Chinese Journal of Physics 55 (2017) 2254–2272

Contents lists available at ScienceDirect

Chinese Journal of Physics

journal homepage: www.elsevier.com/locate/cjph

Radiation effects on heat transfer of three dimensional nanofluid flow considering thermal interfacial resistance and micro mixing in suspensions

M. Sheikholeslami[a], Hari R. Kataria[b], Akhil S. Mittal[c,*]

[a] Department of Mechanical Engineering, Babol Noshirvani University of Technology, Babol, Iran
[b] Department of Mathematics, Faculty of Science, The M. S. University of Baroda, Vadodara, India
[c] Department of Mathematics, Faculty of Science, Gujarat Science College, Ahmedabad, India

ARTICLE INFO

Keywords:
HAM
MHD
Nanofluid
Brownian
Heat transfer

ABSTRACT

In this study, three dimensional Al_2O_3-Water nanofluid flow and heat transfer features between two horizontal parallel plates in the presence of magnetic field through porous medium is scrutinized. System under consideration is rotating. Effects of thermal interfacial resistance, nanoparticle volume fraction, Brownian motion, nanoparticle size, types of nanoparticle and base fluid on thermal conductivity are considered. Also micro mixing in suspensions is taken into account while calculating viscosity. Homotopy Analysis method is employed to solve the system of ordinary differential equations, obtained by reducing original system of partial differential equations using suitable change of variables. Effects of different prevailing parameters: Reynolds number, Radiation parameter, Magnetic parameter, nanoparticle volume fraction, Eckert number, Permeability parameter, Rotation parameter and Prandtl number on Heat transfer and fluid flow are discussed. Also it is observed that the skin friction increases with increase in Reynolds number and rotation parameter but trend is reversed for nanoparticle volume fraction. The magnitude of Nusselt number rises with Reynolds number and nanoparticle volume fraction but it declines with increase of rotation parameters and Eckert number.

1. Introduction

Enhancement of heat transfer is vital in Industrial and engineering processes. High thermal conductivity of nano fluids is a boon in this direction, thus many researchers are working intensively considering heat transfer properties of nanofluids. Sheikholeslami and Seyednezhad [1] investigated heat transfer in nanofluid fluid flow in a permeable enclosure. Sheikholeslami et al. [2] studied MHD nanofluid flow taking heat transfer improvement in account. Forced convection heat transfer was investigated by Sheikholeslami et al. [3]. Sheikholeslami and Bhatti [4,5] considered the analysis of nanofluid heat transfer enhancement. Hayat et al. [6] studied thermally stratified stretching flow with heat flux. Mustafa et al. [7] took care of variable thermal conductivity of Maxwell fluid.

Effect of magnetic field on electrically conducting fluids has many applications in almost all branches of science and engineering such as generators, coolant in huge nuclear power plants, plasma and bearings. Magnetohydrodynamic effect on convective flow of nanofluid was studied by Hayat et al. [8]. Kataria and Patel [9-13] studied MHD flow considering different types of fluids. Hayat et al. [14] analyzed MHD peristaltic flow of Williamson nanofluid numerically. Mustafa et al. [15] revealed buoyancy effects on the MHD

* Corresponding author.
E-mail addresses: mohsen.sheikholeslami@nit.ac.ir (M. Sheikholeslami), hr.kataria-maths@msubaroda.ac.in (H.R. Kataria), akhilmittal-math@msubaroda.ac.in (A.S. Mittal).

http://dx.doi.org/10.1016/j.cjph.2017.09.010
Received 2 September 2017; Received in revised form 22 September 2017; Accepted 26 September 2017
Available online 28 September 2017
0577-9073/

Nomenclature

T	Temperature
T_w	Temperature
u, v, w	Velocity components along x, y, z axes, respectively
B	External uniform magnetic field
C_p	Specific heat at constant pressure
g	Acceleration due to gravity
k	Thermal conductivity
k_1	Permeability of the fluid
M	Magnetic parameter (Ratio of Lorentz force to viscous force)
Pr	Prandtl number (ratio of momentum diffusivity to thermal diffusivity)

Greek symbols

α	Thermal diffusivity
ρ	Density
σ	Electrical conductivity (S/m)
∅	Nanoparticle volume fraction
θ	Dimensionless temperature ($\theta = \frac{T - T_0}{T_w - T_0}$)
μ	Dynamic viscosity
φ	Porosity
κ	Permeability (dimensionless)
Ω	Constant Rotation velocity
ν	Kinematic viscosity
η	Dimensionless variable

Subscripts

f	Fluid phase
nf	Nano-fluid
s	Solid phase

nanofluid flow past a vertical surface. MHD effect on Eyring–Powell magneto nanomaterial was studied by Hayat et al. [16].

