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Thermal radiation effect on an unsteady magnetohydrodynamic flow past inclined porous heated plate in the presence of chemical reaction and viscous dissipation

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ABSTRACT

An analysis is made for the unsteady magnetohydrodynamic (MHD) flow of a viscous, incompressible, electrically conducting fluid in a porous medium. Considering the viscous dissipative term in energy equation which is important in free convective flow. The coupled non-linear partial differential equations are solved by using an implicit finite difference method of Crank Nicolson type. The effects of chemical reaction, viscous dissipation and radiation on velocity, temperature and concentrations are discussed. More importantly, the results of numerical solution of the present study agree well with the analytical solution of the earlier study in a particular case (i.e. without viscous dissipation). It is interesting to note that the Hartmann number reduces the velocity at all points of the flow domain as expected. An increase in viscous dissipation contributes slightly but uniformly to the rise of temperature as well as velocity distribution.

1. Introduction

Several problems related to transfer of mass over inclined beds finds numerous applications in geophysical, petroleum, chemical, bio-mechanical and chemical technology. The viscous drainage over an inclined porous plane is a subject of considerable interest to both theoretical and experimental investigators, especially in the flow of oil through porous rock, the extraction of geo-thermal energy from the deep interior of the earth to the shallow layers, flow of liquids through ion exchange beds, chemical reactor for economical separation or purification of mixtures. Another area of bio-medical application is the drug permeation through human glands, flow of fluids in lungs, blood vessels, arteries and so on.

Raptis and Kafousias [1] studied the magnetohydrodynamic free convective flow and mass transfer through a porous medium bounded by an infinite vertical porous plate with constant heat flux. Gebhart [2] and Gebhart and Mollendorf [3] showed that the viscous dissipative heat in natural convection is important when the free convective flow field is of extreme size or at extremely low temperature or in high gravity field. Reddy et al. [4] investigated mass transfer and radiation effects of unsteady MHD free convective fluid flow embedded in porous medium with heat generation/absorption. The effects of the chemical reaction and radiation absorption on free convective flow through porous medium with variable suction in the presence of uniform magnetic field was studied by Sudheer Babu and Satyanarayana [5]. Bhaskar et al. [6] studied radiation and mass transfer effects on MHD free convection flow past an impulsively started isothermal vertical plate with dissipation. Muthucumaraswamy and Vijayalakshmi [7] investigated MHD and chemical reaction on flow past an impulsively started

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Nomenclature

A	a constant
B_o	magnetic field component along y'-axis
C_p	specific heat at constant pressure
Gr	Grashof number
Gc	modified Grashof number
g	acceleration of gravity
K'	the permeability of medium
K	the permeability parameter
M	Hartmann number
Pr	Prandtl number
Sc	Schmidt number
N	thermal radiation parameter
Q	heat absorption parameter
Ec	Eckert number
k_r	chemical reaction parameter
D	chemical molecular diffusivity
T'	temperature of fluid near the plate
T'_w	temperature of the fluid far away of the fluid from the plate
T'_∞	temperature of the fluid at infinity
C	concentration of the fluid
C'	concentration of fluid near the plate
C'_w	concentration of the fluid far away of the fluid from the plate
C'_∞	concentration of the fluid at infinity
t'	time in x', y' coordinate system
t	time in dimensionless co-ordinates
u'	velocity component in x'-direction
u	dimensionless velocity component in x'-direction
Nu	Nusselt number
α	Sherwood number
q_r	radiative heat flux
R_{e_x}	Reynolds number
k_1	mean absorption coefficient
$\bar{K}$	chemical reaction of first order with rate constant
x', y'	co-ordinate system
x, y	dimensionless coordinates
U_o	reference velocity
Greek symbolsβ	
	coefficient of volume expansion for heat transfer
β^*	coefficient of volume expansion for mass transfer
κ	thermal conductivity of the fluid
σ	electrical conductivity of the fluid
ν	kinematic viscosity
θ	non-dimensional temperature
ρ	density of the fluid
α	angle
τ	skin-friction
μ	viscosity, Ns/m^2

semi-infinite vertical plate with thermal radiation. The radiation and mass transfer effects on an unsteady MHD convection flow past a semi-infinite vertical permeable moving plate embedded in a porous medium with viscous dissipation was studied by Prasad and Reddy [8]. Kumar and Verma [9] studied the radiation effects on MHD flow past an impulsively started exponentially accelerated vertical plate with variable temperature in the presence of heat generation. They [10] also studied the thermal radiation and mass transfer effects on MHD flow past a vertical oscillating plate with variable temperature and variable mass diffusion. Pattanaik et al. [11] studied the radiation and mass transfer effects on MHD free convective flow through porous medium past an exponentially accelerated vertical plate with variable temperature. Rajesh and Verma [12] considered the radiation and mass transfer effects on MHD free convection flow past an exponentially accelerated vertical plate with variable temperature. The radiation effects on MHD free convective flow over a vertical plate with heat and mass flux was studied by Sivaiah et al. [13].