forchheimer nanofluid flow over a rotating disk. Sheikholeslami [11] considered the Brownian motion effect on nanofluid flow in a porous cavity due to magnetic field. Bondareva et al. [12] utilized heatline analysis for natural convection of nanofluid in an open cavity.

Sheikholeslami and Rokni [13] investigated nanofluid forced convection heat transfer in presence of Coulomb force. They considered the thermal radiation effect on energy equation. Sheikholeslami et al. [14] presented the convection heat transfer in a nanofluid filled enclosure with elliptic inner cylinder. They utilized single phase model. Heat flux boundary condition has been utilized by Sheikholeslami and Shehzad [15] to investigate the ferrofluid flow in a porous media. Sheikholeslami and Rokni [16] reported the completed review for application of magnetic nanofluid. Sheikholeslami et al. [17] examined the nanoparticle transportation under the impact of thermal radiation. Sheikholeslami and Seyednezhad [18] utilized LBM for simulation of water based nanofluid in a porous cavity with hot obstacle. In recent years, various scientists published articles about heat transfer of nanofluid [19–47].

This research intends to investigate the impact of thermal radiation and electric field on nanofluid treatment inside a porous medium via CVFEM. Roles of Rayleigh number, supplied voltage, Darcy number, Radiation parameter and nanofluid volume fraction are presented in outputs.

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Nomenclature

S_E	Lorentz force number
D_e	diffusion number
v, u	vertical and horizontal velocity
$\overrightarrow{F_E}$	electric force
N_E	electric field number
Ra	Rayleigh number
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

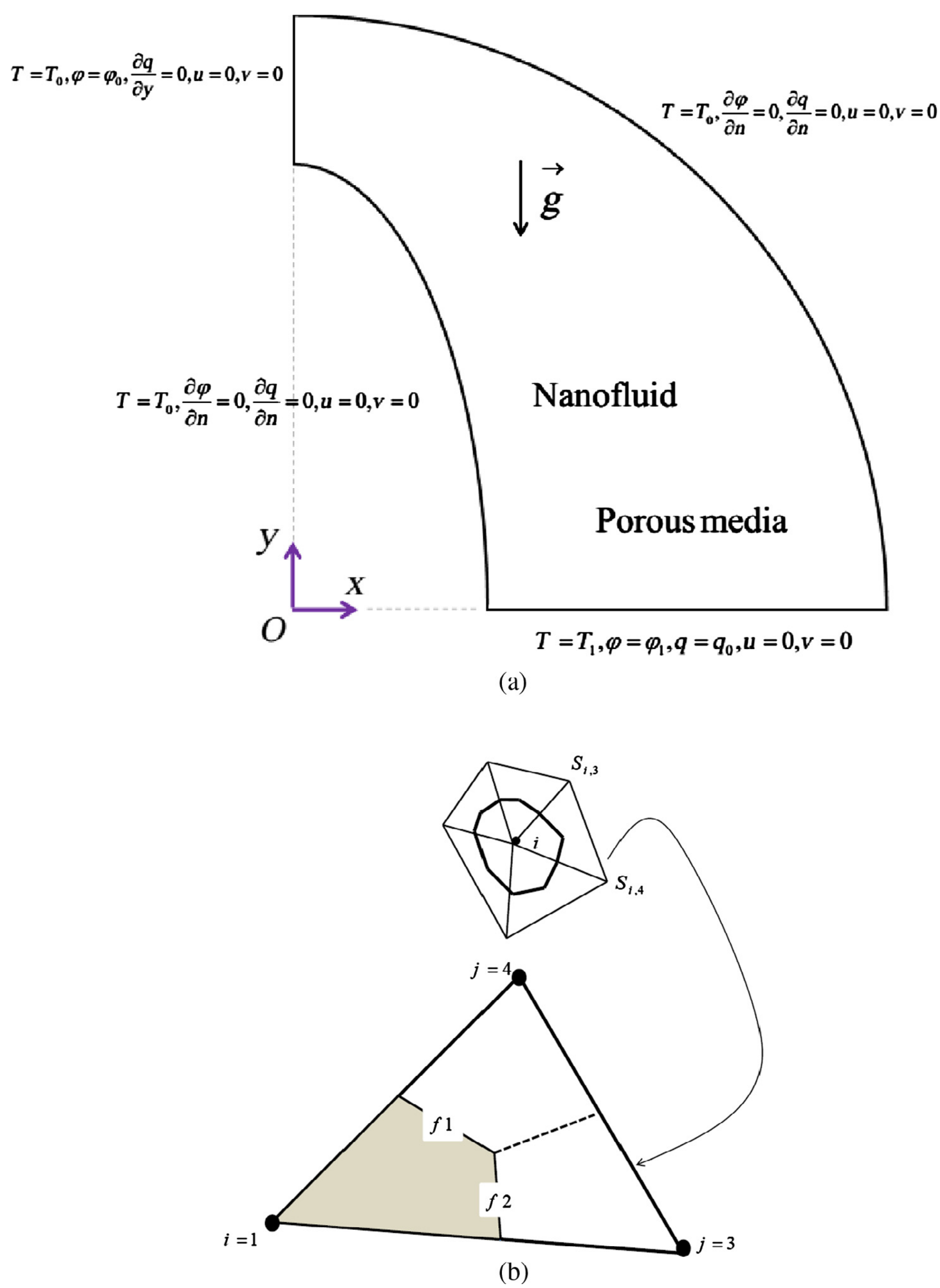

Fig. 1. (a) Geometry and the boundary conditions with; (b) A sample triangular element and its corresponding control volume.

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