Oil extraction, Pollution of Ground water, filtering media, geothermal energy recovery and thermal energy storage are some problems involving heat transfer in porous media. Sheikholeslami and Shehzad [17] studied MHD nanofluid convective flow in a porous enclosure. Kataria and Mittal [18] analyzed velocity, mass and temperature of nanofluid flow in a porous medium. Sheikholeslami and Zeeshan [19] investigated $CuO{-}H_2O$ nanofluid in a porous enclosure with heat source. Sheikholeslami and Rokni [20] employed Mesoscopic method to natural convective CuO−H2O nanofluid flow in a curved porous enclosure, this work was extended considering shapes of nanoparticles by Sheikholeslami and Sadoughi [21].

In real world problems, thermal radiation is evident which is reflected in study of various researchers. Kataria and Mittal [22] discussed optically thick nanofluid flow past an oscillating vertical plate in presence of radiation. Akbar et al. [23] analyzed induced transport of $CuO{-}H_2O$ nanofluid flow. Hayat et al. [24] considered heat source while studying MHD. Hayat et al. [25] studied flow in presence of convective conditions. Hayat et al. [26] discussed Radiative flow of Powell–Eyring nanofluid. Recently, MHD nanofluid flow and heat transfer has been considered by some authors [27–40].

The aim of this study is to analyze heat transfer in nanofluid flow in presence of magnetic field and thermal radiation between horizontal parallel plates in a rotating system. Effects of many vital phenomenon like thermal interfacial resistance, nanoparticle volume fraction, Brownian motion, nanoparticle size, types of nanoparticle and base fluid on thermal conductivity are often neglected.

Novelty of the present work is the inclusion of above phenomenon along with micro mixing in suspensions. The simplified systems of ordinary differential equations are solved using the Homotopy analysis method. The effects of the pertinent parameters are discussed.

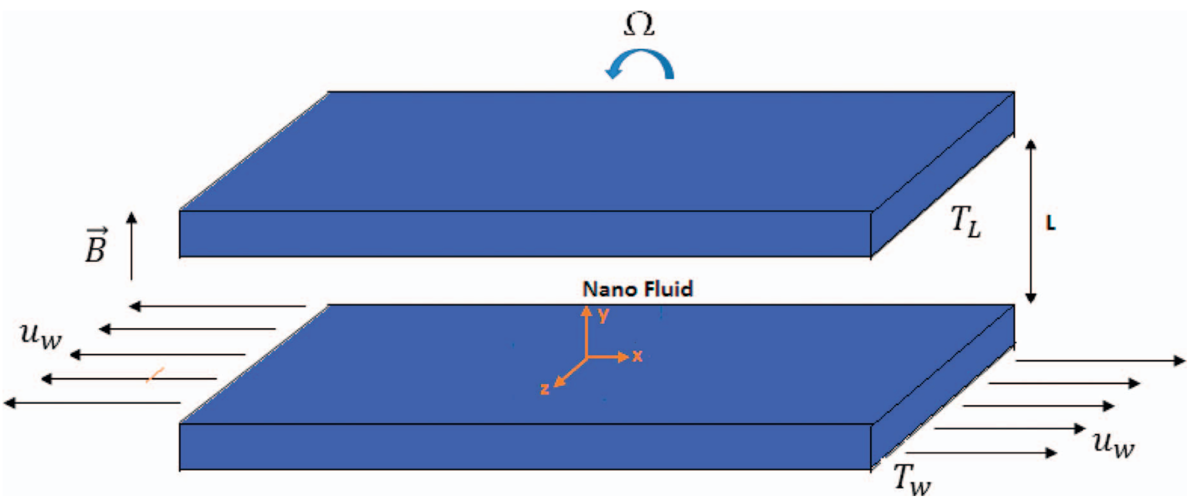

Fig. 1. Physical sketch of the problem.